BEAMS STRENGTHENED BY GLASS FRP LAMINATES BYFLEXURAL BEHAVIOUR OFHYBRID FIBER REINFORCED CONCRETE

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Abstract. The flexural conduct of remotely justified fiber solid compound (GFRP) concrete (RC) radiates fusing each 'basalt' and 'polyolefin' filaments at a persevering connection of 70:30 and in a few blends of fiber volume portions (Vf) extending from zero-2% (at a tireless addition zero-0.5%) were explored, to highlight to part of reinforcing and conjointly the cross breed strands in radiates. type of pillars, altogether a controlled shaft, GFRP covered RC bar and overlaid half breed fiber solid bars. Were projected and tried under a four-reason bowing. The outcomes demonstrate that there is a 'joined impact' of cover and consolidation of the upper than half and half filaments in contributory to the truly high burden conveying ability and improved physical property of overlaid HFRC bar. fundamentally fiber volume substance of 1.5%.

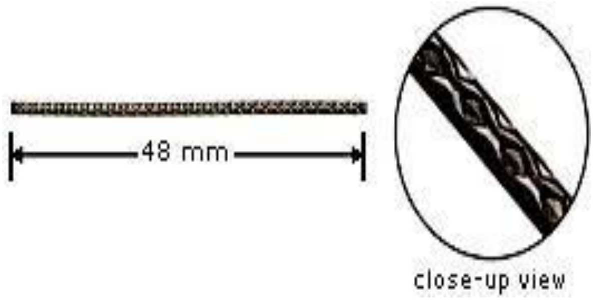
Keywords: GFRP; Polyolefin Fiber; Steel Fiber; HFRC; Strength; Ductility

1.Introduction

Geo polymer concrete, associate degree nonindustrial material in Republic of India,goes to beare volution not solely within the analysis field however conjointly industry. Geopolymers associate degree distinctive category of inorganic polymers are new encouraging folios and are processing plant made by the actuation of a strong state alumino -silicate with a very antacid activating resolution exploitation thermal drive.Anendeavor has been created during this project to check the advantages, application and practicability of geo polymer concretein Republic of India. An essential fixing inside the normal cement is that the concrete. The gathering of 1 ton of concrete emanates around 1 ton of carbon dioxide to the climate. concrete is chargeable for upward of 85 percent of the vitality and 90 percent of the carbon dioxide credited to a normal prepared blended cement.

The geopolymer solid uses major mechanical waste-fly debris. debris is created from modern waste and handily offered far and wide. The greater part of the debris is not viably utilized partner degree an external zone of it is arranged in landfills. Thinking about this, plainly the utilization of geo polymer cement can be demonstrated practical and assembled eco-accommodating. In today\'s time, this innovation is being utilized wide inside the USA, Europe and Australia. To overcome the upper than issue, a simple and effective technique is to incorporate very little amounts of short fibres into concrete.

This might greatly improve concrete toughness or ability to resist crack growth which will be estimated by methods for the equal break vitality of RC (CNR- DT204/2006 2007, Singh and Singhal 2011, The most familiar kind of an amorphous solid is glass (Bentur, Mindness et al.1998).



(a) Polyolefinfibre

(b) Hooked end steelfibre

(c) Glass fibrecloth

Raijiwala et al (2011) have revealed the advancement of the exploration on making geopolymer solid utilizing the warm force plant fly debris, Gujarat, India. The task targets making and examining the various properties of geopolymer solid utilizing this fly ash and different fixings locally accessible in Gujarat. Potassium Hydroxide and Sodium Hydroxide arrangement were utilized as salt activators. activators.

Table 1 Properties of fibres

Sl. No.	Fibre properties	Type of short-fibre	
		Polyolefin	Steel
1	Length (mm)	48	30
2	Shape / Type	Straight	Hooked ends
3	Size (mm)	1.22 × 0.732	0.5 Ø
4	Aspect Ratio	39.34	60
5	Density (kg/m^3)	920	7850
6	Tensile strength (MPa)	550	532
7	Young's modulus (GPa)	6	210

Table 2 Properties of steel rebar and GFRP laminate

Sl. No.	Properties	Tensile steel ratio (%)	No. of layer	Yield / failure stress* (MPa)	Elasticity modulus (MPa)	Poisson's ratio
1	Main steel rebar	0.60	-	415.00	200000	0.30
2	GFRP laminate	-	3	503.52	1603.50	0.38

*Yield for steel rebar and failure for GFRP laminate

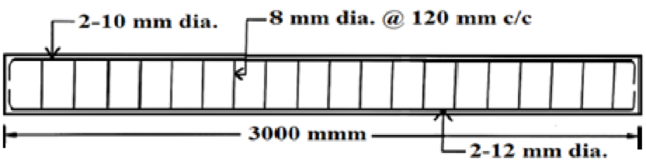


Fig. 2 Steel reinforcement details of beam

Table 3 Details of tested beams

Sl. No.	Beam ID	Beam size B × D × L (mm)	Total volume of fibre (%)	Fibre proportion		GFRP laminate thickness (mm)
				Polyolefin	Steel	
1	RB+		0	--	--	--
2	RB1++		0	--	--	5
3	HB1		1.0	0	100	5
4	HB2	150 × 250 × 3000	1.0	20	80	5
5	HB3		1.0	30	70	5
6	HB4		1.0	40	60	5
7	HB5		1.0	50	50	5

+RB: Control (RC) beam; ++RB1: GFRP strengthened RC beam

Fig. 1 Pictorial view of fibres

Glass fiber is made up from 200-400 individual fibers which are softly attached to make up a stand. These stands can be cleaved into different lengths or joined to make fabric tangle or tape. Utilizing the customary blending procedures for ordinary solid it is unimaginable to expect to blend more than about 2% (by volume) of filaments of a length of 25mm.

The significant apparatus of glass fiber has been in strengthening the concrete or mortar networks utilized in the creation of slight sheet items. The generally utilized verities of glass strands are e-glass utilized. In the fortified of plastics and AR glass E-glass has lacking protection from antacids present in Portland concrete where AR-glass has improved soluble base safe qualities. Some of the time polymers are likewise included the blends to improve some physical properties, for example, dampness development.

The normally accessible economical mineral fiber, asbestos, has been effectively joined with Portland concrete glue to shape a broadly utilized item called asbestos concrete. Asbestos strands here warm mechanical and compound obstruction making them appropriate for sheet item lines, tiles and layered material components. Asbestos concrete board is

2. Experimental Programme

2.1 Material properties and specimen characteristic

Blend extent was intended to create functional cement with target quality of 26.6 MPa for the control blend. The longitudinal fortification comprised of 2 quantities of 12 mm breadth HYSD bars in the strain zone and 2 quantities of 10 mm width HYSD bars in the pressure zone. The cross over fortification for all the pillars.

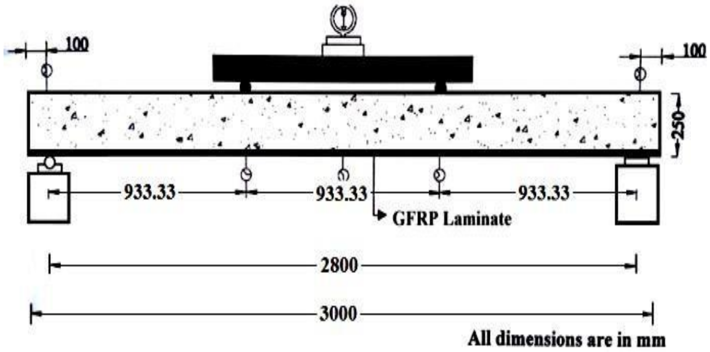


Fig. 3 Test set-up and instrumentation

Fig.4 Surface grinding in progress

the makers are given in Table 1. Properties of steel rebar and GFRP laminate are presented in Table 2.

The fibre volume content was assumed as 1% and kept up steady all through the examination (the higher than fiber volume content corresponds to 'medium level',as reported in literature). As two types of fibres are used, it's necessary.

To determine their strength properties/optimum content. For the higher than purpose, HFRC cylindrical specimens of size 200 mm dia.×300 mm height for evaluating the compressive strength and 100 mm dia.×200 mm height for evaluating the split-tensile (or indirect tensile) strength of the above Examples were projected, as per the individual

Fig. 5 GFRP lamination in progress

Fig. 6 Photographic view of test set-up

Indian standard codes (IS: 516-1959 and IS: 5816-1999). One plain concrete (R-P0S0) without fibres to serve asa ‘control’ specimen, and 6 HFRC specimens reinforced with completely different volume proportions of polyolefin and steel fibres (0:100, 20:80, 30:70, 40:60, 50:50, 100:0) were forged. Three cylindrical specimens of each sorts of concrete were forged and tested for getting the (average) compressive strength and split-tensile strength.

2.2 Casting and strengthening of beams

An aggregate of seven bars were fashioned and tried in this investigation. All the shafts were of same cross-segment 150 mm×250 mm (breadth depth) and had a transparent span of 3000 mm. One RC beam (RB) was left with none internal fibres or external GFRP and one RC beam was strengthened with GFRP (RB1) to act as management beams.

Fig two shows the standard steel reinforcement details of beams. The strengthened beams consisted of 5 mm thick GFRP laminates warranted to the stress face of the beams. The assignment and details of tested beams are given in Table 3. The details of instrumentation, GFRP length, support and loading conditions square measure shown in Fig. 3.

After casting and hardening the beams for 28 days, the beams were reinforced by external bonding of unifacing glass fiber sheets victimization synthetic resin because adhesive at the bottom of the beams (i.e., on the tension

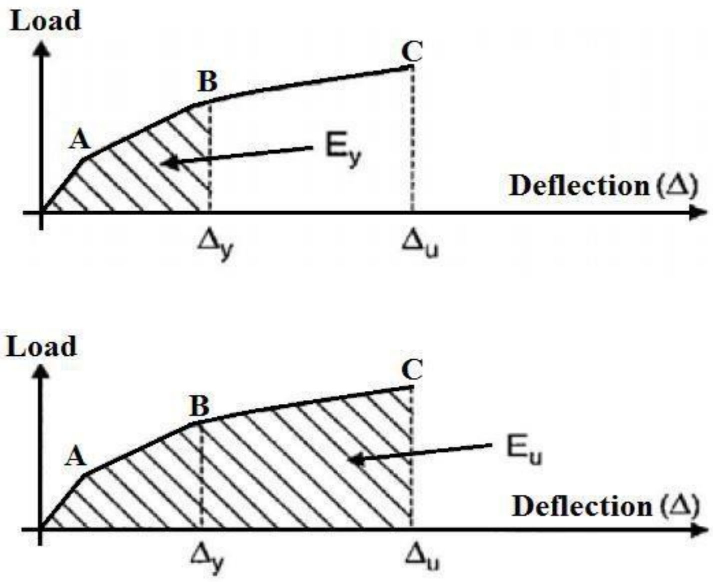


Fig.7Deflectionductilityandenergyductilitydefinitions

face). In order to ensure proper bonding between concrete and laminate, the beam surface was prepared using mechanical grinding as shown in Fig. 4 and then the surface was cleaned with the help of air blower to remove all fine particles from the prepared surface. By thusly, surface planning was finished on the designated specimens prior to bonding of the sheets. Wet layup system was used for strengthening the beam specimens and complying with ACI Committee440recommendations(ACI440-2R2008).Fig.5 shows the simultaneous process of the application of resin and removal of air bubbles by using a roller. The laminated beams were left free for curing at room temperature before testing.

2.1 Instrumentation and test procedure

All the bars were tried during a stacking outline having an ability of 500 kN underneath static monotonic stacking. The stacking design had a successful range of 2800 mm and a rentless second district of 933.33 mm. The majority were applied in additions of 2.5 kN under four-point twisting. The avoidances were estimated at mid-length and at load focuses utilizing mechanical dial measures having 0.01

Sl. No.	Specimen ID	Compressive strength (MPa)	Tensile strength (MPa)
1	R-P0S0	26.70	3.78
2	H1-P0S100	27.80	4.12
3	H2-P20S80	28.25	4.20
4	H3-P30S70	28.50	4.29
5	H4-P40S60	30.28	4.58
6	H5-P50S50	28.67	4.34
7	H7-P100S0	27.12	4.10

Table 5 Principal test results of HFRC beams

Sl. No.	Beam ID	First crack Load (kN)	First-crack load deflection (mm)	Yield Load (kN)	Yield load Deflection (mm)	Ultimate Load (kN)	Ultimate load deflection (mm)	Maximum crack-width (mm)
1	RB	19.62	3.48	39.24	8.83	49.05	30.25	0.58
2	RB1	29.43	3.70	73.58	12.45	88.29	21.22	0.52
3	HB1	39.24	7.75	78.48	17.25	112.82	34.92	0.38
4	HB2	41.69	7.04	83.39	15.61	115.27	35.40	0.36
5	HB3	44.14	6.33	88.29	15.11	117.72	37.55	0.34
6	HB4*	46.59	6.19	90.74	14.78	120.17	38.62	0.32
7	HB5	44.14	6.98	85.83	15.36	115.27	36.75	0.34

*HB4: Optimum performance level of GFRP strengthened HFRC beam

‘Ductility’ of a structural element is its ‘ability to endure dead deformation’ and with no substantial reduction in strength. plasticity of a specimen was found supported the deflection and energy absorbed. The deflection plasticity ($\mu\Delta$) is that the magnitude relation of final deflection (Δu) tothatatthefirstyieldingofsteelreinforcement(Δy)(Fig.7). Vitality flexibility record (μE) is characterized as the 'proportion between the vitality of the framework at disappointment (Eu)' and the 'vitality of the framework at yielding heap of pliable steel (Ey)' (Fig. 7) (Vijayakumar and Babu 2012).

3. Results anddiscussion

Table 4 shows the aftereffects of HFRC examples. It tends to be seen that the compressive quality of HFRC examples are somewhat higher than that of the 'control example'. This is in accordance with the perception/(s) of a couple of agents (Ferrari and Hanai 2012, Qureshi et al. 2013). The principal check results of beams square measure respectively, when put next to the control beam (RB) and 23.3% and 36.1% respectively, when compared to GFRP laminatedRCbeam(RB1).Whereas,polyolefinfibreshavea low modulus and high elongation, having the capacity to absorb large amount of energy, thereby impart toughness to the composite, steel fibres have high modulus and high elongation, thereby impart strength and stiffness to the composites, as well asdynamicproperties to varying degrees (Mahadik et al.2014).Two types of flexural strength for the beams were ascertained.

The primary one is: first-crack flexural strength, which shows a linear behavior. The second one is the final flexural strength, which is related to maximum load achieved, and so is a lot of necessaryfor style concerns. Flexural strength will be enhanced by increasing fibre volume fraction and aspect ratio

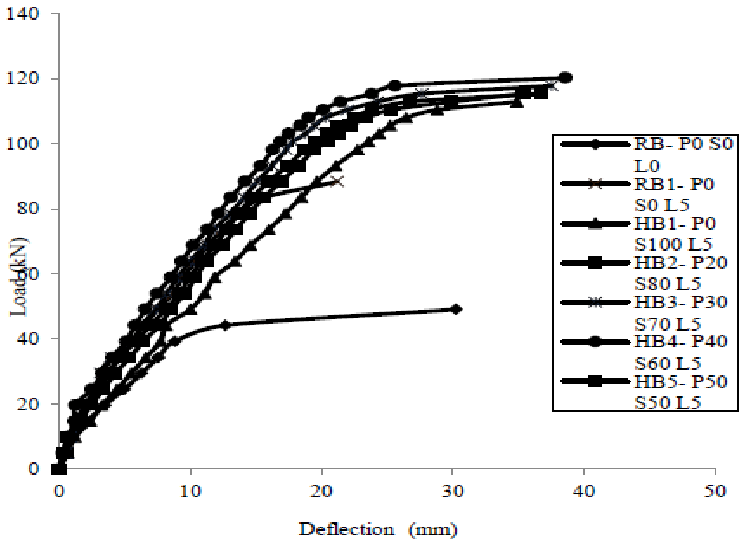


Fig. 8 Load-deflection response of tested beams

Table 6 Ductility and failure details of tested beams

Sl. No.	Beam ID	Deflection ductility	Energy ductility	Failure mode
1	RB	3.43	4.28	Concrete compression failure
2	RB1	1.70	2.04	Debonding of laminate
3	HB1	2.02	2.91	Debonding of laminate
4	HB2	2.26	3.13	Debonding of laminate
5	HB3	2.48	3.31	Debonding of laminate
6	HB4*	2.61	3.46	Debonding of laminate
7	HB5	2.39	3.21	Debonding of laminate

*HB4: Optimum ductility response level of GFRP strengthened

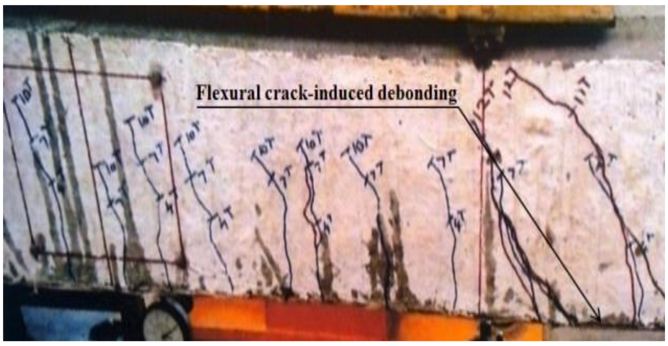


Fig. 9 Failure mode of GFRP laminated HFRC beam (HB4)

The flexibility and disappointment subtleties of tried pillars are given in Table 6. GFRP covered HFRC radiates (HB4) additionally display upgraded flexibility than that of GFRP overlaid RC shaft (RB1). The expansion in avoidance flexibility and vitality pliability were discovered to be 53.5% and 69.6% when contrasted with that of GFRP overlaid RC bar (RB1).

A few examiners have detailed that the pliability of RC beams strengthened with FRP laminates/sheets is impressively diminished because of increment in their solidness, subsequently, prompting surprising disappointment with no earlier notification (Xiong et al. 2004, Bsisu et al. 2012). It can be seen from Table6thatthedeflectionductilityandenergyductilityofthe beams RB1, HB1, HB2, HB3, HB4 and HB5.

It shows the standard steel reinforcement details of beams. The strengthened beams consisted of 5 mm thick GFRP laminates warranted to the stress face of the beams. The assignment and details of tested beams are given in Table 3. The details of instrumentation, GFRP length, support and loading conditions square measure.

The task targets making and examining the various properties of geopolymer solid utilizing this fly ash and different fixings locally accessible in Gujarat. Potassium Hydroxide and Sodium Hydroxide arrangement were utilized as salt activators. activators.

4. CONCLUSION

In view of the trial examinations completed in this investigation following ends are drawn:
•GFRP overlaid shaft with a half breed fiber volume extent of 40:60 (polyolefin-steel) (that is HB4), has fundamentally improved in general execution among the tried pillars.
•An generally assessment of the flexural test results and
load-diversion conduct show that the above GFRP overlaid HFRC pillar display higher burden conveying limit, and twisting limit.
•The increment in extreme burden and extreme diversion (of HB4) were discovered to be 145% and 27.6% separately, when contrasted with the control shaft, and 36.1% and 82% individually, when contrasted with GFRP covered RC bar.
•The most extreme decrease in split width (of HB4) was discovered to be 44.8%, when contrasted with the control shaft, and 38.4% when contrasted with GFRP covered RC bar.
•The increment in diversion malleability and vitality pliability (of HB4) were discovered to be 53.5% and 69.6% when contrasted with that of GFRP covered RC bar.
•All the (tried) radiates flopped in 'flexure mode' as it were.

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