Journal of Advances and Scholarly Researches in Allied Education
Vol. XV, Issue No. 2, (Special Issue) April-2018, ISSN 2230-7540

Behaviour of FRP Strengthening of HYSD-I Section with Artificial Degradation

Mr. Patil Ashish Vinayak[1]* Prof. S. R. Suryawanshi[2]

[1] Post Graduate Student, Department of Civil Engineering, ICOER Pune, India

[2] Assistant professor, Department of Civil Engineering, ICOER Pune, India

Abstract –An innovative use of fiber-reinforced polymer (FRP) composite materials, to control the manifestation of local buckling in a flanged steel section, is proposed. In this method, the high stiffness and linear behavior of FRP materials are utilized to provide ''bracing'' against web or flange local buckling in a manner that strategically leverages the unique mechanical properties of each material in an efficient application domain. The experimental research reported is aimed at demonstrating the feasibility of using small quantities of FRP to provide cross-sectional stability through the bonding of FRP strips to flange elements of the cross-section, thereby increasing the critical load of the member; constraining plastic flow in the cross-sectional flange elements; and facilitating the manifestation of a well-formed and stable hysteretic response of the member under cyclic loading. The member becomes, in effect, an FRP stabilized steel section.

Keywords: ***FRP, Debonding, Strain***

---------------------------------x---------------------------------

INTRODUCTION

Traditional methods of strengthening and rehabilitation of existing structural steel elements are based on adding steel plates to the existing member either by welding or bolting. Although welding is considered a convenient way to add the additional plates, it is usually associated with fatigue problems. On the other hand, bolting might not be a desirable alternative due to its high cost and a significant part of the cross sectional area might be lost as a result of drilling for holes. Accordingly, the need for an alternative technique and/or material has been always advantageous.

Fiber Reinforced Polymer (FRP) materials have been established as alternatives to steel in many infrastructure applications. Among these applications is using them to strengthen existing reinforced concrete elements. The technique of using epoxy-bonded FRP sheets/fabrics to strengthen and rehabilitate reinforced concrete elements is a well-established one. In fact, several design codes are currently available for using epoxy bonded FRP materials to strengthen and rehabilitate reinforced concrete elements. This technique has inspired researchers to investigate the potential to use FRP materials to strengthen and rehabilitate existing structural steel elements. Photiou et al. reported the results of an experimental investigation of box section beams strengthened in bending using different types of FRP materials that included glass, high modulus, and ultra-high modulus carbon FRP. Due to the fact that the capacity of steel elements is in many cases governed by the stability of the section, a number of researchers were interested in investigating the potential to use epoxy-bonded FRP materials to enhance the stability of steel sections. An experimental program on cold formed steel lipped channel columns strengthened with bonded carbon FRP giving special attention to their local and distortional buckling. Their test results showed that the presence of carbon FRP may increase the load carrying capacity by 15% for the short columns and 20% for the long ones. an experimental program on T-section columns strengthened using carbon and glass FRP. Their results showed that longer columns that are controlled by flexural torsional buckling did not exhibit significant increase in axial capacity. On the other hand, shorter samples that were controlled by the web local buckling exhibited between 4% and 14% increase in load capacity and the bifurcation loads were increased by as much as 17%. A finite element study to investigate the effect of bonding glass FRP strips on the behavior of I-shaped cantilever steel beams. Their results showed that providing the FRP strips improved the ductility of the section, which was attributed to the bracing provided by the glass FRP that inhibited the formulation of the local buckling in the compression flange. The bond between the steel and the glass FRP plates was simulated using a set of linear springs. Their beams exhibited several modes of failure that included elastic buckling, steel yielding, FRP rupture, and inelastic buckling. The objective of this paper is to investigate the effect of bonding FRP plates on the elastic local buckling of steel I-sections. An elastic stability model is presented that considers the section of the strengthened beam as being composed of a group of plates that are linked together. The non-strengthened parts of the sections are modeled as isotropic plates while the strengthened ones are modeled as orthotropic plates. A parametric study is presented to investigate the effect of each of the parameters of the problem including the strengthening scheme, the section geometry, and properties of the strengthening material.

REVIEW OF RESEARCH PAPER

Mohammed Kareem Dhahir (2016), Regardless of the transverse tensile strain caused by the FRP reinforcement, the inclined strut seems to maintain about 20% of its ultimate strength. This could be explained by the fact that cracking is generally occur at the interface between the cement paste and aggregate particles, and thus even at high transverse strains the resulting rough cracks are expected to transfer the load by aggregate interlock.

Saad M. Raoof, Lampros N. Koutas & Dionysios A. Bournas (2016), This paper presents an extended experimental study on the bond behaviour between textile-reinforced mortar (TRM) and concrete substrates. The parameters examined include: (a) the bond length (from 50 mm to 450 mm); (b) the number of TRM layers (from one to four); (c) the concrete surface preparation (grinding versus sandblasting); (d) the concrete compressive strength (15 MPa or 30 MPa); (e) the textile coating; and (f) the anchorage through wrapping with TRM jackets. The present paper builds on the results of a comprehensive experimental programme for the investigation of the bond between textile-reinforced mortar (TRM) and concrete. Eighty specimens were fabricated and tested under double-lap shear. This poly-parametric study included the investigation of: (a) the TRM bond length, (b) the number of TRM layers, (c) the concrete surface preparation, (d) the concrete compressive strength, (e) the coating of the textile, and (f) the anchorage through wrapping.

M.S. Alam & A. Hussein (2017), This paper focuses on the relationship between the shear capacity and the flexural cracking load of Fiber Reinforced Polymer (FRP) reinforced concrete beams without stirrups. A relationship between the cracking load that causes a beam to crack at the middle of shear span and the shear capacity of the beam is confirmed based on the test results of 29 beams. The relationship was further examined by comparing the test results of 168 FRP reinforced beams and one-way slabs that were collected from literature. This relationship can be used to develop a shear design method for FRP reinforced members. A good correlation between the shear capacity and the cracking loads at the middle of the shear span was observed. Using this relation, a shear design equation was developed which shows significant improvement in the prediction of shear capacity compared to the flexural cracking loads.

Saad M. Raoof & Dionysios A. Bournas (2017), This paper for the first time examines the bond performance between the TRM and concrete interfaces at high temperatures and, also compares for the first time the bond of both FRP and TRM systems to concrete at ambient and high temperatures. The result showed that overall TRM exhibited excellent performance at high temperature. In steady state tests, TRM specimens maintained an average of 85% of their ambient bond strength up to 400 _C, whereas the corresponding value for FRP specimens was only 17% at 150 _C. In transient test condition, TRM also outperformed over FRP in terms of both the time they maintained the applied load and the temperature reached before failure. The investigated parameters included the strengthening system (TRM vs FRP), the exposure temperature, the number of FRP & TRM layers, and the loading conditions. For this purpose, 68 specimens were constructed, strengthened, and tested under double-lap direct shear at ambient and high temperatures.

Cheng Chen & Lijuan Cheng (2017), A comprehensive prediction and design model is presented in this paper for the fatigue life of reinforced concrete beams strengthened with near-surface mounted (NSM) fiber reinforced polymer (FRP) composites. A previously developed cohesive model is adopted and validated followed by an investigation of effects on the fatigue performance due to various important design parameters. Those design equations are further verified by several independent experimental studies in the literature, which provides satisfactory agreement.

Mauricio Areiza-Hurtado & J. Darío Aristizábal-Ochoa (2017), A research effort is carried out currently to understand the link between the central business processes of construction companies with the performance of constructions projects. A literature review and a case of study have been carried out, and the next steps of the investigation have been described. As a first approach to the research topic, the literature review as well as the case of study has shown that there is no much research on the impact of a construction company business processes on the operational performance of its construction projects. The governing equation of the system is a non-homogeneous sixth-order differential equation with constant coefficients. To find its solution, a total of twelve boundary conditions must be applied (axial forces, shear and bending moments). The solution proposed herein involves a total of twelve actions at the ends of the beam (x = 0 and L) including axial and shear forces, and bending moments at the ends of components 1 and 2. The proposed method is capable to analyze composite beams and beams retrofitted with FRP laminates with any case of end conditions and loadings using a single beam element.

G.M. Chen, S.W. Li, et.al. (2017), This paper has presented a closed-form solution for the whole failure process of FRP wraps in RC beams shear-strengthened with wraps. It has been developed based on the assumptions of a linear critical shear crack shape and the full-range behaviour of FRP-to-concrete bonded joints based on a linearly softening bond-slip model. . A salient feature of the shear strength model developed following this approach is that the effect of beam size can be automatically considered. Such a shear strength model is being developed and will be published in due course.

Bing Fu, Guang-Ming Chen & J.G. Teng (2017), This paper presents the results of an experimental study into the effectiveness of such U-jacketing on delaying or suppressing IC debonding failure, an issue which has not yet been systematically investigated so far. Eight large scale RC beams were tested in the present study to investigate the effects of different forms of FRP U-jacketing on IC debonding failure. The test results indicated that vertical FRP U-jackets have a rather limited effect on IC debonding failure. In the present paper, the results of eight full-scale FRP-plated RC beams with or without FRP anchorages have been presented. The test beams can be divided into two series: in Series I, the FRP soffit plate was anchored with vertical U-jackets or horizontal side strips and in Series II the FRP soffit was anchored with an inclined U-jacket. Detailed results including failure modes, crack patterns, deflections and strains have been presented and discussed to clarify the effects of U-jacket anchorage on IC debonding in FRP-plated RC beams.

Muhammad N.S. Hadi & Jian Song Yuan (2017), This paper presents results of an experimental study on the flexural behaviour of a composite beam, which is reinforced with longitudinal tensile steel bars as well as glass fibre reinforced polymer (GFRP) pultruded I-beam encased in concrete. The test results 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 point of the composite beam is controlled by the tensile steel bars. The ultimate load of the proposed composite beam in this study is higher than the traditional RC beam in this study, and the ultimate load is governed by the encased I-beam. When GFRP bars were used to replace the tensile steel bars to reinforce the composite beams, the brittle failure of GFRP bars caused lack of ductility of the beam members, and both the stiffness and ultimate load were reduced significantly. This paper presents the test results of five beam specimens under four-point bending, including one traditional beam and four composite beams reinforced with GFRP I-beam. The proposed composite beam in this study was reinforced with the I-beam and longitudinal tensile steel bars.

CONCLUSION

In this paper, detailed reviews on the relevant researches were investigated systematically and carried out in respect of CFRP & steel strengthening techniques under fatigue. Significant information and an explanation of the existing research on the fatigue behavior of FRP-strengthened steel structures have been provided. The study also covered the surface treatment techniques, adhesive curing, and support condition under cyclic loading including fatigue performance, crack propagation, and failure modes with FE simulation of the steel bridge girders and structural elements.

1. The remaining service life of structures is limited by fatigue damage, and, in order to ensure the safety of the steel, it is important to regularly check the structure to determine the existence of fatigue cracks.

2. The application of HM, HS, UHM, and prestressed FRP and SW-BFRP strengthening composites not only delays the initial crack, reduces the crack growth rate, and extends the fatigue life, but also decreases the stiffness decay with residual deflection. In addition, strengthened with prestressed FRP had the best strengthening effect.

3. The use of end anchorage prevented debonding of the FRP strips at the beam ends by reducing the local interfacial shear and peel stresses.

4. Epoxy adhesive curing is needed for potential FRP strengthened structures. Cyclic loading during adhesive curing can decrease the fatigue life of the reinforced beam by reducing the bond strength.

REFERENCES

Bing Fu, Guang-Ming Chen & J.G. Teng, (2017). "Mitigation Of Intermediate Crack Debonding In FRP-Plated RC Beams Using FRP U-Jackets", Composite Structures, pp. No. 1-45.

Cheng Chen & Lijuan Cheng, (2017) "Fatigue Life-Based Design Of RC Beams Strengthened With NSM FRP", Engineering Structures, Vol.140, pp. No.256–266.

Dawei Zhang, Haifeng Shi, et.al., (2018) "Cover Separation of CFRP Strengthened Beam-Type Cantilevers with Steel Bolt Anchorage", Engineering Structures, Vol.156, pp. No.224–234.

G.M. Chen, S.W. Li, et.al., (2017) "Full-Range FRP Failure Behaviour In RC Beams Shear-Strengthened With FRP Wraps", International Journal of Solids and Structures.

M.S. Alam & A. Hussein, (2017) "Relationship between the Shear Capacity and the Flexural Cracking Load of FRP Reinforced Concrete Beams", Construction and Building Materials, Vol.154, Pp.No.819–828.

Mauricio Areiza-Hurtado & J. Darío Aristizábal-Ochoa, (2017) "Elastic Analysis Of Composite Beams And Beams Retrofitted With FRP Laminates With Generalized End Conditions", Engineering Structures, Vol.- 147, pp. No. 309–315.

Mohammed Kareem Dhahir, (2016) "Shear Strength Of FRP Reinforced Deep Beams Without Web Reinforcement", Composite Structures, pp. No. 1-21.

Muhammad N.S. Hadi & Jian Song Yuan, (2017) "Experimental Investigation Of Composite Beams Reinforced With GFRP I-Beam And Steel Bars", Construction and Building Materials, Vol.- 144, pp. No. 462–474.

Saad M. Raoof & Dionysios A. Bournas, (2017) "Bond Between TRM Versus FRP Composites And Concrete At High Temperatures", Composites Part B, Vol.127, pp. No.150-165.

Saad M. Raoof & Dionysios A. Bournas, (2017) "TRM Versus FRP In Flexural Strengthening Of RC Beams: Behaviour At High Temperatures", Construction and Building Materials, Vol.154, Pp. No.424–437.

Saad M. Raoof, Lampros N. Koutas & Dionysios A. Bournas, (2016) "Bond between textile-reinforced mortar (TRM) and concrete substrates: Experimental investigation", Composites Part B, Vol.98, pp. No.350 – 361.

Corresponding Author

Mr. Patil Ashish Vinayak*

Post Graduate Student, Department of Civil Engineering, ICOER Pune, India

E-Mail – miashishpatil@gmail.com