To The Study of Retrofitting Method in RC Structure

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Abstract- *Repair and strengthening of damaged or vulnerable reinforced concrete structures is important in order to guarantee the safety of residents or users. Beams are important structural elements for withstanding loads, so finding the efficient repair and strengthening methods are necessary in terms of maintaining the safety of the structures. This research study investigated various repair, retrofit, and strengthening techniques for reinforced concrete beams. The comparison and summary of each repair and strengthening method are provided in this thesis. The thesis involves the literature review of current experimental test of repair and strengthening techniques for reinforced concrete beams. Comparing the numerical investigation we can confirm that the deflection in the strengthened specimen is comparatively lesser than that of the un-strengthened specimen. It is observed that the stress in the specimen is better in the retrofitted with CFRP specimen when compared with the normal specimen without CFRP wrapping. 3. From the overall study, it can be concluded that the strengthening with CFRP structure will increase the serviceability of the structure. CFRP laminates reduces the deformation and stress 59% and 15.79% respectively With the help of this Simulative results we conclude that CFRP laminates provide more strength to the structure.*

Keywords- FRP, FEM, Ansys, CFRP, Roof Joint, RC Structure.

I. INTRODUCTION

There is a considerable number of existing concrete structures in India that do not meet current design standards because of inadequate design and construction or need structural up gradation to meet new seismic design requirements because of new design standards, deterioration due to corrosion in the steel caused by exposure to an aggressive environment and accident events such as earthquakes. Inadequate performance of this type of structures is a major concern from public safety standpoint. Strengthening or upgrading becomes necessary when these structural elements cease to provide satisfactory strength and serviceability. Fiber Reinforced Plastic (FRP) composites can be effectively used as an external reinforcement for upgrading such structurally deficient reinforced concrete structures. One major application of composites to structural retrofit is to increase the flexure and shear capacity of the beams. Strengthening of RC flexural and shear beams with external bonded FRP laminates and fabric has been studied by several investigators. Only recently, researchers have attempted to simulate the behavior of reinforced concrete strengthened with FRP composites using finite element method. Researchers used finite element method to simulate the behavior and failure mechanisms of RC beams strengthened with FRP plates. The FRP plates were modeled using two dimensional plate elements. Few researchers in their study used truss elements to model the FRP composites. Some researchers used the finite elements adopted by ANSYS to model the uncracked RC beams strengthened for flexure and shear with FRP composites. Solid 65 elements were used to model the FRP composites. It has been observed that comparisons between the experimental data and the results from finite element models showed good agreement. In this paper, using finite element method an attempt has been made to study the behavior of retrofitted RCC beams and unretrofitted reinforced concrete beams that is the Control Specimens, subjected to Uniformly distributed loading producing bending as well as deformation. The finite elements adopted by ANSYS were used for this study, that is for analyzing the RCC beams retrofitted using Bamboo Fiber Reinforced Composite, which is a natural fiber. Composite materials from man-made fibers (i.e. glass fiber, carbon fiber etc.) are already available as products for consumer and industrial uses. A relatively newer concept is to consider natural fibers as a reinforcing material. Stringent environmental legislation and consumer awareness has forced industries to support long term sustainable growth and develop new technology based on renewable feedstock that are independent of fossil fuels. As the current status quo, the main reinforcement for the composite industry is glass fibers; 22.3 million tons (metric) are produced globally on an annual basis. Although glass fiber products have somewhat superior mechanical properties, their life cycle performance is very questionable. Manufacturing of these products not only consume huge energy but their disposal at the end of their life cycle is also very difficult since there is virtually no recycling option. Annual industrial crops grown for fiber have the potential to supply enough renewable biomass for various byproducts including composites. The scope of possible uses of natural fibers is enormous. This is substantiated by the declaration of United Nation for 2009 as International Year of Natural Fibers (IYNF).

In recent years, the use of fiber reinforced polymers (FRP) as an externally strip have achieved considerable popularity for the strengthening and repair of concrete structures. The FRP composites have been used successfully for rehabilitation and strengthening of deficient reinforced concrete elements.

In reinforced concrete frames, T connections (exterior beam column joint) have recognised as a weaker components when subjected to cyclic lateral loads. Several damages of connection in general and of a T connection in a particular section may cause deterioration of whole performance of frame. Many RC frames are originally designed to carry only gravity loads. They lack the ductility and strength to present a global failure mechanism caused by cyclic loading conditions. These structures typically have a non-ductile reinforcement at the beam column joint areas in terms of inadequate transverse reinforcement and strong column weak beam design. Strengthening of existing reinforced concrete structures is now a major part of construction activity all over the world. The RCC structures constructed across the world are often found to exhibit distress and suffer damage, even before service life is over due to several causes and earthquakes, corrosion, overloading, change of code provisions, improper design, faulty construction explosions and fire. For all framed structures the most important is beam column joint, and the structural design of joint is neglected during the design stage, attention is only resisted to provision of sufficient anchorage for the beam. Unsafe design and detailing within the joint is dangerous for the entire structure, even though the structural members themselves may confirm to the design requirements. It is well known that joint region in reinforced concrete framed structures are recognized as very critical as it transfer the forces and bending moments between the beams and columns. In most cases during extreme loading, the beam column joints, if not designed properly are the most vulnerable component. With the advent of revised design and detailing codes and detailing codes and increase in the earthquake vulnerability level of many regions, the existing structures needs retrofitting and strengthening.

1.2 Types of Beam Column Joints

Beam column joints are generally classified with respect to geometrical Configuration and identified as interior, exterior and corner joints. The fundamental differences in mechanism the shear requirements, two types of joints such as interior joint and exterior joint are considered. With respect to the plane of loading, an interior beam-column joint consists of two beam on either side 5 of the column and an exterior beam-column joint has a beam terminating on one face of the column.

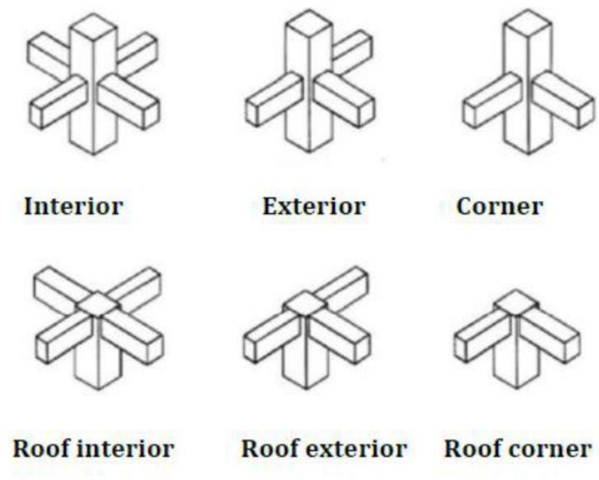

Figure: 1.1 Different types of joints

1.3 Carbon Fibre Reinforced Polymer

Carbon fiber-reinforced polymer, carbon fiber-reinforced plastic or carbon fiber-reinforced thermoplastic (CFRP, CRP, CFRTP) or often simply carbon fiber, or even carbon), is an extremely strong and light fiber reinforced polymer which contain carbon fiber. The reinforcement will give the CFRP its strength and rigidity; measured by stress and elastic modulus respectively. Unlike isotropic materials like steel and aluminium, CFRP has directional strength properties. The properties of CFRP depends on the layouts of the carbon fiber and the proposition of the carbon fibers relative to the polymer. Despite its high initial strength to weight ratio, a degree limitation of CFRP is its lack of a definable endurance limit. This means theoretically that stress cycle failure cannot be ruled out.The results obtained from different investigations regarding enhancement in basic parameters like strength/stiffness, ductility and durability of structural members retrofitted with externally bonded FRP composites, though quite encouraging, still suffers from many limitations. This needs further study in order to arrive at recognizing FRP composites as a potential full proof structural additive.

1.3.1 Advantage for CFRP

- High tensile strength
- High strength to weight ratio
- Low weight to volume ratio
- Excellent fatigue behavior
- Quick application

CFRP composite was able to strengthen the shear capacity as well as the ductility of beam column joint.

1.3.2 Advantages and Disadvantages of FRP

Advantages:-FRP materials have higher ultimate strength and lower density as compared to steel. When these properties are taken together they lead to fiber composites having a strength/weight ratio higher than steel plate in some cases. The lower weight of FRP makes installation and handling significantly easier than steel. These properties are particularly important when installation is done in cramped locations. Other works like works on soffits of bridges and building floor slabs are carried out from man-access platforms rather than from full scaffolding. We all know that steel plate requires heavy lifting gear and are to be held in place while the adhesive gains its strength and bolts are fitted through the steel plate into the parent concrete to support the plate while the adhesive cures.

Disadvantages:-The main disadvantage of externally strengthening structures with fiber composite materials is the risk of fire, vandalism or accidental damage, unless the strengthening is protected. A particular concern for bridges over roads is the risk of soffit reinforcement being hit by over-height vehicles. However, strengthening using plates is generally provided to carry additional live load and the ability of the unstrengthened structure to carry its own self-weight is unimpaired. Damage to the plate strengthening material only reduces the overall factor of safety and is unlikely to lead to collapse. Experience of the long-term durability of fiber composites is not yet available. This may be a disadvantage for structures for which a very long design life is required but can be overcome by appropriate monitoring.In recent years, RCC jacketing is commonly used to increase the seismic strength of a R.C framed structure, for rehabilitation of structures damaged by an earthquake or for strengthening of an undamaged structure made necessary by revision on structural design or for taking additional loads.

1.3.3 Jacketing Techniques:- Jacketing is one of the most frequently and popularly used technique to strengthen reinforced concrete structures. It is mostly for strengthening the R.C columns. With this method, axial strength and stiffness of the original column is increased. Jacketing is a process of fastening durable material over concrete and filling the gap with grout. Jacketing restores the section of an existing member by encasement in a new concrete. This technique is applicable for protecting the member against further deterioration as well as for strengthening. Strengthening of existing structures is needed when – a) Load carried by the column is increased due to either increasing the number of floors or due to mistakes in the design. b) The compressive strength of the concrete or the percentage and type of the reinforcement is not according to the codes requirement.

1.3.4 Jacketing of Column

Column failures have caused the most significant failures of reinforced concrete structures. To prevent the column failure mechanism during earthquakes, column should never be the weaker components in the whole structure. Practical methods available for strengthening existing R.C column include adding concrete jackets, steel jackets, FRP jackets, external prestressing wires, strands or belts and steel collars.

1.4 RCC Jacketing Of Column

RCC jacketing of column consists of adding concrete with longitudinal and transverse reinforcement around the existing columns. Additional concrete and reinforcement contributes to the increase in strength. Reinforced concrete jacketing can be employed as a repair or strengthening scheme. R.C.C jacketing increases the member size significantly, also increases the member’s stiffness and is useful where deformations are to be controlled. Shear and axial load carrying capacity of the structural members can be enhanced by this method.

Figure: 1.4 Picture showing column jacketing

Deep beams serve many applications in buildings and other structures. In some cases, openings through structural members are frequently required. Deep beams, due to nonlinear strain and complex stress distributions, are classified as D-regions. Bernoulli’s hypothesis cannot be applied to these members. In other words, shear deformations against bending deformations cannot be ignored in such a member. Strut and tie method could be considered as a powerful method for the direct design of these members. STM design idealizes a deep member with concrete compressive struts connected with steel tensile ties at nodes as frictionless pins. In other words, STM reduces the complex states of stress in a simple truss, comprised of uniaxial stress paths. Those members deigned based on STM generally have limited postpeak ductility. Choosing inappropriate truss models may result in unacceptable cracks under service loads. The resulting reinforcement layouts based on this method are usually extremely complicated. There are several experimental studies on using SFRC in deep beams with and without opening. Using SFRC in such members provides a better crack control and increases first crack strength. SFRC might cause more widespread cracks in deep beams.

1.5 Flow of Retrofitting Process

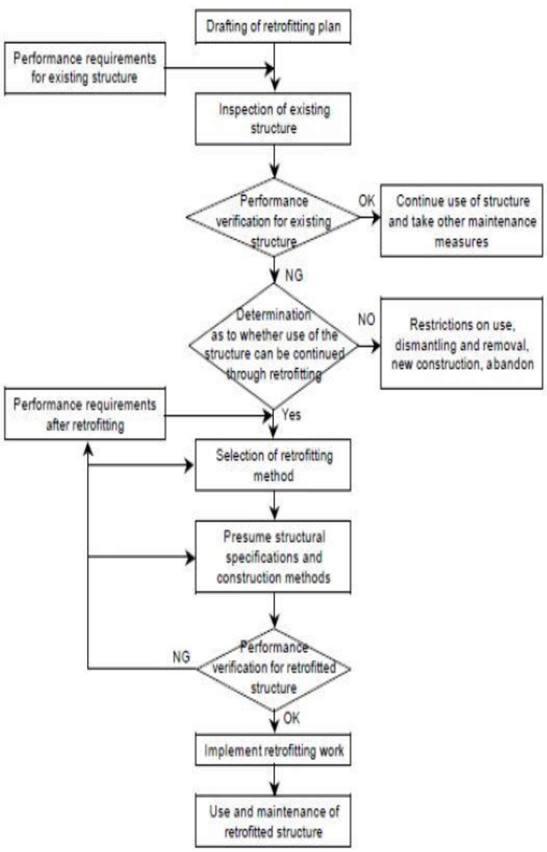

Figure: 1.5 Flow of retrofitting process

1.6 Materials

The characteristics of materials in existing structures to be retrofitted may differ from those assumed when the structure was first designed and built, due to various factors at the construction stage as well as load action and environmental action during use. In retrofitting design, this must be considered and the design values for the materials in existing members must be determined. Even materials not covered here should be verified for quality before use. The design values for materials in existing structures used for retrofitting design shall be determined in accordance with inspection results.

(1) Characteristic values

The characteristic values for materials in the existing structure, after consideration of the variations in measurements obtained through inspections, shall be those that ensure that most of the measurements will not fall below those values. When sections are missing due to corrosion or the like, the cross-sectional area for steel shall be determined using measurements or recommended values calculated with appropriate methods.

(2) Material factors

As a rule, the material factors for materials in the existing structure shall be determined in accordance with the Standard Specification. When the characteristics of materials in the existing structure are different from those assumed at the time the structure was first built, or when the status of use after retrofitting will be different, material factors apart from the values in the Standard Specification shall be determined.

1.7 Steel Plates

(1) The quality of steel plates shall be indicated by their tensile strength and other strength properties, Young's modulus and other deformation properties, and thermal properties and other material characteristics. Steel plates must be those for which weldability and bonding with adhesives can be ensured when necessary.
(2) The surface of steel plates must be suitably protected to prevent their quality from changing over time.

1.7.1. Continuous Fiber Sheets

(1) The quality of continuous fiber sheets shall be indicated by their tensile strength and other strength properties, Young's modulus and other deformation properties, and thermal properties and other material characteristics.
(2) As a rule, the surface of continuous fiber sheets shall be protected to prevent their quality from changing over time.

1.7.2. Adhesive

(1) The adhesive used to bond the concrete and reinforcing material must be one that can ensure the required bonding strength.
(2) The adhesive used for the overlap splices for the reinforcing material must be one that can ensure the strength of the overlap splice section.

(3) The impregnation/adhesive agent used for the continuous fiber sheet bonding method must be one that ensures the strength, Young's modulus and other quality requirements of the continuous fiber sheets as a fiber bonding material.
(4) The adhesive must be one with suitable viscosity, shrinkage and other characteristics in keeping with the coating, fill or other construction method.

1.7.3. Fill Material

(1) The fill material used with the jacketing method must have the required fill properties and fluidity and must be able to seal the reinforcing material to the concrete.
(2) The fill material must form a thick hardening body and must transmit stress effectively between the reinforcing material and the concrete frame.

1.7.4. Cement-Based Reinforcing Material

(1) The quality of cement-based reinforcing material shall be indicated by the compressive strength, tensile strength and other strength properties, Young's modulus and other deformation properties, and thermal properties, water tightness and other material properties needed to evaluate the performance of the retrofitting structure.
(2) As a rule, good quality materials shall be selected for use in cement-based reinforcing materials, and trial mixing using an appropriate mixing design method shall be performed to determine the ideal mixture, so there will be as little change as possible in the quality over time after hardening.

II. LITERATURE REVIEW

[1]N.Naveeena, M.Ranjitham (2016) In reinforced concrete structures, beam column joint are considered as most damageable structural element subjected to lateral loads. In the paper a finite element model for exterior beam column joints is presented to stimulate the seismic behaviour of RC existing structure with design criteria. The Retrofitting of existing structure is one of the major challenges in the modern civil engineering structures. This paper presents the jacketing method for strengthening or retrofitting of exterior beam column joint, to enhance their strength and stiffness. An analytical model is proposed to predict the shear capacity strengthened with carbon fibre reinforced polymer (CFRP).The axial load were applied at the column top of the surface and held constant during the test. The free end of the beam subjected to cyclic loading Two specimen one is unstrengthened and another is strengthened specimen with CFRP were modelled and analysed. An effective re-habitation strategy is in order to increase the ductility of the beam column joint and transfer the failure mode to beam or delay the shear failure mode. The specimens are then loaded with step by step load increment procedure to stimulate the cyclic loading in testing. The stress and deformation results were evaluated and compared their results with strengthened and unstrengthened specimen. The numerical result shows that the beam column joint strengthened with CFRP can increase their structural stiffness, strength and energy dissipation capacity.

[2]WhaBai(2003) Many existing structures located in seismic regions are inadequate based on current seismic design codes. In addition, a number of major earthquakes during recent years have underscored the importance of mitigation to reduce seismic risk. Seismic retrofitting of existing structures is one of the most effective methods of reducing this risk. In this report, the characteristics of various intervention techniques are discussed and the relationship between retrofit and structural characteristics is also described. In addition, several case study structures for which retrofit techniques have been applied are presented.

[3]R.K.L. Su and Y. Zhu (2005) This paper aims to develop a new method for strengthening reinforced concrete coupling beams. Experiments were conducted to test three full-scale RC coupling beams, of which two were strengthened by bolted external steel plates on the side faces of the beams and the other one acted as a control specimen without strengthening. Numerical parametric study found that the small slip (>3mm) between the bolt connection and the concrete wall could significantly affect the load carrying capacity of the bolt connections as well as the structural performance of the strengthened coupling beams. The numerical model developed is very useful for investigating strengthened beams with other configurations and other reinforcement details.

[4]F. Nateghi-Elahi and A. Dehghani (2008) It is obvious from experience that structures which had not been designed and constructed according to standard codes, and therefore do not have enough lateral stiffness, will undergo sever damages during intense earthquakes. In this article, the method of Equivalent Strut for modeling infill walls is analyzed with the aid of finite element (FE) procedure, and then by defining the compressive and tensile strut behavior, URM infills are modeled both in un-retrofitted and retrofitted states. The results of nonlinear push-over analysis show that the proposed model can give the behavior close to the experimental specimens.

[5]G. Genesio, R. Eligehausen, A. Sharma & S. Pampanin(2010) In reinforced concrete framed structures under seismic excitations the beam-column joint cores are arguably one of the most vulnerable zone. Experimental tests have shown that the structural behavior of poorly detailed joints is decisive for the structural response of older frame buildings. In this study exterior beam-column joints designed for gravity only (or mainly) loads as typical of old code provisions are considered. Experimental investigations were conducted in the laboratory of the Bhabha Atomic Research Centre (BARC) in Mumbai. Three exterior beamcolumn joints characterized by lack of shear reinforcement in the joint panel and by different anchorage solutions commonly used in the construction practice until the beginning of the 1970s were tested. The capability to numerically reproduce the joint behavior was discussed and the influence of several parameters such as bond of longitudinal reinforcement of beam and column and shape of the anchored bars were investigated. The results were compared with the available data described in the literature and found in the tests.

[6]SuatYildirim, GoktugAsik, BarisErkus, YuceYetimoglu, YukselTonguc, ImadMualla (2014) This paper presents retrofit project of a reinforced concrete building using friction dampers. The building is an 8-story government office building, where disturbance of the operations cannot be allowed. Preliminary studies shows that this building, which was designed and built using earlier Turkish seismic codes, do not satisfy the current Turkish seismic and structural code requirements.

A study based on conventional retrofit approaches is conducted, where some of the moment frames are converted to shear walls and jacketing or CFRF wrapping of columns are used. Conventional retrofit method requires vacating the building for the construction, which is estimated to be costly, considered to be problematic and which will disturb the operations of the office significantly.

[7]Tara Sen and H. N. Jagannatha Reddy(2011) Many of the existing reinforced concrete structures throughout the world are in urgent need of rehabilitation, repair or reconstruction because of deterioration due to various factors like corrosion, lack of detailing, failure of bonding between beamcolumn joints, increase in service loads etc. FRP composite has been accepted as a promising substitute for repairing and in incrementing the strength of RCC structures. Here a nonlinear finite element analysis is carried out in order to evaluate the performance of Bamboo fibres in structural retrofitting by retrofitting a Plain Concrete Block by using Bamboo fibre reinforced polymer. It is seen that the strengthened specimens exhibit significant increase in strength, stiffness, and stability as compared to controlled specimens.

[8]P. Bhuvaneshwari and K. Saravana Raja Mohan (2015) The restoration of strength and stiffness of damaged reinforced concrete beams with deficient reinforcements, through retrofitting, was experimentally and numerically studied. Retrofitting is carried out by wrapping glass fiber strips using cement-based composite binders. Six beams of size 1500mm (length) x100mm (width) x 150mm (depth) have been tested in four-point bending. It is concluded that the ultimate load and moment carrying capacity were restored in preloaded retrofitted beams. The stiffness and energy absorption are improved in preloaded wrapped beams with deflection at ultimate load being reduced.

III. OBJECTIVE OF THE STUDY

The purpose of this study is to highlight the methods of repair and rehabilitation to be undertaken for structures with defects and deficiencies that necessitate rehabilitation. Repair and Rehabilitation methods currently used are reviewed on the basis of present knowledge and the merit of a holistic system approach. This study focuses on visible symptoms of the problem rather than on visible and invisible problems as well as the possible causes behind them. This thesis focuses about the repair materials and the techniques are essential for the satisfactory performance of the repaired structure. The main objective of this thesis is to study about the strength and serviceability of the CFRP retrofitted beam column Roof joint. We want to study in many areas by FEM method is-

- To develop an effective rehabilitation in order to strengthen the beam column joints to avoid or delay their shear failure.
- To increase the shear capacity of beam column joint using carbon fiber reinforced plastic materials
- To improve the seismic performance of damaged building in terms of lateral strength and serviceability.
- To determine the load deflection behaviour of damaged beam column joint strengthened with CFRP when it is subjected to cyclic loading
- To compare the behaviour of un-strengthened and strengthened specimen.

IV. PROBLEM FORMULATION

4.1 Structure Dimension

Size of the column 150 x 200 mm
Size of the beam 150 x 200 mm

Height of column 800 mm
Length of the beam 600 mm

4.2 Steel Reinforcement Details

COLUMN: 4 no's of 12 mm diameter longitudinal reinforcement. 8mm diameter bars @ 150mm C/C distance.
4.3 Beam **:**4 no's of 12 mm diameter bars 8mm diameter bars @ 100 mm C/C distance Steel reinforcement To model concrete reinforcing, discrete modelling is used by assuming that bond between steel and concrete is 100 percent. Beam column has six degree of freedom at each node. These include translations in the x, y, z directions and rotations about the x, y, z directions. This element is well-suited for linear, large rotation, and large strain nonlinear applications.

4.3 Laminates

To model laminated composites SHELL 91 is used. It may be used for layered applications of a structural shell model or for modelling thick sandwich structures. Up to 100 different layers are permitted for applications with the sandwich option turned off. When building a model using an element with fewer than three layers SHELL91 is more efficient than SHELL 99.

V. METHODOLOGY AND RESULTS

1 .CAD MODEL

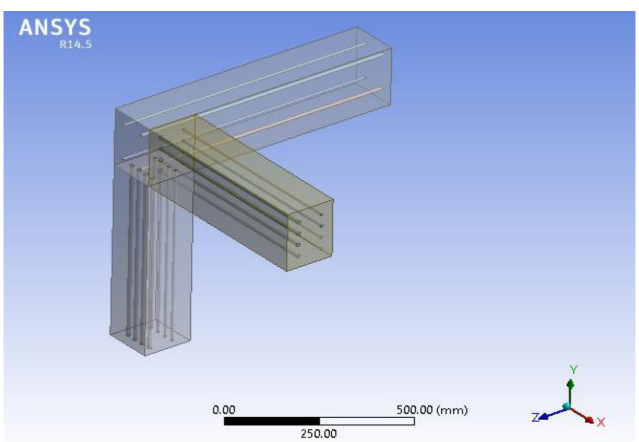

Figure: 5. i. Cad model of steel reinforced roof joint

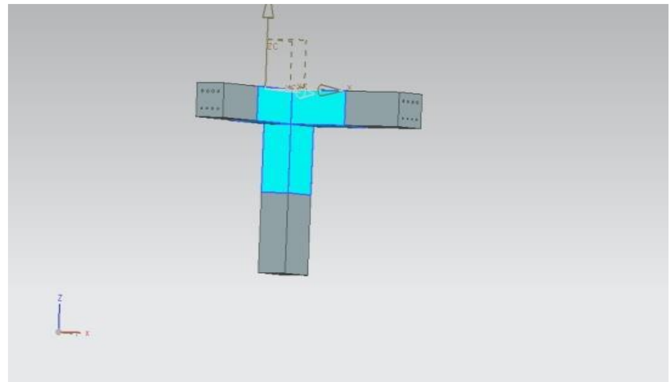

Figure: 5.ii Cad model of CFRP reinforced roof joint

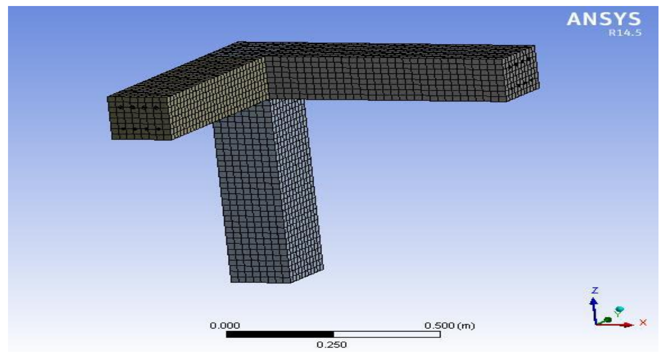

Figure: 5.iii Mesh model of steel reinforced roof joint

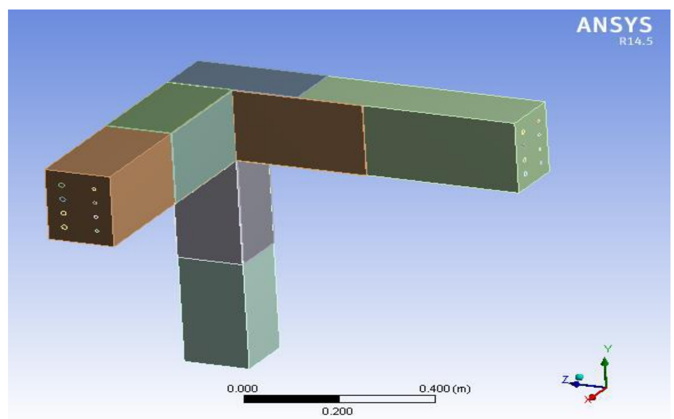

Figure: 5.iv Cad model of CFRP reinforced roof joint

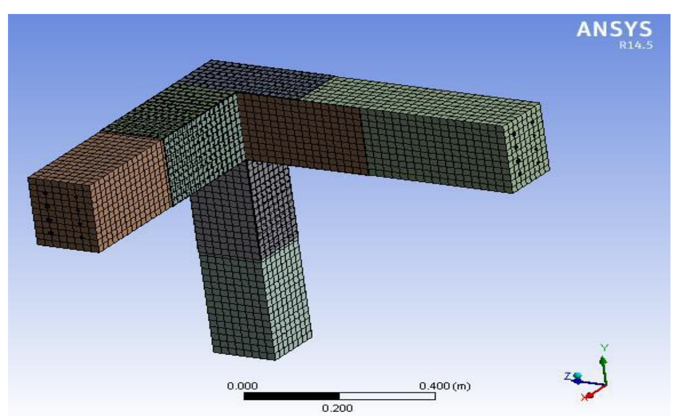

Figure: 5. v Mesh model of CFRP reinforced roof joint

Table: 5 Material Properties

Material used	Modulus of Elasticity (E)	Poisson's Ratio (μ)
Unreinforced concrete	E= 22.36×109N/m2	μ=0.23
CFRP Sheet	E=181×109 N/m2	μ=0.24
Steel	E=2x1011 N/mm2	μ=0.3

5.1 ROOF JOINT WITHOUT CFRP WRAPPING

The structural geometry of exterior beam column joint has been modelled for the mentioned dimension and analysed using ANSYS. The exterior beam column joint has been analysed without CFRP wrapping. The bottom of the column is constrained in all degree of freedom. The load of 30KN is applied on the beam.

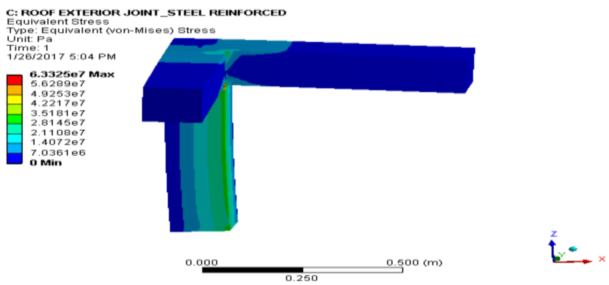

Figure: 5.1.i Stress in steel reinforced roof joint

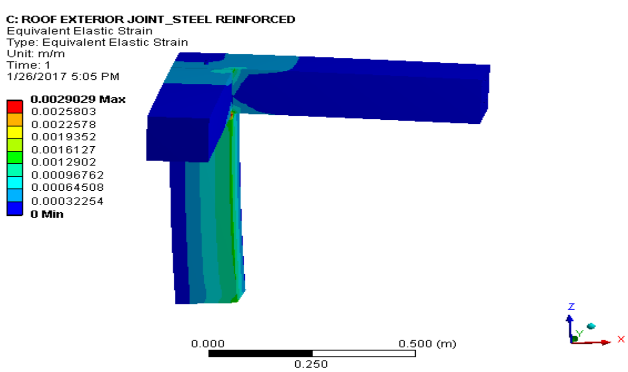

Figure: 5.1.ii Strain in steel reinforced roof joint

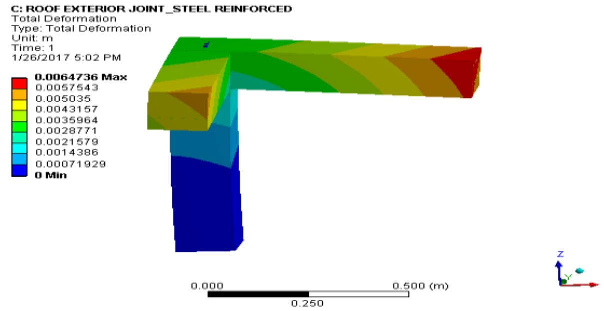

Figure: 5.1.iii Deformation in steel reinforced roof joint

3. ROOF- COLUMN-BEAM JOINT WITH CFRP WRAPPING

The structural geometry of Roof–column-beam joint has been modelled for the mentioned dimension and analysed using ANSYS. The roof joint has been analysed with CFRP wrapping. The bottom of the column is constrained in all degree of freedom. The cyclic load of up to 30KN is applied on the beam. The thickness of wrapping of CFRP is 2 mm. Poison ratio is 0.24young modulus 181x109 N/mm2 And it is wrapped on 300mm length on all sides.

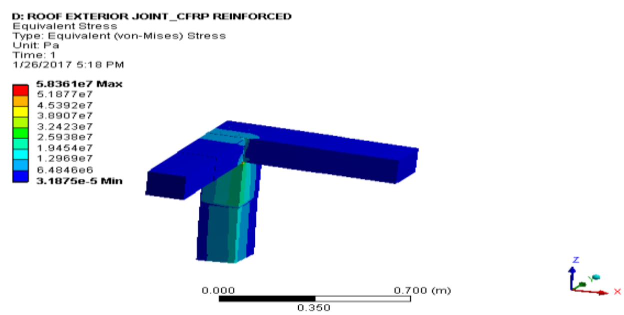

Figure: 5.1.iv Stress in CFRP reinforced roof joint

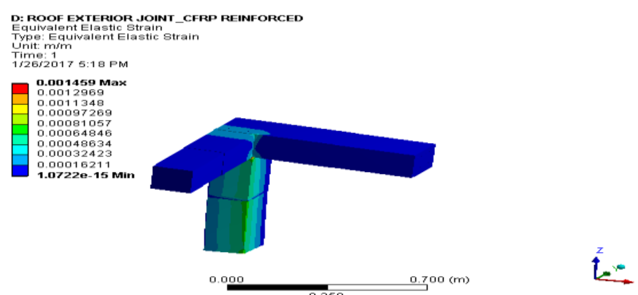

Figure: 5.1.v Strain in CFRP reinforced roof joint

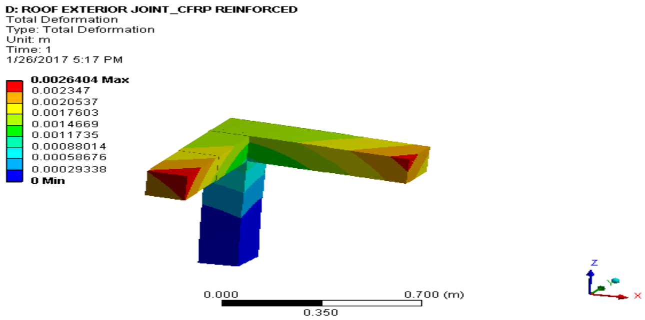

Figure: 5.1.vi Deformation in CFRP reinforced roof joint

Table: 5.1 Result Table

MATERIAL	STRESS (N/M2)	DFORAMATION (mm)	STRAIN
STEEL REINFORCED	6.33e7	6.47	0.0029029
CFRP LAMINATES	5.83e7	2.64	0.001459

VI. CONCLUSION AND FUTURE SCOPE

In this chapter the numerical results of both with CFRP wrapping and without CFRP wrapping are analyzed. Their behaviour throughout the analysis is studied from the recorded data obtained from the deflection behaviour and load carrying capacity using ANSYS. The strengthened and un-strengthened beam column joints are tested for their ultimate strength.

1. The load deformation characteristic is improves to the large extent in case of retrofitted specimen over un-strengthened specimen. 59% Reduction of deformation is carried out in CFRP laminates as compare to the Steel reinforced structure.
2. 15.79% reduction in stress value in CFRP laminates stricture as compare to the STEEL reinforced structure.
3. The ductility of the retrofitted specimen will be more when compared with the normal specimen.
4. CFRP retrofitting specimen of the beam column joint shifted the failure of the joint from column portion to the beam portion of joint which will prevent progressive collapse.

The following observations and conclusions can be drawn based on the analytical results of the study. 1. Comparing the numerical investigation we can confirm that the deflection in the strengthened specimen is comparatively lesser than that of the un-strengthened specimen. 2. It is observed that the stress in the specimen is better in the retrofitted with CFRP specimen when compared with the normal specimen without CFRP wrapping. 3. From the overall study, it can be concluded that the strengthening with CFRP structure will increase the serviceability of the structure.

6.1Future Scope

1. Different RC Structure can be taken.
2. Different wrapping length of CFRP can be Taken.
3. Various thicknesses of CFRP Sheets can be apply.
4. Different FRP'S like Carbon fiber-reinforced polymer, carbon fiber reinforced plastic or carbon fiber-reinforced thermoplastic (CFRP, CRP, CFRTP) or often simply carbon fiber, or even carbon) can be apply as a reinforced material for better strengthened.

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