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IMPACT OF GGBS AS PARTIAL SUBSTITUTION TO CEMENT AND REPLACEMENT OF QUARRY DUST TO FINE AGGREGATE ON M50 GRADE OF CONCRETE

Vinodkumar[1], Dr.ShreenivasReddy.S[2], Maneeth P D[3], Brijbhushan S[4], Siddharth B[5]

[1]*M.Tech. Student, Department of Construction Technology, Visvesvaraya Technological University,* vinodrose457@gmail.com
[2]*Professor, Department of Construction Technology, Visvesvaraya Technological University,* ms srinivas33@yahoo.com
[3] *Assistant Professor, Department of Construction Technology, Visvesvaraya Technological University,* maneeth.pd@gmail.com
[4] *Assistant Professor, Department of Construction Technology, Visvesvaraya Technological University,* brijbhushanvtupgct@gmail.com
[5]*Assistant Professor, Department of Construction Technology, Visvesvaraya Technological University,* siddharthbaeen@gmail.com

Abstract— ***the present evaluation focuses on optimal utilization of GGBS on M50 grade of concrete with various proportions mixes (0%, 10%, 20%, 30%, 40%) and replacement of quarry dust as fine aggregate which was maintained at 30% constant, along with addition of 1% of steel fibre by volume of concrete. For this various cubes, prisms, cylinders were casted and tested for different ages (3, 7, 28 days). To assess the mechanical properties of concrete some test were performed. Mix-3 emerges as the optimal replacement with enhanced value of compressive, split and flexural strength. Addition of steel fibre demonstrates the enhancement of flexural and split properties. Further, Acid attack test was conducted to assess the durability characteristic for optimal mix.***

Keywords— GGBS, Quarry Dust, Steel Fibre, Mechanical Properties, Durability test (Acid Attack).

I. INTRODUCTION

Concrete is an ingredient material used in the construction industry it consists of chemically inert particulate substances like as an aggregate (fine aggregate and coarse aggregate) which is bonded with a cement and portable water. As per WHO concrete is a second broadest material consumption by human resources after food and water. The concrete is prepared by the proper mixing of cement, fine aggregate, coarse aggregate and water as per the mix proportions. Later the mix is allowed to cure and finally it is hardened like as stone. The hardening process is takes place just because of present chemical activities between water and cement for this concrete became strong with age. The concrete strength, durability, and many other properties are mainly dependence on the properties of the concrete ingredients, mix proportions, type of method of compaction and many other controls at the time of mixing, compaction, placing, and transportation and at the end curing at the end. Minimum of two proportions of an elevation amount as much compared to the standard materials. GGBS is a byproduct material which is obtained from a steel manufacture industry which may be a replaceable material partially with the cement because of it reduces the ecologically burden with associating with the concrete at both stages like the hardened state and fresh state of the concrete. Quarry Dust have be proposed for an alternate material for the river sand as it gives an additional strength and profit to concrete and also improves strength in concrete. Quarry Dust is well-known to enlarge the potency of concrete. More over it may concrete through up of with a one and the same quantity of river sand. The strength of Quarry Dust concrete attention ally continues in raise with era for every proportion of quarry dust content in concrete. The proper use of a quarry dust as a fine aggregate it may twirl this desecrate matter. This cause discarding difficulty in nature into a more precious resources the perfect using of quarry dust may reduce the stain problem of supply of natural Fine aggregate and in turns helps cost reduction of concrete.

II. OBJECTIVES

1. To find out the optimum percentage of GGBS replacement to cement in high strength concrete.
2. To assess concrete's compressive strength with a various proportions of GGBS(10%,20%,30%,40%) to the cement, with the fine aggregate is partially replaced with Quarry Dust as maintain 30% constant and addition of steel fibre it is also maintain 1% constant by weight of volume of concrete.
3. To assess the concrete's Flexural strength and the Split tensile strength having various proportions of GGBS with constant materials Quarry Dust and Steel Fibres.
4. To investigate durability characteristics of GGBS content concrete using HCL solution.

III. LITERATURE REVIEW

1. M. Adams Joe et.al [1]

This current paper focus on investigation of features of M40 grade concrete of with a range of proportional for GGBS with cement and addition of 1% of steel fibre. Maintain water cement ratio 0.35. In the present work GGBS is varied in 0%, 10%, 20%, 30%, 40% & 50% and 1% steel fibre is used for getting the better results. At the end of experimental work it is concluded that 40% replacement of GGBS with cement & 1% of steel fibre are help to increase the force of concrete compare to standard design mix concrete.

2. S.P.Sangeetha et.al [2]

For the determination of flexural performance of reinforced concrete beams the cement is replaced by GGBS. This experimental work mainly focuses on flexural force of beam. In this work M30 grade of concrete were used. For cement replacement GGBS are used in the proportion of 0%, 30%, 40%, 50%, 60% tested for 56 days also considering 28 days. Finally this experimental study explains that 40% of GGBS can be a replacement for cement which will be used for reinforced concrete beams. The strength increases about 21% at 56 days as compared to 28 days.

3. B Vidivelli et.al [3]

Has investigated the mechanical & durability characteristics of concrete with GGBS & steel fibre for this grade maintained as M30. In this work maintain the GGBS as 20% & steel fibre about 1% the tests are conducted of for specimen 98, 56 & 28 days of all compressive, flexural force & 28 days test for elastic modulus. Along with this work simultaneously we have carried out the durability tests of sulphate attack, acid attack and water absorption. At the end of this experimental investigation we have concluded that GGBS with 20% replacement & 1% steel fibre addition gives better compressive, flexural & elastic modulus of concrete results of about 47.58, 4.5, 32.18 of about 90 days curing and also sulphate attack, acid attack are tested for about weight loss in respect to 7.94 & 10.45 and water absorption test results are 13.56 of about 20 % of GGBS replaced with cement & 1 % of steel fibre addition.

4. Suchita Hirde et.al [4]

Through the present experimental work is to determine the mechanical properties of GGBS with adding up of steel fiber. For this GGBS is replaced with cement in the proportion of 0%, 10%, 20%, 30%, 40% by mass of cement and steel fiber are kept unvarying 1.5 % the specimens are cured for 28 & 56 days tested under compression & flexural strength along this flexural toughness indices are also determined. Finally the experimental investigation conclude that 20 % replacement of GGBS which maintains 1.5% steel fiber gives good results of compressive strength. This work is mainly concentrated by varying the GGBS content is varied in size of aggregate of about 10mm, 20mm, 12mm which results of about 61.09 MPa, 61.91 MPa, and 61.01 MPa. Along with this 20mm aggregate with 20% replacement of GGBS gives better flexural results of about 10.26% compare to other size of aggregate.

5. G. Balamurugan et.al [5]

In this work variations are considered in the grade of concrete M20& M35. For this the Quarry Dust is replaced with natural sand. In the proportions of 0% to 100% of about 7 days and 28 days curing. But the test results give a clear image of about Quarry Dust. In this work finally concluded that 50% replacement of Quarry Dust material can be replaced to natural sand gives better results of strength achieve in nature beyond this decreases in strength.

6. S.Azhagarsamy et.al [6]

The work is to find out the high performance concrete strength by using quarry dust material as replacement material for sand. For considering M60 grade concrete the Quarry Dust is replaced to natural sand directly i.e. maintained constant & steel fiber are varied in the percentage of 0.5%, 1%, & 1.5% the test were conducted 3, 7 ,28 days . Finally the work is concluded that 60% of Quarry Dust and 1% of steel fiber gives better comfortable results of high performance concrete.

7. R.Rasika Priya et.al [7]

In this work the normal sand is replace by Quarry Dust in this the variations of 10%, 20%, 30%, 40%, 50% & 60%with maintaining 1% of steel powder. At the end of experimental work conclude that 40% of Quarry Dust With 1% of steel powder gives an optimum strength.

8. Santosh Kumar Karri et.al[8]

In this prescribed work explain the GGBS is partially replaced to cement for the grade of concrete M20 and M40 in the range of 30%, 40%, 50%.cubes, cylinders, prisms are casted for determining the compressive, tensile and flexural force of concrete along this durability tests are also conducted like acid tests sulphuric acid and hydrochloric acid used to conduct the work. This experiment finally concluded that for both M20 and M40 grade concrete the GGBS material can be replace of cement up to 40% optimum results for all strengths. In durability properties comparing the H_2SO_4 with HCL. The compressive strength value GGBS concrete effect of HCL more compare to H_2SO_4.

IV. MATERIALS AND MIX PROPORTIONS

A. MATERIALS

1. Cement: In this present investigation we use OPC (ordinary Portland cement) as a binding material.

   The test results are tabulated in a below table.

TABLE I

Shows the Preliminary Test Results Of Cement

Particulars of cement	Normal Consistency	Specific gravity	Fineness	Initial Setting	Final Setting
Test outcomes	33%	3.14	5%	44min.	398min.

2. Fine aggregate:

In this present project work fine aggregate used is naturally available river sand which is under zone-II as per IS 383:1970.The preliminary experimental outcomes of FA are as shown in the below table.

TABLE II

Shows The Preliminary Test Of Fine Aggregate.

Particulars of FA	Specific gravity	Water absorption	Fineness modulus	Silt content
Test outcomes	2.66	1.4%	3.42	2.32%

3. Coarse aggregate:

In this present project work crushed angular stone size is about 10mm and 20mm were used. Table below shows the properties of Coarse aggregate.

TABLE III

Shows The Preliminary Test Results Of CA

Particulars of CA	Specific gravity	Water absorption	Fineness modulus
Test outcomes	2.73	1.1%	2.24

4. Ground granulated blast furnace slag:

The slag is a through invention material from iron manufacturing industry. It is mainly composed of 30% to 40% of silicon did-oxide ($Si0_2$) and also 40% Cao which is also similar as the chemical composition of cement. The GGBS as a replacing material for cement it says that the compressive strength can be high as much as possible. It gives a good workability, durability characteristics in nature and also a cost effective construction material. Test results are shown in Table IV.

Figure 1: Shows sample of GGBS

TABLE IV

Shows The Test Results Of GGBS Provided By JSW.

Particulars	**Specific gravity**	**Fineness (Kg /m^2)**	**45 micron (Residue) (%)**
Test outcomes	2.88	382	07.40

5. Quarry Dust:

Quarry Dust is used for the present investigation work it is partial replacement material for fine aggregate which was collected from stone brick manufacture in Jewargi dist. Gulbarga. The test results are shows in below Table below.

TABLE V

Shows the Preliminary Test Results Of Quarry Dust

Sl. No.	**Particular**	**Test results**
01	Specific gravity	02.570
02	Fineness modulus	03.100

Figure 2: Shows sample of Quarry Dust

6. Steel Fibres:

In this experiment to enhance the tensile strength of concrete we are going to add the steel fibre. The steel fibres are hooked at end it is of 1mm diameter and Aspect ratio 50mm. The steel fibres were collected from Maruthi steel suppliers, Bangalore. Figure 3 shows steel fibres sample and Table VI shows the property of Hooked End SF.

Figure 3: Shows sample of steel fibres

TABLE VI

Properties of Steel Fibres Used

Properties of SF	Length	Diameter	Aspect Ratio	Specific gravity	Tensile-Strength	Density
Approved values	50 mm	01.0 mm	50	7.80	1200 MPa	7860 kg/m^3

7. Chemical Admixture:

Fosroc auramix 300-plus is used as a chemical admixture and its specific gravity is about 1.06.

9. Potable Water:

In this experimental work water is used for concrete mixing and curing. water used as clean, clear & free from acid content and portable water used which is referred from IS - 456 2000 are used.

B. MIX DESIGN BY ABSOLUTE VOLUME METHOD

According to IS: 10262-2009 mix design was done for the purpose of concrete casting of various mixes with the help all above preliminary investigation test outcomes. The mix design was done for M50 grade. From the mix design conventional trial mix was prepared and it having mix ratio is 1:2.38:3.10 and the w/c of 0.40

TABLE VII

Mix Proportions Of Concrete

Material	Quantity (kg/m^3)	Proportion
Cement	342	1
FA	816.12	2.38
CA	1061	3.10
Water	131.42	0.40
Chemical admixture	4.5	1.2%

V. EXPERIMENTAL PROGRAM

A. GENERAL

In this present experimental investigation involves casting of 45 cylinders, 45 cubes and 45 prisms and testing is conducted after curing period of 3, 7 & 28days to assess compressive strength, split-tensile strength & flexural-strength of casted concrete. In this work there are five mix proportions to study the variation of strength and to conclude with optimum percentage of the GGBS. The below table VIII represents the different mix proportion details and their percentage. To determine the durability characteristics of concrete, 3 conventional cubes and 3 cubes having an optimum percentage of GGBS, QD and Steel fibres are casted.

TABLE VIII

Shows Mix Proportions Were Involved In This Present Work

Mix	Cement (%)	GGBS (%)	Quarry dust (%)	Steel fibre (%)
CC	100	-	-	-
Mix 1	90	10	30	1
Mix 2	80	20	30	1
Mix 3	70	30	30	1
Mix 4	60	40	30	1

B. PROCEDURE FOR CONCRETE CASTING

As per design mix the material are weighed and mixed in tray by hand mixing. The water cement ratio is maintained for this work is 0.40. The specimens are will be casted uniformly distributed & randomly the specimen used trowel with in one hand & in other hand is will be taken by the concrete which it helps to fill the concrete in the specimen. Conventional concrete is casted without any replacement for the purpose of comparing the strength. To get high strength in concrete the variations are made of the GGBS material. With the help of the tamping rod the concrete is tamped in the specimen with 3 layers the casting will be done by hand mixing method. The cylinders & prisms are casted same as that of the cube casting. After casting the specimen is kept it for 24 hours after this the specimen are de molded & kept it in curing tank. Maintain normal temperature the specimens are kept in curing tank for the purpose of curing to getting the high strength. The specimen are keeping it for 3, 7, 28 days respectively. After 3, 7, 28 days curing the testing process are conducted on specimen and note down the all the readings and calculations are done for determination of compressive, split, flexural strength as per our Indian force values.

Figure 4: Shows freshly casted specimens

Figure 5: Shows the casted Cured specimens

B. RESULTS AND DISCUSSIONS

1. Slump cone test:

In the fresh state of concrete the test is conducted is slump test for the purpose of checking of the workability of concrete with many trails are conducted. The slump test shows the workability which may increase by rising in proportion partially replaced of GGBS in OPC.

Figure 6: Shows Slump cone test

TABLE IX

Represents Slump Test Results

Sl.no	% of GGBS added	Slump value in mm
1	0%	45
2	10%	58
3	20%	63
4	30%	68
5	40%	59

2. Compaction factor test:

For the determination of fresh concrete workability compaction factor test also conducted.

Figure 7: Shows compaction factor test

TABLE X
Represents Compaction Factor Test Results

Sl.no	% of GGBS added	Slump value in mm
1	0%	0.91
2	10%	0.95
3	20%	0.96
4	30%	0.97
5	40%	0.92

3. Compressive strength:

From the below Graph and table, we can said that there will be a considerable increase in strength of replacement concrete compare to the conventional concrete. Mix 3 i.e., GGBS 30%, Quarry Dust 30% and 1% of Steel fibre shows the superior strength compare to other mix.

TABLE XI

Shows The Compressive-Strength Results

Mix	Compressive Strength in N/mm^2		
	3 days	7 days	28 days
CC	23.4	37.86	57.86
Mix 1	23.95	30.96	43.62
Mix 2	30.96	33.47	55.18
Mix 3	43.96	37.92	59.96
Mix 4	43.62	36.29	53.69

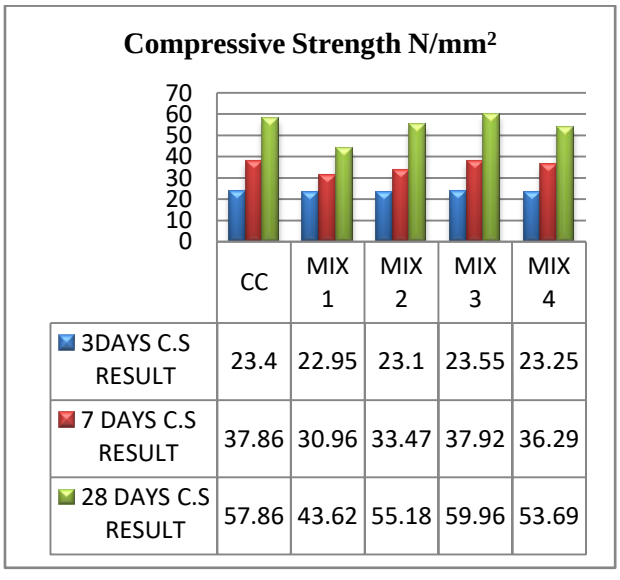

Figure 8: Shows the Compressive-Strength results

4. Split-tensile strength

From the below graph and table we can say that there is a great influence of presence of chemical admixtures, Mix 3 i.e., GGBS 30%, Quarry Dust 30% and 1% of Steel fibre shows the better split tensile strength of concrete compare to other mix.

TABLE XII

Shows The Split-Tensile Strength Results

Mix ID	Split-Tensile Strength in N/mm^2		
	3 days	7 days	28 days
CC	2.26	3.54	4.33
Mix 1	2.8	2.68	3.92
Mix 2	2.26	2.99	4.29
Mix 3	3.13	3.62	4.98
Mix 4	3.03	3.34	4.71

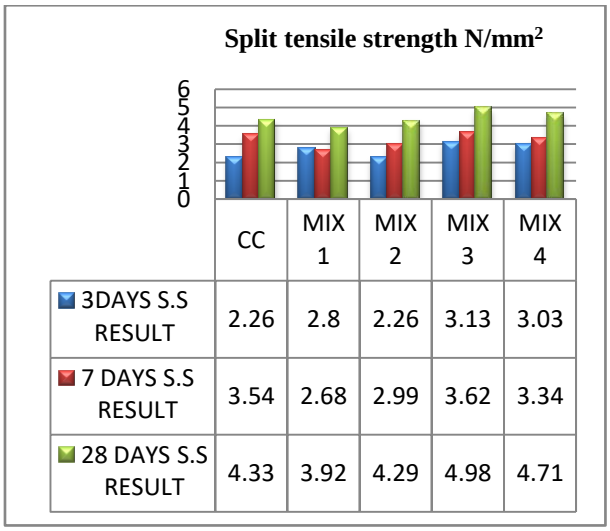

Figure 9: Shows the Split-Tensile Strength results

5. Flexural Strength

The flexural prism having size is about 700mm×150mm×150mm were casted and tested under two point load testing machine to assess the flexural-strength. The results show that, the integration of SF shows the good ductility to flexural force. The Mix 3 i.e., GGBS 30%, Quarry Dust 30% and 1% of Steel fibre shows the extraordinary flexural strength of concrete compare to other mix.

TABLE XIII

Shows The Flexural-Strength Test Results

Mix ID	Flexural-Strength in N/mm^2		
	3 days	7 days	28 days
CC	3.960	5.62	6.03
Mix 1	4.36	6.16	6.5
Mix 2	4.83	6.13	7.16
Mix3	5.8	7.23	7.43
Mix4	5.06	6.23	6.33

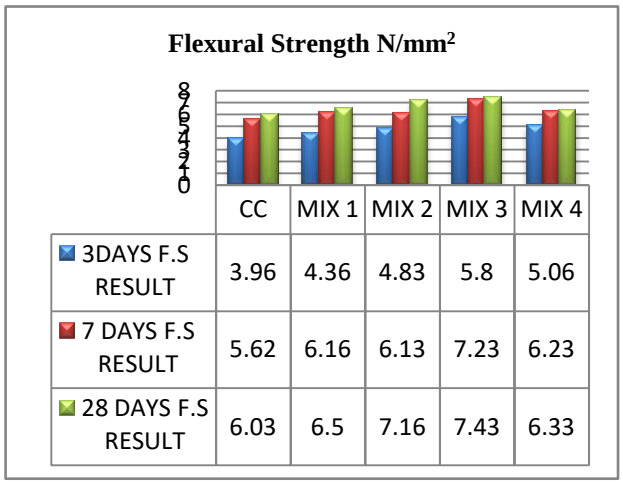

Figure 10: Shows the Flexural Strength results

5. Acid test

- To check the durability characteristics of concrete we considered the optimum mix3 i.e. GGBS 30%, Quarry Dust 30% and 1% of Steel fiber. The cubes were casted and immersed in 5% concentrated hydro chloric acid [HCL] solution for 28 days to examine the weight loss in concrete which shows the resistance of concrete against the acid attack environment.
- The resistance to acid for the Mix3 integrated concrete was superior to the CC. From the HCL solution water was absorbed by cubes and forms black whitish film appears on the concrete surface.
- The below Table represents the results for the weight loss in percentage. The presence of GGBS in concrete improves the resistance against the acid attack.
- The average percentage loss in weight was 3.40% whereas GGBS, QD and steel fiber content concrete i.e. MIX3 was 1.15%

TABLE XIII

Shows the weight loss in cubes after 28 days curing due to acid effect

Sl.No	Mix	Weight of cube before 28days (W1) gms	Weight of cube before 28days (W2) gms	% of Weight loss in cubes
1	CC	8.760	8.40	4.100
		8.778	8.46	3.500
		8.768	8.53	2.600
2	Optimum Mix (Mix 3)	9.456	9.166	3.000
		9.365	9.126	0.239
		9.434	9.210	0.224

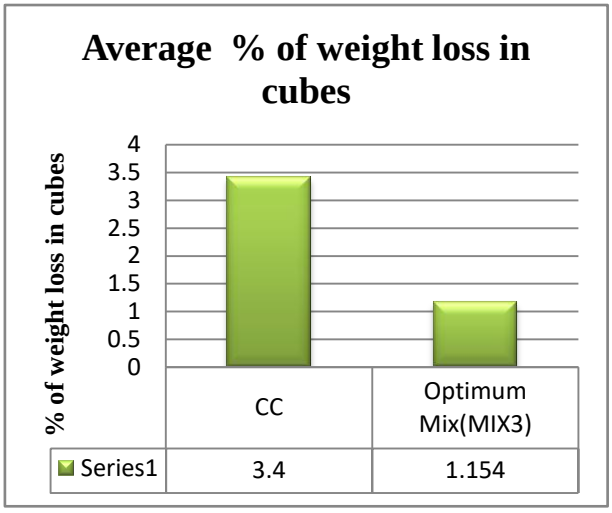

Figure 11: Represents average %age weight loss

VI. CONCLUSIONS

- The workability is to be improved markedly by fresh concrete up to 30% replacement of GGBS to cement above this percentage workability decreases.
- The Compressive Strength increases with the use of GGBS material as replaceable material for cement. The maximum strength achieved in concrete having 30% GGBS, 30% QD and 1% SF i.e., Mix 3.the strength increased 2.1% as compare to CC.
- The adding up of steel fibers also improves the split tensile strength of concrete. The maximum strength achieved in concrete having 30% GGBS, 30% QD and 1% SF i.e., Mix 3.the strength increased 0.65% as compare to normal concrete.
- The Flexural-Strength also shows the enhancing in strength of concrete with the presence of GGBS, The maximum strength achieved in concrete having 30% GGBS, 30% QD and 1% SF i.e., Mix 3.the strength increased 1.4% as compare to normal concrete.
- Hence for the above experimental investigation has concluded that cement with GGBS, sand with Quarry Dust for 30% partial replacement with addition of steel fiber gives a optimum good results of forces and also helps in improving the strength & durability properties of high strength concrete
- The % of weight loss in GGBS is less as compared to normal concrete i.e. MIX3 (30% GGBS, 30% QD, 1% SF) the average weight loss in CC is about 3.4% and in Mix3 the average weight loss is 1.154%.

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