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

S.k.Sirajuddin, T.Venkat Das

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 the fine aggregate with Quarry Dust (QD). GGBS is the by-product of iron and steel industry which is produced in large quantities as a solid waste. It is highly cementitious. Quarry Dust is a byproduct of the crushing process which is a concentrated material to use especially as fine aggregates. The replacement percentages of cement with GGBS are 20%, 40% and 60% by weight and fine aggregate with QD are 25%, 50% and 75% by weight. These combinations of materials were used to study compressive strength, spilt tensile strength and flexural strength tests and the results obtained were compared with the control concrete. It is observed that the optimum replacement percentages of GGBS and QD are 40% and 50% respectively.***

Index Terms: GGBS, Quarry Dust, Compressive strength, Spilt tensile strength and Flexural strength.

I. INTRODUCTION

Concrete is the most important material used for construction all over the World. The components of concrete are cement, fine aggregate, coarse aggregate and water. Cement acts as a binding material for concrete. During the production of cement, CO_2 emissions are more in the environment. Many researchers have worked out on the ways of reducing the cement content to avoid the CO_2 emissions. Various by-products like Fly ash, Silica fume, Metakolin, GGBS can be used as replacement of cement. Due to high price of Natural Sand we have to choose alternative material for it. Quarry dust is the better choice for replacement of sand. Therefore in this study, we have chosen GGBS as replacement of cement and Quarry dust as replacement of fine aggregate.

GGBS is obtained by burning molten Iron slag from a blast furnace in water or steam to produce a glassy, granular product which is dried and grounded into a fine powder. Quarry dust is a by-product of the crushing a rock or boulders which results as dust after the crushing process. This dust is known as Quarry Dust (QD).

Concrete is known for its compressive strength & used for the construction of the concrete structures.

GGBS concrete is majorly used in so many construction projects. In New York, construction of the World Trade Centre has about 40% GGBS as replacement of cement in the concrete (Slag Cement Association, 2005). At Minneapolis Airport, the construction of airfield pavements are using 35% GGBS replacement in the concrete. The Detroit Metro Airport Terminal Expansion used 30% GGBS as replacement of cement in the concrete.

II. RESEARCH SIGNIFICANCE

The main objective of this study is to determine the compressive strength, spilt tensile strength and flexural strength of concrete by partially replacing cement with GGBS and fine aggregate with Quarry Dust (QD).

III. PROPERTIES OF MATERIALS

A. Cement

The cement used in this study is Ultra-Tech Ordinary Portland Cement (OPC) of 53 grade. The properties of cement are confirmed according to IS 12269-2011 specifications and used for the experimental specimens preparation.

B. Fine aggregate

Fine aggregate which is used in this study is locally available and it confirms to IS specifications. The properties of Fine aggregates are summarized in Table I which was used in the preparation of cubes, cylinders and prisms.

Table I: Physical properties of Fine aggregate

S.No.	Property	Result
1	Specific gravity	2.5
2	Fineness modulus	2.2
3	Water absorption	3.70%

C. Coarse aggregate

Coarse aggregate of nominal size 20mm and 10mm, obtained from our University confirming to IS specifications. The physical properties of coarse aggregate which were used in the experimental work was summarized in Table II.

Table II: Physical properties of Coarse aggregate

S.No.	Property	Result
1	Specific gravity	2.72
2	Water absorption	0.4%

D. Ground Granulated Blast furnace Slag (GGBS)

GGBS is obtained from local available industries. It is obtained by burning molten Iron slag from a blast furnace in

Revised Manuscript Received on April 09, 2019.

Sk.Sirajuddin, Master of Technology Student, Civil Engineering Department, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, A.P. India.

T.Venkat Das, Assistant Professor, Civil Engineering Department, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, A.P., India.

water or steam to produce a glassy, granular product which is dried and grounded into a fine powder. The properties of GGBS are tabulated in Table III.

Fig. 1 shows the GGBS that is used in the experimental work to replace cement.

Fig.1: GGBS

Table III: Physical properties of GGBS

Characteristics	Result
Fineness modulus	3.80
Specific gravity	2.85

E. Quarry Dust (QD)

Quarry dust is obtained from the local quarry. It is a by-product of the crushing a rock or boulders which results as dust after the crushing process. This dust is known as Quarry Dust (QD). The physical properties of QD that was used in the preparation was tabular in Table IV.

Fig. 2 shows the Quarry dust that is collected near the industry of cement and used for the replacement of cement in this experimental work.

Fig.2: Quarry dust

Table IV: Physical Properties of QD

S.No.	Property	Result
1	Specific gravity	2.62
2	Fineness modulus	3.66
3	Zone	Zone-II

F. Water

Distilled water is used for casting & curing of concrete specimens, which is free from organic matter

G. Creep

The deformation of concrete structure under sustained load is termed as creep of concrete. Many researchers has reported that GGBS concrete can withstand up to the replacement levels ranging from 30% to 70% with higher or lower creep. (Brooks et al, 1992).

H. Drying Shrinkage

Most of the papers reported that use of GGBS is directly influenced on the shrinkage of concrete. It has been observed that under a curing condition of 20^{o}C GGBS have relative humidity of 60%, after that it gets reduced to 50% So, by using the ultra fine GGBS could greatly reduce the drying shrinkage.

IV. EXPERIMENTAL PROGRAMME

M40 grade of concrete is used in the present investigation. The mix design is done as per IS code of practice.

W/C = 0.45
Cement = 437.78 kg/m^3
F.A. = 692.39 kg/m^3
C.A. = 1129.70 kg/m^3

Final mix proportion is,
C : F.A : C.A = 1: 1.58 : 2.58

For each mix 32 samples of 150mm*150mm* 150mm cube for compressive strength was prepared. The cement in OPC concrete mixes was directly replaced by the equal weight of GGBS with cement replacement of 20, 40 and 60 percent respectively. The fine aggregate is partially replaced with QD by 25, 50 and 75 percent respectively.

V. TESTS & RESULTS

Table V: Designation of Mix

Designation of Mix	Replacements
M1	Conventional mix
M2	Partial replacement of cement with 20% GGBS & Fine aggregate with 25% QD by weight
M3	Partial replacement of cement with 40% GGBS & Fine aggregate with 50% QD by weight
M4	Partial replacement of cement with 60% GGBS & Fine aggregate with 75% QD by weight

A. Compressive strength test

The compressive strength test carried at the age of 7, 28days. The load is applied gradually until the specimen fails. The load at which the specimen fails is divided by area of the specimen gives the Compressive strength of concrete. The cube dimensions 150mm*150mm*150mm.

The characteristics strength of a concrete cube is obtained from its 7-day & 28-day strengths. In this study, we observed that GGBS gives lesser strength as compared to Portland cement concrete.

Fig. 3 shows that the cube testing is done under the compressive testing machine and the dial gauge gives the readings for the strength.

Fig.3: Concrete cube test in Compressive test machine(CTM)

Table IV shows the results that are obtained for the cube specimens for 7 days and 28 days and the Fig. 4 shows the graphical representation for the 7days and 28days results that which shows the result 10% increment in M3 mix when compared with control mix.

Table VI: Compressive strength for 7 and 28 days

Designation	F_{ck} (N/mm^2)	F_{ck} (N/mm^2)
	7 days	28 days
M1	38	42
M2	32	41
M3	36	43
M4	33	40

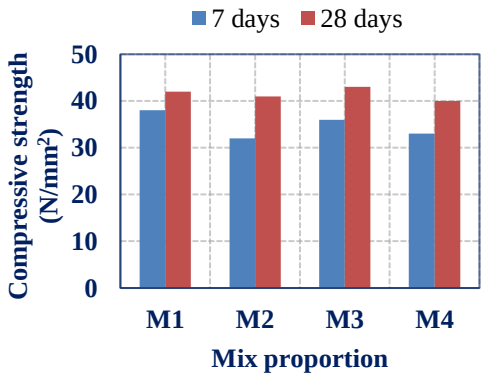

Fig.4: Compressive strength for 7 & 28 days

B. Spilt tensile strength

The Spilt tensile strength of concrete obtained using cylinder specimens of size 150mm*300mm. Calculation of splitting tensile strength of each sample was calculated by the Eq. 1

$$T = 2P/\pi LD \quad (1)$$

Where

T = split tensile strength in psi.

P= maximum load applied in pounds.

L= average sample length in inches.

D = sample diameter in inches.

Fig.5: Concrete cylinder in CTM

Fig. 5 shows the split tensile strength testing for the cylinder under compressive testing machine.

Table VII gives the Spilt tensile strength test results of all mix proportions at 7 & 28 days respectively.

Table VII: Split Tensile Strength for 7 and 28days

Designation	Spilt tensile strength (N/mm^2) 7 days	Spilt tensile strength (N/mm^2) 28 days
M1	4.315	4.536
M2	3.959	4.482
M3	4.200	4.590
M4	4.021	4.427

By observing the above result, 12% increment in M3 mix when compared with control mix.

Fig. 6 is the graph representing spilt tensile strengths of all mix proportions at 7 & 28 days respectively.

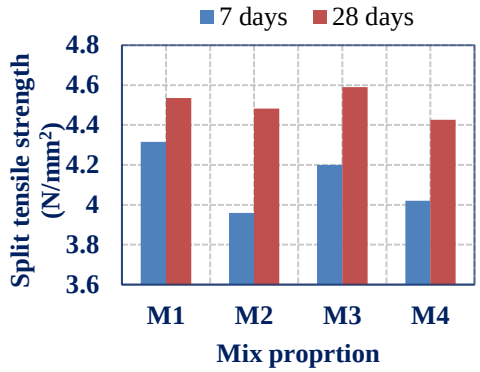

Fig.6: Spilt tensile strength for 7 & 28 days

C. Flexural strength test

Flexural strength is a measure of tensile strength of concrete prisms of size 750mm*100mm*100mm were used. It is 12-20 % of compressive strength.

Fig. 7 shows the flexural strength testing conducts on the prism for 7 days and 28 days respectively and the comparison of the results are shown in the Fig. 8. From the results it is observed that the result 15% increments in M3 mix when compared with control mix.

Fig.7: Flexural strength testing

Table VIII: Flexural strength for 7 and 28days

Designation	Flexural strength (N/mm^2) 7 days	Flexural strength (N/mm^2) 28 days
M1	6.84	7.56
M2	5.76	7.38
M3	6.48	7.74
M4	5.94	7.20

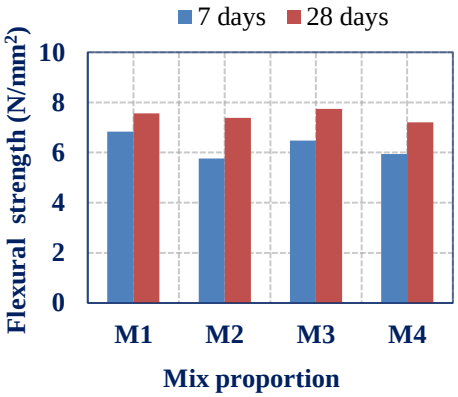

Fig.8: Flexural strength for 7 & 28 days

VI. CONCLUSION

From the test results, an increment of 10%, 12% and 15% observed in Compressive strength, Spilt tensile strength and Flexural strength obtained at 40% GGBS and 50% QD replacements of cement and fine aggregate respectively. Finally, we conclude that replacement of cement with 40% GGBS and fine aggregate with 50% QD is suitable for getting higher strengths compared with control mix.

ACKNOWLEDGMENT

The author would like to acknowledge T.Venkat Das is working as assistant professor in the department of civil engineering at Koneru Lakshmaiah Educations Foundations (Deemed to be university) for his support and encouragement during his research.

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AUTHORS PROFILE

Sk. Sirajuddin received the B-tech Degree in Civil Engineering from Andhra Loyola Institute of Engineering & Technology JNTUK Kakinada, Andhra Pradesh, India in 2017. He is pursing M-tech Degree in Structural Engineering from K L Deemed to be university, Guntur, Andhra Pradesh, India. He actively participating in workshops and seminars in and around the University.
If any quarries are there please inform me through this mail, siraj90598@gmail.com.

T. Venkat Das working as an Assistant Professor in Civil Engineering Department from K L Deemed to be University since 2014. Before he worked in KMC constructions and KIRBY building systems. He completed his B-Tech in Sun Flower Engineering College JNTUK Kakinada, Andhra Pradesh, India, 2009. M-Tech in Structural Engineering IIIT Hyderabad, Telangana state, India, 2011. He actively organized conferences, workshops and Guest lecturers in the Civil Department, K L University.