Experimental Study on Strengthening Existing Column By RC Jacketing

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Abstract- *In this Paper, a review on behaviour of Reinforced concrete columns when strengthened by providing reinforced concrete jacketing is discussed. Large number of studies on the reinforced concrete column jacketing are already conducted and reported. Even though, there is a need to improve the performance of RC Jacketing by applying new techniques. Columns are the most important member of the framed structure. Columns are subjected to continuous loading and if there is a failure on the column it may lead to total collapse of the structure. To overcome the failure of column due to any calamity/ excessive loading, the damaged column should be given immediate attention and they should be repaired by providing Reinforced Concrete Jacketing. This review focus on the use of providing cross ties to the new longitudinal bars, use of providing shear keys/ dowels bars to increase bond between existing and new reinforcement and the use of self-compacting concrete. It is also found whether using of the shear keys, self-compacting concrete in the jacket increased the overall load carrying capacity, bond strength and to achieve monolithic behaviour after RC jacketing.*

Keywords- Reinforced Concrete Column Jacketing, Retrofitting of Column, Shear keys, Strengthening of Column.

I. INTRODUCTION

Column is a Structural Element / Member which transmits the load through compression to the foundation. In framed structures Column's behaviour is very important since the failure of the column leads to additional structural damage even a structure collapse. Replacement of damaged structures are highly risk. Thus, repairing the damaged structure / strengthening the particular damaged member is advisable. In other words, it is also referred as Retrofitting of structures, it is the modification of existing structures by addition of new technologies. There are two types of Retrofitting Techniques

1)Global Retrofitting and
2) Local Retrofitting Techniques.

Global Retrofitting Technique:

In Global Retrofitting it is Retrofitting to improve the overall behaviour of entire structure. Some examples of this method are addition of Shear walls and Steel bracings which affects the improvement of whole structure. Some types of global retrofitting techniques are,

- Adding Shear Wall.
- Adding Infill Wall.
- Adding Bracing.
- Adding Wing Wall.
- Wall Thickening.
- Mass Reduction.
- Base Isolation.
- Mass Dampers.

Local Retrofitting Technique:

Section enlargement consists in placing additional concrete around an existing structural element to increase its seismic resistance. This is the oldest method of seismic retrofitting. Typical applications include bridge deck, column wrapping, and join strengthening. This method is easy and economically effective, but labor intensive. Adding traditional concrete has been used as a means of retrofit for many years. It is used to reinforce columns either by themselves or in the context of retrofitting gravity designed frames. It can also be used for other structural features such as foundation. It is used mainly when strengthening is needed. In case Local Retrofitting individual structural members are strengthened invidually. For example, a particular beam / column is Retrofitted for its improvement of strength it is Local Retrofitting. Some types of Local Retrofitting are,

- Jacketing of Beams.
- Jacketing of Columns.
- Jacketing of Beam-Column Jacketing.
- Strengthening of Individual Footing

Jacketing:

Jacketing is one of the most favourable and well-known strengthening methods of poor detailed or deficient RC

members and structures. It has long been recognized that RC jackets do provide increased strength, stiffness, and overall enhancement of the structural performance. It is the popularly used method for Strengthening of damaged columns. Jacketing consists of added concrete with Longitudinal and Transverse Reinforcement around the existing column. Jacketing can be done in many ways

1)Reinforced Concrete Jacketing.
2)Wire-Mesh Mortar Jacketing.
3)Steel Jacketing or Caging. In these above said Techniques let's see RC Jacketing in detail.

Reinforced Concrete Jacketing: Reinforced Concrete Jacketing is a very effective and mostly used technique to repair damaged column due to its easiest way of construction, cost effective & availability materials. This also one of the oldest techniques used to increase the strength and stiffness of the column. In this technique, we have to prepare the surface of the existing damaged column or roughening of the surface is must to increase the bond between the new concrete to be applied. Holes are drilled, bonding agents like epoxy paste are applied and provided with shear keys to hold the new reinforcement with existing new reinforcement. Different types of concrete can be used in the jacket to increase the strength. Concrete jacketing is needed to increase bearing load capacity following a modification of the structural design or to restore structuraldesign integrity due to a failure in the structural member. This technique is used on vertical surfaces such as walls, columns and other combinations such as beam sides and bottoms.

II. LITERATURE REVIEW

Bett, R.E. Klingner and J.O. Jirsa (1988) [1] studied the effectiveness of strengthening technique in enhancing the Lateral Load response of reinforced concrete short columns. Constant axial load was used for all tests. It was found that the repaired and strengthened columns performed better than the original column. Columns strengthened by jacketing, both with and without cross ties, were much stiffer and stronger laterally than the original column.

Erosy.U, A.T. Tankut and R. Suleiman (1993) [2] conducted two series of tests on RC columns. The first series consisted of Uniaxially Loaded specimens and the behavior of Jacketed Column was compared with the Original column. In the second series, Jacketed Columns were tested under combined axial load and bending. It was concluded that repair and strengthening jackets behaved well with both under uniaxial and combined loading.

Valluvan .R, Kreger M.E and Jirsa J.O (1993) [3] tested column specimens with lap splicing of the longitudinal bars. From the tests it was concluded that removing the concrete cover for adding the new ties is not an effective method for strengthening the splice location because it results in micro-cracking of the concrete core. External reinforcement (i.e., steel element or tie) around the splice region significantly improves the confinement of the concrete and the strength of the splice. Steel dowels were inserted at the face of the original columns for better transfer of shear at the interface of the old concrete and the jacket.

M. Rodriguez and R. Park (1994) [4] tested four reinforced concrete column units subjected to simulated Seismic Loading to investigate the repair and strengthening techniques. The as built columns were square and contained low quantities of transverse reinforcement. Two column units were tested, repaired and strengthened by jacketing and retested. The other two columns were strengthened by jacketing and tested. The as built column displayed low available ductility and significant degradation of strength during testing and the jacketed column behaved in ductile manner with higher strength and much reduced strength degradation. The retrofit of columns using reinforced concrete jacket was found to be successful.

Fukuyama, Y. Higashibata, and Y. Miyauchi (2000) [5] investigated jacketing with RC steel plates and carbon fibre sheets. This method has been widely used to repair or strengthen the RC columns damaged by the Hyogoken-Nanbu earthquake in 1995. They tested eight column specimens under Constant Axial Compressive Load And Cyclic Shear Forces. They investigated the shear strength and ductility of RC columns repaired or strengthened by jacketing.

III. RC COLUMN JACKETING

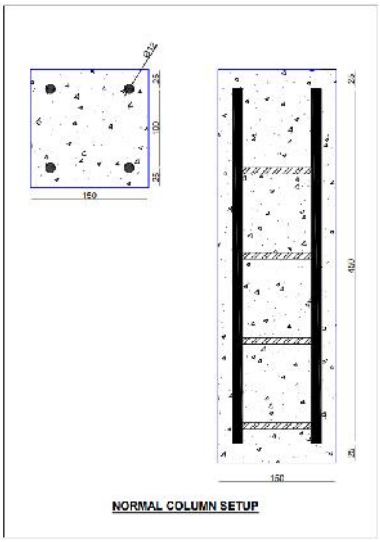
CONCRETE MIX RATIO:

MATERIAL	BY WEIGHT	BY PROPORTION
CEMENT	447kg/m3	1
FINE AGGREGATE	625kg/m3	1.4
COARSE AGGREGATE	1139kg/m3	2.54
WATER	197 litres	

Concrete Mix Ratio= 1: 1.4: 2.54

COLUMN PHYSICAL PROPERTIES:

Normal Column cross-section = 500mm x 150mm x 150mm.



- Two Normal columns are casted as per given reinforcement and specified mix proportion.
- The form-work are provided correctly before casting and the reinforcement are setup accordingly.
- Concrete mix are done as per mix proportion and casted.
- After casting two normal columns, they are cured for 28 days to attain its full strength. The next step is providing jacketing to the normal columns casted.

Jacketing of the Column:

- The two normal columns are roughened using Metal wire brush, so that the area of normal concrete becomes rough to hold the new concrete.
- Now jacketing is done for both columns,

1) Jacketing with shear key provided.
2) Jacketing without providing shear-key.

Jacketing of column with shear key provided:

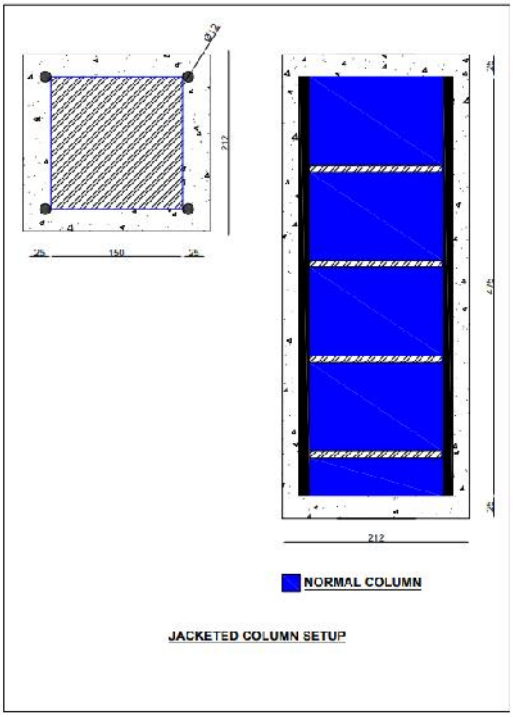
- The normal column is roughened and holes are drilled on thenormal column it to hold the shear-keys.
- The drilled holes can be filled with epoxy bonding agent (fig-6) to hold shear key stiffer.
- Now the jacketing reinforcement is provided around the normal column.

Jacketing of column without shear key:

- Another normal column has to be provided jacketing without shear key.
- The normal existing column is just roughened using Metal wire brush and Jacketing reinforcement is provided around it directly.
- The form work and reinforcement are provided around the existing normal column.

Casting of Jacketed Column:

- Concrete mix are done according to Mix proportion.
- Now, the concrete is casted / grouted around the normal column to the new jacketing reinforcement provided.
- As normal column, Jacketed column is also cured until it attains its full strength.



IV. TESTING OF COLUMNS

Test on Columns:

- The two jacketed columns are tested on loading axially.
- Axial compression test is to be carried out on both the jacketed columns one with shear key and other without shear key respectively.

Axial Load carrying capacity:

- Axial loading of column means load is acting on longitudinal axis of column this produces no moment.
- We can also calculate axial load carrying capacity of the column theoretically and experimentally.

Calculation of Axial Load carrying capacity:

- Size of the jacketed column = 150mm x 150mm
- Size of the jacketed column = 212mm x 212mm
- Characteristic strength of concrete Fck = M30
- Grade of steel = Fe 415= fy = 415.

Axial load carrying capacity of the column is given by,
Pu= 0.4fck.Ac + 0.67 fy.Asc

Where Pu = Ultimate Load carrying Capacity of the column.
Ac = Area of concrete in the column.
Asc = Area of steel provided in the column.

IV. RESULTS AND DISCUSSSION

Axial Load carrying capacity calculation:

- From the above said formula, the axial load carrying capacity of the Normal existing column is,

Pu = 390.24 KN

- From the above said formula, the axial load carrying capacity of the jacketed column is,

Pu = 779.85 KN

Experimental results:

- The axial load carrying capacity of the jacketed column with shear key is,

Pu = 721.17 KN

- The axial load carrying capacity of the jacketed column without shear key is

Pu = 650.43 KN

Comparison of results:

PROPERTY	Axial Load Carrying Capacity (KN)	Increase in Load Carrying Capacity compared to normal column
Normal Column (theoretical value)	390.24	**0**
Jacketed Column (theoretical value)	779.85	**199%**
Jacketed column with shear-key	721.17	**184.8%**
Jacketed column without shear key	650.43	**166.67%**

V. CONCLUSION

- From the results obtained form the testing of two jacketed columns, it is clear that the Colum Jacketed with Shear key showed more increase in axial load carrying capacity when compared to the column jacketed without shear key.
- The part of shear key in the jacketed column increases the bond strength between the normal existing column and the new jacketed column.
- As increase in bond strength there is also increase in the load carrying capacity of the jacketed column.
- The jacketed column without shear key has also showed increase in load carrying capacity by 166%.
- Both the ways of RC jacketing with and without shear key has showed increase in load carrying capacity.
- These two types of RC jacketed columns can be used to increase the load carrying capacity of Existing column based on the site conditions, requirement and availability of the materials.

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