FRP-Based Shear and Flexural Strengthening in RC Beams

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ABSTRACT

This study oversees an investigation into the use of glass fiber fortified polymers (GFRP) and carbon fiber reinforced polymers (CFRP) to increase the flexural and shear limit of RC bars. In the research center, fifteen cement shaft specimens measuring 110 mm in width, 200 mm in stature, and 1300 mm in length were produced. A 30-mm longitudinal gap was provided beneath the impartial pivot in the strain zone of each bar for future reinforcing, benefit lines, and other considerations, in accordance with the reasonable pre-focused on connect supports. While the steel support varied based on the initial layout, the geometry of each pillar remained the same. Four of the fifteen pillars were control bars. One shaft was constructed without any steel fortification and was U-jacketed throughout the traverse with two layers of GFRP texturing. Five shafts that were weak in flexure were strengthened using shifting configurations in the higher flexural zone using GFRP texturing. Four bars were weak in shear and were strengthened with GFRP textures with different configurations in greater shear zones near to both underpinnings. They were coupled with two 6-Ø stirrups in each help and one 6-Ø stirrup at mid traverse to hold the grill in position for cementing. Fortified with CFRP texturing in higher shear zones near both bolsters, one bar was rendered weak in shear. With a 1000mm compelling range and a 150mm course, each shaft was effectively reinforced at the two finishes and stacked under more sensible stacking conditions, i.e. consistently circulated stacked (UDL) and tried up to disappointment by bit by bit expanding super forced load. The readiness of solid surface was finished with extraordinary care and demonstrated no security disappointment in all U-jacketed and slanted stripped pillars. One pillar reinforced with GFRP texture in the soffit base just bombed because of debonding.

I. INTRODUCTION

There are many existing scaffold and building structures all through the world, which don't satisfy determined outline necessities. This might be because of overhauling of the plan measures, expanded stacking because of progress of utilize, maturing, consumption of the support bars, minimal plan, development mistakes and poor development, utilize of mediocre material, and mischances, for example, flames and seismic tremors, which renders the structure unequipped for opposing the connected administration loads. In this way the structure needs entire substitution or fortifying. The arrangement in such cases is finished destroying and new development or expanding the heap bringing limit through fortifying of the affected structures in different ways. In view of the restrictive cost of supplanting vast number of weakened structures all through the world, look into endeavors have concentrated on numerous techniques for fortifying of structures. The reinforcing and retrofitting of solid structures speaks to a standout amongst the most testing issues looked by engineers today. Generally, steel has been the essential material used to reinforce solid scaffolds and structures. Fortified steel plates or stirrups have been connected remotely to effectively reinforce and repair solid supports that are inadequate in flexure or in shear. In any case, utilizing steel as a reinforcing component adds extra dead load to the structure and typically requires consumption security. These strategies experience the ill effects of inborn detriments going from troublesome application technique to absence of toughness. As of late, the holding of fiber strengthened polymer (FRP) textures, plates or sheets has turned into a exceptionally well known strategy for reinforcing of RC bars. Actually, the use of FRPs to the fortifying of structures was first looked into amidst 1980s for the flexural fortifying of RC shafts utilizing CFRP plates at the Swiss Federal Laboratory for Materials Testing and Research (Meier et al. 1993). Lately, there is broad research on the utilization of FRP textures, plates or sheets to supplant steel plates in plate holding. FRPs are utilized broadly for pillar and segment reinforcing by outer wrapping. At introduce there are various investigate groups everywhere throughout the world endeavor look into here. The fundamental preferences of FRP textures, sheets or, on the other hand plates are their high quality to - weight proportion and high erosion protection. The previous property prompts extraordinary simplicity in site dealing with, diminishing

1.1 Fiber Reinforced Polymer (Frp)

Fiber strengthened composite materials comprise of strands of high quality and modulus implanted in or attached to a network with particular interfaces between them. In this shape, the two strands and grid hold their physical and concoction characters, yet they create a blend of properties that can't be accomplished with both of the constituents acting alone. Strands are the essential load conveying individuals, while the network keeps them in the wanted area, introduction and shield them from natural harms. The fiber grants the quality, while grid keeps the fiber set up, exchange worries between the strands, gives a boundary against an unfavorable condition, for example, chemicals and dampness, shields from scraped spot. FRP is an acronym for Fiber Reinforced Polymer and distinguishes a class of composite materials comprising of weak, high quality andstiffness strands installed at high volume divisions in malleable low firmness and quality polymeric pitches called matrix.FRP with polymeric framework can be considered as a composite. They are generally utilized as a part of reinforcing of common structures for example, pillars, braces, chunk, segments and edges. There are many points of interest of FRP because of light weight, erosion safe, great mechanical properties. The fundamental capacity of filaments is to convey stack, give quality, solidness and dependability. The capacity of the network is to keep filaments in position and fix it to the structures. There are fundamentally three sorts of filaments commanding the structural designing industry, for example, glass, carbon and aramid strands. Every ha its own focal points and inconveniences 1.2 Methods of Forming Frp Composites FRP composites are shaped by installing nonstop filaments in sap grid, which ties the filaments together. The basic pitches are epoxy tars, polyester saps and vinylester saps, contingent upon the filaments utilized. FRP composites are characterized into three sorts:

- Glass-fiber-fortified polymer (GFRP) composites
- Carbon-fiber-fortified polymer (CFRP) composites
- Aramid-fiber-fortified polymer (AFRP) composites

1.3. Snapshot of protection of rc shafts

The snapshot of protection of all RC shafts are ascertained utilizing limit state technique for outline according to IS 456 - 2000.

II. LIMIT STATE METHOD OF DESIGN (IS 456 - 2000)

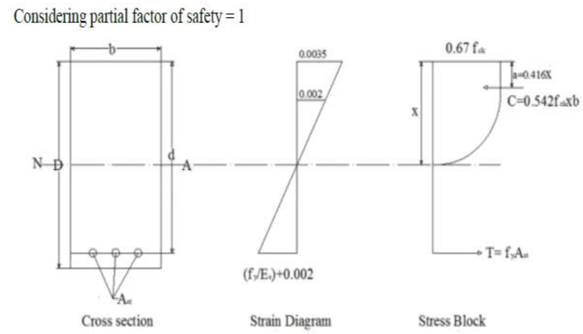

Fig.1 Stress Block Parameters for LSM

2.1 Ultimate Load Method of Design

There are many theories in practice, out of which Whitney's theory (37) has been the most popular and applied to calculate moment of resistance and initial cracking load.

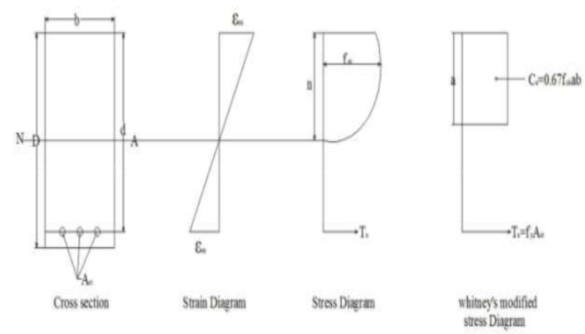

Fig..2 Stress block parameters for ULM

2.2 Flexural Strength of RC Beams with FRP

Existing research suggests that the ultimate flexural strength of FRP strengthened RC beams can be predicted using existing design approaches with modifications to account for the brittle nature of FRPs. The beam is deemed to have reached failure when either the concrete compressive strain attains the maximum usable strain 0.0035 according to BS 8110-1997 and/or the FRP reaches the rupture strain. The following presentation is based on British code BS 8110-1997.

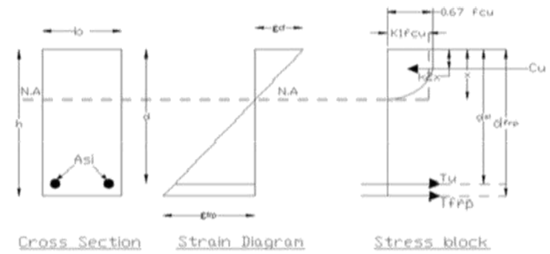

Fig. 3 Stress-Strain Diagram

2.2.1 Deflection of Beams

The avoidance of control shafts are anticipated for consistently conveyed stacked basically upheld bars according to Annexure C of IS 456– 2000. The avoidance of FRP reinforced bars are anticipated according to proposed display proposed by Gorji (2009). In view of the changed broke segment, the impartial hub profundity Z can be unraveled from, Redirection

$$y = \frac{q\,[\ell^2 x\,(\ell - x) + x^2\,(\ell - x)^2]}{24 d_1^2\,[\,E_c A_c Z_1^2 + E_s A_{st} + E_s A_{sc} Z_2^2 + E_f A_f Z_3^2]}$$

Where E_c = modulus of elasticity of concrete

E_s = modulus of elasticity of steel

E_f = modulus of elasticity of FRP

A_{sc} = Area of compression steel

A_{st} = Area of tension steel

A_f = Area of FRP

Z = neutral axis depth

q = load per unit length

ℓ = effective length of span, b = width of beam, h = depth of beam

2.2.2 Experimental Set Up for Testing of Beams

Every one of the examples are tried in stacking casing of the Structural Engineering Laboratory, National Institute of Innovation, Rourkela. The testing techniques for all examples are same. In the wake of curing for 28 days, control pillars CB arrangement are tried one by one applying load gradually up to disappointment stack. So also, subsequent to curing for 28 days, CFRP/GFRP texture in different layers, in factor lengths according to configuration are attached to the solid surface, cured for over 3 days to RB, RF and RS arrangement bars. The pillars are tried one by one applying load gradually up to the disappointment stack. In the testing course of action, various concentrated burdens proportional to consistently circulated stack (UDL) is connected on every one of the shafts bit by bit expanded up to disappointment. The heap is transmitted through two load cells, at that point to the spreader bars, at long last to four steel pieces of 75mm width×125mm length put over the test shaft. Considering scattering of load at 450 over the bar, the heap is for all intents and purposes spread over the whole pillar proportional to UDL. The bar is set more than two steel roller heading, kept more than two steel platforms at each end, leaving 150mm bearing from either end with a powerful traverse of 1000mm.The stacking outline is equipped for conveying the normal pinnacle stack without huge twisting .Loading is finished by two pressure driven jacks of 500 KN limit each. Three number of dial gages are set underneath the shaft at quarter traverse, mid traverse and three-fourth traverse to gauge avoidance of the shaft. The dial gages are taken out, when these demonstrated fast diversion showing inevitable approach towards top/disappointment load to evade harm.

2.2.3 Loading Pattern

The Fig.4. given beneath demonstrates the common test course of action under different concentrated burdens proportionate to consistently appropriated stack done in the auxiliary research facility. The BM and SF graphs are appeared in Fig. 5

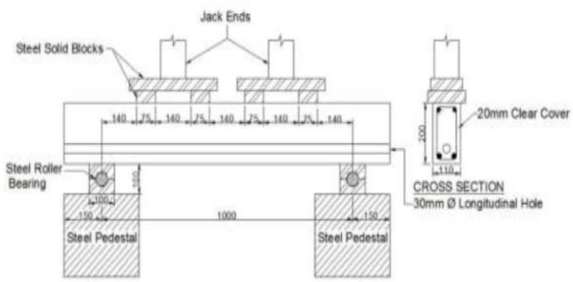

Fig. 4 Typical Test Arrangement Under Multiple Concentrated Loads

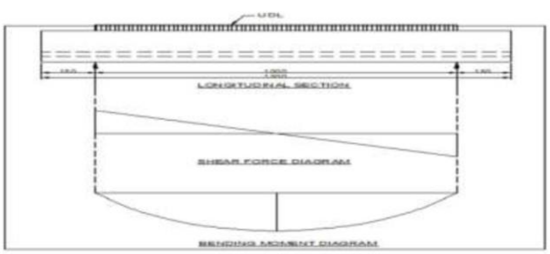

Fig. 5 Shear Force and Bending Moment Diagram

2.3 Tensile quality of Reinforcing Steel

All the strengthening steel utilized are of Shristhi mark and are tried to get elastic yield worry in an Electronic UTM Model No. UTES 100 appeared in Fig. 5.1, push strain bend in Fig. 5.2 and the outcomes in Table 5.1. The normal yield quality utilized as a part of the investigation fy =531 N/mm2.

Fig6 Tensile Strength of Steel in Electronic UTM

III. DETERMINATION OF YIELD STRESS AND YOUNG'S MODULUS OF FRP

The yield worry (at 0.2% strain) and Young's Modulus are gotten tentatively by performing unidirectional ductile tests on examples cut in longitudinal and transverse bearings as endorsed in ASTM:D3039M-08 from the FRP plates manufactured before having consistent rectangular size 250 mm length × 25mm width. The examples are cut from the plates by a precious stone cutter or by mechanically worked hex saw. Subsequent to cutting, the sides are cleaned by sand paper. At least three example examples are set up from each plate of 2 PLY GFRP, 3 PLY GFRP and 2 PLY CFRP in this examination, points of interest appeared in Table 5.2, 5.3 and 5.4 separately. The examples are tried in INSTRON 1195 widespread testing machine. Every example is settled in the upper jaw in the first place, and grasped in the versatile lower jaw having a gage length of 150 mm. Grasping of example ought to however much as could reasonably be expected to counteract slippage. The heap and augmentation are recorded carefully with the assistance of a heap cell and an extensometer individually. The example step by step stacked up to disappointment which is unexpected and sudden as the FRP material is fragile in nature. The INSTRON 1195 machine appeared in Fig. 5.3 specifically demonstrated the yield push, Young's Modulus, extreme quality and plotted the heap redirection bend appeared in Fig. 4.The test consequences of 2 PLY CFRP, 2PLY GFRP and 3 PLY GFRP textures . . All the 15 pillars are tried up to disappointment. Preceding testing of pillars, the malleable test consequences of strengthening steel according to IS 1786-1985 and test comes about relating to tractable trial of FRP overlays according to ASTM: D3039M-08 are displayed. The compressive quality of controlled solid blocks are additionally displayed alongside the flexural and shear quality of test pillars. Their conduct all through the test up to disappointment are portrayed as for beginning and extreme load conveying limit, diversion conduct, inflexibility, flexibility, split example and method of disappointment.

Fig.7 Test of FRP plate in INSTRON 1195

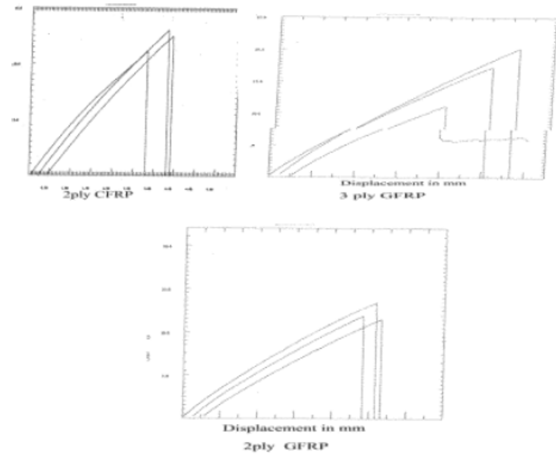

Fig.8 Stress-Strain Curve for FRP

3.1 Testing of Beams, Crack Pattern and Failure Mode

All the 15 pillars are tried one by one in the stacking outline. Three dial gages are settled underneath the pillar each one at quarter traverse, mid traverse and three-fourth traverse. The heap is step by step expanded up to disappointment. The redirections are recorded up to beginning breaking load. After the needles in the dial gage pivoted quickly demonstrating approach of inescapable disappointment, the dial gages are expelled to spare from harm amid disappointment of shafts.

3.2 Beam CB1

The geometry and fortification in the shaft is appeared in Fig.5.18. The shaft is furnished with adjusted (somewhat under fortified) support. It is step by step stacked up to disappointment. The stacking of shaft, break design with disappointment mode and load-redirection bend is appeared in Fig. separately given beneath. Hair splits are showed up at mid traverse base, advanced upwards, progressively splits broadened, yielding of steel seen, at that point smashing of concrete at mid traverse best and disappointment happened. It is an unadulterated flexural disappointment. The hypothetical breaking load according to LSM and ULM of configuration is 138 KN and 141 KN individually. The exploratory outcomes demonstrated an underlying breaking heap of 210 KN and extreme heap of 292KN

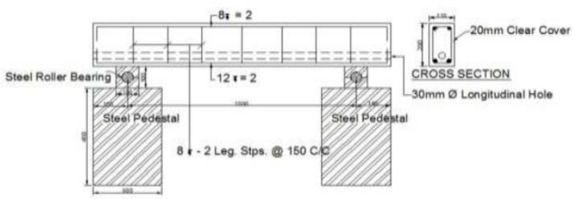

Fig. 9Longitudinal Section Beam CB1

Fig 10Loading arrangement beam CB1

Fig. 5.20 Failure of beam CB1

IV. SHEAR STRENGTH OF FRP STRENGTHENED BEAMS (RS1)

Beam RS1 The cross section of the beam RS1 is shown in Fig.5.11

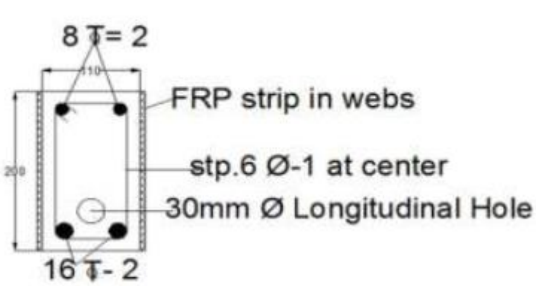

Fig. 5.11 Cross Section RS1

Strengthened with 2 layers of GFRP in webs near supports for a length of 300mmVs = 0

$V_{frp} = \Phi_{frp} A_{frp} f_{frp}$ ( ) d

$\Phi_{frp} = 0.80$, d = effective depth of beam = 164mm

$A_{frp} = t_{frp} \times w_{frp}$, t_{fp} = thickness of FRP = 1mm, w_{frp} = width of FRP = 300mm

$f_{frp} = 241$ N/mm², Angle β = (oriented 90⁰ to the horizontal) = 90⁰

V_{frp} = . × × × ×164 =63.24 KN

V_n = 79+0+63.24=142.24

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