

Study the Evaluations of Beam Element Retrofitted with Glass Fiber Reinforced Polymer

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Abstract – Reinforced concrete (RC) structures require reinforcing for various components, for example, expanded load, change of the structural systems, basic overhaul or mistakes in the outline and development stages. The side near surface mounted (SNSM) fortifying strategy with glass fiber-reinforced polymer (GFRP) bars is a moderately new rising method for upgrading the flexural limits of existing RC components. Nine RC rectangular pillars were flexural Reinforced with this method and tried under four-point bowing burdens until disappointment. The primary objective of this investigation is to upgrade the basic limit of the RC shafts by fluctuating the measure of fortifying support and bond length. The trial test comes about demonstrated that reinforcing with SNSM GFRP bars altogether upgraded the flexural reactions of the examples contrasted and the control example. The primary splitting and extreme burdens, vitality ingestion limits, malleability and solidness were surprisingly improved by the SNSM strategy. It was likewise affirmed that the bond length of the Reinforced fortification extraordinarily impacts the vitality ingestion limits, pliability and firmness. The impact of the bond length on these properties is huger contrasted with the measure of fortifying support.

Keywords: Reinforced, Polymer, Glass

1. INTRODUCTION

Recovery or reinforcing of structural building foundation has increased noteworthy consideration because of weakening issues of structures and getting together to-date outline necessities. Various materials and techniques have been utilized for fortifying structural components. The most as often as possible used materials for structural fortifying are steel plate and fiber-reinforced polymer (FRP). There are three sorts of FRP (carbon, glass and aramid) utilized for reinforcing of structures. The outer holding support (EBR) and near surface mounted (NSM) methods are exceptionally well known for fortifying or updating of basic individuals. The fortifying plates or overlays are stuck on the strain face of the Reinforced concrete (RC) pillars in the EBR procedure. The debonding disappointment of the reinforcing bars because of the high shear worry at the plate end and erosion of the plates because of the ecological impacts are a portion of the principle worries of the EBR system. The middle of the road split debonding is a disadvantage of the EBR system due to the continuous debonding disappointment mode contrasted with the end disappointment of the overlaid end for shafts that are all around moored.

In the NSM procedure, the fortifying fortifications are embedded into the solid cover by making notches and after that topping off the furrows with concrete or bond

grout. In any case, in this method, the fundamental downside is the untimely debonding of the fortifying fortifications and solid cover partition. Besides, the NSM procedure defers the debonding disappointment in contrast with the EBR strategy. Tang et al. contemplated the execution of RC typical and lightweight polystyrene total solid bars that were flexurally reinforced utilizing NSM GFRP bars. The overwhelming disappointment method of these reinforced shafts was debonding. Reda et al. contemplated the flexural execution of NSM-GFRP bar-Reinforced RC pillars utilizing distinctive end-dock conditions. The NSM procedure utilizing GFRP bars and end-safe haven uncovered higher solidness and enhanced disappointment modes contrasted with reinforced shaft without end safe haven. Escórcio et al. (Ceroni, 2010) explored the test conduct of RC pillars' principle steel rebars supplanted with GFRP bars as a restoration of consumed Reinforced solid shafts. GFRP bar-restored pillars displayed higher flexural limit and less avoidance contrasted and the first RC shaft. Almusallam et al. directed the exploratory and numerical examination on the RC pillars that were flexurally reinforced by NSM steel/GFRP bars. The majority of the reinforced shafts bombed because of the yielding of inward steel bars and the devastating of pressure concrete. Jung et al. examined the flexural conduct of Reinforced RC pillars with the NSM and EBR system utilizing CFRP support. The NSM CFRP bars and EBR-Reinforced

examples flopped by debonding, while mechanical interlocking depressions were utilized to take out debonding. Al-Mahmoud et al. and Kalayci et al. done a trial program to assess the flexural quality of RC shafts reinforced with NSM FRP bars, and they revealed untimely debonding disappointment of the Reinforced pillars. Soliman et al. examined the conduct of RC shafts flexurally reinforced with NSM utilizing diverse bond lengths, distances across and sorts of FRP bars. The test outcomes showed that the use of NSM FRP bars was helpful for enhancing the flexural quality, and every single Reinforced bar flopped by solid cover part.

Sharaky et al. researched the flexural conduct of NSM-Reinforced RC bars by applying FRP (carbon and glass) bars or strips. The test factors were the width and the quantity of NSM bars and different sorts of NSM fortification and epoxy. The reinforced examples bombed by untimely debonding, i.e., concrete and epoxy interface disappointment, epoxy part and concrete part or cover division. Hosen et al. proposed the creative side near surface mounted (SNSM) system to alleviate the issue (covering stress and solid cover partition) in the NSM procedure for flexurally-Reinforced RC pillars. In this examination, distinctive widths of steel and CFRP-Reinforced bars were utilized for trial and expository examination. The test outcomes uncovered that the SNSM system fundamentally enhanced the flexural reactions and serviceability of the RC bars. Shukri et al. explored the flexural conduct of pre-broken RC shafts reinforced by the SNSM procedure utilizing CFRP bars, and the test comes about were confirmed by the occasion revolution approach. The pre-broken examples demonstrate similar disappointment modes, yet had higher solidness contrasted with the non-pre-split examples.

From the writing, it is uncovered that the SNSM procedure with GFRP bars has once in a while been joined. The point of this paper is to additionally explore the flexural conduct of RC bars reinforced by the SNSM procedure utilizing GFRP bars. The impact of SNSM-GFRP bars on the heap conveying limit, avoidance, disappointment mode, vitality ingestion limit and flexibility and firmness was analyzed and contrasted and the control examples. In addition, the impact of the measure of fortifying fortification and bond length on the structural execution was additionally surveyed.

Crumbling of solid structure is one of the significant issue of development industry now a days. Besides, a bigger number of structure developed in past utilizing more seasoned outline codes in various parts of the world are fundamentally dangerous as indicated by most recent plan codes and substitution of such lacking structure needs a gigantic measure of open cash and time. Consequently, fortifying turn into the worthy method for enhancing their heap conveying limit and expanding their valuable administration life.

Fiber Reinforced Polymers (FRP) have risen as promising material for recovery of existing RC structures and fortifying of new respectful designing structures in view of their few points of interest, for example, high quality to-weight proportion, high exhaustion resistance, adaptable nature, simplicity of taking care of and incredible solidness. There are distinctive sorts of FRP materials are utilized for fortifying like Glass Fiber (GFRP), Carbon Fiber (CFRP), Aramid Fiber (AFRP) and so forth. Be that as it may, as far as cost viability and quality correlation many creators had suggested GFRP sheets among all.

The utilization of outside FRP reinforcing to bar might be named flexural and shear fortifying. The shear disappointment of a RC shaft is totally not quite the same as the flexural one as in that the flexural is malleable in nature, while the shear one is fragile and cataclysmic. In this way, In flexural reinforcing, FRP sheets are connected on pressure face of RCC pillar though In shear fortifying, FRP sheets are connected on side face of RCC shaft utilizing legitimate epoxy concretes.

2. REVIEW OF LITERATURE

M. A. Saafan (2006) tentatively examined the proficiency of GFRP composites in fortifying essentially bolstered Reinforced solid pillars outlined with inadequate shear limit. Add up to 18 pillars were tried with various shear reinforcing plans like U – coat, Full wrapping of sides and rectangular side wrap of (130 × 300 mm) and so on and variable longitudinal fortification proportion. Results demonstrated that the serviceability execution of reinforced shaft was relied upon to be better with respect than expanded breaking loads and the set number of splits and little splitting width. They additionally demonstrated that GFRP composites created adequate pliability regardless of their weak nature through legitimate outline.

E. Grande (2013) et al. displayed an examination on RC shafts Reinforced in shear by remotely Reinforced fiber reinforced plastic (FRP) sheets. Three arrangement of RC pillars Reinforced in shear via carbon fiber sheets connected on the outside shaft surface through epoxy pitch have been tried. Three arrangement of bars relying upon their shear traverse to successful profundity proportion (λ) 3, 4 and 2.5 separately. They utilized finish wrapping, U-jacketing wrapping and side holding as a wrapping method. At long last creators watched that FRP application prompts a variety of some of huge basic angles like the splitting example and the distortion level in shear fortifying system. They likewise found that the bars with thinness proportion equivalent to 3 and 4 have no impact over disappointment mode and breaking design.

AnumolRaju (2013) et al. tentatively contemplated R.C.C. pillars Reinforced with different sorts of strands remotely. They threw add up to 30 pillars with cross area of 150 mm × 150 mm × 1000 mm. They connected distinctive sorts of fiber sheets i.e. Carbon, Glass, Steel, Polypropylene and Coir. The full wrapping system around every one of the sides of the pillars is utilized as the technique for reinforcing. They presumed that a definitive quality addition in carbon, glass, steel and coir fiber sheet Reinforced shaft by 125%, 89.6%, 45.02% and 37.9% separately. However, considering cost adequacy and quality addition, they prescribed Glass FRP sheets for utilize.

Rudy Djamaluddin (2015) et al. tentatively examined the holding conduct of GFRP sheets on the reinforced solid pillars due to flexural loadings.

A progression of solid bars was set up with parameter of the holding zone of GFRP sheets. The example was partitioned into two sorts, which reinforced on all traverse (BFL) and Reinforced on 33% traverse at the traverse focus (BFH), separately. In last, creator reasoned that holding length of GFRP sheet was fundamentally impacted the most extreme minute limit. They additionally found that the expanding of holding length diminished the normal holding weight on GFRP sheets.

Tarek h. Almusallam et al. tentatively and systematically assessed flexural quality and focal diversion of RC bars reinforced with GFRP sheets to the pressure sides of bars. Add up to 12 light emissions 150×200×2050 mm were readied. Shafts were partitioned into six gatherings relying upon utilization of GFRP sheets. They additionally diagnostically researched these bars. At last they presumed that great addition in flexural quality can be accomplished by holding GFRP sheets to the strain face of Reinforced solid pillars. They likewise assessed pliability record in light of diversion and vitality assimilation ability. Their systematic model was in great concurrence with exploratory outcomes.

M. C. Sundarraja (2009) et al. tentatively found the part of glass fiber Reinforced slanted strips epoxy attached to the pillar web for shear reinforcing of RC shafts. This investigation meant to check viability as far as width and dispersing of slanted GFRP strips on shear limit of the RC pillars. A two-point stacking technique was embraced for the test. A no. of disappointment mode has seen in the trials of RC pillars reinforced in shear by FRPs. These incorporate shear disappointment because of FRP burst, shear disappointment without FRP break, smashing of concrete at the best and flexure disappointment. At last, they found that the utilization of GFRP strips are more successful on account of reinforcing of the structures in shear and hindered the improvement of

the inclining splits. They likewise found that the heap avoidance conduct was better for reinforced pillars and load conveying limit was observed to be more noteworthy than that of the control bars.

Kaushal Parikh (2012) did a trial and scientific examination on preloaded retrofitted shaft for improvement in flexural quality. They examined add up to seventeen pillars out of which two were control bar and fifteen were preloaded at 0%, 40% and 90% quality of control shaft. They connected two sorts of plans on bar comprising of Traditional (T) game plan and New powerful (N) game plan. They likewise did explanatory examination by utilizing limited component displaying. At long last creators touched base on conclusion that shafts with New powerful course of action moves the flexural break far from flexural area and henceforth by deferring the debonding, demonstrated a decent answer for retrofitting strategy. They additionally found that heap versus redirection between anticipated diagnostically and tentatively esteems are not changed over 5% and disappointment mode was wonderful thought about.

Daniel Baggio (2014) et al. explored the shear execution of eight Reinforced solid bars Reinforced with Carbon FRP, Glass FRP and Fiber Reinforced Concreteitious Matrix sheets and FRP stays and one control example. Add up to nine shears lacking slim RCC shaft were threw. Bars were tried in four point twisting utilizing a shut circle water powered MTS actuator with a 500 kN limit in a MTS 322 test outline. The shafts were essentially upheld with a reasonable traverse of 2200 mm with 400 mm separating between the two stacking focuses and a shear traverse of 900 mm. At last they found that shafts Reinforced with GFRP full profundity and incomplete profundity indicated half and 36% expansion in extreme load at that point control example though bars reinforced with CFRP and FRCM demonstrated 34% and 75% increment in extreme load over control example. Creators likewise found that when the accessible Reinforced length is restricted then the establishment of FRP as a reasonable choice to keep a weak shear disappointment mode because of FRP debonding.

J. dong (2013) et al. completed a test look into on Structural conduct of RC bars with outside flexural and flexural-shear reinforcing comprising of carbon FRP (CFRP) and Glass FRP (GFRP). They tried aggregate 14 pillars with two sorts of fortifying i.e. flexural reinforcing and joined flexural-shear fortifying under four-point bowing. They watched two noteworthy sorts of disappointment for Reinforced pillars i.e. Snapping and debonding of frp sheet. They likewise hypothetically anticipated the flexural quality and a definitive shear conveying limit which

demonstrate sensibly great relationship with exploratory outcomes. At long last creators presumed that shear limit of the GFRP and CFRP Reinforced bar was between 31% to 74%. They likewise found that the flexural stack conveying limit of shafts with same fortifying courses of action essentially expanded with an extra layer of FRP sheet.

A. K. Panigrahi (2014) et al. tentatively explored the execution of RC T-bars reinforced in shear utilizing epoxy Reinforced bi-directional GFRP texture. Add up to 12 shafts were thrown and tried less than 4 point stacking. Test parameters included GFRP sum and circulation, reinforced surface, quantities of layers and fiber bearing. The test outcomes demonstrated that the outer reinforcing with GFRP composites can be utilized to expand the shear limit of the shaft, however the proficiency changes rely upon the different parameters. They found that the strips slanted at 45° was more powerful than the vertical strips. A definitive load conveying limit of reinforced shaft were observed to be 6% to 65% more prominent than that of control bar. S. Deepa Raj (2012) et al. tested a program to assess viability of two unique techniques i.e. Near Surface Mounted (NSM) and Externally Reinforced Reinforced (EBR). Pillars were thrown in two distinctive arrangements i.e. S1 and S2.

The diversions at mid-traverse and 33% traverse were measured at standard interims of 0.5T of stacking utilizing dial gages having minimum number of 0.01mm. They planned to dissected impact of sort of fortification, dividing and arrangement of support on the productivity of the reinforcing procedure as far as upgrade of the shear limit of the shaft. At last, they found that the GFRP sheets were observed to be more compelling in fortifying than the stiffer GFRP roundabout poles. They likewise found that example Reinforced with EBR demonstrated an expansion of 1.33 times in extreme load, when contrasted with the control shaft example

N. Pannirselvam (2008) et al. displayed an examination to assess the basic conduct of reinforced bars with remotely Reinforced FRP fortifications. Add up to fifteen bars example having three distinctive steel proportions, wrap thickness and wrap material were tried. The Variables in think about were longitudinal steel proportion, sort of GFRP overlays, thickness of GFRP covers and composite proportions. A two point stacking system was received for testing. Creators discovered 28.57% to 40% augmentation of extreme load for 3 mm thick GFRP sheet and 28.57% to 128.57% addition of extreme load for 5 mm thick GFRP sheet.

T. Manikandan (2013) et al completed examination to research the flexural normal for RC shafts with help of GFRP sheets and strips. Ten just upheld Reinforced solid pillars with square cross area of 150 × 150 and a traverse length of 1000 mm were tried as two of them were tried as a controlled shafts. The method of

disappointment was discovered flexure zone as load expanded higher. These breaks step by step increment in stature with an expansion in stack. At last they watched that moderate split debonding of the base FRP for all the reinforced pillars described the method of the disappointment. They additionally found the impact of width of GFRP overlay on debonding component.

3. EXPERIMENTAL PROCEDURE

The investigation on the behavior of RC beams strengthened with the side near surface mounted (SNSM) technique using glass fiber-reinforced polymer (GFRP) bars was carried out. The variables investigated include strengthened bar diameter and bonded length, as shown in Table 1.

Table 1. Test details for side near surface mounted technique.

Beam ID	Description	Strengthening configuration			
		Materials	Bar diameter (mm)	Bonded length (mm)	Groove size (mm)
CB	Control beam (unstrengthened)				
S1.6D8	RC beams strengthened with the SNSM technique using different amounts of GFRP reinforcements	Glass fiber-reinforced polymer (GFRP) bars	8	1600	25 × 25
S1.7D8				1700	
S1.8D8				1800	
S1.9D8				1900	
S1.6D10	RC beams strengthened with the SNSM technique using different amounts of GFRP reinforcements	Glass fiber-reinforced polymer (GFRP) bars	10	1600	25 × 25
S1.7D10				1700	
S1.8D10				1800	
S1.9D10				1900	

The prepared blended concrete was utilized to cast the shaft examples, crystals, chambers and shapes. The prepared blended concrete was utilized to cast the pillar examples, crystals, chambers and 3D shapes. Squashed stone totals of 20 mm greatest size were utilized as the coarse total. The Crushed stone totals of 20 mm most extreme size were utilized as the coarse total. The compressive quality was resolved as per BS EN 12390-3 (Escórcio and França, 2016) utilizing three 100 mm 3D square compressive quality was resolved as per BS EN 12390-3 (Escórcio and França, 2016) utilizing three 100 mm examples, bringing about a normal compressive quality of ~26 MPa, the modulus of crack and 3D square examples, bringing about a normal compressive quality of ~26 MPa. The modulus of burst part rigidity tests were completed in view of BS EN 12390-5 [25] and BS EN 12390-6 [26], and part elasticity tests were done in light of BS EN 12390-5 [25] and separately; normal estimations of ~2.71 MPa and 3.86 were gotten for the part elasticity and BS EN 12390-6 [26], individually; normal estimations of ~2.71 MPa and 3.86 were acquired for the modulus of crack, individually. The modulus of flexibility (MOE) estimation of 28.50 GPa was acquired part rigidity and modulus of crack, individually. The modulus of flexibility (MOE) for the solid tried according to ASTM C469 [27] value of 28.50 GPa was acquired for the solid tried according to ASTM C469 [27].

Table 2. Properties of GFRP bars

Diameter (mm)	Density (g/cm ³)	Ultimate tensile strength (MPa)	Ultimate shear strength (MPa)	E-Modulus (GPa)
8	2.2	1080	150	40
10	2.2	980	150	40



Figure 1. GFRP bars

4. STRENGTHENING PROCEDURE AND EXPERIMENTAL SET-UP

A total of nine RC rectangular beam specimens was prepared and tested. The cross-section of the specimen was 125 mm * 250 mm, total span length 2300 mm, clear span length 2000 mm and a shear span length of 750 mm, as shown in Figure 2. The 12-mm bars were used as tension rein for concrete with both ends bent (90°) to fulfill the anchorage criteria. The 10-mm bars were used as hanger bars up to the shear span zone, and 6-mm bars were used for stirrups.

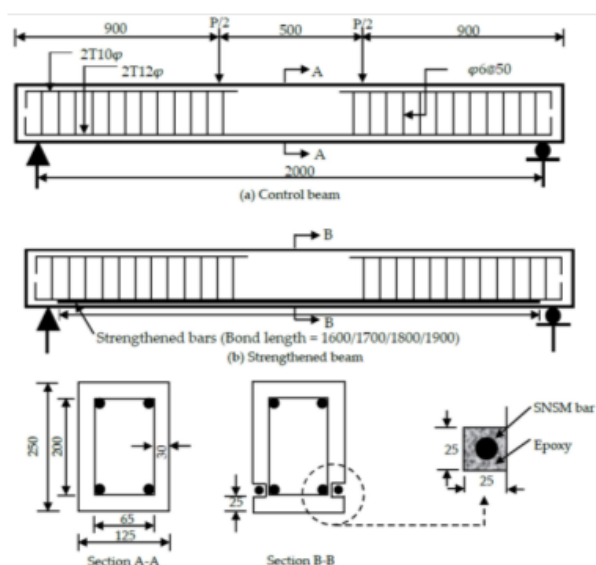


Figure 2. Details of the beam specimens (dimensions in mm)

The SNSM fortifying strategy was utilized as a part of this examination. In this strategy, reinforcing bars were introduced into grooves a longitudinal way on the two sides of the examples. The notches were cut in the

solid cover utilizing an exceptional solid saw with a precious stone sharp edge. The measurement of the furrows is appeared in Figure 2. A mallet expelled the remaining solid carries from the lower surface of the sections and hand etches. At long last, the sections were cleaned with CH₃CO and a high weight air stream.

The depressions were half-filled utilizing epoxy glue and fortifying GFRP bars put into the furrows with slight drive as appeared in Figure 3. This compel made the glue stream around the reinforcing GFRP bar. More concrete was utilized to top off the notch and level the surface. The reinforced example were put away to solidify for a week and cure the epoxy glue to achieve full quality.



(a) Groove cleaning by high pressure air jet



(b) Groove half fill using epoxy adhesive



(c) Strengthening bar inserting



(d) After fill up the groove level the surface

Figure 3. SNSM technique strengthening procedure

All the RC beam specimen (control and reinforced) were tested under four-point bending until failure using an Instron Universal Testing Machine, as shown in fig 4. One vertical linear variable differential transducer (LVDT) was placed at the mid-span of the beam to measure the deflection and ensure that the transducer touched the bottom face of the specimen. The compressive strains of the top surface of the concrete specimen were measured using a 30-mm strain gauge that was affixed at mid-span of the beam specimen. A 30-mm strain gauge was fixed at the center of the strengthening bar using Araldite epoxy adhesive to measure the tensile strain of the strengthening reinforconcrete. All of the data were recorded at 10-s interval using a TDS-530 data logger. A Dino-Lite digital microscope measured the crack width of beam specimen.

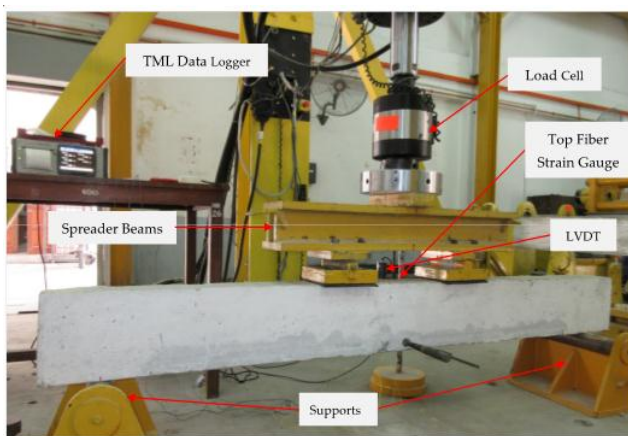


Figure 4. Laboratory loading setup. LVDT, linear variable differential transducer

CONCLUSION

The exploratory examination was directed to research the execution of RC shafts Reinforced with SNSM-GFRP bars. The accompanying conclusions were produced using the trial program:

1. Flexural fortifying of RC shafts with the SNSM system utilizing GFRP bars is viable, as SNSM bars fundamentally enhanced the flexural execution by means of the lessening of the diversion, the deferral in the development of first break, the reduction in split width and the expansion in the quantity of splits and extreme heaps of the examples contrasted and the control example.
2. Strengthening utilizing SNSM-GFRP bars improved the primary make and extreme burdens laugh out loud to 4.38-and 1.55-times contrasted and the control example.
3. The utilization of GFRP as a SNSM fortification has displayed a tri-straight reaction in stack avoidance conduct and decreased the

redirection at any heap level of the examples, which would address the serviceability concerns.

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