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# Design and Detailing of RC Jacketting for Concrete Columns

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***Abstract :*** *Retrofitting is a technique to enhance the structural capacities including the strength, stiffness, ductility, stability, and integrity of a building that is found to be deficient or vulnerable. It can effectively raise the performance of a building against earthquake to a desired level, and to even satisfy the requirements of an upgraded design seismic code. The building need not be deteriorated or damaged. The retrofit is intended to mitigate the effect of a future earthquake. In this paper, an effort is made to elaborate the procedure of providing concrete jacketing to the column as per guidelines of IS 15988: 2013. It is seen that the overall performance of the column significantly improves after jacketing.*

***Keywords -*** *Concrete Jacketting, Ductility, Retrofitting, Stiffness, Structural Capacities.*

## I. Introduction

Considering the past Earthquakes, a strong need for the retrofitting of the existing buildings has been felt. Existing structures need strengthening in the following circumstances:

1. Buildings have not been designed and detailed to resist seismic forces [1]
2. Buildings might have designed for seismic forces, but as per old seismic codes.
3. The lateral strength of the building does not satisfy the seismic forces as per the revised seismic zones or designed base shear.
4. Construction is apparently of poor quality.
5. There have been additions of change of use of building with increased vulnerability.

Retrofitting can generally be classified in two categories: Global and the local. The global retrofitting technique targets the seismic resistance of the building. It includes adding of infill wall, adding of shear wall, adding of steel bracings and base isolation. Adding of infill wall in the ground storey is a viable option to retrofit buildings with soft storey. Shear walls can be introduced in a building with flat slabs or flat plates. A new shear wall should be provided with an adequate foundation. Steel braces can be inserted in frames to provide lateral strength, stiffness, ductility, and to improve energy dissipation. These can be provided in the exterior frames with least disruption of the building use [2]. Local retrofitting technique targets the seismic resistance of a member. The local retrofit technique includes the concrete, steel or Fibre reinforced polymer Jacketting to the structural members like beams, columns, beam column joint, foundation. Concrete jacketing involves adding a new layer of concrete with longitudional reinforcement and closely spaced ties. The jacket increases both the flexural strength and the shear strength of the beam or the column. The following are the advantages of retrofitting. It increases the seismic resistance of the building without any demolition. It increases the ductile behaviour and lateral load capability of the building Strength and stiffness of the building is also improved [3]

## II. Strengthening Of Existing Columns By Jacketting

There are two main purpose of jacketing of columns. (i) To increase in shear capacity of columns (strong column-weak beam design) (ii) To improve the column's flexural strength. After carrying out the detailed analysis of the existing building, deficient members are identified. A list of provided and required reinforcements is tabulated and highlighted. All these members require strengthening in order to increase their ductile strength. Hence, retrofitting of these members is carried out using Jacketting.

### 2.1 Reinforced concrete jacketing of columns.

In this paper, column jacketing is carried out as per recommendations of Indian standard code IS 15988 (2013): Seismic Evaluation and Strengthening of Existing Reinforced Concrete Buildings – Guidelines published By Bureau of Indian Standards [4]. Reinforced concrete jacketing improves column flexural strength and ductility. Closely spaced transverse reinforcement provided in the jacket improves the shear strength and ductility of the column. The procedure as per article 8.5.1.1 of the code for reinforced concrete jacketing is as follows:

1. The seismic demand on the columns, in terms of axial load P and moment M is obtained.
2. The column size and section details are estimated for P and M as determined above.
3. The existing column size and amount of Reinforcement is deducted to obtain the Amount of concrete and steel to be provided in the jacket.
4. The extra size of column cross-section and Reinforcement is provided in the jacket.
5. Increase the amount of concrete and steel actually to be provided as follows to account for losses,

$$A_c = (3/2)\, A'_c \text{ and } A_s = (4/3)\, A'_s$$

Where $A_c$ and $A_s$= actual concrete and steel to be provided in the jacket; and $A'_c$ and $A'_s$ = concrete and steel values obtained for the jacket after deducting the existing concrete and steel from their respective required amount.

The minimum specifications as per article 8.5.1.2 of the code for jacketing Columns are:

a) Strength of the new materials shall be equal or greater than those of the existing column. Concrete strength shall be at least 5 MPa greater than the strength of the existing concrete.
b) For columns where extra longitudinal reinforcement is not required, a minimum of 12φ bars in the four corners and ties of 8φ @100 c/c should be provided with 135° bends and 10φ leg lengths.
c) Minimum jacket thickness shall be 100 mm.
d) Lateral support to all the longitudinal bars shall be provided by ties with an included angle of not more than 135°.
e) Minimum diameter of ties shall be 8 mm and not less than one-third of the longitudinal bar diameter.
f) Vertical spacing of ties shall not exceed 200 mm, whereas the spacing close to the Joints within a length of ¼ of the clear height shall not exceed 100 mm. preferably, the spacing of ties shall not exceed the thickness of the jacket or 200 mm whichever is less.

## III. Design Of Rc Column Jacketting Using Is 15988: 2013

The firs Details of existing column are as follows:

Height of the Column=1500mm, Cross-Section= (250X400) mm, Effective Cover=40mm

Grade of Concrete =20 N/mm$^2$ and Grade of steel=415 N/mm$^2$

Load, $P_u$=1528.68 KN, Moment, M=72.33 KN-m, Reinforcement provided=8-16mmØ bars

Procedure:

$$P_u = 0.4 \times f_{ck} \times A_c + 0.67 \times f_y \times A_{sc}$$

According to the provisions provided in to 8.5.1.2 (a) of IS 15988: 2013, Concrete strength shall be at least 5 MPa greater than the strength of the existing concrete.

Thus, taking value of $f_{ck}$ =25 N/mm$^2$ and assuming $A_{sc}$ = 0.8% $A_c$

1528.68 x $10^3$=0.4 x 25 x $A_c$ + 0.67 x 415 x (0.8 % $A_c$) or 1528 x $10^3$= 12.22 $A_c$ or $A_c$=125096.56mm$^2$

According to 8.5.1.1 (e) of IS 15988:2013, $A_c$=1.5 $A'_c$

Thus, $A_c$=187644 mm$^2$

Assuming the cross sectional details as:

B=400mm, D=187644/400=500mm

Jacketting details of cross section:

B = (400-250)/2=75mm, D = (500-400)/2=50mm

However, According to the code specified above, Minimum jacket thickness shall be 100 mm as per 8.5.1.2 (c) of IS 15988:2013

Thus, New size of the column:

B = 250+100 +100=450mm,

D =400 +100 +100=600mm

New concrete area=450x600=270000mm$^2$ > $A_c$=125096.56mm$^2$

Area of steel, $A_s$=0.8% x 450 x 600=2160mm$^2$

But according to 8.5.1.1 (e) IS 15988:2013, $A_s$= (4/3) $A'_s$

$A_s$= (4/3) x 2160=2880 mm$^2$

Assuming 16mm Ø bars,

Thus, number of bars, N =2880 x 4/ ($\pi$ x $16^2$) = 16 bars
Provide 16 NO. -16mm Ø bars for jacketed section.
Therefore, revised jacketed section will be 450mm x 600 mm. The details of RC Jacketting are provided in Fig.1.

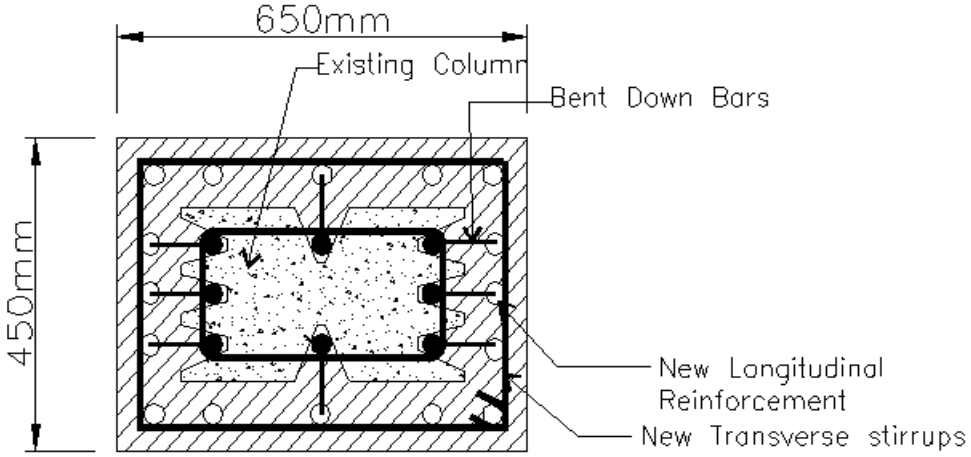



**Fig.1.** Typical Column section showing Jacketting

**Design of Lateral Ties**

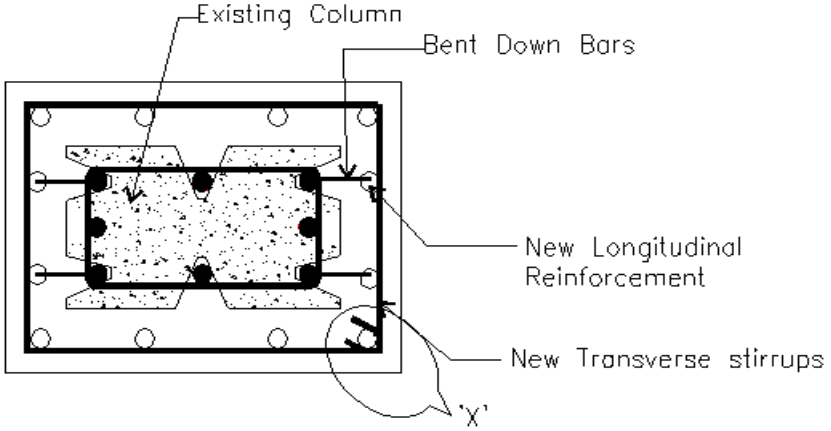
As per 8.5.1.2 (e) of IS15988: 2013, Minimum diameter of ties shall be 8 mm and not less than one-third of the longitudinal bar diameter.
Diameter of bar =1/3 of Ø of largest longitudinal bar = $1/3$ x 16 = 6mm ….take 8mm
Spacing of ties as per 8.5.1.1 (f) of IS 15988:2013- The code suggests that the spacing, s of ties to be provided in the jacket in order to avoid flexural shear failure of column and provide adequate confinement to the longitudinal steel along the jacket is given as:

$$s=\frac{f_y\ d_h^2}{\sqrt{f_{ck}}\ t_j}$$

Where
$f_y$ = yield strength of steel, $f_{ck}$ = cube strength of concrete,
$d_h$= diameter of stirrup, and $t_j$ = thickness of jacket

$$s=\frac{415\ x\ 16^2}{\sqrt{25}\ x\ 200},\ s=110mm$$

Provide 8mm Ø @110mm c/c.
However, For columns (Figure 2) where extra longitudinal reinforcement is not required, a minimum of 12φ bars in the four corners and ties of 8φ @100 c/c should be provided with 135° bends and 10φ leg lengths.



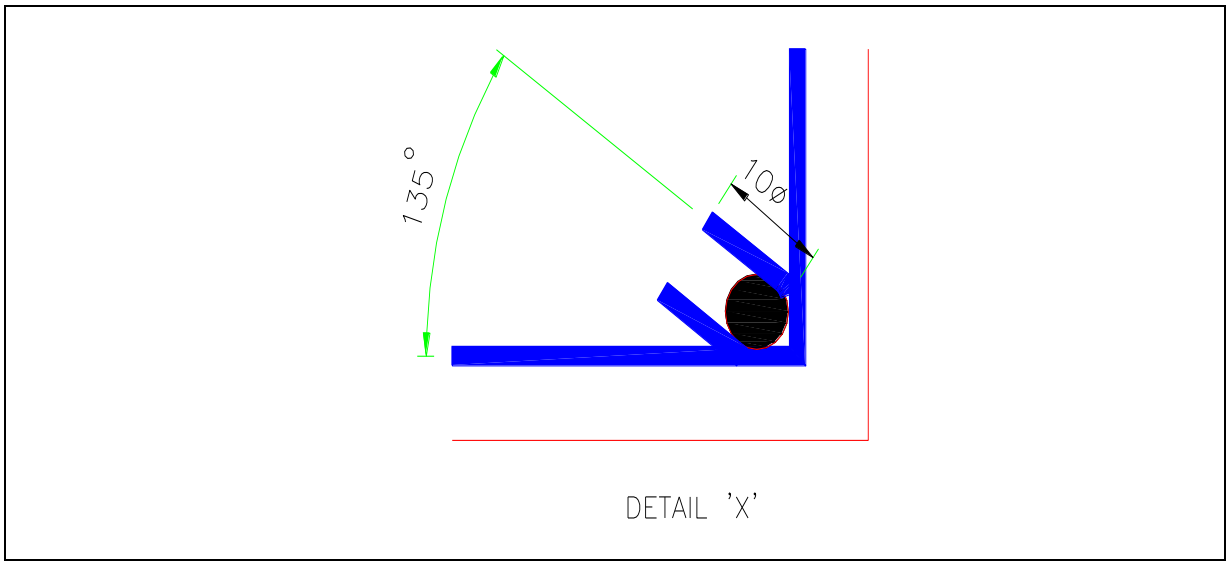



**Fig.2.** Reinforcement Jacket detailing for minimum level of retrofit

## IV. Practical Method Of Rc Jacketting

The above solved problem is an example of designing RC jacket for columns. However, the practical technique of surrounding the old and existing columns with a new RC jacket involves a sequence of actions. There are few steps which are to be followed before applying Jacketting. First step is to repair the surface of old and existing column. This can be done by removing the deteriorated concrete by hand chipping, jack hammering or any other method that causes micro cracking of substrate (concrete of existing Column). This is then followed by sand blasting or water demolition technique [5], which makes the surface of column rough. The third and an important step is to use a bonding agent like epoxy resin. After the resin application, steel connectors are used. This is then followed by temporary shoring of existing RC columns. Finally, adding of longitudional and transverse reinforcement with steel connectors. This is how RC Column Jacketting is given a practically shape.

## V. Conclusion

The method of RC Jacketting is suitable for the following situations:

(1) The old and existing building that are constructed without considering IS 1893:2002, are very liable for damage during an earthquake.
(2) The columns that are damaged in the past earthquake during an accident like fire, explosions.
(3) Situations involving change in the functionality of the structure.
(4) The weak columns of monumental buildings.
(5) The weak columns of soft storey and extremely soft storey.

Thus, Jacketting for these types of building becomes a necessity in order to minimize the effects of future seismic shaking. The Jacketting of the existing building is carried out by using IS 15988:2013. This code also provides the data for retrofitting of the buildings by means of adding shear wall and bracings.

**Table 1. Symbols used in the paper**

| Symbol | Meaning | Symbol | Meaning |
|---|---|---|---|
| $f_{ck}$ | Characteristic Strength of Concrete | $P_u$ | Axial Load |
| $f_y$ | Yield Strength of Steel | B | Width of the Column |
| $A_c$ | Total Cross-Sectional Area of Columns | D | Depth of the Column |
| $A_{sc}$ | Area of Reinforcement. | Ø | Diameter of the reinforcing bar |

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