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Experimental study on behaviour of beam-column joints with special confinements

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ABSTRACT

This paper presents the seismic behavior of beam-column joints with special confinement in the joint region along with different reinforcement detailing for anchorage of beam bars, confinement in joint and additional reinforcement in beam and column. External confinement is carried out by glass fiber reinforced polymer(GFRP).The performance of the specimens are compared in terms of lateral load- versus displacement curves. The dimensions of the specimens were fixed to be 0.2m x 0.2m cross section and the height of the column was fixed as 1m and the cantilever length of the beam was fixed as 0.6m to carry out the experimental work. Five numbers of exterior beam-column joints were designed according to Bureau of Indian Standards were cast and tested under lateral loading. The specimen was designed as per IS 456:2000 and IS 13920-1993 and reinforced accordingly with that. Out of five specimens three specimens were designed with special confinement one was control specimen and the final one was control + GFRP. Results by experimental and analytical shows that special confinement specimen carries more load carrying capacity than the control specimen and almost close to control + GFRP.

Introduction

In RC buildings, portions of columns that are common to beams at their intersections are called beam-column joints. Beam-column joints being the lateral and vertical load resisting members in RC structures are particularly vulnerable to failures during earthquakes and hence their confinement is the key to successful seismic strengthening strategy. Beam column joints in a reinforced concrete moment resisting frames are crucial zones for transfer of loads effectively between the connecting elements (i.e. beams and columns) in the structure. In normal design practice for gravity loads, the design check for joints is not critical and hence is not usually done. But, the failure of reinforced concrete frames during many earthquakes has demonstrated heavy distress due to shear in the joints that culminated in the collapse of the structure.

Strengthening the RC structural members is done by internal and external confinement. Internal confinement is done by different detailing using various standards and the external confinement of concrete by Glass Fibre Reinforced Polymer. Both techniques are significantly enhance the strength and ductility as well as result in large energy absorption capacity of structural members and used to strengthen a variety of RC elements to enhance the flexural, shear, and axial load carrying capacity of elements.

In this thesis an attempt has been made to study an experimental study on behavior of reinforced concrete beam-column joints with special confinements.

Objectives

This investigation was carried out to study the behavior of the beam-column joint under cyclic loading. In more specific terms this research was conducted to achieve the following objectives

- Strengthening the beam column element using internal and external confinement under seismic loading.
- To enhance the flexural, shear, and axial load carrying capacity of elements.
- Compare the results of internal and external confinement under cyclic loading.
- Finite element modeling of beam-column joint will carry out under cyclic loading.

Experimental Programme

HSC mix proportion for M 50 grade concrete was obtained based on the guidelines given in IS 10262 : 2009. Portion of the cement was replaced by micro fillers, such as silica fume and fly ash. In this study 10% replacement of cement by silica fume and 15% by fly ash were considered. To increase the workability of concrete super plasticizer was added. The HSC mix proportion was M 50 grade concrete

The dimensions of the specimens were fixed to be 0.2m x 0.2m cross section and the height of the column was fixed as 1m and the cantilever length of the beam was fixed as 0.6m to carry out the experimental work in the laboratory. The grade of concrete proposed was M50 and the grade of steel was Fe 415. The performance of the specimens are compared in terms of lateral load- versus displacement curves. Five numbers of exterior beam-column joints were designed according to Bureau of Indian Standards were cast and tested under lateral loading. The specimen was designed as per IS 456:2000 and IS 13920-1993 and reinforced accordingly with that. Out of five specimens three specimens were designed with special confinement one was control specimen and the final one was control + GFRP.

Test setup and Loading

The reinforced concrete beam-column joint specimens were tested using loading frame in the structural laboratory. A push jack was set up in structural laboratory. Both the column ends were provided fixed boundary conditions. A transverse load was applied at the free end of the beam by using a hydraulic jack of 500 kN capacity. A deflectometer was placed on the other side

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of the beam which shows the deflection that occurs at the point of application of load on the beam. The testing involves pushing of the beam using the push jack by applying the load in the pushing direction up to ultimate failure and deflection was measured for each 20KN loading.

Details of test specimens

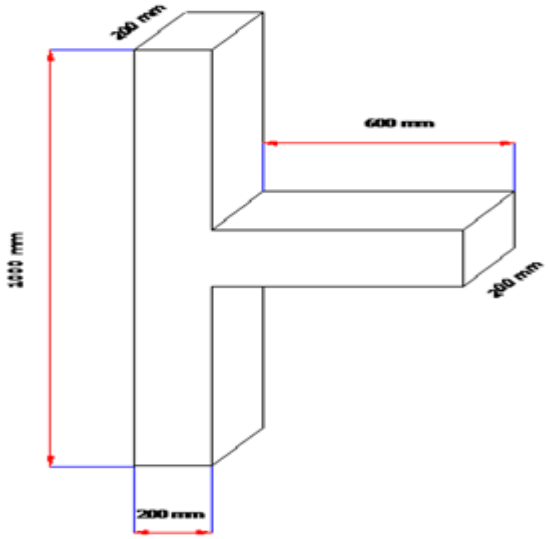


Fig 1. Beam-Column Joint Specimens

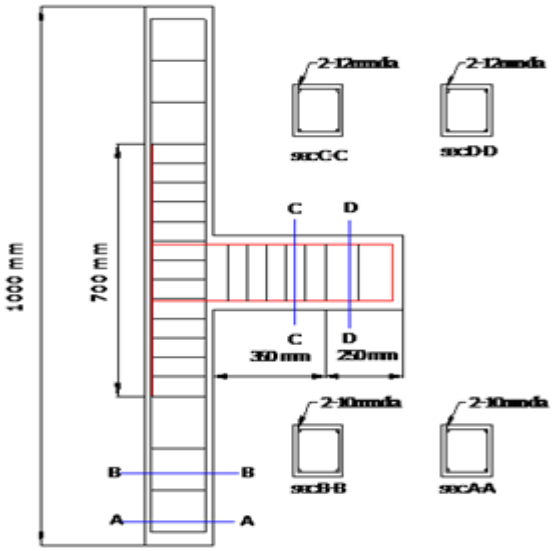


Fig 2. Reinforcement Details of Beam-Column Joint Specimen

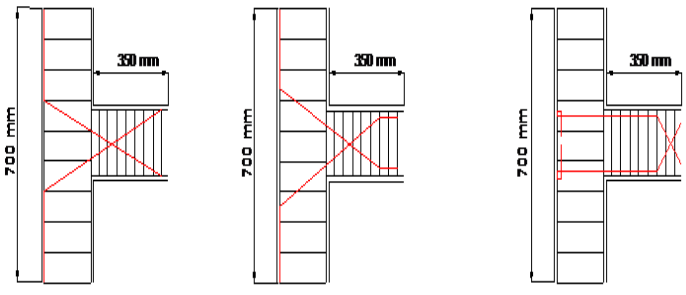


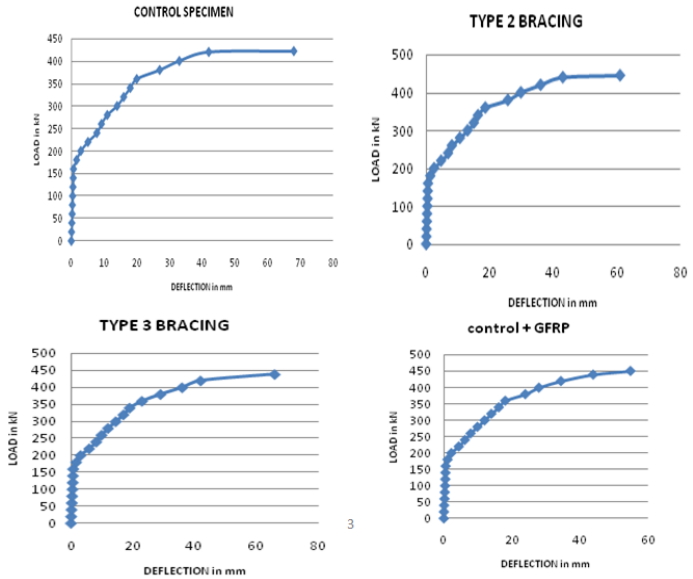
Fig 3 Fig 4 Fig 5

Fig 3 Indicates specimen having longitudinal beam bars with inclined anchorage (Bracing 1)

Fig 4 It had four inclined bars that extend from column portion above the joint and two from the column portion below the joint (Bracing 2)

Fig 5 It provided with four supplementary bars in beam, two at top and two at bottom which were intersected to form X shape (Bracing 3)

Special confinements



Analytical Programme

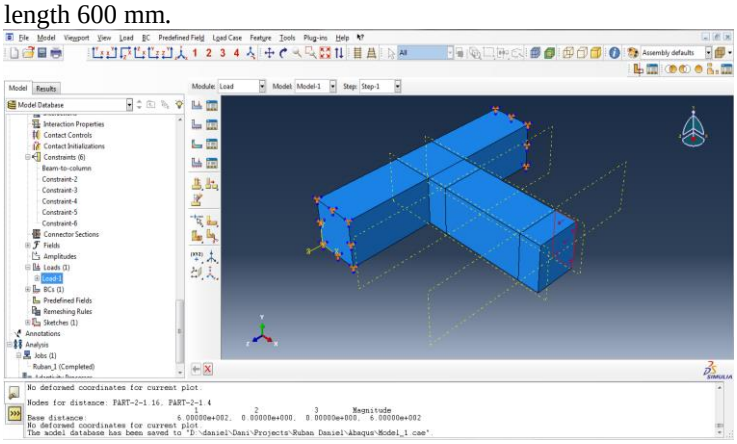
ABAQUS is a finite-element analysis software. Abacus provides a pre-processing and post processing environment for the analysis of models. It is used in a wide range of industries like automotive, aerospace etc., and also is extensively used in academic and research institutions due to its capability to address non-linear problems. The Finite Element Method (FEM) is a numerical analysis for obtaining approximate solutions to a wide variety of engineering problems. This has developed simultaneously with the increasing use of high-speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis.

Finite Element Modeling of Beam-Column Joints

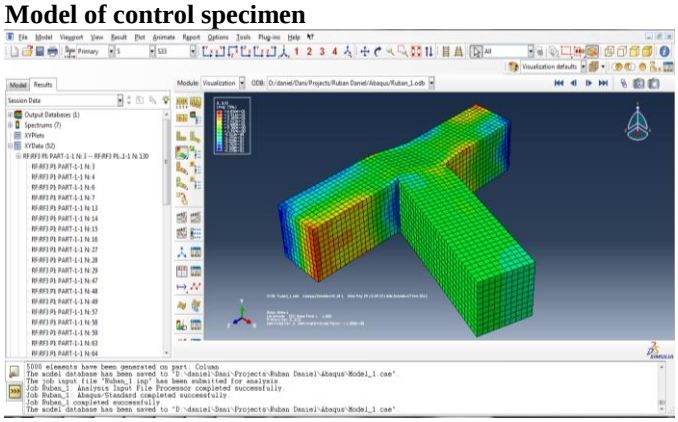
Modeling is one of the important features in Finite Element Analysis. It takes around 40% to 60% of the total solution time. Improper modeling of the structures leads to the unexpected errors in the solution. So, proper care should be taken for modeling the structures.

A good idealization of the geometry reduces the running time of the solution considerably. A three dimensional structure can be easily analysed by considering it as a two dimensional structure without any variation in results. So, creative thinking in idealizing and meshing of the structure helps not only in considerable reduction of time but also in reducing the memory requirement of the system.

In this study two models were created. Out of which one type had details as per code IS 456:2000 another had details as per code IS 13920:1993. The columns had a cross section of 200 mm x 200 mm with an overall length of 1000 mm and the beams had a cross section of 200 mm x 200 mm with a cantilever length 600 mm.

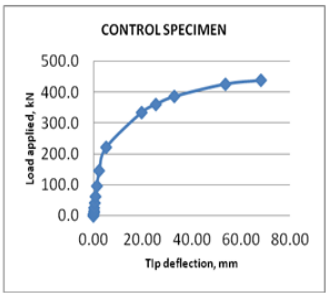


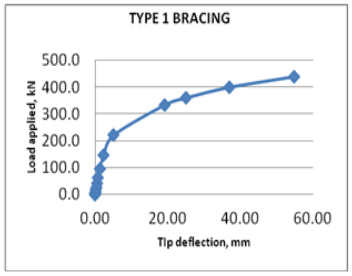
Model of control specimen

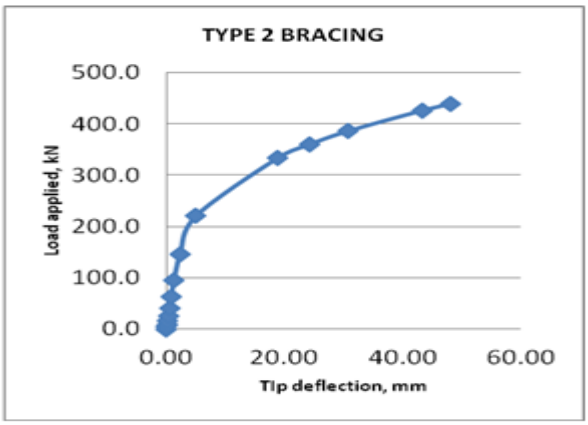


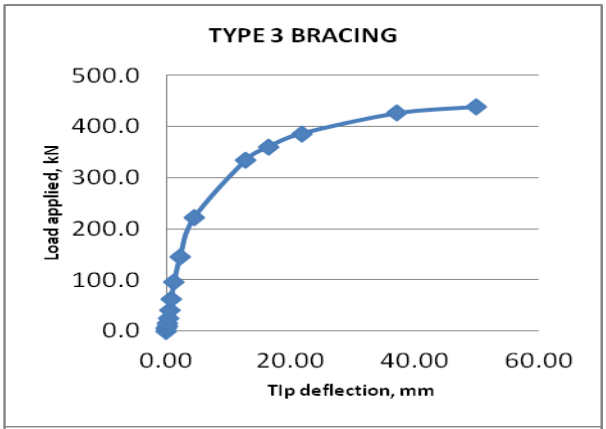
Stress contour of control specimen

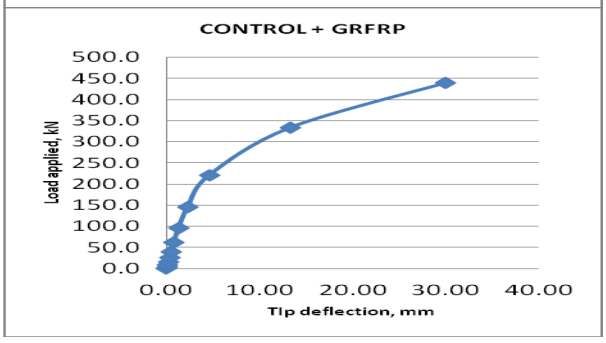
Results and Discussions

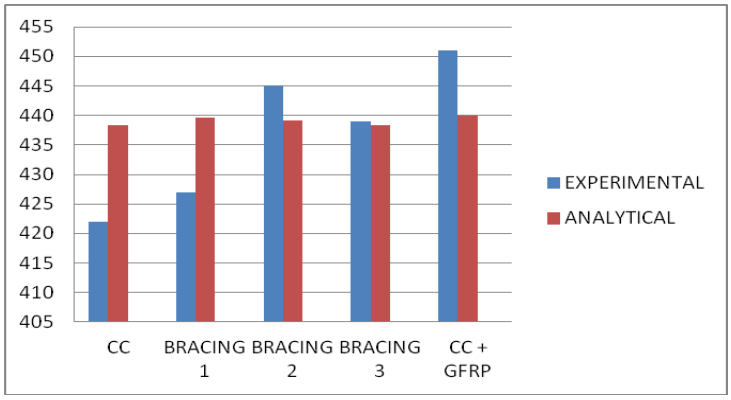












Comparison of Experimental and ABAQUS Load Carrying Capacity of Beam Column Specimens

Conclusions

- The load carrying capacity of type 1 bracing is 1.2% greater than the control concrete.
- Type 2 bracing is 5.4% more load carrying capacity than the control concrete.
- The load carrying capacity of type 3 bracing is 4.2% greater than the control concrete.
- Control + GFRP is 6.9% more load carrying capacity than the control concrete.
- The load-deflection results obtained from ABAQUS is very close to the load – deflection curve obtained from the experimental study.
- The ultimate load obtained in ABAQUS is lower than the values obtained from the experimental study.
- Comparison between the load-deflection results obtained from ABAQUS for control and confined specimens shows that the ultimate load has significantly increased for the special confined specimen.

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