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Experimental Study on Load Carrying Capacity of RCC Beam by Using Pultruded Frp I- Section & C-Section

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Abstract: ***The Steel widely used as reinforcement material in construction industry But, steel fails to perform structurally when it exposed to harsh environment such as bridges, chemical plants and other structures. This has been already tested on GFRP bars many techniques to prevent corrosion of steel reinforcement. When tor steel bars are replaced by GFRP bars to reinforce composite beams, brittle failure of GFRP bars caused due lack of ductility of beam members. Due to lack of ductility of conventional beam both stiffness and ultimate load were reduced significantly. Therefore, for overcoming these effects we introduced GFRP I-section beam and C-Channel section in conventional beam. Pultruded GFRP I-section beam and C-Channel section are usually made by pultrusion process. In pultrusion process, materials such as fiberglass & resin are pulling by extrusion process. In this experimental study on load carrying capacity, failure pattern and deflection of a composite beam, which is reinforced with longitudinal tensile steel bars as well as glass fibre reinforced polymer (GFRP) pultruded I-section beam and C-Channel section encased in concrete. The beam specimens, including one Conventional reinforced concrete (RC) beam, GFRP I-beam in center and GFRP I-beam bottom, GFRP C-channel in center and GFRP C-channel bottom and GFRP I-beam is replaced by bottom steel bars, were cast and tested under two-point bending.The Result will use to analyze Load carrying capacity of beam. The present project work aims for studying suitability of GFRP as strengthened material for rolled RC beam. In this paper to study load carrying capacity of RC beam strengthened with glass fiber reinforced polymer I-section beam and C-channel section. Also, check suitable position and pattern of pultruded GFRP member.***

Keywords: GFRP I-section Beam and C-section Chanel, RCC composite beams, Load carrying capacity, pultrusion process

1. Introduction

In previous works done on repair and strengthening of steel and RCC structures by use of FRP materials. An FRP structure generally consist raw materials such as glass roving, glass mad & unstructured polyester (UP), Resin applied to mould in combination with steel reinforcement, most commonly glass fibers, to form a part which is rigid and highly durable & lightweight. Due to low maintenance & lightweight, FRP is used in many applications building & infrastructure projects. To cast synthetic marble & solid surface for kitchens, bathrooms and roof tiles, UP resins can be mixed with glass fiber & fillers. FRP is more suitable option to conventional materials for bridges, wind generators because it has advantages like lightweight, low maintenance & easy installation process.

Fiber Reinforced Polymer (FRP) is increasingly used in civil engineering construction in last two decades because of excellent properties of corrosion resistance as well as high strength & lightweight. Wide research has been conducted on to retrofit existing structures by using FRP.

Whereas, FRP composites such as FRP bars and FRP pultruded profiles are also exploited as standard construction product for new construction. Due to advantages of convenient installation and customized cross-sections (e.g. I-beam, square tube or circular tube), application of FRP pultruded profiles it has been widely used in recent year). FRP pultruded profiles are suitable for all FRP structures such as building floor, cooling towers and offshore platforms. Moreover, it can be used in combination with other materials to develop composite structures. Lot of research were carried out on GFRP I- beam reinforce beam specimen, thus forming a composite structural member.

In order to improve the load carrying capacity of the composite beam reinforced with I-beam and C-channel, a type of composite beam is proposed in this study. The composite beam created by using I beam & longitudinal tensile steel bars, and those I beam is encased in concrete. The load carrying capacity and corrosion resistance of conventional beam are increase by encased of GFRP I-beam or C-channel is contributed to improvement of to achieve enough bending, stiffness and ductility of composite beams use tensile steel bars in this composite beam. The concept of incorporating FRP and steel materials together to enhance ductility of structure has been proven to be effective by both experimental and numerical approaches. Steel stirrups are employed to confine the concrete and enhance the shear strength of beam members.

The advantages of this type of composite beams are apparent when compared with existing conventional beams. Compared with the conventional beam reinforced with composite beam with GFRP I-section, although configurations of both are similar, self-weight of the Proposed composite beam is decreased & the corrosion resistance capacity is increase due to existence of I-beam. In comparison of composite beam with GFRP I-beam, there are below advantages of composite beam:

- The surroundings concrete of I –beam fire performance can be improved
- Stability of the I-beam can be increased due to encased in concrete; and
- By using tensile steel bars, ductility can be improved.
- In the type of composite beam also have significant advantages in practical applications, such as: All materials

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which are using that is standard which is without special treatment like drilling holes, riveting or welding, Because of existence if steel bars inside, it is easy for connecting columns.

2. Literature Survey

The recently research paper "Experimental investigation of composite beams reinforced with GFRP I-beam and steel bar" in 2017. The experimental study on flexural behaviour of a composite beam, which is reinforced with longitudinal tensile steel bars as well as glass fiber reinforced polymer pultruded I beam encased in concrete. Five beam specimens, including one traditional reinforced concrete beam and four composite beams, were cast and tested under four-point bending. The variables involved in the composite beam include the type of longitudinal tensile bars and the location of the I beam in the cross- section. The test result presented in this study show that the proposed composite beams have a very ductile response due to the existence of the tensile steel bars, and the yield of the composite beam is controlled by the tensile steel. The ultimate load of the beam in this study is higher than the traditional RC beam.

3. Methodology

Pultrusion: Pultruded GFRP sections are usually made by pultrusion process, The pulling raw material composite through a heated die, this process are create continuous composite profile. In pultrusion process extrusion is pulling of materials such as fibreglass and resin, through a shaping die.

Polyester, polyurethane and vinyl ester epoxy resins etc. are types of resin can be used in pultrusion including Fiber is wetted or impregnated with resin and is organized and then removed of excess resin. After that composite is passed through a heated steel die. Puller clamps also provided for pulling structural profile.

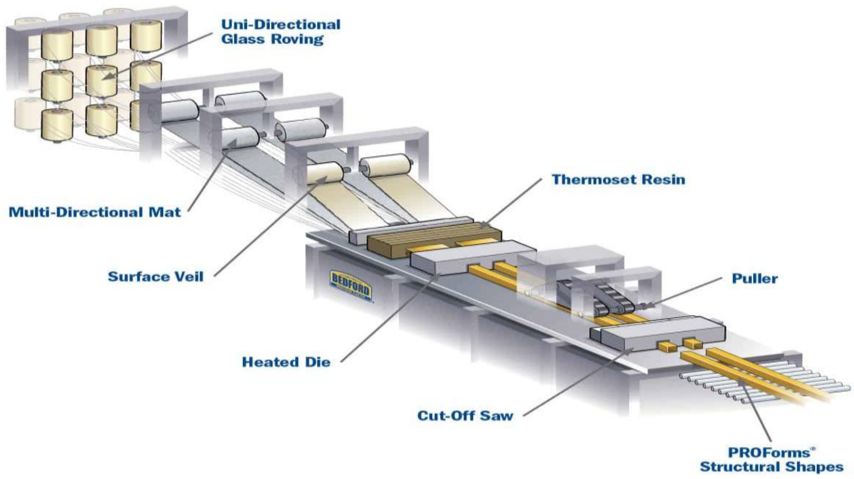

Figure 1: Pultrusion Process

Mechanical, physical and electrical properties of GFRP I-section beam and C-section gives by manufacturer **Atul Electro Formers Ltd., Pune.**

Table 1: Mechanical, physical and electrical properties of GFRP I-section beam and C-section

Description	*Code No*	*Minimum Required*	*Material value*
Density	ASTM D 792	-	1.9
Barcol Hardness	ASTM D 2583,	50-65	50
Water Absorption	ASTM D 570,	< 0.25%	0.24%
Ultimate Tensile Strength	ASTM D 638,	392 Mpa	403 Mpa
Flexural Strength	ASTM D 790,	245 Mpa	400 Mpa
Compressive Strength	ASTM D 638,	150	150 Mpa
Flammability	UL 94 V0	-	-
Flammability	[IS:6746, CLASS 1]/ PR	-	-
Sp. Gravity	IS : 10192	-	-
Fire Retardancy	: 11731, PASS	-	-
Surface Burning	ASTM E-84 / IS : 6746,	< 15	8
Dielectric Strength (Axial)	ASTM D 149,	1.2 KV/MM	4.8 KV/MM
Dielectric Strength (Radial)	ASTM D 149,	10.0 KV/MM	33.7 KV/MM
Arc Resistance	ASTM D 495	120s	122.7s
Oxygen Index	ASTM D 2863,	30	41
UV Resistance	SIN MFR. TC	-	-

Collection of required material like cement, sand, aggregate, GFRP I-section, GFRP C-channel section, steel etc. is done. The cross section of an elements comprises of beam size is 150 X 150 X 700 mm with 2#8 mm diameter steel bars at top & 2#8 mm diameter steel bars bottom and 6 mm stirrups at spacing 100mm c/c inclusive of GFRP I and C Channel section.

Evaluate load carrying capacity of reinforced elements of M20 grade and determine corresponding strength after 28 days by applying two point loading. Comparisons of results with conventional beam, composite beam using GFRP I-beam and C-channel.

Modelling

The reinforcement of beam 2#8mm diameter of steel bar use for main bar, 2#8 mm Anchor bar and 6 mm@100mm c/c diameter use for stirrups. 40mm×25mm×3mm (flange x

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web × thickness) of GFRP I-section placed at bottom, center, and replacement of main bar for load carrying capacity of RCC beam. 40mm×25mm×3mm (flange web × thickness) of GFRP C-channel placed at bottom and center for taking load carrying capacity of RCC beam.

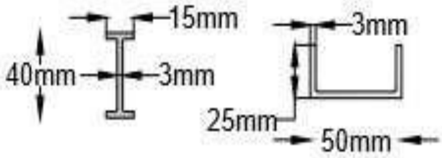

Figure 2: Details I-section beam and C-channel of GFRP

Detailing of Specimen

For this investigation Specimen specification was consider as per following specification for RCC beam by using I-section beam and C-channel of GFRP. Total 18 number specimens will be casted then testing of beams on Universal Testing Machine (UTM) by applying two point loads on a beam.

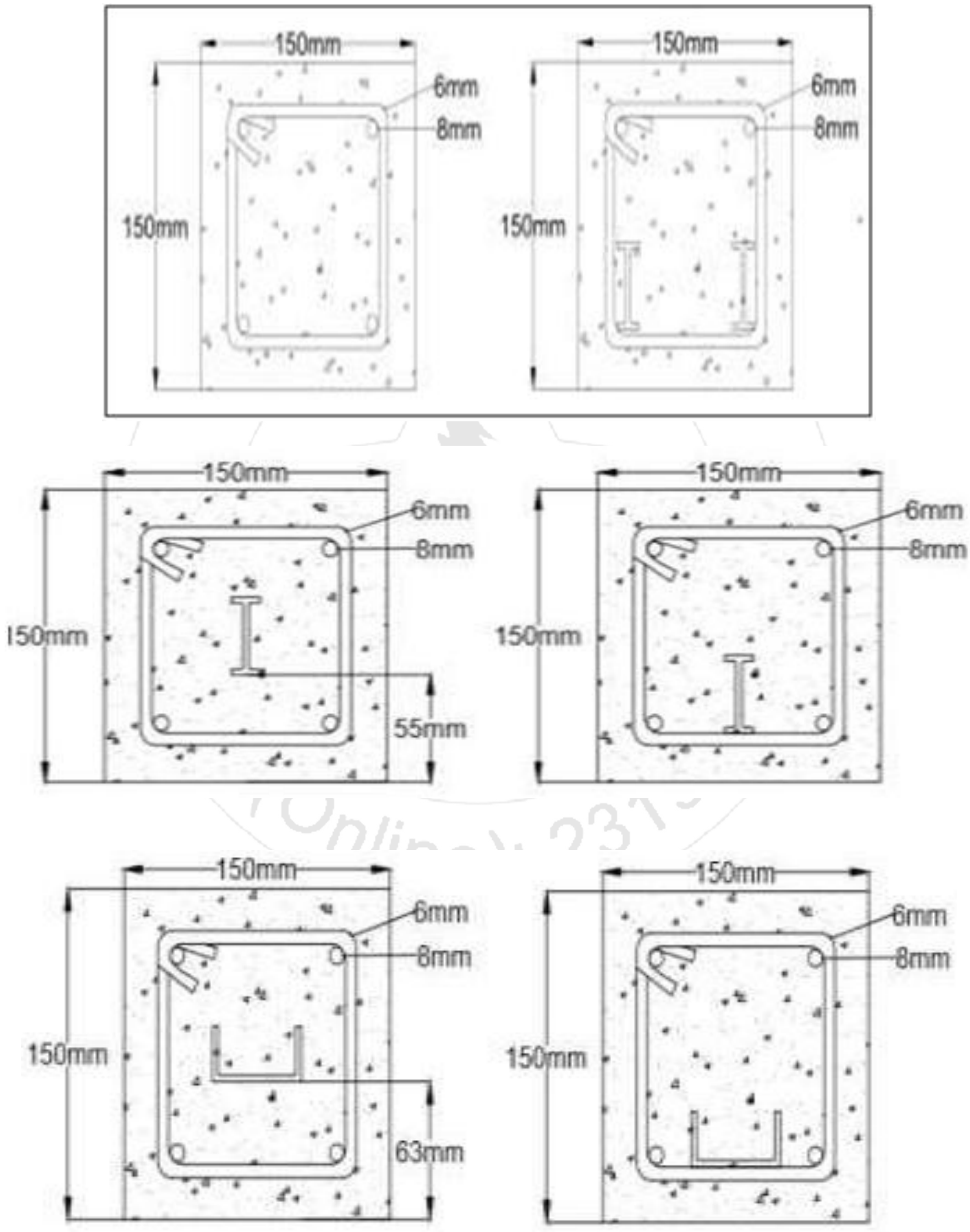

Figure 3: Different combination of beams

The beam dimensions selected: 700 mm X 150mm X 150mm (length x width x depth)

GFRP I- beam dimensions: 40 X 15 X 3 mm (web × flange × thickness)

GFRP C-channel dimensions: 50mm X 25 X 3 mm (web× flange × thickness)

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Table 2: Percentage of material in beams

Sr. No.	Name of Specimen	% of area of bottom steel	% of area of GFRP
1.	Conventional beam	0.44%	0%
2.	I section beam in bottom or center position	0.44%	0.58%
3.	C channel section in bottom or center position	0.44%	0.92%
4.	Double I section beam in bottom	0.44%	1.17%

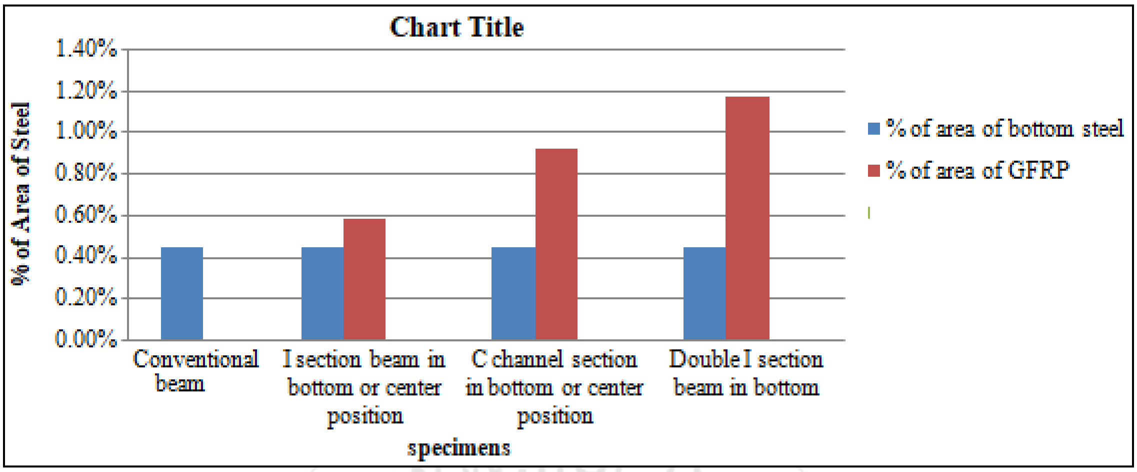

Chart 1: Chart of Percentage of material in beams

Figure 4: Casting of I-section GFRP beam

Figure 5: Casting of C-Channel GFRP beam

Test Setup

The eighteen specimens were tested with Centre point bending with 700 mm effective span. The sample was placed on two supporting pins a set distance apart. Load specimen continuously without shock. The load applied at constant rate to the breaking point. The load applied at the rate of 0.9- 1.2 MPa/min. The specimens' cracks will map and the observations were record during the loading and at the time of failure.

4. Result and Discussion

Table 3: Load Carrying Capacity of Samples by Experimentally

Specimen	Load Carrying Capacity	Average Load Carrying capacity	% of increased load
1IC	69		
2IC	68	69.80	16.25
3IC	72.4		
12IB	76		
22IB	78.5	76.67	39.4
32IB	75.5		
1IB	71	70.83	28.78
2IB	72.5		
3IB	69		
1CC	58.6		16.25
2CC	65	63.83	
3CC	68.2		

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1CB	65.2	67.55	22.08
2CB	66.3		
3CB	70		
1A	55	55.00	0
2A	52		
3A	58		

Numbers:-Specimen No.
IC:- I-Section GFRP Beam In Center Position
2IB:- Double I-section GFRP Beam in bottom position
IB:- I Section GFRP Beam in Bottom position
CC:- Channel Section GFRP in centre position
CB:-Channel Section GFRP in bottom position
A:- Conventional Beam

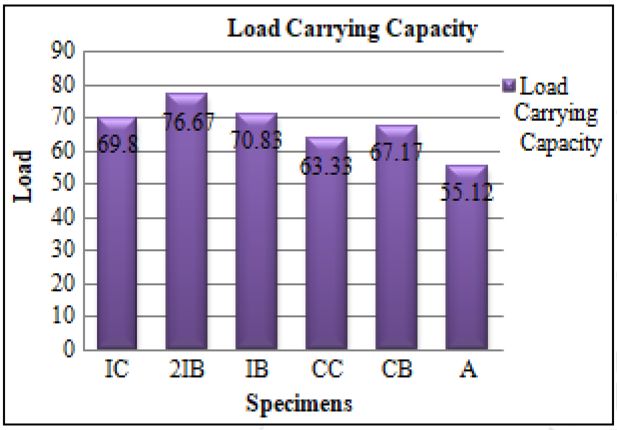

Chart 2: Load Carrying Capacity of Beams

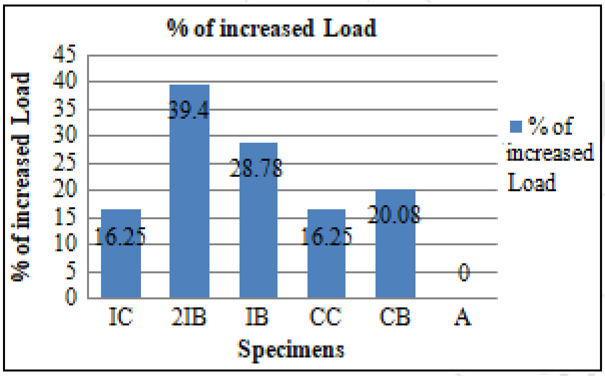

Chart 3: Percentage of increased load carrying capacity of beams

Load carrying capacity of various beams having different section of GFRP, position is carried out. It is observed that load-carrying capacity of 2IB is increased. i.e. 39.4% than conventional beam. IB is combination of steel and GFRP I-beam having load carrying capacity increase by 28.78% than conventional beam.

Results of Load Carrying Capacity Vs Deflection

Table 4: Load Vs Deflection

Load	Deflection (mm)					
	IC	2IB	IB	CC	CB	A
0	0.0	0	0	0	0	0
5	0.7	0.2	0.2	0.1	0.2	0.8
10	1.2	0.7	0.8	0.3	0.4	1.1
15	1.4	0.9	1.0	0.5	0.6	1.5
20	1.7	1.2	1.1	0.8	0.9	1.8
25	2.1	1.3	1.4	1	1.3	2
30	2.5	1.7	1.9	1.4	1.7	2.4
35	2.8	1.9	2.2	1.6	2.1	2.8
40	3.1	2.1	2.4	1.9	2.4	3.2
45	3.4	2.2	2.7	2.2	2.9	3.6
50	3.8	2.3	2.9	2.8	3.3	4.1
55	4.2	2.5	3.2	3.5	3.8	5.1
60	4.6	2.9	3.6	4.3	4.4	5.4
65	5.1	3.5	4.1	4.5	5.3	
70	5.7	4.2	4.6	4.7	6.7	
75		4.6	5.1			
80		4.9				

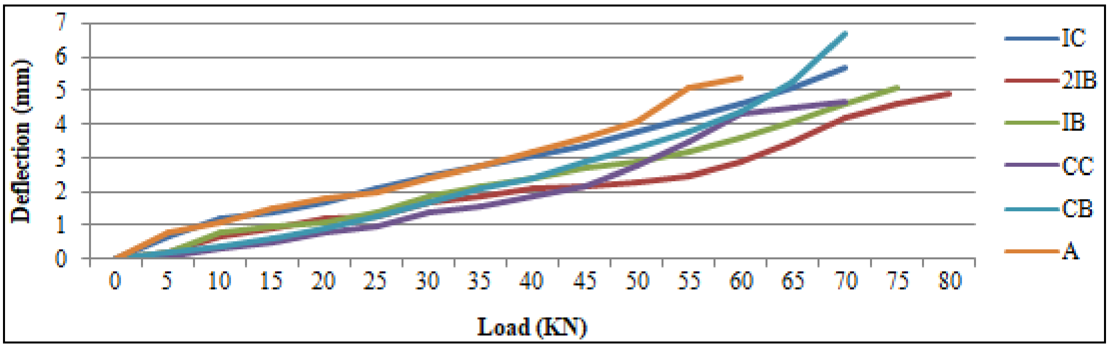

Chart 4: Deflection Vs Load Carrying capacity

Load carrying capacity Vs Deflection curves of experimental results are plotted. It is observed that load carrying capacity increases deflection also increases that is load carrying capacity is directly proportion to deflection. Load carrying capacity is more GFRP I-section beam in case in RC beam compare to other cases & Deflection is less

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in GFRP RC beam compare to conventional beam.

5. Conclusion

The experimental work and testing of specimen following conclusion have been concludes that conventional beam compared with composite beam by using pultrated profile in RC beam although the configuration of both are similar self weight of beam is reduced density of FRP pultrated profile is less than concrete or steel

It seen that,

- Load carrying capacity of specimens increases in case of double I section encase of beam but it is similar to single I section is same when placed at bottom along with steel bars.
- In case of composite beam deflection is less compared with conventional beam.
- The I-section GFRP beam carries more load as compare to C-channel section of GFRP beam.
- The stability of GFRP I section beam and C section will be improved by it encased in concrete.
- As compare to channel section GFRP in bottom position strength of beam increase by 12% to 35% for various combinations.
- There is no any requirement of special treatment like drilling holes, riveting or welding.

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