Comparision of GFRP & Reinforcement Bar and Strength of Beam

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***Abstract*—In the present years, due to enhanced properties of glass fibre- reinforced polymers(GFRP) reinforcing bar for concrete structure The GFRP bars have been used extensively in the structures where the conventional steel reinforcement which is affected by corrosion is more overriding. Deterioration of structures due to corrosion can be solved by the GFRP rebar which is reinforced in concrete structures that were subjected to harsh environments, such in high temperature. After all these years of investigation and implementation, researchers have concluded GFRP as the corrosion resistant reinforcing material in the corrosion protection policies. The present study made the comparative analysis of concrete cube of size 150 mm x 150 mm x 150 mm which was cured in water were compared to investigate the strength characteristic of test specimens. Further, concrete beam of size 500 mm x 100 mm x 100 mm with 8,10, and 12-mm diameter GFRP rebar and reinforcement steel rebar which was cured in potable water for 28 days. Then the Flexural test has been conducted experimentally for both the beams and the results which were obtained from experimentally are compared with results which are obtained. For conducting tensile strength specimen of 1m GFRP bar 8,10 and 12mm bar anchoring with epoxy resin and hardener both edges of specimen. And comparing with reinforcement steel of 8,10and 12mm bar.**

***Index Terms*—GFRP, Steel, Concrete, Flexural Beam, Compression and Tension.**

I.INTRODUCTION

Concrete reinforced with steel bar is one of the typical materials used for constructing structures. Usually, concrete have low tensile strength hence steel bars are used as the reinforcement which are cost efficient, but the steel bars are not recommended as reinforcements in coastal region. The factors like faulty design, bad workmanship, inadequate cover in concrete and other environmental factors leads the concrete to crack and the steel to corrode. To avoid corrosion, the utilization of FRP (Fibre reinforced polymer) rebar instead of steel rebar is recommended in aggressive and marine environment. FRP (Fibre reinforced polymer) obtained in various forms like bars, hooks are used as the reinforcement in various structures like marine structures, parking garages, roads and pavement, water treatment plants, bridge decks, compound wall and tunnels.

The fibres are embedded in the polymeric resin to form FRP (fibre reinforced polymer). Because of the non-metallic and non-corrosive properties of the FRP rebar the problem of corrosion is avoided. FRP is used for repairing and strengthening of the concrete structures which already exist. The externally bonded FRP (fibre reinforced polymer) are highly vulnerable of damaging from temperature and fire, moisture absorption, ultraviolet rays. Lacking of maintenance and protection may reduce the durability, economy and service life of the structure.

II.LITERATURE REVIEW

Jose Sena-Cruz et al. (2018) they intend to study the RC structures where the concrete is mixed with sea water and also the change of conventional steel rebar is replaced with GFRP rebar. They concluded in the result that there is no effect on the bond behaviour even when the concrete is mixed with sea water and there was also no severe problem with the properties of both concrete and the GFRP rebar

Edgaras Atutis et al. (2015) had investigated experimentally the concrete beams reinforced with GFRP rebar based on flexural strength. Both the prestressed concrete and the reinforced concrete beams had tested. The effect of prestressing on the cracking and deflection was analyzed and it is possible to predict the mode of failure of concrete members with GFRP reinforcement considered of flexural strength design methodology which is grounded on reinforcement ratio. Experimental and predicted mode of failure of concrete beams is coincided.

III SCOPE AND OBJECTIVES

The scope of this present study is to investigate the flexural behavior of the GFRP reinforced concrete beams and steel reinforced concrete beams that had been carried out to find the structural behavior of the beams by using one point loading. The flexural behavior conducted includes the first crack, failure of the beam, load–deflection curves and load capacity are compared and analyzed thoroughly based on the experimental results.

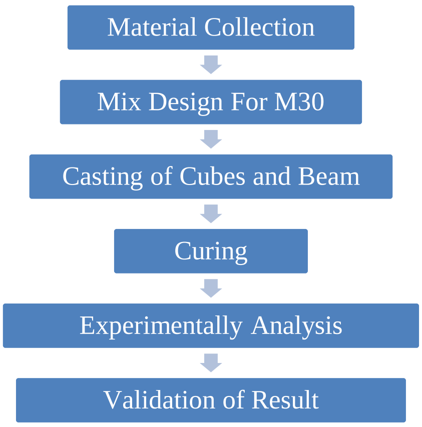
OBJECTIVES

By conducting the literature survey, the following objectives.

1.To compare the compressive strength characteristics of concrete cubes cured in water.
2.To compare the flexural behaviors of GFRP rebar concrete and conventional rebar concrete.
3.To compare tensile behavioral rebar and conventional rebar.

IV.METHODOLOGY AND MATERIAL

The present point elaborate the methodology of the study.



1.cement

Cement is one of the important key ingredients used to make concrete which behave as a binding material which have both cohesive and adhesive properties. It is manufactured by using clinkers which is pulverized by utilizing raw materials like silica, alumina, calcium oxide, ferric oxide combined with some other oxides.

Properties of cement

PROPERTIES	RESULTS
Specific gravity	3.12
Consistency	25%
Initial setting time	50 min
Final setting time	650 min
Fineness	4.5%

2.crushed sand (fine sand)

Crush sand is widely used in the construction field, this material is granular which is used to manufacture mortar or concrete. The aggregates are fine when it passes through a 4.75 mm sieve. The crushed sand that is used in concrete. The density and quality of the crushed sand affects the hardened properties of the concrete.

PROPERTIES	RESULT
Particle size	4.75 mm
Silt content	1.67%
Specific gravity	2.73
Bulking of sand	4.19%
Bulk density	1793 kg/m3
Water absorption	0.28
Fineness modulus	4.12%

3.coarse aggregate

Coarse aggregate is one of the important material and widely used as building material in construction industries. It is the key component in concrete and gains volume to the concrete. It is chemically inactive and serves as the filler material and gives strength to the concrete which will provide a homogeneous mass of the concrete.

PROPERTIES	RESULTS
Particle shape and size	Angular, 12mm
Specific gravity	2.66
Water absorption	0.62%
Bulk density	1497 kg/m3
Fineness modulus	5.8

4.Reinforcement

The properties of both steel bar and GFRP bar are mentioned as below.

SR NO	PROPERTIES	STEEL	GFRP
1	Modulus of elasticity (Mpa)	200000	50000
2	Elongation (%)	25	2.2

3	Density (Kg/m^3)	7850	1900

MIX DESIGN PROCEDURE

The mix design was done based on the Indian Standard Recommended Method (IS 10262-2009).

PROVISION FOR PROPORTIONING

Grade of concrete= M30

Aggregate type= Crushed angular aggregates

Size of aggregate= 20

cement type= OPC 53 Grade

Cement content = 375 kg/m^3

Workability (slump)= 100 – 120 mm
Water to cement ratio= 0.40

Degree of supervision= Good

Exposure condition= Moderate
MATERIAL TEST DATA

Specific gravity of cement= 3.15

Specific gravity of coarse aggregate= 2.67

Specific gravity of Crushed sand = 2.65

Water absorption of coarse aggregate = 0.5%

Water absorption of crushed sand= 1.2%

TARGET STRENGTH OF THE MIX

f'ck=fck+1.65s where,

fck = Compressive strength achieved at 28 days

f'ck = Targeted Compressive strength achieved at 28 days

s= standard deviation (From table 1 of IS 10262:2009) =5N/mm^2.

Targeted Compressive strength f'ck) =30+ (1.65 x 5) = 38.25 N/mm^2.

WATER CEMENT RATIO SELECTION

Water cement ratio adopted = 0.45 From table 5 of IS 456,Water cement ratio (Very severe exposure) = 0.40 . 0.4 < 0.46 hence ok.

WATER CONTENT SELECTION

From table 2 of IS 10262-2009

Maximum water content (20 mm aggregate) (For 25 to 50 mm slump) = 186 litre Maximum water content expected for 100 mm slump = 186 + (6/186) = 197 liter.

CEMENT CONTENT CALCULATION

Water cement ratio adopted = 0.45

Cement content= 197/0.45 = 437.77 Kg/m^3 .Minimum cement content (Very severe exposure) =375 Kg/m^3 437.77Kg/m^3 > 375Kg/m^3 Hence okay.

PROPORTION OF COARSE AGGREGATE AND CRUSHED SAND

From table 3 of IS 10262-2009

Volume of coarse aggregate (size 20 mm) corresponding to crushed sand (zone II) for water cement ratio of 0.50 = 0.62

In this mix the water cement ratio = 0.44

Corrected proportion of coarse aggregate for the water cement ratio of 0.44 = 0.65 Volume of the coarse aggregate = 0.65 x 0.9 = 0.585 m^3.

Volume of crushed sand = 1 – 0.585 = 0.415 m^3

MIX CALCULATION

The mix calculation for a unit volume of concrete is given below Concrete volume = 1 m^3

Cement volume = (Mass of cement) / (specific gravity of cement x 1000) = (375) / (3.15 x 1000) = 0.120m^3

Volume of water = (Mass of water) / (specific gravity of water x 1000)= (197) / (1 x 1000) = 0.197 m^3

Volume of aggregate = [1-(0.120+0.197)] = 0.683m^3

Mass of coarse aggregate = 0.678 x 0.60 x 2.8x 1000 = 1139.04Kg/m^3

Mass of crushed sand = 0.678 x 0.40 x 2.65 x 1000 = 718. Kg/m^3

MIX PROPORTION OF THE CONCRETE

Cement = 375Kg/m^3

Water = 186 lt/m^3 Crushed sand =718Kg/m^3
Coarse aggregate= 1139 Kg/m^3

Density of concrete = 2451 Kg/m^3 Water cement ratio= 0.45

Mix proportion = 1 :1.9 :3.0

Mix proportion for per beam	
Size of beam	500x100x100mm
Volume of beam mould	0.005m3
Quantity of cement required	0.005x375=1.875kg
Quantity of crushed sand required	0.005x718=3.60kg
Quantity of coursed aggregate required	0.005x1139=5.7kg
Quantity of water required	0.005x186=0.93 liter

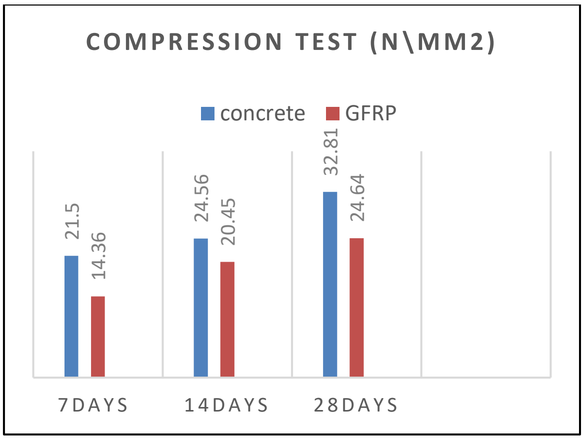
Mix proportion for per cube	
Size of cube	150x150x150mm
Volume of cube mould	0.003375 m^3
Quantity of cement required	0.003375x375= 1.265kg
Quantity of crushed sand required	0.003375x718= 2.42 Kg
Quantity of coursed aggregate required	0.003375x1139=3.84 Kg
Quantity of water required .	0.003375 x 186= 0.62 liter

V.TEST RESULT

1.Compression strength test

The cube specimen of size 150 mm x 150 mm x 150mm is subjected to the compressive strength test. The concrete cubes are cured in potable water for 7 days, 14 days, 28 days respectively. The concrete cubes were tested using compression testing machine. The load was applied gradually till the concrete cube fails. The reading in which the load go reverse that instant load is the ultimate load.

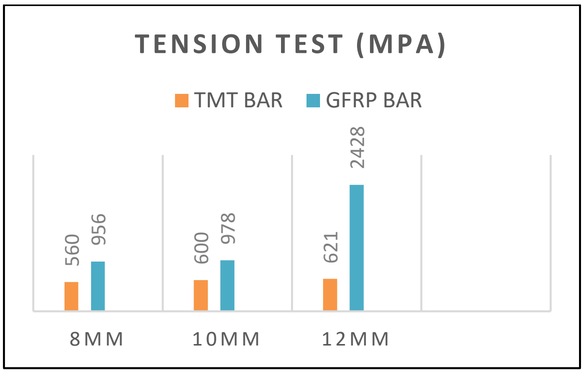
Compression test (N\mm2)					
Regular concrete			GFRP concrete		
7Days	14Day	28Day	7Day	14Day	28Day
20.2	25.2	32.35	13.96	20.12	25.68
22.40	23.28	34.18	14.28	21.38	23.32
21.90	24.90	31.90	14.85	19.85	24.92
Average			Average		
21.5	24.56	32.81	14.36	20.45	24.64



2.tension test

The steel rebar and GFRP rebar of 8,10and 12 mm diameter was firmly held by top and bottom grips attached to the universal testing machine (UTM).and for gfrp bar grip resin used bar both ends. During the tension test, the grips are moved away from each other at a constant rate to pull and stretch the specimen. The test specimen is put back together to measure the final length, and then this measurement is compared to the original length to obtain elongation.

Diameter of bar (mm)	Weight of tmt bar /m (gm)	Tensile strength TMT (mpa)	Weight of gfrp/m (gm)	Tensile strength GFRP (mpa)
8	390	560	51.63	956
10	605	600	80	978
12	870	621	115.18	983

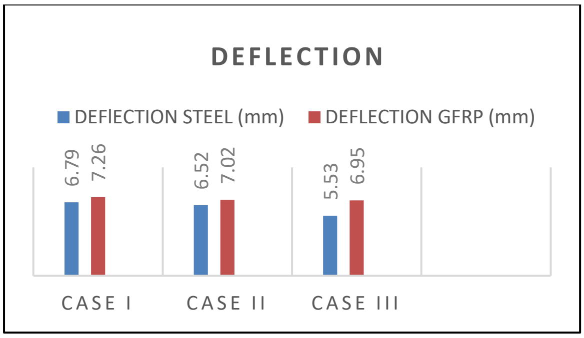


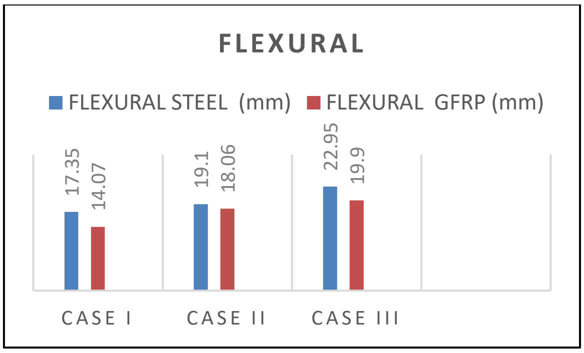
3.flexural test on beam

A total of 4 beams sized 500 mm X 100 mm X 100 mm were reinforced with both steel rebar and GFRP rebar. In which 2 beams are reinforced with steel bars and the other 2 beams are reinforced with GFRP bars and these 4 beams are cured potable water then the one -point bending flexural test were conducted on 14 days and 28 days. The test was performed on the universal testing machine (UTM). The beam specimen was placed on the UTM and the load was applied gradually and the deflections were noted.

Case	TMT+concrte beam		flexural strength (mpa)	Deflection (mm)
	top bar	bottom bar		
CASE I	2-8mmø	2-10mm ø	17.35	6.79
CASE II	2-8mmø	2-12mm ø	19.1	6.52
CASE III	2-10 mmø	2-12 mmø	22.95	5.53

CASE	GFRP+concrte beam		flexural strength (mpa)	Deflection (mm)
	top bar	bottom bar		
CASE I	2-8mmø	2-10mm ø	14.07	7.26
CASE II	2-8mmø	2-12mm ø	18.06	7.02
CASE III	2-10 mmø	2-12 mmø	19.9	6.95





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