EXPERIMENTAL STUDY ON GLASS FIBRE REINFORCED CONCRETE WITH THE REPLACEMENT OF NATURAL SAND WITH QUARRY ROCK DUST

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Abstract— *In general, concrete is strong in compression & weak in tensional property. The inclusion of fibers in concrete have significantly improves its compressive as well as tensile strength. The use of different types of fibers & their orientation in the matrix have shown positive responses among the researchers. In this thesis, to increase the tensile property of Concrete, Glass Fibers are added with dosage of five different percentages of 0, 0.4, 0.8, 1.2 and 1.6% in concrete. The tensile strength of concrete is improved with the use of glass fibers in concrete mixes may reduce its shortcoming of low tensile strength and compressive strength. Concrete is one of the most important material in construction industry and the River sand is one of the essential material used in the concrete, has become expensive and also a scarce material. Due to continues increase of its usage there is depletion of sand deposits in nature. Quarry Rock Dust (QRD), a by-product from crushing process during quarrying activities is one of the substitute materials for the natural river sand. In this investigation, an attempt is made to introduce the QRD in a percentage variation along with the different percentages of glass fibers and to quantify the optimum usage of QRD in replacement to Natural Sand for Fiber Reinforced Concrete (FRC).Compressive Strength & Split Tensile Strength. tests were conducted to study the Mechanical Properties of FRC for the replacement of Natural Sand with QRD and also study the cost variation due to replacement of QRD.*

Keywords—Fiber Reinforced Concrete (FRC), AR Glass Fibers, Quarry rock Dust (QRD), Strength Properties, Cost Effectiveness.

I. INTRODUCTION

Concrete occupies unique position among the modern construction materials. Concrete is an important material for making different buildings and structures. It is a composite made of Portland cement, sand, gravel or aggregate and water in varying proportions depending on the task. Performance of civil engineering structures to a great extent depends on the characteristics of the materials used for their construction. Innovation in construction is highly linked with development of advanced construction materials and methods. Concrete has a few attractive mechanical properties like stiffness, durability and high compressive quality; however in the meantime, cement is feeble in tension and has brittle characteristics. This shortcoming of the Concrete makes it to split under little loads. To increase the tensile strength of concrete many endeavors have been made, one of the effective and most regularly utilized ways is giving steel reinforcement. Steel bars, however, strengthen concrete against local tension only. Cracks in strengthening concrete develop unreservedly until experiencing the bar. Therefore, the requirement for multidirectional and firmly divided steel support emerges there, that can't be for all intents and purposes conceivable. Fiber support is one of the ways, which gives the answer for this sort of issue.

A. Fiber Reinforced Concrete (FRC)

Fiber Reinforced Concrete can be defined as composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Continuous meshes, woven fabrics and long wires or reds are not considered to be discrete fibers. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers.

B. Quarry Rock Dust (QRD)

Some developing countries are facing a shortage in the supply of natural sand. The expertise of construction industries is investigating the other alternatives to eliminate the demand of natural sand. There were some alternatives that have been used in concrete mixing such as fly ash, slag and limestone. Another alternative is by using quarry waste to replace the use of natural sand. Quarry dust can be defined as residue, tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles less than 6mm.Natural sand in many parts of the country is not graded properly and has excessive silt. On the other hand, quarry dust does not contain silt or organic impurities and can be produce to meet desired gradation and fineness as per requirement. Consequently, it improves the strength of concrete. Besides, waste can be used to produce new products or can be used as admixtures so that natural sources are used more efficiency and environment is protected from waste deposits.

II.METHODOLGY:

To study the strength characteristics of concrete with the replacement of QRD with varying percentages of glass fibers first mix design should be done for M30 concrete, collect all required materials and tests should be conducted for materials to verify the properties with respect to the respective IS codes .Then by doing weigh batching caste the cubes of size 150mm x 150mm x150mm and cylinders of size 300mm depth ,150mm diameter. After 24hours remolding the cubes and cylinders then it is allowed for curing in water at 7days,14days and 28 days. Then conduct tests on cubes and cylinders at 7,14 and 28 days and compare the conventional concrete with concrete with the QRD replacement at varying glass fibers percentages and at last compare the costs between without WRD and with QRD. Estimate the cost of concrete without QRD and with QRD compared the cost effectiveness.

III.EXPERIMENTAL INVESTIGATION:

The experimental investigation has been performed to investigate about the strength of the M30 concrete by adding Glass Fibers are added with dosage of five different percentages of 0, 0.4, 0.8, 1.2 and 1.6% by weight of cement in concrete and Replacement of Fine Aggregate (i.e., Sand) with QRD for different dosages of 0%,40% and 80%. However the workability of concrete mixes is not much affected.

In this experiment, one set of conventional high strength concrete and another set of glass fiber reinforced concrete with the replacement of fine aggregate with QRD of different dosages of 7days ,14days,28days curing were conducted. Subsequent tests such as compressive strength, split Tensile strength, Flexural strength, Test are carried out for conventional High Strength Concrete. The tests results were analyzed and compared. Cost reduction by replacing fine aggregate with QRD is studied.

Table.3.1Experimental details of project

S.NO	Replacement of sand with QRD in %ge	%ge of glass fibers of cement weight	Compressive strength			Split tensile strength
			7days	14days	28days	28days
1.	0%	0	3	3	3	3
2.	40%	0	3	3	3	3
		0.4	3	3	3	3
		0.8	3	3	3	3
		1.2	3	3	3	3
		1.6	3	3	3	3
3.	80%	0	3	3	3	3
		0.4	3	3	3	3
		0.8	3	3	3	3
		1.2	3	3	3	3
		1.6	3	3	3	3
Total specimens			33	33	33	33
Grand total						132

IV. MATERIALS USED:

The different types of materials used in this investigation are given below:

A.Cement:

OPC 53 grade is used throughout the investigation. The cement is tested for its various properties as per IS: 4031 – 1988 and found to be confirming to the requirements as per IS: 1489-1999 Part . The results of tests concluded on cement are as follows.

Table.4.1.Test results of cement

S.NO	Property	Requirement as per IS:1489-1	Value
1.	Fineness	<10%	3%
2.	Soundness	<10mm	1.5mm
3.	Standard consistency	With in codal provisons	30%
4.	Initial setting	>30min	32min
5.	Final setting time	<600min	500min

B. Fine Aggregate:

The sand obtained from Saradha river near Anakapalle is used as fine aggregate in this project investigation. The sand used in this investigation confirmed to Zone-I according to BIS. Sand which is passed on 4.75mm sieve & retained on 150µ sieve are used.

C. Coarse Aggregate:

The Coarse aggregate is free from clayey matter, silt and organic impurities etc., the coarse aggregate is also tested for specific gravity and it is 2.82, fineness modulus of coarse aggregate is 7.0 Aggregate of normal size 20 mm

downgraded 60% passed on 20.0 mm sieve and remaining 40% is taken from the sieve 10.0 mm (passing) and 4.75 mm (retained) is used in the experimental work, which is acceptable according to IS: 383– 1970.

Table.4.2.Test results of coarse aggregate

S.No	Property	Values	Requirements As Per Is 383
1.	Coarse aggregate	Machine crushed Granite	Within the Codal Provisions
2.	Specific Gravity	2.8	2.6-2.8
3.	Density	1600kg/m3	Within the Codal Provisions
4.	Water absorption	0.31%	Should not be > 1%
5.	Fineness Modulus	7.0	6.5-8.5

D. Quarry Rock Dust (QRD):

Quarry Rock Dust can be defined as residue, tailed waste material after the extraction and processing of rocks to form fine particles less than 4.75mm. The utilization of Quarry rock dust which can be called as manufactured sand has been accepted as a building material in the industrially advanced countries of the west for the past three decades.QRD which is used in our Project work is brought from the premises of Thummpala of Anakapalli. QRD is tested in accordance with IS:2386 and it is found to be satisfied for its use in the concrete. It is confirmed to Zone- I according to BIS. Dust which is passed on 4.75mm sieve & retained on 150µ sieves are used.

Table.4.3.Test results of Sand And Quarry Rock Dust

S.No	Particulars	Fine Aggregate	QRD	Requirements As Per Is 383
1	Specific Gravity	2.7	2.8	2.6-2.8
2	Bulking value	30%	35%	40%
3.	Water absorption	0.27%	0.58%	Should not be > 1% for construction
4.	Fineness Modulus	2.8	2.91	2.6-2.9

D. Glass Fibers:

The Glass fiber used in this investigation is high-quality Alkaline–Resistant glass fiber which is designed to reinforce cementitious and other alkaline matrix Glass Fibers used have the following properties of Aspect Ratio is 857:1,tensile strength of 1700MPa,modulus of Elasticity of 73GPa and Specific gravity of 2.6 .Cem-FIL anti-crack high dispersion glass fibers which are manufactured at SAINT GOBAIN GLASSWARES PVT LTD

Fig.4.1.Glass fibers

Table.4.4.Properties of Glass fibers

S.No	CHARACTER	GLASS FIBERS
1	Number of fibres	212 million/kg
2	Aspect ratio	857:1
3	Typical addition rate	0.6 to 1.0 kg/m3 of concrete
4	Tensile strength	1700 Mpa
5	Modulus of elasticity	73 Gpa

6	Corrosion resistance	Excellent
7	Specific gravity	2.6
8	Density	26 KN/m3
9	Filament diameter	14 μ
10	Filament length	12 mm

V.RESULTS AND DISCUSSIONS:

A. Compressive strength of cube:

The cube specimens were tested on compression machine of capacity of 2000kN. The machine was cleaned and the specimen was placed in such a manner it was given load on opposite sides equally. All the concrete specimens were tested in a 2000kN capacity compression testing machine. Concrete cube of size 150mm X 150mm X150mm is placed on the Compressive Testing Machine and grip it firmly between top and bottom plates. Apply the load at the rate of 140 kg/sq.cm/minute till the specimens failed. Note down the ultimate load at the failure of specimen, when the load is Applied. Divide the ultimate load by the area of specimen, Then the compressive strength has been calculated. Compressive strength has been calculated by using formula Compression test is done as per IS: 516-1959.

$$\sigma c = \text{load/area in N/mm}^2$$

Fig:5.1. Compression Testing Machine With A Cube Speciation

Table5.1.Compressive strength of cubes at 7 days of curing

S.NO	Percentage of QRD replaced	Percentage of GF	LOAD at Failure (KN)	Compression value (N/mm^2)
1	0%	0 %	378	16.83
2	40%	0 % 0.4 % 0.8 % 1.2 % 1.6 %	357.50 339.75 342.60 362.2 348.75	14.92 15.12 15.23 16.16 15.55
3	80%	0 % 0.4 % 0.8 % 1.2 % 1.6 %	290.47 291.75 301.5 317.25 306.05	11.91 12.18 12.46 13.14 12.63

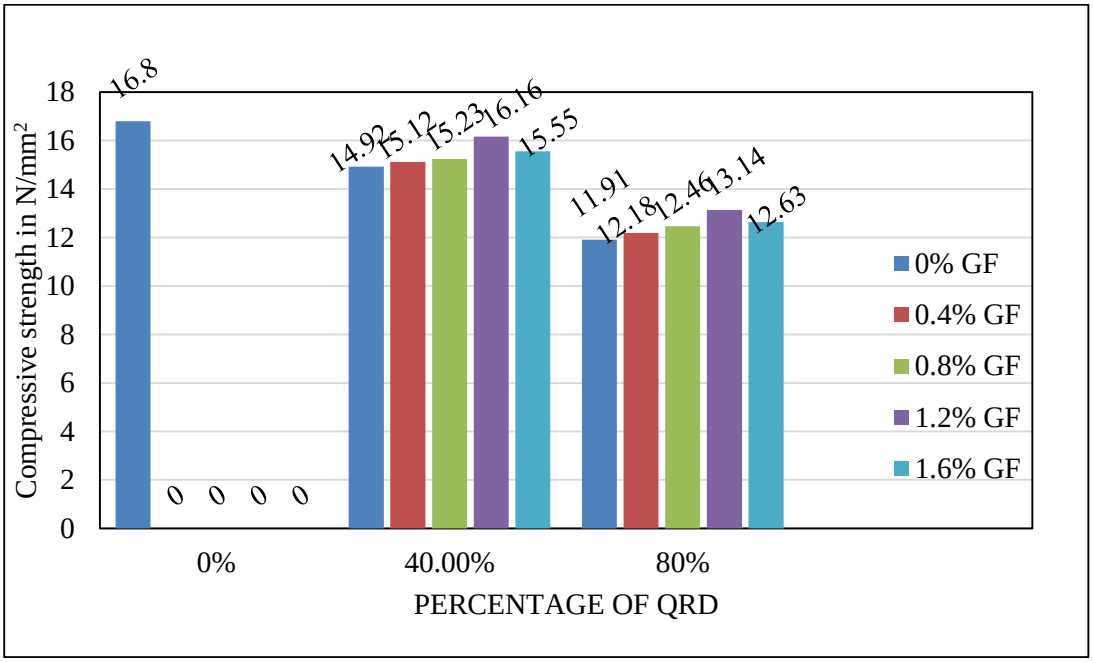

Fig.5.2.Compressive strength values for 7-days

Table.5.2.Compressive strength of cubes at 14 days of curing

S.NO	Percentage of QRD replaced	Percentage of GF	Load at failure (KN)	Compression value (N/mm^2)
1	0%	0 %	477.0	23.54
2	40%	0 % 0.4 % 0.8 % 1.2 % 1.6 %	488.15 411.75 414.00 420.70 425.25	21.72 21.45 21.98 22.21 21.09
3	80%	0 % 0.4 % 0.8 % 1.2 % 1.6 %	401.85 378.00 369.01 364.54 357.35	17.86 17.98 18.01 18.45 17.34

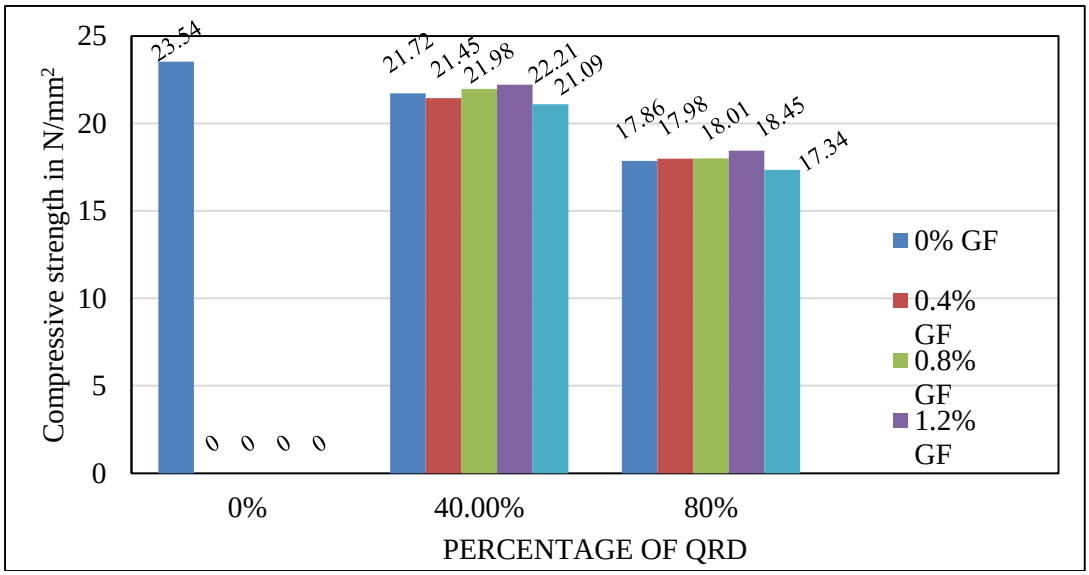

Fig.5.3.Compressive strength values for 14-days

Table.5.3.Compressive strength of cubes at 28 days of curing

S.no	Percentage of QRD replaced	Percentage of GF	Load at failure (kN)	Compression value (N/mm^2)
1	0%	0 %	567.0	25.2
2	40%	0 % 0.4 % 0.8 % 1.2 % 1.6 %	490.00 501.75 506.25 522.0 497.25	22.0 22.3 22.5 23.2 22.1
3	80%	0 % 0.4 % 0.8 % 1.2 % 1.6 %	443.25 447.75 454.50 461.25 441.0	19.7 19.9 20.2 20.5 19.6

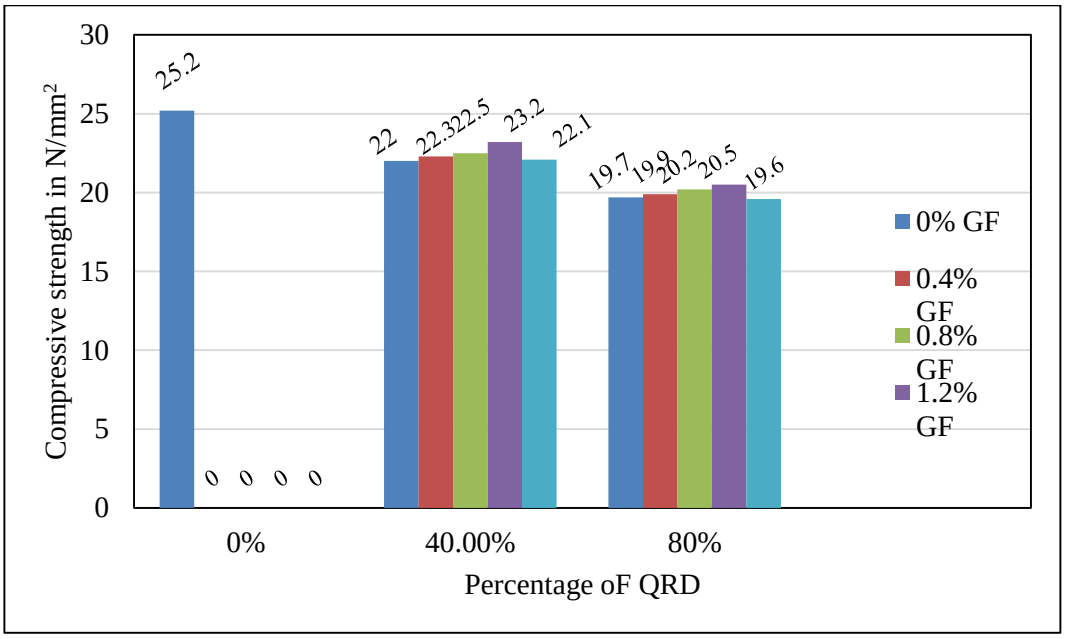

Fig.5.4.Compressive strength values for 28-days

From the above figures and tables it is observed that compression strength of conventional concrete at 7days,14days,28days compared with replacement of sand with 40% and 80% QRD with the varying percentages of glass fibers. Fig.5.2 & table 5.1,fig.5.3&table5.2 and fig.5.4 &table5.3 shows the compressive strength values at 7 days ,14days and 28 days respectively which indicates compressive strength of conventional concrete is 16.8 N/mm^2 ,23.54N/mm^2 and 25.2 N/mm^2 at 7 days ,14days and 28 days respectively with the replacement of QRD strength is very slightly decreases but with the 40% replacement at varying percentage of glass fibers 1.2% glass fiber have the values 16.16 N/mm^2,22.21N/mm^2 and 23.2 N/mm^2 at 7 days ,14days and 28 days respectively very nearer to conventional concrete and it decreases for 80% QRD replacement in which G.F 1.2% having maximum values.

B. Testing of cylinders for split tensile strength:

The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. This test is Compression–testing machine by placing the cylindrical specimen horizontally, so that its axis is horizontal between the plate's of the testing machine. The load is applied uniformly at a constant rate until failure by splitting along the vertical diameter takes place. Load at which the specimen failed is recorded. Test is performed as per IS: 5816-1970. The following relation is used to find out the split tensile strength of the concrete.

$$\sigma t = \frac{2P}{DL} \text{ in N/mm2}$$

Fig.5.5.Split tensile strength testing of specimen

Table.5.4.Flexure values for 28days curing of cylinders

S.NO	Percentage of QRD replaced	Percentage of GF	Load at failure (KN)	Compression value (N/mm^2)
1	0%	0 %	306.30	3.25
2	40%	0 % 0.4 % 0.8 % 1.2 % 1.6 %	303.47 317.60 320.40 447.67 412.8	3.22 3.37 3.40 4.38 4.75
3	80%	0 % 0.4 % 0.8 % 1.2 % 1.6 %	296.87 306.30 311.01 452.38 391.12	3.15 3.25 3.30 4.15 4.80

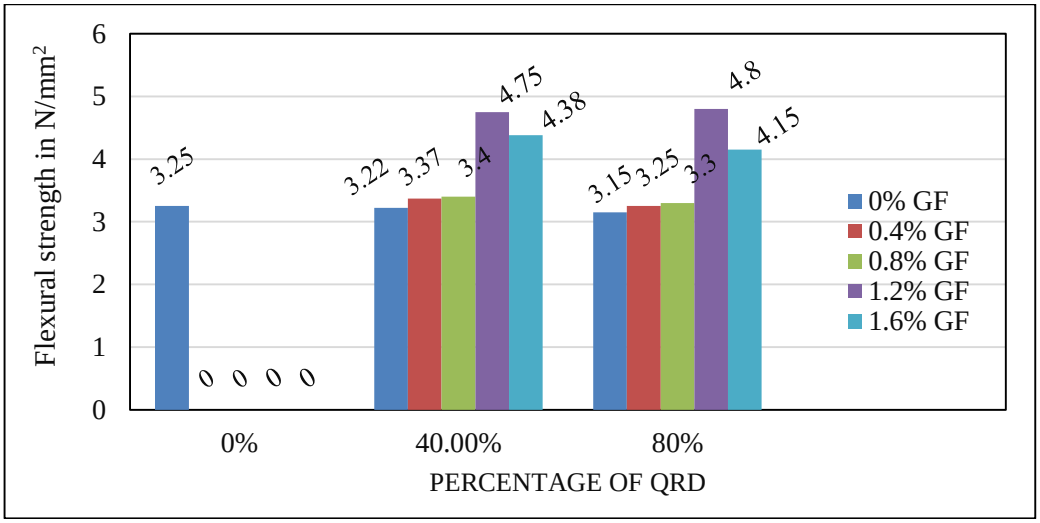

Fig.5.6.flexuraL strength values for 28-days

Fig.5.6 & table 5.4shows the split tensile strength values at 28 days which indicates split tensile strength of conventional concrete is 3.25 N/mm^2 at 28 days and with the replacement of QRD with the 40% replacement at varying percentage of glass fiber sand at 1.2% glass fiber the strength is increases to value 4.75 N/mm^2 value 28 days and it increases for 80% QRD replacement in which G.F 1.2% having maximum value of 4.8N/mm^2.

C. Cost effectiveness:

The river sand per ton costs RS. 850/- and Quarry Rock Dust costs RS.550/-per ton. The quantity of sand and QRD required for this investigation are tabulated in table5.5. According to that the cost of concrete with QRD reduces when compared to without QRD replacement by 35%.

Table5.5.Quantity of materials per 1 cube

S.NO	Materials	0% (Kg)	40% (Kg)	80% (Kg)
1.	Fine aggregate	7.68	4.602	1.536
2.	QRD	0	3.072	6.144

VI.CONCLUSIONS:

From the tests conducted on materials the following points are concluded the following points

1. There is an increase in compressive strengths of partially replaced M30 grade of concrete with 40% QRD and 1.2% GF at 7,14 and 28 days of curing and it is decreases for 80% QRD replacement.
2. From the compressive strength test it is concluded that the compressive strength attained 66.66% of total strength at 7 days and 93.4% at 14 days in conventional concrete, 69.65% of total strength attained at 7 days and 95.7% total strength at 14 days in 40% QRD replacement in sand and 64.09% of total strength attained at 7 days and 90% total strength at 14 days in 80% QRD replacement in sand.
3. From the split tensile strength test it is concluded that the flexural strength is increases for 40% QRD with 1.2%G.F by 46.15% than conventional concrete and for 80% replacement of QRD with 1.2%G.F by 47.69% than conventional concrete.
4. By replacing of QRD in the place of sand there is decrease in compressive strength by 7.936% than conventional concrete but by using 40% QRD with 1.2%G.F there is 35% reduction in cost when compared with conventional concrete .

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