International Journal of Technical Innovation in Morden Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 3, March-2018

STRENGTHENING OF RCC SLABS AND BEAMS BY FRP COMPOSITES

M.K.RATH

Centurion University of Technology & Management
Corresponding authors: manojrat@yahoo.com

Abstract: There are many problem in civil engineering Infrastructure but the solution of all the problems can done by only two ways either by repair/retrofit or demolition/reconstruction and by strengthening the structure by looking all types of problems. So to reduce the problem and to strengthen the concrete structure we have a research work on the FRP sheet laminates on beam and slab.

1. Introduction

In our research work we consider concrete slab structure for strengthening by GFRP sheet lamination. Concrete slab is a very common structure in all type of civil work. Previously the design of slab, beam and any other structure were design according to the load, capacity and weather condition. But now a day we found damages and early crack in structure because load, capacity and weather condition is changed. Solution of all the problems and fulfillment of the all the needs, many materials and new techniques are introduce day by day from the experiment and research work .So in our research work we choose Glass woven fiber reinforce polymer due to its excellent properties and lamination or wrapping process which is a very easy technique of strengthening of civil structure as RC slab

This paper aims to contribute to the classification and specification of glass fiber when it is use as reinforcing agent for slab or other civil structure, worldwide, a measure research work is currently being conducted concerning the use of fiber reinforced plastic wraps, laminates and sheets in strengthening and repair of reinforced concrete members. The fiber composite materials are more considerable for concrete structure for their high specific strength, lightweight & biodegradability. Fiber – reinforced polymer application is a very effective & easy way by wrapping for strengthen to prevent shrinkage cracking in structures that have become subjected to various loads and during their life span

Faizal` M.A et al, Beng YK and Dalmin MN (2006) investigated the tensile behavior of plane woven. E-GF reinforced polyester composite using different curing pressure like 35.8 kg/m^2, 70.1 kg/m^2, 104 kg/m^2 and 138.2 kg/m2. Colakoglu M.(2006) investigated the damping and vibration analysis of polyethylene fiber composite using finite eliminate program of various temperatures ranging from 10^{0}c to 60^{0}c. A damping monitoring method was used to experimentally measure the frequency response. Araujo M et al , Kasselyne Araujo D(2006), investigated the mechanical properties and water absorption behavior of fiber glass wastage reinforce polyester composites. Botelho EC, Bravim JC (2013), investigated the environmental effects on thermal properties of behavior of woven mat GF – reinforced poly etherimide thermoplastic matrix composites by testing varying temperature at real time humidity of 90% for 60 days under sea water. The moisture absorption depend on temp^2 and relative humidity. L.L am and J.G Teng worked on strengthening of RC slab using bonded glass fiber reinforced plastic strips. The strips should be anchored to the supporting wall using epoxy-mortar horizontal slots, to prevent or limit deboning. A report was given by Itaru Nishizaki & ScishiMeiaashi examines the effect of water & moisture on the durability of pultruded glass fiber reinforced polymers using vinyl ester resin in normal air conditions. The local bond mechanics of glass-fiber reinforced polymer bars in normal strength concrete was investigated by S.P. Tastani & S. J. Pantazopa through experimental testing & analytical modeling. Priestley, M.J.N., Seible, F and Fyfe E (1992), Given Column seismic retrofit using fiberglass/epoxy jackets. herbrooke. Xiao, Y., Martin.G.R. Yin,Z.,and Ma, R.(1995),Given Retrofit design of existing reinforced concrete bridge columns using prefabricated composite Jacketing. Spoelstra, M.R. and Monti, (1999), Given FRP- confined concrete model. Journal of Composites in Construction

2. Mathematical Formulation

Table 1 (Design mix proportion)

Cement	W/c	Water	Sand	Coarse Aggregate	
				20 mm	10 mm
400	0.43	172	642	619	546
1	-	0.43	1.6	1.547	1.36

Units – Kg/m^3

Ratio – Cement: Sand: Coarse Aggregate = 1:1.6:2.907

3.2 Design Details of slab According to IS456: 200

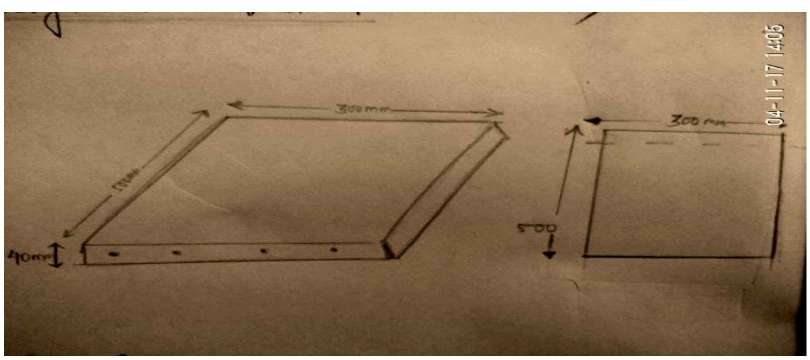


Fig:-1 (Design of slab)

Data for design and casting of slab:-

For experimental use we

Consider – 500 X 300 X 40 mm size slab

Providing 6 mm Ø dia bar, Ø

Using – M_{35} mix design, opc 53 grade cement

Length = 500 mm

Breadth = 300 mm

Thickness = 40 mm

Clear cover = 15 mm

Dia of bar (Ø) = 6 mm

fck = 35 N/mm^2

fy = 415 N/mm^2

Effective depth calculation:-

Eff. Depth = Span/20

= 500/20 = 25 mm

Overall depth/ Total depth = eff. Depth + clear cover + Ø/2 (Ø=6 mm)
= 25 + 15 + 6/2= 43 mm

Ultimate load calculation:-

Consider, live load = 3 KN/m^2

Self weight = Thickness X 25

= 40 mm X 25= 400/1000 X 25= 1.5 KN/m^2

Floor finish = f KN/m^2

Total service load (w) = 5.5 KN/m^2 (α. α + S. W + Floor Finish)

Ultimate design load (Wu) = self weight X service load

= 1.5 X 5.5 = 8.25 KN/m^2

Effective Span:-

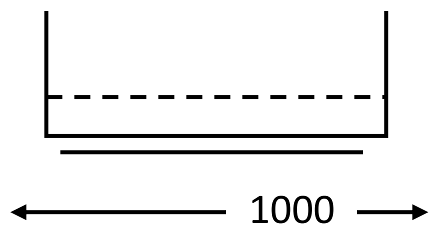
Eff. Span = Span + eff. Depth
= 500/1000 + 25/1000
= 0.5 + 0.025 = 0.525 m
Eff. Span (l) = 0.525 m
Total load per meter width = E. span + U. load

(w) = 0.525 X 8.25

W = 4.33 KN

Ultimate moments and shear force**:-**

Consider 1000mm width



Yield or ultimate moment (Mu) $= \frac{WL}{8}$

$= \frac{4.33 \times 0.525}{8}$

= 0.28 KN

Shear force (Vu) $= \frac{W}{2}$

$= \frac{4.33}{2}$

= 2

Checking bending for E. depth (d) :-

mu = 0.138 fck bd^2

$d = \sqrt{\frac{Mu}{0.138\ fck\ b}}$

$= \sqrt{\frac{0.28 \times 10^6}{0.138 \times 35 \times 1000}}$

d = 7.61d computed = 7.61

$\left(\begin{matrix} fck = 35 \\ b = 1000 \end{matrix}\right)$

d provided = 25

so d provided (25) > d computed (7.61)

Steel calculation in Longitudinal Direction

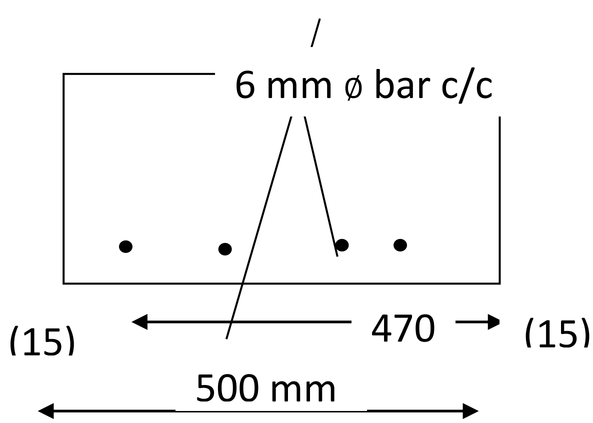
{1 – (Ast) (fy) / (fck) (bd)}

Mu = 0.87 fy Ast d [1 – (Ast fy/bd fck)]

Ast = 118.72 mm^2

Provide 6mm Ø diameter bars,

Spacing = $\frac{\pi/4 \times ø^2}{Ast} \times 1000$



= 237.53

Number of steel reinforcement (n) = $\frac{Ast}{\pi/4 \times \phi^2}$

= 118.72/2

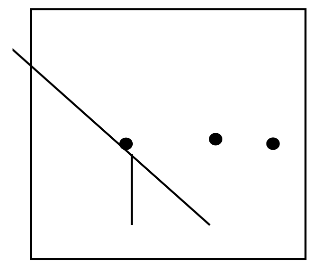
= 4.21 = 4 Nos

Steel calculation in horizontal direction:-

Ast = 90.24 mm^2

number of steel reinforcement (n) = $\frac{Ast}{\pi/4 \times \phi^2}$

6 mm ø bar c/c



= 90.24/28.2 = 3.2 = 3 Nos.

Check for shear:-

$\tau_v = \frac{Vu}{bd} \quad \frac{2.165 \times}{10^3 N}$ = 0.08 N/mm^2

(Table 19 456 : 2000 pg 73)

Pt = $\frac{100 Ast}{bd} \quad \frac{100 \times 118.72}{1000 \times 25}$ 0.47 for which τ_c = $\frac{M_{35}}{0.37}$

$\tau_c > \tau_v$ ok.

Checking bending for E. depth (d):-

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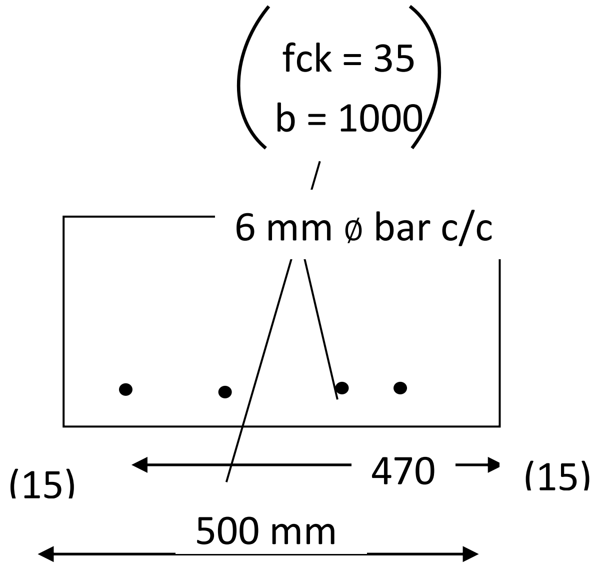

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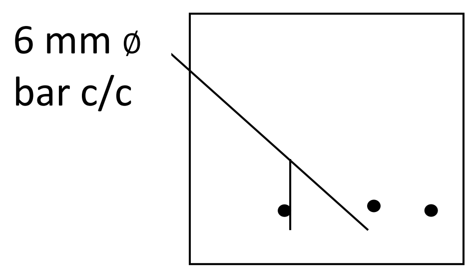

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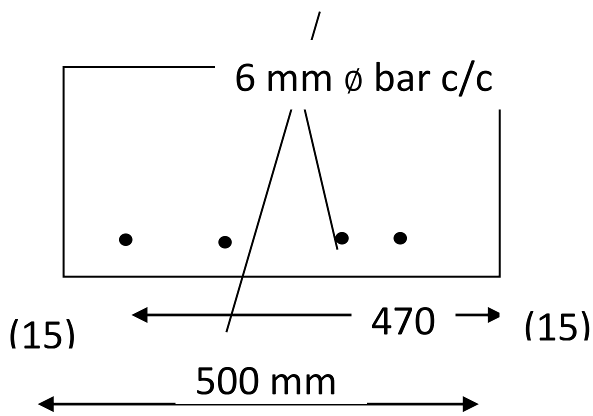


$$\text{Spacing} = \frac{\pi/4 \times ø^2}{Ast} \times 1000$$

= 237.53

$$\text{Number of steel reinforcement (n)} = \frac{Ast}{\pi/4 \times ø^2}$$

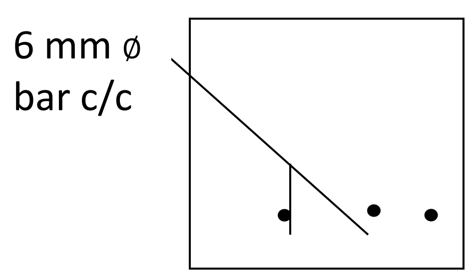
= 118.72/2

= 4.21 = 4 Nos

Steel calculation in horizontal direction:-

Ast = 90.24 mm^2

$$\text{number of steel reinforcement (n)} = \frac{Ast}{\pi/4 \times ø^2}$$



= 90.24/28.2 = 3.2 = 3 Nos.

Check for shear:-

$\tau_v = \frac{Vu}{bd} \quad \frac{2.165 \text{ X}}{10^3 \text{ N}} = 0.08 \text{ N/mm}^2$

(Table 19 456: 2000 pg 73)

$Pt = \frac{100 \text{ Ast}}{bd} \quad \frac{100 \text{ X } 118.72}{1000 \text{ X } 25}$ 0.47 for which $\tau_c = \frac{M_{35}}{0.37}$

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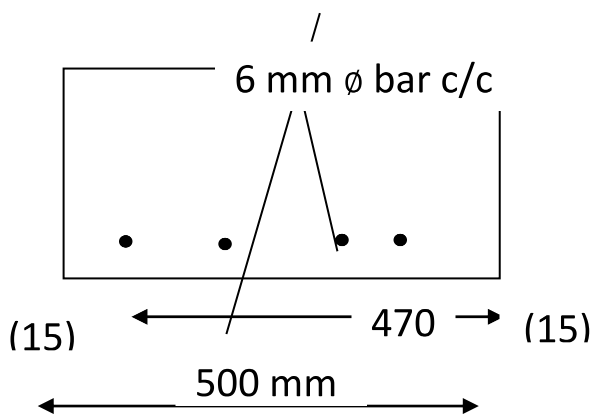


$\text{Spacing} = \frac{\pi/4 \text{ X } \text{ø}^2}{Ast} \text{ X } 1000$

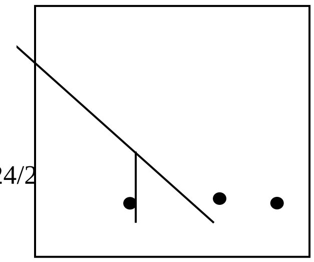
= 237.53

Number of steel reinforcement (n) = $\frac{Ast}{\pi/4 \text{ X } \text{ø}^2}$

= 118.72/28.2

= 4.21 = 4 Nos

6 mm ø
bar c/c



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number of steel reinforcement (n) = $\frac{Ast}{\pi/4 \times ø^2}$ = 90.24/2

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(Table 19 456 : 2000 pg 73)

Pt = $\frac{100\ Ast}{bd} \quad \frac{100 \times 118.72}{1000 \times 25}$ 0.47 for which τ_c = $\frac{M_{35}}{0.37}$

$\tau_c > \tau_v$

In our research work we use opc 53 for mix design M_{35} with 28 % normal consistency conforming to code IS : 8112 – 1989.

Table 2 (The detail test result of cement)

Characteristics	Observed value	Requirement as per IS : 8112 – 1989
Standard Consistency	28.5%	-
Initial setting Time	165 minutes	Not less than 30 minutes
Final Setting Time	270 minutes	Not more than 600 minutes
Specific gravity	3.15	-

Table 3 (Properties of opc 53)

Compressive strength of cement at: (Mpa)	Result of compressive strength in N/mm^2	Required compressive strength in N/mm^2 as per IS : 8112-1989
3 days	30.22	Min : 29.0
7 days	46	Min 33
28 days	53	-

2.2 STRENGTHENING USING FRP COMPOSITES

Only a few years ago, the construction market started to use FRP for structural reinforcement, generally in combination with other construction materials such as wood, steel, and concrete. FRPs exhibit several improved properties, such as high strength-weight ratio, high stiffness-weight ratio, flexibility in design, non-corrosiveness, high fatigue strength, and ease of application. The use of FRP sheets or plates bonded to concrete beams has been studied by several researchers. Strengthening with adhesive bonded fiber reinforced polymers has been established as an effective method applicable to many types of concrete structures such as columns, beams, slabs, and walls. Because the FRP materials are non-corrosive, non-magnetic, and resistant to various types of chemicals, they are increasingly being used for external reinforcement of existing concrete structures. From the past studies conducted it has been shown that externally bonded glass fiber-reinforced polymers (FRP) can be used to enhance the flexural, shear and torsional capacity of RC beams. Due to the flexible nature and ease of handling and application, combined with high tensile strength-weight ratio and stiffness, the flexible glass fiber sheets are found to be highly effective for strengthening of RC beams. The use of fiber reinforced polymers (FRPs) for the rehabilitation of existing concrete structures has grown very rapidly over the last few years. Research has shown that FRP can be used very efficiently in strengthening the concrete beams weak in flexure, shear and torsion. Unfortunately, the current Indian concrete design standards (IS Codes) do not include any provisions for the flexural, shear and torsional strengthening of structural members with FRP materials. This lack of design standards led to the formation of partnerships between the research community and industry to investigate and to

3. Experimental Procedure

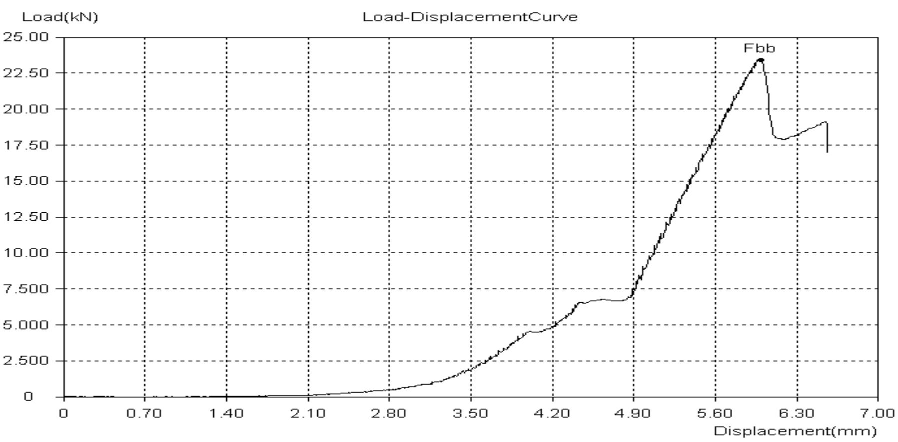
All the specimens were tested in the loading frame of the "Structural Engineering" Laboratory of Centurion University of Technology, Bhubaneswar. The testing procedure for the entire Specimen was not same. Two type of testing procedures are adopted .After the curing period of 28 days & 7 days was over, the beam as washed and its surface was cleaned for clear visibility of cracks. The most commonly used load arrangement for testing of beams will consist of one point loading & two-point loading. This has the advantage of a substantial region of nearly uniform moment coupled with very small shears, enabling the bending capacity of the central portion to be assessed. If the shear capacity of the member is to be assessed, the load will normally be concentrated at a suitable shorter distance from a support. One-point loading can be conveniently provided by the arrangement of UTM machine .Two point loading can be provided by the arrangement of flexural testing machine. The loading frame must be capable of carrying the expected test loads without significant distortion. Ease of access the middle third for crack observation. The specimen was placed over two steel rollers bearing leaving 50mm from the end of the beam. The remaining was divided into three equal parts. Two point loading and one point loading arrangement was done as shown in the figure. Loading was done by the machine of capacity 100 KN. In SET 1, SET 2, SET 3 four beams (1, 2, 3and 4) weak in flexure are tested SET-1: Test conducted using one point load

Beam-1

Figure 2 Experimental setup for control beam

flexural strength of rcc beam at 28 days

SampleID	flexural strength of rcc b	TestDate	2/18/2016
Operator	Preeti Rekha	Type	Flat
Size(mm)	100*100	So(mm²)	10000.00
Ls(mm)	500	Fbb(kN)	23.40
Rbb(MPa)	18		



Sl.no	Sample reference	Age in days	Size of the beam in mm	Load in kn
01	Control beam	28	500x100x100	23.40 KN
02	Beam in 8 layer	28	500x100x100	28.70 KN
03	Beam in 14 layer	28	500x100x100	53.20 KN
04	Beam in 16 layer	28	500x100x100	74.85 KN

4. Conclusion

Under One point static loading of SET I beams, at each increment of load, deflection and crack development were observed. In beam 1 initiation of the crack takes place at a load of 23.40 KN which is lower than beam 2 in which crack initiation started at 28.70 KN. The crack initiation of beam 3 at a load of 53.20KN.The crack initiation of beam 4 at a load at 74.85kn. Beam no-4 has the maximum load carrying capacity. SET-2 & SET-3-Test conducted using two point load SET-2:

Four beams are casted beam (1, 2, 3, 4) weak in flexure.

1. Initial flexural cracks appear at a higher load by strengthening the beam with 8 layer. The ultimate load carrying capacity of the strengthen beam -2 is 19% more than the controlled beam -1.
2. Load at initial cracks is further increased by strengthening the beam with 14 layer. The ultimate load carrying capacity of the strengthen beam 3 is 56 % more than the controlled beam -1 and 46 % more than the strengthen beam -2.
3. Load at initial cracks is further increased by strengthening the beam with 16 layer. The ultimate load carrying capacity of the strengthen beam -4 is 69 % more than the controlled beam -1 and 29 % more than the strengthen beam -3

SET 2 Beams (1, 2, 3 and 4)

1. Initial flexural cracks appear at a higher load by strengthening the beam with 4 layer. The ultimate load carrying capacity of the strengthen beam -2 is 24% more than the controlled beam -1.
2. Load at initial cracks is further increased by strengthening the beam with 6 layer. The ultimate load carrying capacity of the strengthen beam 3 is 37.5 % more than the controlled beam -1 and 5 % more than the strengthen beam -2.
3. Load at initial cracks is further increased by strengthening the beam with 8 layers. The ultimate load carrying capacity of the strengthen beam -4 is 74 % more than the controlled beam-1and 27 % more than the strengthen beam -3.

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