Journal of Theoretical and Applied Information Technology
20th October 2013. Vol. 56 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

RETROFITTING OF COLUMNS WITH RC JACKETTING AN EXPERIMENTAL BEHAVIOR

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ABSTRACT

Columns are important structural elements in a multi storey building since it transmitting the entire loads to the foundation. If the columns are subjected to lateral loading due to wind/ earthquake, the load carrying capacity of the column member is substantially reduced. Hence the load carrying capacity of the compression member has to be increased. One way of increasing the load carrying capacity is by the way of confining the columns. There are a lot of confinement materials that are used for strengthening of concrete structures. Ferrocement, glass fiber, aramid fiber, carbon fiber, etc. are some of the few materials that are used in the confinement of concrete columns. Section enlargement is one of the methods used in retrofitting column concrete members. Enlargement is the placement of reinforced concrete jacket around the existing structural member to achieve the desired sectional properties and performance. This experimental study aims in assessing the behavior of such reinforced concrete columns confined with external Reinforced Concrete jacketing technique. This would enable in arriving at the effectiveness of the confinement in concrete columns in seismic regions. In this study we have tried with helical ties and vertical rods to improve the strength of column.

Keywords: *Multi Story Building Columns, Confinement Of Concrete, Section Enlargement, Effectiveness Of The Confinement In Concrete Columns*

1. INTRODUCTION

The dimensions of the column section is dictated, from a structural viewpoint, by its height and the loads acting on it which, in turn, depend on the type of floor system, spacing of columns, number of storey, etc. The column is generally designed to resist axial compression combined with (biaxial) bending moments that are induced by 'frame action' under gravity and lateral loads. When a column is subjected to an axial load within elastic limits, just like any other composite section, the stresses induced in steel and concrete are in proportion to their modules of elasticity, Es and Ec, respectively. The failure of the tied column occurs suddenly with the breaking down of concrete and the buckling of longitudinal bars between the ties in a pattern similar to that for a concrete cylinder in a compression test. On the other hand, a column reinforced with a spiral exhibits considerable deformation before complete failure on reaching the yield point, with the concrete shell outside the spiral spalling off. This reduces the load-carrying capacity because of the reduction of the concrete area, but the spiral prevents buckling of the longitudinal bars and confines the crushed concrete in the core. Thus, the spiral may offset the loss sustained due to loss of cover by an increase in the load-carrying capacity of the concrete core. An optimum volume of spiral shall result in the value of the failure load to be equal to the load carried at the time of the spalling of the cover concrete. Thus, the spiral adds little to the strength of the column but provides considerable ductility until the spiral steel yields and undergoes large deformations. The behavior of tied and spiral column is shown in Figure.1.

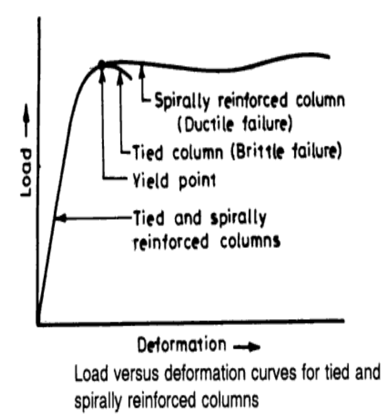

Figure.1: Behaviour Of Tied And Spiral Column

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2. REVIEW OF LITERATURE

2.1 Seismic Deficiency of RC Column

Identification of detailing deficiencies is significant in selection of mitigation strategies because acceptable performance often may be achieved by local adjustment of detailing rather than by adding new lateral force- resisting elements. The columns which suffer severe damage during earthquakes lack ductile design and detailing. Lack of confinement due to large tie spacing, insufficient development length, inadequate splicing of all column bars at the same section, hook configurations of reinforcements lack ductile detailing practices.

Longitudinal reinforcing bars under compression in columns are prevented from buckling by the lateral restraint provided by concrete. Under cyclic loading, that does not involve alternating flexure, the compression steel in the columns does not ordinarily buckle out of concrete, even at high strains or in the absence of restraining stirrups and ties. However when covering concrete subjected to high compressive stresses become unstable, the restraining effect is reduced and the bar buckles. Hence to ensure sufficient ductility, code limits are placed on the ratio of the distance between transverse reinforcement to the diameter of the longitudinal reinforcing bar. The buckling of column during earth quake as shown in Figure.2

Figure.2: Failure Of Column Due To Lateral Buckling Of Longitudinal Reinforcement

2.2 Seismic Retrofitting

Confinement of reinforced concrete columns significantly enhances the performance under axial load, bending and shear, because of the increase in concrete compressive strength, the increase in ductility, the increase in shear strength and the higher resistance against buckling of the steel reinforcement in compression. Over the years, different methods and techniques have been used to retrofit existing structures by providing external confining stresses. The confinement of the columns is achieved by means of internal lateral reinforcement (hoop or closed stirrups) or by external reinforcement (steel or FRP jackets). For the past few years, the concept of jacketing has been investigated to provide the confining forces. Externally applied jackets have been used as a reinforcement to contain concrete for different reasons. Traditional materials such as wood, steel, and concrete have been used to confine and improve the structural behavior of concrete members.

3. METHODS AND METHODOLOGIES

3.1. Confinement Techniques

Jacketing is one the most frequently used techniques to strengthen reinforced concrete columns. With this method, axial strength, bonding strength, and stiffness of the original column are increased. It is well known that the success of this procedure is dependent on the monolithic behavior of the composite element. To achieve this purpose, the treatment of the interface must be carefully chosen. The common practice consists of increasing the roughness of the interface surface normally an epoxy resin is applying a bonding agent.

The axial stress-strain behaviors of unconfined concrete columns differ significantly from that of the confined columns. The confining pressure is typically passive in nature. This means that the confining pressure is engaged by the transverse dilation of concrete accompanying principal axial strain, the so called Poisson effect. Passive confinement may be constant or variable through an axial load history. Confining pressure is increased in cases where the confining materials behave in a plastic manner. This is assumed to be the case where the confinement is provided by conventional transverse reinforcing steel which is yielding. Variable confining pressure is generated when the confining material has an appreciable stiffness. Variable passive confinement is dependent on the level and stiffness of confinement provided.

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3.2. Research Significance

It is necessary to arrive at an efficient method of retrofitting the damaged RC columns. A detailed experimental study has been carried out and the various parameters such as load deflection behavior, stress strain relationship

3.3. Experimental Program

Totally eighteen numbers of Columns specimen had been used for the experimental study. The details of the specimen are shown in Figure.3. For experimental model, the dimension of column was 150mm diameter with helical reinforcement has been used. Height of the Column was kept 1200mm. The main reinforcement used for the specimen was 6 numbers of 6 mm diameter bar. The lateral helical reinforcement 6mm spaced at 100mm c/c. IS specifications were used to investigate the test result.

Figure.3: Reinforcement Details Of The Specimen

Design mix of M 25 grade concrete (1: 1.85: 3.07) water cement ratio of 0.45 was used for casting the column specimens. The reinforcement details of the specimens are shown Figure3. Six numbers and 2 numbers of 6mm diameters were used for main reinforcement of column and 6mm diameter helix with 100mm c/c spacing was adopted for both the types of specimens.

3.4. Properties of Companion Specimens

To find the properties of hardened concrete, the following tests are carried out

- Compressive strength test for cubes
- Flexural strength test.

The test results of the companion specimens are shown in Table.1

Tabl.1: Test Results Of Companion Specimens

S.No.	Properties of the Companion Specimens	Average strength value in N/mm^2
1	Cube Compressive Strength Test	27
2	Flexural strength of prism Test	3.35

3.4.1. Test Setup

Each specimen was tested by means of 50 tones capacity hydraulic jack in the structural Laboratory. The column of the test assembly was placed on the loading platform. The column was centered accurately using plumb bob to avoid eccentricity. The bottom end was placed in the frictionless surface. It's used for applying axial load for column and also avoids the movement of column. To avoid local failure, the top and bottom side of the column steel cap were used. Two Dial gauges were used to measure the lateral displacements in the column at mid height of the column. Electrical strain gauge was used to measure the strain in concrete.

Figure.4:Test Setup

A strain gauge which is fixed to the side face of the specimen is connected to the electronic strain indicator. The axial load is applied gradually by means of the hydraulic jack. The testing is done to a specified percentage of the calculated theoretical ultimate load. The specimens were grouped based on the percentage of ultimate load applied namely 50%, 60%, 70% (121KN, 145KN, 170KN). The test setup is shown in Figure.4.

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Figure.5a: Before Retrofitting Of Specimen

Figure.5b: Detailing Of Retrofitting Specimen

Figure .5c: After Retrofitting Specimen

3.4.2. Testing of Retrofitted Specimens

The retrofitted specimens were shown in the following Figure.5a, Figure.5b and Figure.5c. The retrofitted specimens were tested in the same manner as that of the conventional specimens. The results and inferences were presented in a detailed manner

4. ANALYSIS AND DISCUSSION OF TEST RESULTS

Six sets of columns have been studied experimentally to assess the behavior of retrofitted columns as given in Table.2 and Table.3, where C stands for conventional specimen.

Table.2: Load Carrying Capacity Of Specimens

Specimen	Cracking Load (Kn)	Ultimate Load (Kn)
C	180	242
RC1	336	410
RC2	383	470
RC3	323	406
RC4	373	450
RC5	350	422
RC6	360	440

Table.3: Details Of Test Specimens

Group	% of ultimate load applied	Number of longitudinal reinforcement
RC1	50	2
RC2	50	6
RC3	60	2
RC4	60	6
RC5	70	2
RC6	70	6

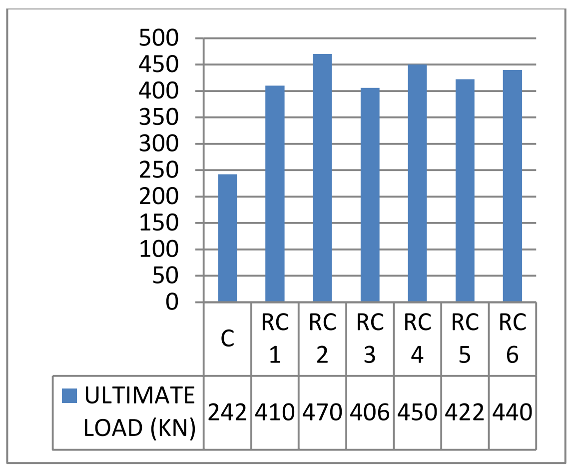

Figure.6: Comparison Of Ultimate Load Carrying Capacity Of Various Groups

4.1 Loading and Load Deflection Behaviors

The axial load was gradually applied till the failure of the specimen takes place. The deflection (lateral) reading was taken up to failure of each specimen. The average values of three specimen's deflection (lateral) were taken into account. The load versus lateral deflection diagram and the axial stress - axial strain diagrams were presented in Figure 7 and Figure 8.

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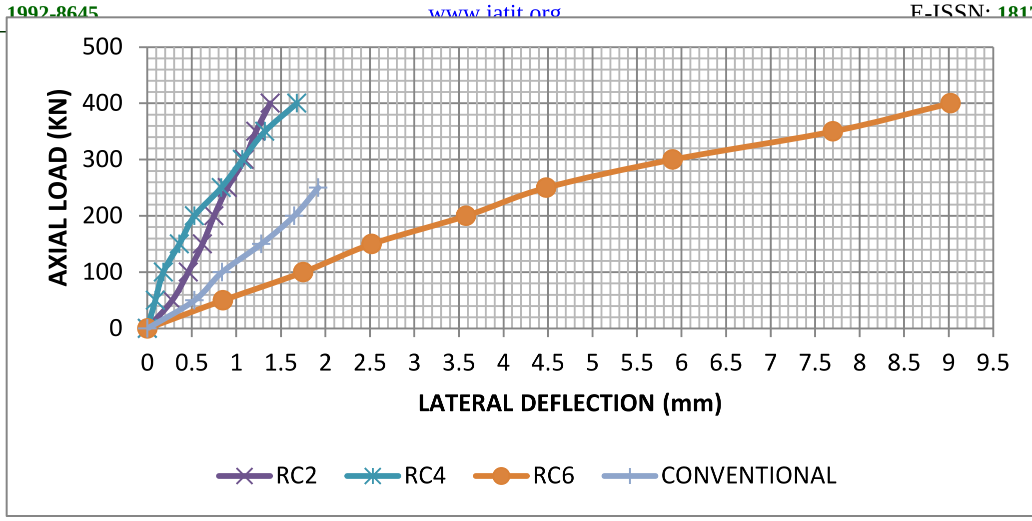

Figure.7: Load versus Lateral deflection diagram for specimens RC2, RC4, Rc6 and Con

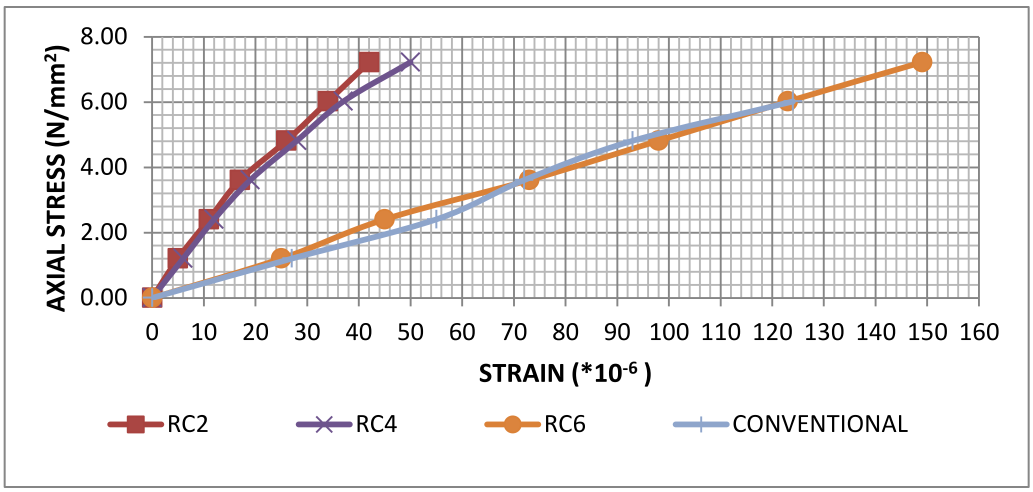

Figure.8: Axial Stress versus Axial Strain diagram for specimens RC2, RC4, Rc6 and Con

The following conclusions were drawn on the basis of the available results.

5. CONCLUSIONS

Based on the results of the experimental investigation on RC columns with and without retrofitting the following conclusions were arrived.

1) The initial portion of the load-deflection curve of the conventional column is almost same for jacketed columns. The later portion of the load-deflection curve of the Retrofitted column clearly shows the effect of confinement.
2) RC6 group of columns have more ductile behavior than RC2 and RC4 group of columns.
3) The columns of RC2 and RC4 group show their lateral deflections are nearly equal.
4) The average ultimate load carrying capacity is found to increase significantly.
5) The axial stress-strain behavior of all the columns has similar characteristics. However from the observation it is found that the retrofitted RC columns shows enhancement of ultimate strength and exhibits ductile behavior even after failure stage.

In general, it is concluded that the RC Jacketing technique is one of the efficient technique for repair and rehabilitation of the damaged RC columns.

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