International Journal on Science and Technology (IJSAT)

E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

# A Review of comparative Study of Steel Sections with Strengthening under Different Loadings.

**Mr. Rahul Anandrao Patil[1], Dr. Satish Kashinath Kamane[2]**

[1]Ph.D Research Scholar, [2]Chief Executive Officer
[1]Department of Civil Engineering, Srinivas University, Mangaluru, Karnataka, India
[2]Pinaka Consultancy, Services, Sangli, Maharashtra

**Abstract:**
**In recent years, fiber-reinforced polymer (FRP) composites have been utilized to strengthen structural components to effectively tackle increased cycling loads or repair challenges caused by wear or fatigue fractures. Consequently, this research is focused on exploring existing FRP reinforcement techniques for structural steel components that have experienced fatigue damage. This research examines surface treatment techniques, adhesive curing methods, and support configurations under cyclic loading through finite element (FE) modeling of steel bridge girders alongside structural principles, focusing on fatigue performance, crack development, and failure modes.FRP-strengthening composites increase fatigue life, minimize stiffness degradation with residual deflection, postpone initial cracking, and slow the rate of crack propagation. CFRP, or prestressed carbon Fiber-reinforced polymer, is the finest choice for improvement.**

**Keywords: Fiber-reinforced polymer composite, Bending,TorsionAnalytical modeling**

## 1. Introduction

One of the most important things structural engineers take into consideration is the reinforcement of existing steel structures that were built in the last few years. Steel structures constructed in the past frequently require enhancement due to issues like corrosion, fatigue cracking, increased life loads, and other influences. Recently, fiber-reinforced polymer (FRP) composites have attracted more interest as a strengthening option for steel structures. For a long time, FRP has served as a viable alternative to steel in the field of construction engineering. Hybrid structural systems offer two primary benefits: cost efficiency and the ability to optimize cross-sections based on the properties of the materials used. This study evaluates the performance of circular hollow section (CHS) and square hollow section (SHS) steel members, both with and without additional reinforcement, to strengthen the section that exhibits the highest load-carrying ability under compressive, tensile, and torsional stresses. Addressing the reinforcement of existing steel structures from previous periods is one of the most critical concerns examined.Necessity: Study of Behaviour of Steel section externally attached with fiber-reinforced polymer sheet under combined bending and torsion….

Why FRP?

- High strength-to-weight ratio

- Easy attaching to apresent structure
- High resistance alongside corrosion and chemical attacks

Types of fibers

- Glass
- Carbon
- Aramid
- Basalt

Structural Safety and Performance: More reliable design subjected to complex loading, Enhanced Design Guidelines

Optimization of Material Usage: More efficient designs, reducing material costs without compromising structural integrity

Innovative Structural Solutions

Application in Real-world Scenarios

## 2. Literature review

**Emine Aydin, 2023**-InvestigatedHigh-local stresses and a substantial impact on structural behavior can result from torsional demand acting on beams. The torsional strength of beams can be enhanced by the application of fiber-reinforced polymer (FRP) sheets. Carbon fiber-reinforced polymer (CFRP) and basalt (BFRP) textiles in different configurations are used to reinforce the steel I-beams in this study, and the increase in torsional strength is investigated both experimentally and numerically. To conduct the experimental study,Using CFRP and BFRP fabrics adhered to the web of steel I-beams in 03 different configurations, 12 specimens are first strengthened. Two reference beams and a total of 14 specimens are put through torsion tests. Second, the torsional performance of web-reinforced steel beams is captured using a numerical model. Following a satisfactory verification of the numerical model, a parametric study isincorporated to assess how FRP strengthening affects steel beams for both full and flange-only reinforcement options. Compared to the reference, the fully web-glued FRP reinforcement configuration increased the torsional capabilities of CFRP and BFRP sheets by 14% and 18%, respectively, in the experiments. Finally, the parametric analysis found that a 43% increase can be achieved with full strengthening employing FRP on the web and flanges.

**Omnia R. AbouEl-Hamd et al,2023-.**The application of hybrid fiber-reinforced polymers (HFRPs) for strengthening steel beams has seen a considerable rise in popularity over recent decades.Researchers have yet to thoroughly investigate the efficacy of fastening methods that do not rely on a bonding agent to prevent unwanted debonding failure. This work presents the findings of numerical and experimental investigations on steel beams reinforced with steel bolts and HFRP. 22 steel beams underwent four-point loading tests to determine the effects of the bolt configuration and HFRP length on the flexural conduct of the reinforced systems. Measurements of strain, load-deflection relationships, deflection profiles, and observed failure modes were also investigated. With improvements in yield and ultimate flexural capacities of 15.1% and 22.2%, respectively, the tested beams demonstrated ductile behavior. The ultimate load of the bolted HFRP-steel beams was predicted using simplified empirical equations. The behavior of the beams was modeled using ANSYS software, which also examined how the steel grade, beam length, bolt spacing, HFRP thickness, and loading scheme affected how well the chosen fastening method worked. The mid-span deflection was reduced by up to 51.2% when the HFRP length was increased, improving both the ductility of the beam and the use of HFRPs. Furthermore, an 87.2% decrease in interfacial slippage enhanced the strain compatibility of the HFRP–steelgirders. The bolt configuration has a negligible impact on the beams' overall performance.

**Mohamed Kamruzzamanet al. 2014** investigated fiber-reinforced polymer (FRP) compoundsthat have been used for reinforcing structural parts in recent decades as an effective way to handle increased cycle loads or restoration damage from corrosion or fatigue cracking. Hence, the study aims to investigate the current FRP strengthening methods for structural steel elements that have been fatigue damaged. This researchincludesUsing finite element (FE) simulation of the steel bridge elements and structural parts, the surface handling methods, glue curing, and support conditions under cyclic loading, including fatigue performance, crack propagation, and failure mechanisms. FRP-strengthening composites increase fatigue life, minimize stiffness degradation with residual deflection, postpone initial cracking, and slow the rate of crack propagation. CFRP, or prestressed carbon fiber-reinforced polymer, is the finest choice for strengthening.

**Vidya M. Patilet al.2024**By applying the analytical and numerical models created in research to improve the performance of structures subjected to various loading scenarios, the study advances our understanding of structural engineering and establishes a solid foundation for the design of rolled steel I beams reinforced with fiber-reinforcing polymers, ultimately resulting in safer and more durable structures. By assessing how well Fiber Reinforced Polymer (FRP) materials enhance the strength and functionality of rolled steel I-beams, this study explores structural engineering.

The study's analysis forecasts how I-beams reinforced with FRP will respond to applied loads by utilizing both analytical and numerical modeling techniques.

**A.H. Keykha, 2020,**in the application of carbon fiber-reinforced polymer (CFRP) to enhance the strength of steel components. These structures can experience combined loads due to various factors. Fatigue cracking, construction errors, and other factors could be the cause of the steel member shortage. The performance of deficient square hollow section (SHS) steel members reinforced with CFRP sheets under two different kinds of combined loads was examined in this study. To investigate the effect of CFRP strengthening on the structural behavior of the weak steel elements, 12 out of the 17 specimens that were strengthened with CFRP sheets were inspected. The steel members were subjected to three-dimensional (3D) modeling and nonlinear static analysis using ANSYS software.

**Bibek Regmi Bagalet al. 2021**investigated the performance of steel girders retrofitted with fiber-reinforced polymer (FRP) under static and fatigue loadings using nonlinear finite element analysis (FEA). Carbon fiber reinforced polymer (CFRP) was used to retrofit damaged and undamaged steel beams under static loading in order to examine the impact of bond length and transverse anchorages on failure styles and flexural performance. Steel beams retrofitted with aramid FRP (AFRP), basalt FRP (BFRP), fatigue loading, and damaged control were analyzed in order to predict their fatigue life. The CFRP laminates enhanced the flexural capacity of the damaged and undamaged beams by approximately three and 1.7 times, respectively, in comparison to their equivalent control beams.

**Ashmi Thaha and Sreeja S 2022 are** interested in strengthening steel sections using various fiber-strengthened polymers (FRP). The shortage of steel elements may be affected by corrosion, fatigue cracking, construction errors, and other factors. By employing HYBRID FRP composites to strengthen the steel section with the highest load-carrying capacity under compressive, tensile, torsion, and seismic loadings, this study examines the behavior of circular hollow section (C.H.S.) and square hollow section (S.H.S.) steel members, comparing them with and without deficiencies. ANSYS software performed nonlinear static analysis and three-dimensional (3D) modeling on the steel elements. The anticipated outcome is that the improvement of the steel segmentwith the highest load-carryingcapability by the HYBRID FRP composites increased.

**A.H Keykha 2020**examined the performance of lacking square hollow section (SHS) steel section reinforced by CFRP sheets in02 different kinds of combined loads in his study, "Reinforcement of Deficient Steel Sections Consuming CFRP Composite under Combined Loading." Twelve of the 17 specimens that were reinforced with CFRP sheets were examined to examine the effect of CFRP strengthening on the structural behavior of the weak steel members. ANSYS software performed nonlinear static analysis and three-dimensional (3D) modeling on the steel members. The findings demonstrated the effect of CFRP reinforcement on increasing and improving the ultimate capacity of steel members with deficiencies and the ability to restore the strength lost because of the deficiency.

**A.H Keykha2017** Through numerical and analytical studies, the study "Analysis and strengthening of SHS steel columns using CFRP composite materials" examined the use of elastic adhesively bonded CFRP pieces in retrofitting thin SHS steel sections. The finite element method (FEM) was used for modeling. Models were analyzed using ANSYS. Fifteen CFRP-reinforced models were analyzed under different support conditions in order to determine the critical load of SHS steel sections. The results showed how well CFRP coverage and support conditions worked for sections' critical loads.

## 3. OBJECTIVES OF THE STUDY

1. To study the **bending** effect on virgin steel I section and steel I section bonded with Glass, Basalt, and Carbon fiber using finite element modeling (Ansys) and validate the analytical models developed through experimental testing.
2. To study the **bending** effect on artificially degraded steel I section and artificially degraded steel I section bonded with Glass, Basalt, and Carbon fiber using finite element modeling (Ansys) and validate the analytical models developed through experimental testing.
3. To study the **torsion** effect on virgin steel I section and steel I section bonded with Glass, Basalt, and Carbon fiber using finite element modeling (Ansys) and validate the analytical models developed through experimental testing.
4. To study the **torsion** effect on artificially degraded steel I section and artificially degraded steel I section bonded with Glass, Basalt, and Carbon fiber using finite element modeling (Ansys) and validate the analytical models developed through experimental testing.

## 4. DISCUSSION

In-depth analyses of pertinent, carefully carried out research on CFRP/steel strengthening methods under fatigue are presented in this paper. Important details about the existing literature on the fatigue performance of fiber-reinforced polymer-reinforced steel structures have been included. Using finite element simulation of the steel bridge struts and structural elements, the study also looked at surface behavior techniques, adhesive curing, and support conditions under cyclic loading, including fatigue behavior, crack propagation, and failure modes.

- Experimental Testing:

The behavior of Steel sections externally bonded with FRP sheets under bending, torsion, and combined torsion and bending loads

- Analytical Modelling:

Study characteristics of steel sections and FRP sheets like tensile strength,modulus of elasticity, shear strength, and Bond strength between steel and FRP

**REFERENCES**

1. Emine Aydin, Investigation of Steel I-Beams Strengthened Using CFRP and BFRP Sheets under Torsion, Hindawi Advances in Civil Engineering, Volume 2023, Article ID 4322246, 16 pages.
2. Omnia R. AbouEl-Hamd, Amr M. I. Sweedan, Bilal El-Ariss and Khaled M. El-Sawy, Experimental and Numerical Investigation of the Behavior of Steel Beams Strengthened by Bolted Hybrid FRP Composites, Buildings 2023, 13, 824.
3. Mohamed Kamruzzaman, Mohd Zamin Jumaat, N. H. Ramli Sulong, and A. B.M. Saiful Islam, A Review on Strengthening Steel Beams Using FRP under Fatigue, Hindawi Publishing Corporation the Scientific World Journal Volume 2014, Article ID 702537, 21 pages
4. Vidya M. Patil, Mahesh M. Awati, Sandeep S. Ahankari, Abhijeet C. Lande, Enhancing Rolled Steel I Beam Performance Through FRP Strengthening: Analytical and Numerical Modelling for Behavior Prediction, The Institution of Engineers (India) 2024
5. A.H. Keykha, Strengthening of Deficient Steel Sections using CFRP Composite under Combined Loading, Mechanics of Advanced Composite Structures 7 (2020) 287 – 296
6. Bibek Regmi Bagale, S.M. ASCE; and Azadeh Parvin, Fiber-Reinforced Polymer Strengthening of Steel Beams under Static and Fatigue Loadings, Pract. Period. Struct. Des. Constr., 2021, 26(1): 04020046
7. Ashmi Thaha, Sreeja S, Strengthening Of Deficient Steel Sections Using Hybrid Frp Composites Under Various Loading Scenarios, International Research Journal of Engineering and Technology (IRJET) Volume: 09 Issue: 06 | Jun 2022
8. A.H Keykha, "Strengthening of deficient steel sections using CFRP Composite under combined loading," Mechanics of advanced composite structures, Vol. 7, 2020, pp 287-296
9. A.H Keykha,Numerical investigation on the behavior of SHS steel frames strengthened using CFRP," Steel and Composite Structures, Vol. 24, 2017, pp 561-568.
10. A. Kumar, A. Chakrabarti, P. Bhargava, R. Chowdhury, Probabilisticfailure analysis of laminated sandwich shells based onhigher order zigzag theory. J. Sandw. Struct. Mater.Sandw. Struct.Mater. 17, 546–561 (2015)
11. B.B. Mishra, A. Kumar, P. Samui, T. Roshni, Buckling of laminatedcomposite skew plate using FEM and machine learningmethods. Eng. Comput.Comput. 38, 501–528 (2020)