



Article Title: Structural Performance and Strengthening of RCC Interior Joint with Variable Beam Depth Using Sikawrap

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ABSTRACT

Sikawrap becomes preferable for strengthening and retrofitting of RC structural elements due to its high strength-to-weight and high stiffness to weight ratios. This study examines the structural performance and strengthening of RCC interior joint with variable beam depth using Sika wrap. In the first model, conventional connection is compared with beam, column and joint failure connection. In the second model, strengthening of beam connection is done by Lstrip method, embedment method and web-bounded method. In the third model, strengthening of column connection is done by L-shaped plate method and near surface mounted and wrap method. In the fourth model, strengthening of joint connection is done by X, U and T-shape method. In the fifth model, strengthening of beam column connection is done by L-shaped plate and wrap method and full wrap method. The structure will be analyzed using seismic analysis. This can be done by varying the depth of beam and finding which one possess more strength. Non-linear lateral loading test is carried out for beam-column connection with varying depth of beam on studying joint strength, target displacement and ductility for above all methods.

This joint is the most critical portion of a building under earthquake due to diagonal crack failure, which leads to the collapse. Therefore, such joints need special attention to increase the capacity of existing damaged joints through retrofitting. In this paper the idea of using Sikawrap are studied. Sikawrap becomes preferable for strengthening and retrofitting of RC structural elements due to its high strength-to-weight and high-stiffness-to- weight ratios. Sika wrap comprises of unidirectional, carbon or glass fibre fabrics and structural epoxy resin based, impregnating resins. These unique combinations provide a wide range of strengthening and upgrading solutions to meet the many varied demands of different product and application. Strengthening methods are provided for defected beam, column and joints. The structure will be analysed using seismic analysis. It can be analysed by first finding the best model. This can be done by varying the depth of beam and finding which one possess more strength. Non-linear lateral loading testing is carried out for a beam-column connection with varying the depth of beam on studying the joint strength, target displacement and ductility for above all methods. The effective specimens are then studied under cyclic test.



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1 Introduction

In reinforced concrete (RC) buildings, the connections between beam and column called beam column joints are crucial parts of a building. Several parameters affect the behaviour of RC beam-column joints such as relative stiffness between beam and column, strength of concrete and reinforcement details. In fact, only vertical load is taken into consideration. This joint is the most critical portion of a building under earthquake due to diagonal-crack failure, which leads to the collapse. Therefore, such joints need special attention to increase the capacity of existing damaged joints through retrofitting. Nowadays, Sikawrap becomes preferable for strengthening and retrofitting of RC structural elements due to its high strength-to-weight and high-stiffness-to-weight ratios. Sika wrap comprises of unidirectional, carbon or glass fibre fabrics and structural epoxy resin based, impregnating resins. These unique combinations provide a wide range of strengthening and upgrading solutions to meet the many varied demands of different product and application. They are used for Strengthening of reinforced concrete, masonry, brickwork, correcting structural design and construction defects, increasing resistance for Increasing the strength and ductility and to seismic performance Improving service life and durability. Sikawrapcarbon and glass fabrics are high strength materials that are bonded to structures for strengthening purposes. Sharing the attributes of composite strengthening as previously listed, Sikawrap also offers the additional benefits of being able to conform to almost any complex or geometric shape. The perfect high-tech answer to structural strengthening under these conditions, Sikawrap's unique benefits include ease of handling, appearance, minimum structure downtime, economical to use, for both wet and dry lay-high strength, light weight, significant gain in load-bearing capacity, minimal change to structure weight, shape and up applications, non-corrosive, confirm to irregular shapes and surfaces, and minimal clearance needed to install. No studies have been performed on strengthening the beam-column connections with variable moment capacity beams and increases it performance with different strengthening schemes with Sikawrap. The main objective is to study the structural performance and strengthening of RCC interior joint with variable beam depth using Sikawrap. The shear 2 strengthening of joints by different method and the different retrofitting scheme as for beam column joints under severely damaged conditions are also studied.

Experimental results illustrated that the rehabilitated specimens of glass fibre reinforced polymer and carbon fibre reinforced polymer beam-column joint specimens exhibited an improved load carrying capacity and a higher rate of stiffness than the virgin specimens. . Beam-column joints, being the lateral and vertical load resisting members in reinforced concrete structures are particularly vulnerable to failures during earthquakes and hence their rehabilitation is often the key to successful seismic rehabilitation strategy. FRPC based strengthening strategy could be an attractive option in order to restore joints. The rehabilitation technique using wrapping system for the damaged R.C.C interior beam – column joints have proved to be effective. The rigidity and ultimate load carrying capacity of the restored beam



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was improved with decrease in deflections. Both glass and carbon composite materials can be efficiently used for rehabilitation of reinforced concrete joints. Joints can exhibit enhanced performance for different reinforcement detailing and damage states. Considerable increase in yield load can be achieved by use of glass and carbon reinforced polymer materials. Considerable increase in first crack load can be achieved by using glass and carbon reinforced polymers. Tests on rehabilitated specimens suggest that FRP not only restores its original strength but also considerable enhancement in its yield load and initial stiffness. The rehabilitated specimens are stiffer than the virgin specimen and the crack widths in the rehabilitated specimens are relatively less.

2 Literature Review

The study of literature is an important part of a project to review the previous works done. In this chapter, some of the technical papers, related to retrofitting of structures, FRP and analytical studies, published in journals and conference proceedings have been discussed. Reinforced concrete beam-column joints have an important function in the structural concept of many structures. Often these joints are vulnerable to loads due to impact, explosion or seismic loads. These joints are also sensitive to corrosion of steel reinforcement. On the other hand, confinement has proven to be very efficient in increasing concrete strength and ductility of members. Wrapping by means of FRP reinforcement enhances the structural behaviour of concrete beam-column joints considerably. This chapter presents most of the available literature on the usage of FRP composites in the retrofitting of reinforced concrete beam-column joints. Keywords: Beam-column joints, FRP, seismic loads.

2.1 Validation

The Finite Element Analysis (FEA) is a numerical method for solving problems of engineering and mathematical physics. It is used mainly for problems for which no exact solution, expressible in some mathematical form, is available. As such, it is a numerical rather than an analytical method. Methods of this type are needed because analytical methods cannot cope with the real, complicated problems that are met with in engineering. For example, engineering strength of materials or the mathematical theory of elasticity can be used to calculate analytically the stresses and strains in a bent beam, but neither will be very successful in finding out what is happening in part of a car suspension system during cornering. One of the first applications of FEA was, indeed, to find the stresses and strains in engineering components under load. FEA, when applied to any realistic model of an engineering component, requires an enormous amount of computation and the development of the method has depended on the availability of suitable digital computers for it to run on. The method is now applied to problems involving a wide range of phenomena, including vibrations, heat conduction, fluid mechanics and electrostatics, and a wide range of material properties, such as linear-elastic (Hookean) behaviour and behaviour involving deviation from Hooke's law (for example,



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plasticity or rubber-elasticity).

Cracks often appear in structures that pose a threat to strength and durability, which ultimately affect the structural integrity of concrete. Extensive work has been carried out in past on utilization of Carbon Fiber Reinforced Polymer (CFRP) as a repair material. But, this research particularly focuses on: multiple fiber layers i.e. single and double, traditional concrete mix ratio with locally available materials and varying flexural reinforcement. Furthermore, this work presents an experimental analysis to strengthen the Reinforced Concrete (RC) beams using SikaWrap- 230 C as a CFRP wrap, and Sikadur-330 as a bonding material. The comparison between single and double layers of CFRP is of major interest in this research. Six reinforced concrete beams were repaired with CFRP and tested under three-point bending test. For these specimens, load deflection behavior along with crack propagation and failure of beams were studied. The research work presented herein, was conducted to investigate the behavior of flexural strength of RCC beams, by utilizing layers of CFRP and Epoxy as repairing materials. Based on the experimental investigations, it is concluded that: RCC beams repaired with CFRP sustain higher load as compared to reference beams. Hence, CFRP can be used for strengthening of damaged beams. Flexural strength capacity of single and double layer of CFRP repaired beams increases 24.35% and 28.34% respectively, for category A beams. Similarly, flexural strength of single and double layer of CFRP repaired beams increases 25.09% and 30.29% respectively, for category B beams. Sikadur-330 as repairing material is very effective bonding material, it traps the cracks, when applied on concrete surface. By providing one additional (second) layer of CFRP, only 4 - 5.2 % increment in flexural strength was observed. CFRP is very effective in resisting the flexural cracks. Hence, it can be used for enhancing the flexural strength of RCC beams.

3 Introduction To ANSYS

ANSYS is a finite element analysis tool used for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation products provides finite elements to model behavior and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled- 14 physics capabilities involving acoustics, piezoelectric, thermo-structural and thermos-elastic analysis. ANSYS structural analysis software enables to solve complex structural engineering problems and make better, faster design decisions. With the finite element analysis tools available in the suite, we can customize automate solutions for our structural mechanics problems and parameterize them to analyze multiple design scenarios. It is used throughout the industry to enable engineers to optimize their product designs and reduce the cost of physical testing. Different types of structural analysis can be performed.



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3.1 Modelling of Beam-Column Joint with Various Strengthening Methods

In this paper the idea of using Sikawrap are studied. Sikawrap becomes preferable for strengthening and retrofitting of RC structural elements due to its high strength-to-weight and high-stiffness-to-weight ratios. Sikawrap comprises of unidirectional, carbon or glass fibre fabrics and structural epoxy resin based, impregnating resins. These unique combinations provide a wide range of strengthening and upgrading solutions to meet the many varied demands of different product and application. Strengthening methods are provided for defected beam, column and joints. The structure will be analysed using seismic analysis. It can be analysed by first finding the best model. This can be done by varying the depth of beam and finding which one possess more strength. Non-linear lateral loading testing is carried out for a beam-column connection with varying the depth of beam on studying the joint strength, target displacement and ductility for above all methods.

The defected beam-column joint with various strengthening schemes are taken for analysis. In the first case interior beam connection failure is studied. The beam has 900 mm length and cross-sectional dimensions of first beam is 200x300 mm and cross-sectional dimensions of second beam is 200x200 mm. The cross-sectional dimension of the column is 200x300 mm and first column has 1000 mm length and second column has 1300 mm length. The total length of the columns was 2.3 m divided into two equal parts, lower part and upper part. Bilinear isotropic hardening is used to reproduce the plastic behaviour of materials.

Some of the technical papers, related to retrofitting of structures, FRP and analytical studies, published in journals and conference proceedings have been discussed. Reinforced concrete beam-column joints have an important function in the structural concept of many structures. In which two specimens were taken as control specimen. Then these two and remaining two specimens were subjected to cyclic loading, the damaged specimens were retrofitted with the four different types of retrofit schemes, Repaired specimen after control test, then rehabilitated with one bidirectional U shaped GFRP sheet, same height as the joint with added cover plates and anchors through the joint.

4 Conclusion

This study represent the behaviour of Sikawrap for strengthening beam, column and joint connection. Finite element analysis is conducted to develop models for the analysis of beam column joints. Different methods are used for strengthening beam, column and joint connection. Best method is obtained from beam, column, joint and beam-column strengthening methods. From the analysis following conclusions can be recorded.

- Comparing conventional connection and failure connections, ultimate load carrying capacity and ductility of conventional connection is higher than failure connections. Beam failure connection has low ultimate load carrying capacity and joint failure connection has low ductility.



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- On the beam retrofitting case, the best load carrying capacity is obtained in the embedment method performing 34.08 % better than failure beam connections. L-strip method have maximum ductility.
- On the column retrofitting case, the best load carrying capacity is obtained in the Lshapeplates method performing 24.02 % better than failure column connections. Lshapeplates method have maximum ductility.
- On the joint retrofitting case, the best load carrying capacity is obtained in the U-shape plate's method performing 12.29 % better than failure column connections. X-shape plate's method have maximum ductility.
- On the beam column retrofitting case, the best load carrying capacity is obtained in the L-shape plate and wrap method performing 30.56 % better than failure beam column connections. L-shape plate and wrap method have maximum ductility.

References

1. R. Prasanth; G. Silambarasan; V. Chandrikka, Year: 2019, "Review on Reinforced Concrete Beam-Column Joint", International Research Journal of Engineering and Technology, Vol: 06, no: 05.
2. Yasmeeen Taleb Obaidat; Ghazi AFR Abu-Farsakh; Ahmed M. Ashteyat, Year: 2019, "Retrofitting of partially damaged reinforced concrete beam-column joints using various plate-configurations of CFRP under cyclic loading", Construction and Building Materials, Vol: 198, pp. 313 – 322.
3. Ali Raza Khoso; Muhammad Akram Akhund; Shankar Lal Menghwar; Fida Hussain Siddiqui, Year: 2018, "Effect of Multiple Layers of Carbon Fiber Reinforced 3 Polymer on Flexural Strength of Reinforced Concrete", Journal of Advanced Research.
4. N. Naveena; M. Ranjitham, Year: 2016, "Numerical study on retrofitting of beam column joint strengthened with CFRP", International Research Journal of Engineering and Technology, Vol: 03, no: 01.
5. V. Desai Ashutosh; Y. DhariaRajen; B. Shah Parth; J. Sheikh Khuzaim, Year: 2016, "Performance Evaluation Study of an Innovative Material to Improve the Strength of Conventional Concrete", Global Research and Development Journal for Engineering(2016).
6. M. Rajeshwaran; T. Manikandan, Year: 2015, "Retrofitting of Reinforced Beam-Column Joints Using Hybrid Laminates", International Journal of Science and Research (2015).
7. M. B. S. Alferjani; A. A. Abdul Samad; Blkasem S. Elrawaff, Year: 2015, "Study on Shear Strengthening of RC Continuous T-Beams Using Different Layers of CFRP Strips", Journal of Advanced Research, (2015), Vol: 5, pp. 67 – 77.
8. Mohamed H. Mahmoud; Hamdy M. Afefy; Nesreen M. Kassem; Tarek M. Fawzy, Year: 2014, "Strengthening of defected beam-column joints using CFRP", Journal of Advanced Research (2014),



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Vol: 5, pp. 67 – 77.

9. Ciro Faella; Carmine Lima; Enzo Martinelli; Annalisa Napoli; Roberto Realfonzo; JG Ruiz Pinilla, Year: 2012, “Seismic Upgrade of Exterior RC Beam-to-Column Joints with CFRP Jacketing: Experimental Investigation”, International Journal of Engineering Science and Technology (2012), Vol: 27.
10. R. V. S. Ramakrishna; V. Ravindra, Year: 2012. “Experimental investigation on rehabilitation of reinforced cement concrete interior beam-column joints using CFRP and GFRP sheets”, International Journal of Engineering Science and Technology (2012), Vol: 4, no: 3, pp. 874 – 881.
11. S. S. Al Kamaki; Riadh Al Mahaidi; Ahmeds Mohamed, Year: 2012, “Effectiveness of CFRP strengthening of concrete with recycled waste”, Recent trends and construction technology and management (2012).
12. Mehran Gholami; Abdul Rahman Mohd Sam, Year: 2012, “CFRP strengthening systems focusing environmental performance”, Fiber-Reinforced Polymer-Based Composites: Processing, Characterization and Performance, Vol: 2.
13. Kambiz Narmashiri; N. H. Ramli Sulong, Year: 2012, “Failure analysis and structural behavior of CFRP strengthened steel beams”, Engineering structures (2011), Vol: 283.
14. Tomasz W. Siwowski; Paulina Siwowska, Year: 2011, “CFRP strengthened steel beams”, Composites part B: Engineering, Vol: 156.
15. Nangallage Dilum Fernando, Year: 2010, “Bond behaviour and debonding failures in CFRP-strengthened steel members”, Maintenance, management life cycle design and performance volume.
16. Mehran Ameli; Hamid R. Ronagh; Peter F. Dux, Year: 2010, “Fiber reinforced plastics (FRPs) for flexural and shear strengthening of reinforced concrete beams”, Materials Science Forum, Vol: 866.
17. G. Al Chami; M. Thériault; K.W. Neale, Year: 2010, “creep behavior of CFRP strengthened reinforced concrete”, Construction and building material, Vol: 201.
18. Hussien Abdel Baky, Usama A. Ebead, Year: 2010, “Flexural and interfacial behavior of FRP strengthened reinforced concrete beams”, Composite structures, Vol: 282.
19. Daniel Baggio; Khaled Soudki; Martin Noel, Year: 2009, “Strengthening of shear critical RC beams with various FRP system”. Construction and building material, Vol: 66.
20. O. F. Almuslehi; N. I. Fomin; T. K. Rutkauskas, Year: 2009, “Strengthening of reinforced concrete beams in a damaged building using carbon fiber materials”, Journal of Construction Science and Technology, Vol: 8.