A Review on Internal Beam-Column Joint Strengthening using Different Configuration of Basalt Fibre, Aramid Fibre and Kevlar Fibre Wrapping

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Abstract

Recently, the utilisation of FRP composites is one of the advanced procedures for repairing, strengthening, or retrofitting the existing structures to resist the higher loads and rectify the damage issues. This paper displays the experimental investigation of the use of unidirectional Basalt fibre, Aramid fibre and Kevlar fibre wrapping to strengthen the beam-column joints, which are the critical regions of the structures. Twenty-seven interior beam-column joints were cast for this study and were named virgin specimens.

These specimens were tested up to failure point. The damaged specimens were rehabilitated using nine different wrapping configurations, including both single and hybrid wrapping. For each type of wrapping configuration, three specimens were tested. This study is just limited to static loading. The effect of the different wrapping techniques has been concentrated on. The performance of the Rehabilitated specimens concerning load-carrying capacity at first crack and Ultimate deflection is compared with that of virgin specimens.

Keywords: - *FRP (Fibre Reinforced Plastic), Basalt fibre, Aramid fibre, Kevlar fibre, Beam-Column joints, Hybrid wrapping*

INTRODUCTION

Reinforcing structures to higher seismic zones of a few urban communities and towns in the nation has also been required to develop new methodologies. Late seismic tremors have shown that a large portion of the reinforced concrete structures was seriously harmed amid quakes, requiring significant repair. One of the procedures of fortifying the structural members is through external confinement by high-quality fibre composites, which can improve the quality, flexibility, strength, and ductility and bring about a large energy absorption capacity of structural members.

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Some of the time, structures require fortifying or retrofitting to resist higher configuration loads.

Reinforcing may likewise be required because of a change of utilisation or when the structures are harmed because of a forceful situation. In these cases, the most well-known strengthening procedure has been expert by the utilisation of routine materials, for example, steel plates externally bonded or steel and concrete jackets. Be that as it may, as of late, the utilisation of creative materials like fibre strengthened polymer (FRP) has developed as a contrasting option to the utilisation of the conventional procedures, and it is by all accounts the most encouraging technique to be utilised as a part of structural designing. The FRP is portrayed by high-quality fibres implanted in polymer resin. They demonstrate a straight stress-strain relationship until breakdown. The most well-known kind of FRP in the industry is made with carbon, aramid or glass fibres. Since FRP speak to the principle load-carrying element and have an extensive variety of stiffness, strengths and qualities, they are ordinarily utilised. Fibre materials are used to fortify an assortment of RC elements to improve the flexural, shear and axial load carrying capacity.

Beam column joints, the lateral and vertical load resisting members in RC structures, are especially helpless against earthquakes. Subsequently, their strengthening is the way to effective seismic strengthening techniques. The study of existing developments uncovers that strengthening of structures is fundamental in three conditions. The structure is insufficiently intended for the present load conditions. The insufficient design of the structure cannot cater for the present scenario of loads. This additionally incorporates those structures that are discovered inadequate under seismic conditions. The structure is harmed and requires strengthening. The inspiration driving this system is to look at the execution of fibre reinforced polymeric composites (FRPC) in the strengthening of harmed joints for reinforcement of the structures even under various forms like strips, bars, and sheets. By alluding to the reinforcement of the beam elements, the remotely fortified CFRP composites, comprising sticking CFRP covers at the intrados of the beam, are ordinarily connected to the structural component. Once in a while, for the increased bearing limit, the concrete compressive zone is not equipped to bear the new internal forces on its crush. For this situation, the system of increasing the lever arm of the internal couple is by all accounts the most proper. As of late, logical & scientific consideration has concentrated on utilising FRP composites as the most encouraging advances for repairing and reinforcing existing structures to resist higher loads and correct the harm. The utilisation of external FRP as flexural reinforcing gives favourable circumstances regarding resistance, stiffness, ductility and flexibility. Another reinforcement technique is applied on a beam-column joint, keeping in mind the end goal to enhance its load carrying limit by producing a higher internal couple of the transversal section, yet leaving the weight of the component the same. This was conceivable by utilising another composite joist, joined at the intrados of the original beam. Usually, it is demonstrated that this philosophy is extremely valuable because of the transformation of the utilisation of a civil structure when an increase of the resistance section is required.

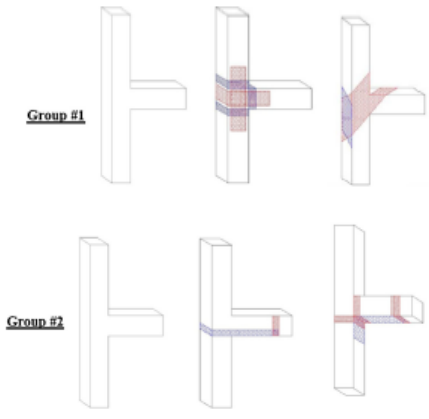
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The serviceability conditions of many such structures have been changed to meet present requirements. Wrapping structural members with FRP is found to be a suitable method for strengthening from various researches. The wrapped beams were tested under static and cyclic loading conditions, and columns were tested to ultimate load level under unit axial.

LITERATURE REVIEW

As a part of the literature survey, we have gone through various research papers, well-known reference books and articles etc. In this section, we have summarised some of the important aspects of all related articles. All the paper describes the basic information related to my work. Some methods/techniques are identified. This section will give information about the literature survey.

- MAHMOUD [1] presents a test study for the structural performance of reinforced concrete (RC) external beam-column joints restored utilising carbon-fibre strengthened polymer (CFRP). Three distinctive strengthening plans were used to restore the damaged beam-column joints, including externally bonded CFRP strips and sheets despite near-surface mounted (NSM) CFRP strips. On the other hand, NSM-CFRP plates showed the highest performance in an inadequate spliced column.



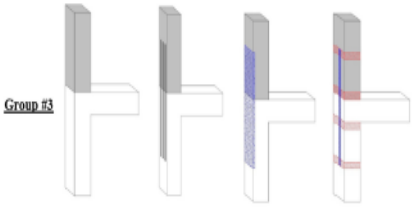


Figure (1): Schematic Representation for the considered three groups

- John Branston, Sreekanta Das, Sara Y. Kenno, Craig Taylor [2]present a Mechanical behaviour of BFRC was evaluated by flexural and impact testing. BFRC was made of basalt bundled fibres and basalt minibars. BFRC increased pre-cracking strength; had little effect under impact loading. The addition of BF increased the first-crack strength of concrete subjected to flexural loading but was not significantly influential when subjected to impact loading. In the case of flexural loading, the first-crack strength increases with increasing fibre dosage. The strength improvement was greater using longer,50 mm BF than with 36 mm BF.

- Granata P, Parvin A. [3] In this paper, they performed Experimental studies specifically for evaluating the instant capacity of the beam-column connections wrapped with Kevlar fibre composite fabric. Scaled-down exterior beam-column connections were tested to determine the effect of varied thicknesses and configurations of FRP fabric applied to those connections. The experiment results showed numerous improvements in the flexural capacity of beam-column connections and supplied certain guidelines for the correct FRP fabric thickness. The external FRP reinforcement effectively increases the moment capacity of beam-column connections

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by up to 60%, as observed in this experimental study.

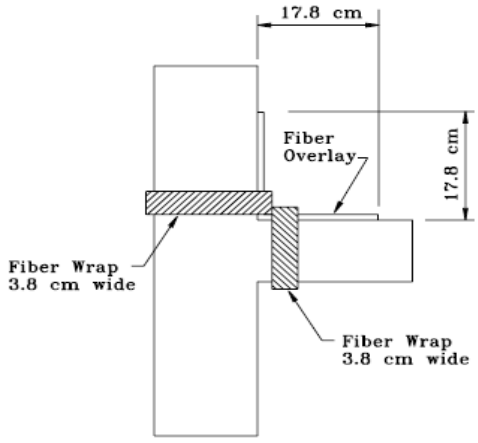


Figure (2): Arrangement of fibre overlay on a beam-column joint specimen.

- YASER [4] here explores the seismic conduct of three full-scale external RC beam-column connections restored and reinforced with externally bonded carbon fibre–reinforced polymers (CFRP). Seven tests were performed in two progressive stages. The exposed joints were initially subjected to reversed cyclic loading tests to survey their fundamental seismic performance. These underlying tests delivered extreme harm in the core. The harmed concrete was replaced with new high-quality concrete. The specimens were in this way reinforced with CFRP sheets, and the cyclic tests were again performed. The outcomes demonstrate that the core replacement with new concrete upgraded the sheer quality of the substandard connections by up to 44% over the uncovered counterparts. ASCE guidelines anticipate precisely the sheer quality of the uncovered and restored connections. The CFRP strengthening upgraded further the joint quality by up to 69%, accomplishing a shear quality equivalent to that of joints designed by seismic procurements.
- Joints under the static loading. Specimens exhibited an improved load carrying capacity and a more robust rate of stiffness than the Mary specimens. The rehabilitated specimens are stiffer than the blessed specimen. So the crack widths within the rehabilitated RAMAKRISHNA [5] propose a rapid Strengthening scheme for moderately damaged RC internal beam-column specimens that are relatively less.

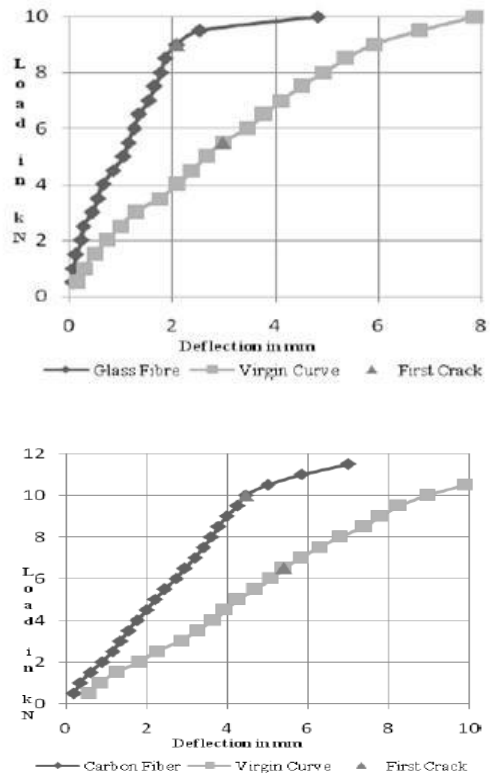


Figure (3): load-deflection curve

- GARCIA [6], in their research work, presents preparatory aftereffects of tests on three inadequate full-scale reinforced beam-column T-joints reinforced with FRP composites. The uncovered joints were initially tried under cyclic load to assess their essential seismic performance. After the initial tests, the harmed

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concrete in the core was evacuated and replaced with new concrete. The connections were in this way reinforced utilising externally bonded FRP sheets, and the tests were again performed. The outcomes demonstrate that the strengthening with FRP sheets was exceptionally compelling at enhancing the load carrying limit of the deficient joints by up to 66%.

- PAMPANIN[7] contribute the latest research findings into the effects of multi-axial loading on the seismic performance of as-built and FRP retrofitted three-dimensional beam-column joints with and without floor slabs are presented. Special emphasis is given to the feasibility and efficiency of a retrofitting intervention using glass fibre reinforced polymer (GFRP) composites. In addition, a numerical study is presented to develop a versatile finite element (FE) model, based on Microplane concrete, to simulate the response of the 3D corner as-built joint under bidirectional loading with varying axial load and compared with the experimental results.

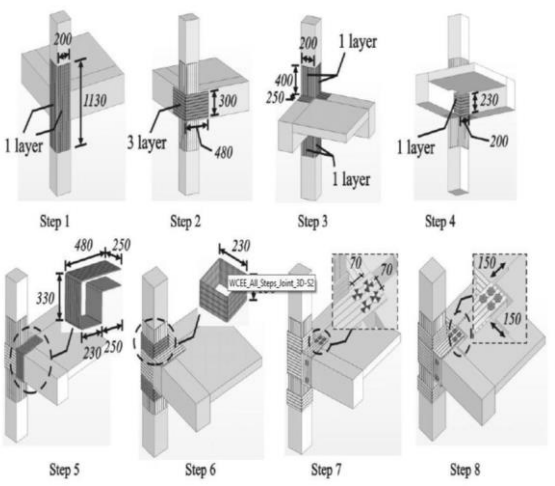


Figure (4): Dimensions and application sequence of FRP sheets for Specimen 3DFS

- SINAEI [8] demonstrates the adequacy of composite fibre strengthened polymer layers for external beam-column joints by concentrated on them through a finite element model (FEM). The FEM results were approved by comparing past exploratory test outcomes done in the ABAQUS environment by HIBBITT et al. (1988). Five external strengthened beam-column connections specimen, including a control specimen (non-retrofitted) and four retrofitted specimens with modified plans of CFRP, were produced. From the practical nonlinear analysis of RC joints with FRP overlays. It is resolved that L shape overlays from FRP composites at the beam column are properly utilised to build flexibility. Additionally, U shape overlays under the beam and FRP utilisation on both sides of the beam are great reinforcing methodologies for quality, strength, and ductility up-gradation in the RC connections. However, FRP just on the top and bottom of the beam diminishes the ductility.

TABLE (1): Ductility factor for specimens

	SC	S1	S2	S3	S4
Ductility (μ_θ)	1.118	1.042	1.935	1.222	1.667
Maximum strength	24917	27111	26586	28551	26814

- VIJAYALAKSHMI [9]work here on an exploratory study on the Corner beam-column connection of a multistory RC building (G+ 4 storeys) in Salem Zone falling under the seismic Zone – III has been ANALYSED utilising STADD.pro. Furthermore, Corner beam-column connections and their detailing were conducted according to IS 13920: 1993 under seismic conditions. The specimens were designed for seismic load as per IS 1893(Part

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I): 2002 and IS 13920: 1993. The test specimen is lessened to the one-fifth model of beam-column connections from model specimens. Column confinement and beam stirrups are given intently in the joint region as indicated by IS 13920: 1993.

- In conclusion, the Provisions lack for stalls shears and bond failure of beam-column connections in severe seismic shaking. Accordingly, these provisions should be redesigned considerably with consideration of provisions on shear configuration and anchorage prerequisite. This paper provides the shear configuration of beam-column connections and anchorage prerequisites of tension beams in the joint territory. It additionally recommends provisions for the confinement of wide beam and column joints—the plastic pivot development at the joint after an ultimate load.
- ANANIA [10] embrace another philosophy in that reinforcement is applied on a beam keeping in mind the end goal to enhance its load carrying limit by producing a higher inside a couple of the transversal sections, yet leaving the weight of the component the same. This was conceivable by utilising another composite joist, joined at the intrados of the original beam. The study was done on beam specimens scaled 1:2 size. In this study, another CFRP reinforcing framework has been produced, applied, and tried. This framework comprises enhancing the bearing limit of the beam to more than 70% in appreciation to the original beam.
- TRIANTAFILLOU [11] presented an essential comprehension of the conduct of shear-critical external RC joints fortified with fibre strengthened polymers under re-enacted seismic load. The different parameters on the adequacy of FRP are analysed through 2/3-scale testing of 18 external RC joints. The tests performed in this study exhibited that externally bonded FRP fortification is a feasible arrangement towards improving the quality, strength, energy dissipation, and stiffness characteristics of ineffectively detailed in shear RC connections subjected to re-enacted seismic loads. Moderately low FRP zone parts enhanced the strength peak load limit, and the aggregate dissipated energy up to around 70–80%. The enhancement in stiffness differed with the forced displacement level, and achieved values were around 100%.

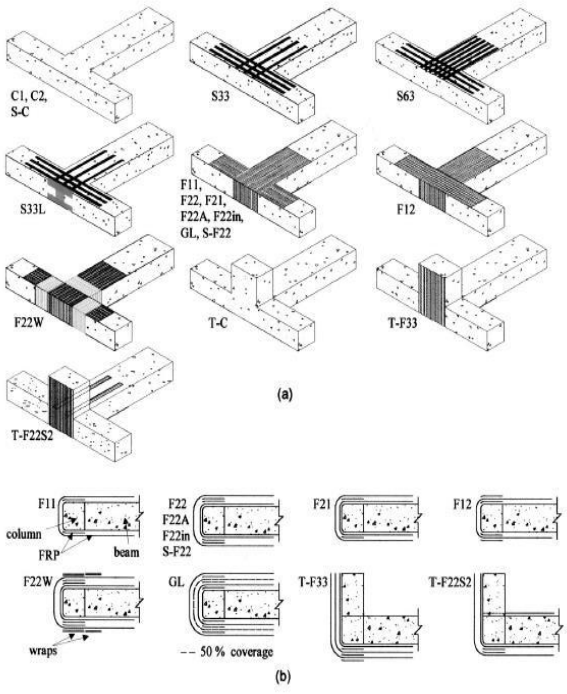


Figure (5): Description of specimens and strengthening alternatives; (b) layout of FRP layers

CONCLUSION

1. FRP re-establishes its original strength additionally significant upgrades its yield load

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and initial stiffness within the restored specimen.

2. The exterior FRP fortification is a compelling approach to enhance the moment limit of beam-column joints by up to 60%.
3. The FRP composite materials give practical yet imaginative ways foru pgrading the load carrying limit of concrete structures with negligible interruption of their use amid repair.
4. Kevlar fibre and Aramid fibre are good heat resistance and Strong Synthetic Fibre.
5. The adequacy of FRP enhances as the transverse steel reinforcement in the joint reduces.
6. From the test outcomes, it was found that the load-carrying limit of the RC beams enhances with the number of layers of the carbon fibre sheet.
7. In Kevlar fibre, the numerous improvements of the flexural capacity of beam-column connections and supply certain guidelines for the correct FRP fabric thickness.

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