



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Special Issue 3, December 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Numerical Study on the Strength Performance of Rectangular RC Columns with Multi spiral BFRP Confinement

Shamily Monikka K J¹

Assistant Professor, Department of Civil Engineering, Royal College of Engineering and Technology, Thrissur, Kerala, India

ABSTRACT: The strength and ductility of reinforced columns can be improved by using effective confinement. Previous researches on rectangular columns with multi spiral interlocking has shown that the structural behavior of column can be enhanced by using spiral confinement. Steel is one of the best reinforcing materials. But it has many pros and cons. Fiber Reinforced Polymer (FRP) have over the previous years turned into a best decision as a reinforcement for concrete. This paper focused on an alternative approach for replacing steel confinement in rectangular column with Basalt Fiber Reinforced polymer (BFRP) in compression through the finite element analysis (FEA) method using ANSYS Software. BFRP has been known for several years in Structural engineering. To utilize its high tensile strength, high strength-weight ratio, no corrosion and light in weight characteristics, replacing steel in rectangular multi spiral columns with BFRP spiral confinement.

The analysis shows that replacing steel by BFRP in multi spiral configured columns exhibited better strength and energy capacities as compared with existing one. Finite Element analysis was also carried out for rectangular columns with multi spiral steel confinement to get a better understanding about the study.

KEYWORDS: BFRP, FRP, High-tensile strength, Confinement, Finite element, Axial Compression

I. INTRODUCTION

A Concrete is the world's most utilized man-made construction material today. It is generally modest and simple to frame when cast in India. The most well-known building material for Reinforced Concrete (RC) utilized until now is steel. Utilizing steel as a reinforcing material provides various benefits; it is strong in tension and has a high modulus of elasticity. The thermal expansion is like cement and it functions admirably with concrete under loading.

Conventional columns generally consist of cross ties and hoops. According to the recent studies Yin spiral were introduced which is much more efficient than the conventional confinement. The circular cages cannot be installed in rectangular columns, because it creates an uneconomical design and also creates weak points in compression member. So, these kinds of practices cannot be adopted. We also know that utilization of circular cages can improve the strength capacity as well as the ductility of the structural member. So, the initiation of rectangular columns with multi spiral interlocking confinement can improve the overall structural behavior. Steel is one of the oldest construction materials which has a great influence in the construction field. Steel has its own advantages and the same time it has several disadvantages too. So, replacement of steel with composites materials, is one of the emerging researching ideas, which have a positive impact on the construction field. The Fiber Reinforced Polymer, have high strength capacities, light weight and cost effective than the traditional steel. GFRP and CFRP are few of the FRP's.

Basalt Fiber Reinforced Polymer is one of the environmentally friendly FRP as compared with the others. It can be produced from melted basalt rock in a natural way. It has high tensile strength, light weight, high flexibility and low cost as compared with steel. Many studies have been going on with the BFRP in structural engineering field.

Jongsung Sim, Cheolwoo Park, Do Young Moon have studied the applicability of BFRP as strengthening material. The experimental analysis shown that the BFRP can improve the strength by 27% according to the number of layers included. Thilan Ovitigala conducted investigation to find out the bond strength and shear strength of BFRP as structural material. Tehmina Ayub, Nasir Shafiq, M. Fadhil Nuruddin studied the economical application of BFRP as a construction material.

In this study ANSYS finite element models were used to stimulate the compressive behavior of different column configurations with BFRP confinement. The analysis of columns with complicated configurations is not easy to carry out. So, the research presents a comparison study between the conventional column configuration with multi-spiral configurations using ANSYS software. Due to the better performance of five spiral configurations, replacement of steel confinement study was carried out on it to understand the application of such configurations in real life.

II. FINITE ELEMET ANALYSIS

The FEA method is much easier to analysis the complicated structures. Here the analysis of multi spiral columns is done using the FEA method.

A. Element Type

SOLID186 Element was used to model the concrete. It is a higher order 3-D, 20-node solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials.

BEAM188 Element was used for steel section modeling. The element is a linear, quadratic, or cubic two-node beam element in 3-D. BEAM188 has six or seven degrees of freedom at each node. These include translations in the x, y, and z directions and rotations about the x, y, and z directions. A seventh degree of freedom (warping magnitude) is optional. This element is well-suited for linear, large rotation, and/or large strain nonlinear applications.

B. Material Properties

The finite-element study in this paper was conducted within the elastic range, only essential material properties were used. For both the longitudinal and transverse reinforcing steels, a Young's modulus, E_s of 200GPa and a Poisson's ratio, μ_s of 0.3 were used for modeling. Also yield stress of steel was taken as 314MPa. The Poisson's ratio of concrete, μ_c of 0.2 was used in this study. The modulus of elasticity of concrete, E_c can be determined according to the formula suggested by IS 456:2000, as follows,

$$E_c = 5000 \sqrt{f_{ck}} \quad (1)$$

The material properties of BFRP, Young's modulus, E_s of 39GPa and a Poisson's ratio of 0.3 were used for modeling. The density and Yield strength were taken as 2.67 g/cm³ and 1051.79 MPa respectively.

C. Finite Element Modelling

The ANSYS software is used to perform the analysis and to predict the axial compression behaviors of the columns incorporated with multi-spiral configurations. Due to the symmetry of the modeled structure, half of the column height was considered for the modeling, which will reduce calculation effort. Mesh convergence determination was also done. Boundaries were kept as effectively held in position at both ends, restrained against rotation at one end. Steel reinforcement modeling was done by adopting the discrete method

III. NUMERICAL RESULTS

The Fig.1 shows the four configurations used to study which includes a traditional stirrup design (C), the combination of two spirals (2S), the combination of four spirals (4S) and the combination of five spirals (5S).At the first the study was carried out for the steel confinement. After that the replacement study was done. The vertical spacing of the confinement varies from 50 to 100 mm. Ten models of each configuration with different geometrical characteristics were studied and the comparison analysis were carried out.

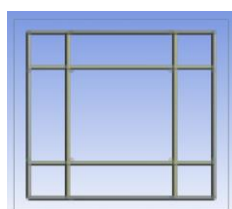


Fig. 1.a C Configuration

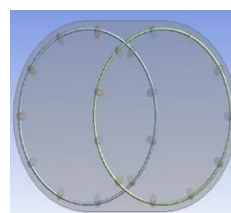


Fig. 1.b 2S Configuration

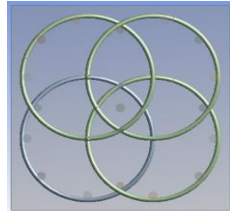


Fig. 1.c 4S Configuration

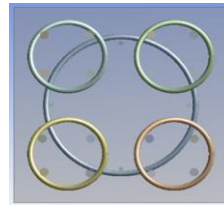


Fig. 1.d 5S Configuration

Fig.1 Different Confinement Configuration modelled in ANSYS Software

The size of all rectangular columns was chosen as 600*600*3000 mm while the oblong column as 610*915*3000 mm. Yield strength of longitudinal bars were given the same as the transversal bar. They were taken as 16-25 mm Ø. The four spiral configuration consists of four spiral interlocking with each other having a spiral diameter as 360 mm. The five spiral configuration has one large spiral with a spiral diameter of 420 mm which is interlocked by four small spirals with 210 mm spiral diameter at the corner of the large spiral perimeter. The two spiral configurations consist of two circular cages interlocking with each other having a spiral diameter of 540 mm. Fig.2 shows the comparison of stress Vs strain relationship of the four configurations with steel and BFRP confinement. This figure shows the axial compression behavior of rectangular columns can be improved by using BFRP multi-spiral interlocking configurations. Also, oblong two spiral configuration is considered for the study to conform spiral configurations efficiency as compared with the rectangular columns.

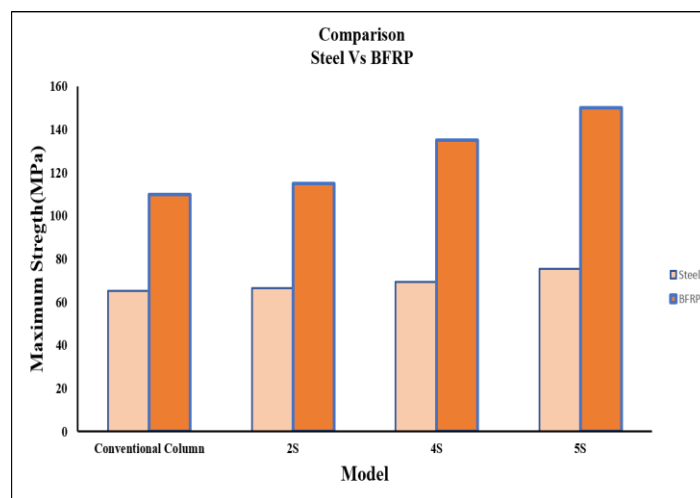


Fig.2 Comparison of configurations with BFRP confinement

IV. CONCLUSION

The numerical analysis of rectangular columns with multi spiral steel and BFRP confinement was studied. The study confirms that replacing steel by BFRP can enhance the structural behavior of rectangular columns with multi spiral confinement. It can be concluded that the multi spiral columns perform better than traditional columns. The stress strain relationship obtained from the analysis clearly states that the axial load carrying capacity of columns incorporated with multi spiral configuration can be increased by 25% than the traditional columns. Also, the transversal steel required for the construction can be reduced by 30% by replacing the traditional columns with multi spiral columns. So, by replacing the steel confinement material by BFRP can further increase the strength by twice of the strength. The bond characteristics between BFERP and concrete is more than between steel and concrete. During numerical analysis using ANSYS Software, it was also observed that with an increase of compressive strength, the carrying capacity of the column increased significantly in comparison to strength of column reinforced with steel bars. The current analyses suggest that the BFRP reinforcement can be considered as a promising alternative to steel bars.



National Conference on Emerging Technologies [NCET' 2021]

Organized by

Royal College of Engineering and Technology, Thrissur, Kerala, India

ACKNOWLEDGMENT

The author acknowledges the support provided by Ms. Nisha Varges, Assistant Professor, Civil Engineering Department, VAST. The author also expresses her gratitude to the Civil Engineering Department of Vidya Academy of Science and Technology, Kerala.

REFERENCES

- [1] Juan F. Correal, M. Saiid Saiidi and David H. Sanders (2004).” Seismic Performance of RC Bridge Columns Reinforced with Two Interlocking Spirals”, ASCE journal of the structural division, 108 (4), 728742.
- [2] Marek Urbanski, Andrzej Lapko, Andrzej Garbacz, “Investigation on Concrete Beams Reinforced with Basalt Rebars as an Effective Alternative of Conventional R/C Structures” 11th International Conference on Modern Building Materials, Structures and Techniques, MBMST 2013.
- [3] Maximus Pearson, Ted Donchev, “Experimental Study on the Behavior of Prestressed Concrete Beams with Internal BFRP Reinforcement”. Kingston University, London. 2013
- [4] Tehmina Ayub, Nasir Shafiq, M. Fadhil Nuruddin, “Mechanical Properties of High-Performance Concrete Reinforced with Basalt Fibres” Fourth International Symposium on Infrastructure Engineering in Developing Countries, IEDC 2013.
- [5] Ping-Hsiung Wang, Ph.D., Kuo-Chun Chang, M. ASCE and Yu-Chen Ou, M. ASCE (2020).” Simplified Finite-Element Analysis Method for Rectangular Concrete Columns with Interlocking multi-spiral Reinforcements”, ASCE-ST.1943-541X.0002489.
- [6] Qian, Lia and A. Belarbi (2011).” Seismic Behavior of RC Columns with Interlocking Spirals under Combined Loadings Including Torsion”, SCIENCE DIRECT- Elsevier journal of the engineering mechanics division, 103 (2), 229241.
- [7] Yin, S.Y. L., T.L. Wu, T. C. Liu, S.A. Sheikh and R. Wang (2011).” Interlocking spiral confinement for rectangular columns”. Concr. Int. 33 (12): 3845.
- [8] Yu T., J.G. Teng, Y.L. Wong and S.L. Dong (2010).” Finite element modeling of coned concrete-I: Drucker Prager type plasticity model”, Eng. Struct.32 (3): 665679.



**Impact Factor:
7.569**



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details