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A Technique Used for Strengthening of Existing Columns with Reinforced Concrete Jacketing

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Abstract: ***The present paper gives a technique used for strengthening of existing columns with reinforced concrete jacketing. After a massive earthquake of Nepal in 2015 also known as Gorkha Earthquake huge amount of lives as well as buildings, infrastructure was damaged. After that earthquake, lots of building needed to be strengthening its capacities to meet present code provision and to make them earthquake resistant building. In this paper, a non-destructive test of existing column will be first presented and after that strengthening techniques for that column will be described.***

Keywords: Strengthening, Jacketing, NDT test, Retrofitting, RC building

1. Introduction

Seismic retrofit or Strengthening is to enhance the structural capacities (strength, stiffness, ductility, stability and integrity) of structure, so that the performance level of the building can be raised to withstand the design earthquake consideration. In the context of Nepal, mainly in urban areas most of the houses are constructed with RCC structure by considering certain level of design parameter. The performance level of building reducing along with its life time. The design consideration also effects on its structural capacity, safety level due to varieties of causes or situations such as deterioration of concrete, alternation of building units, larger loads due to extension of structure etc. These structure behaves normally during its life time but after meeting with design period, it cannot capable to take the existing loads and obviously it will not be possible to take the extra loads on it. Enhancement of structural behaviour or performance level of such a deficient building can be done by increasing strength of structure element through the process of retrofitting.

2. Methodology

2.1 Assessment of physical condition of existing Columns

Non-destructive test (NDT) can be used to determine the physical condition of an object without affecting that objects ability. NDT method is considered as an effective method for evaluation of existing concrete structures with regard to their strength, durability and quality.

Various NDT methods can be used for testing concrete:
1) Ultrasonic pulse velocity test
2) Schmidt Rebound hammer test
3) Surface hardness tests
4) Penetration and pull out tests
5) Dynamic or vibration tests
6) Combined methods
7) Radioactive and nuclear methods
8) Magnetic and electrical methods
9) Acoustic emission techniques

The commonly used NDTs are the Rebound hammer tests and Ultrasonic pulse velocity test.

2.1.1 Ultrasonic pulse velocity test

UPV method is one of the important method of NDT for determination of quality of concrete. UPV method involves a measurement of travel time over the known path distance (Length) pulse of ultrasonic compressional waves. Generally, the pulse velocity is determined by using following equation.

Pulse Velocity=Path Length/Transmit time

Figure 1: Ultrasonic pulse velocity instrument

Generally, the higher value of pulse velocity reflect higher the quality and durability of concrete and lower value of pulse velocity stands for lower quality of concrete.

IS 13311-1992 code of practice for Ultra sonic pulse Velocity describes the details of pulse velocity and condition of concrete.

Table 1: Quality of concrete as per IS 13311 (part 1) 1992

	Ultrasonic pulse velocity(km/sec)	Quality of concrete
1	Above 4.5 km/sec	Excellent
2	3.5-4.5 km/sec	Good
3	3-3.5 km/sec	Medium
4	Below 3 km/sec	Doubtful

2.1.2 Schmidt Rebound hammer test

Schmidt rebound hammer test is one of the non-destructive test in order to determine the compressive strength of concrete. It is developed in 1948 by a Emst Schmidt a Swiss

engineer for testing concrete, based upon rebound principle when strikes concrete.

As per Indian code IS: 13311(2)-1992, the rebound hammer test has the following objectives:

1) To determine the compressive strength of the concrete by relating the rebound index and the compressive strength
2) To assess the uniformity of the concrete.
3) To assess the quality of the concrete based on the standard specifications.
4) To relate one concrete element with other in terms of quality.

Procedure for Schmidt rebound hammer test:

- Firstly, concrete surface should be smooth, clean and dry.
- Any loosing particles should be rubbed off from the concrete surface with grinding wheel or stone before hammering test.
- The point of impact of rebound hammer on concrete surface should be at least 20mm away from edge or shape discontinuity.
- The body of the hammer is then pushed towards the concrete surface and when pushed to the limit, the catch is released and the hammer is propelled towards the concrete by the combination of gravity and spring forces.
- After then hammer strikes up to the shoulder of plunger and it rebounds. The rebound distance travelled by a spring control mass is called the rebound number and it is measured on a scale which is attached to a rider.
- This test can be conducted horizontally, vertically or at any intermediate angle.
- Six readings of rebound number is taken at each point of testing and an average of value of the readings is taken as rebound index for the corresponding point of observation on concrete surface.
- After knowing rebound number, the calibration chart is used which shows the relationship between compressive strength and rebound number.

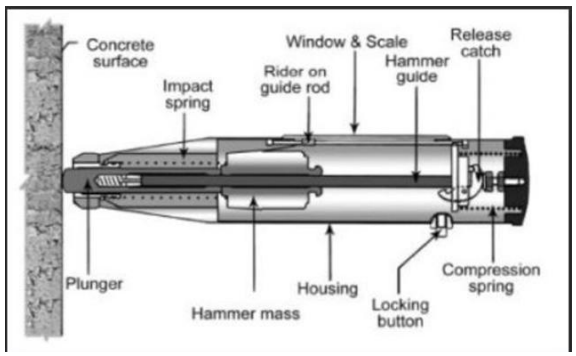


Figure 2: Schmidt rebound hammer instrument

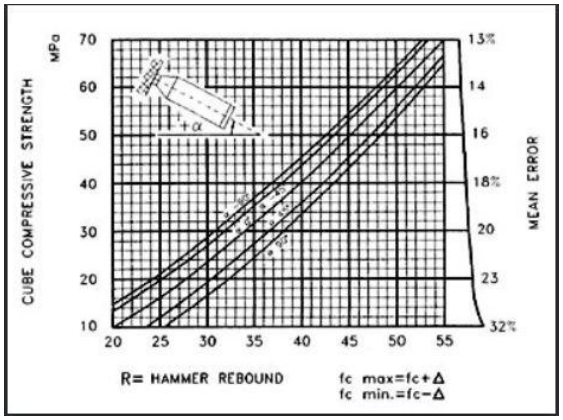


Figure 3: Calibration Chart

2.2 Techniques for strengthening of RC column

This paper deals general techniques used for seismic retrofitting or strengthening of RC structural elements i. e. column by various approaches. Generally, reinforced cement jacketing, steel jacketing and FRP jacketing are preferred in the context of Nepal. Nowadays, RC jacketing and steel jacketing are the popular retrofitting techniques for strengthening of existing column.

2.2.1 Reinforced Cement Jacketing

Jacketing is one of the popular technique used for strengthening reinforced concrete structures. It is mostly used for strengthening the R.C columns. By which, axial strength and stiffness of the original column is increased. Jacketing is a process of fastening with a durable material over concrete and filling the gap with grout. Jacketing restores the section of an original member by encasement in a new concrete. This method is applicable for protecting the member against further deterioration as well as for strengthening. Retrofitting or Strengthening of existing structures is needed when – a) Load carried by the column is increased due to either increasing the number of stories 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 code provision.

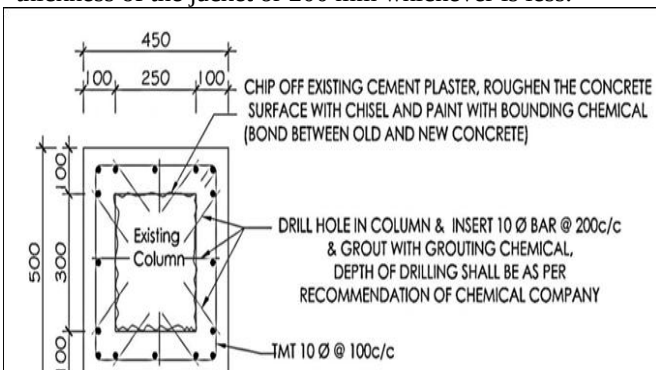
The main objectives of reinforced concrete jacketing are to improve column flexure strength and ductility. Closely spaced transverse reinforcement provided in the jacket improves the shear strength and ductility of the column.

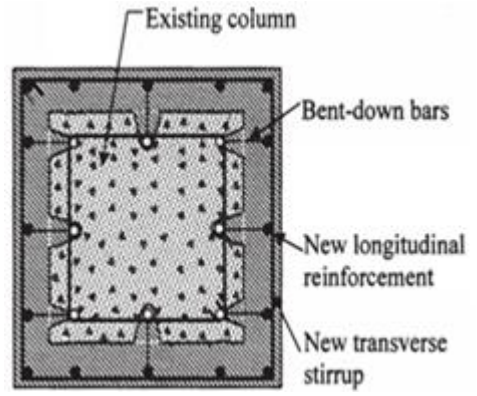
RC Jacketing calculation in columns are carried out as per IS 15988: 2013 (clause no: 8.5.1.1)
Step 1: Identify the members that have failed
Step 2: Increase cross section (100mm at least in each side)
Step 3: Check for further failure of components by analysing in the software.
Step 4: Obtain area of steel from Software.
Step 5: Calculate actual area of steel and concrete
Ac = (3/2) Ac' & As = (4/3)As'
Where;
Ac and As = actual concrete and steel to be provided in the jacket;
A'c and A's = concrete and steel values obtained for the jacket.

Details for Reinforced Cement Jacketing:

According to IS 15988:2013, 8.5.1.2, The minimum specification for RC jacketing are as follows;

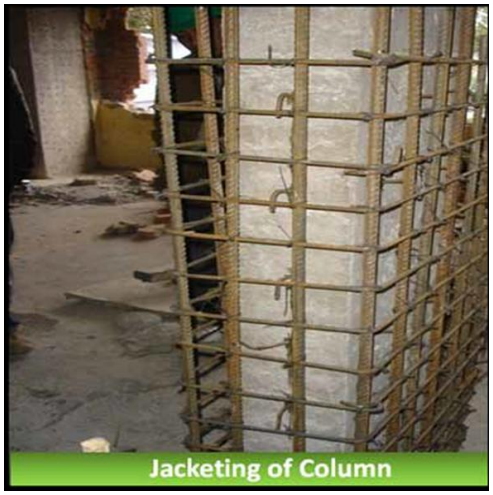
a) Strength of the new materials should be equal or greater than those of the existing column. Concrete strength should be at least 5 Mpa greater than the strength of the existing concrete.
b) For columns where extra longitudinal reinforcement is not required, a minimum of 12φ bars in the four corners 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 should be provided by ties with an included angle of not more than 135°.
e) Minimum diameter of ties should be 8 mm and not less than one-third of the longitudinal bar diameter.
f) Vertical spacing of ties should 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.





Construction Procedure:

- Diameter and number of steel bars as well as size of jacket in the jacketing process depend on the structure analysis of column.
- Steel connectors should be adding in to the existing column in order to fasten new stirrups and vertical steel bars at the spacing of not more than 50 cm. These steel connectors are added in to the column by making holes 2-3 mm larger than the diameter of steel connectors at 10-15 cm depth.
- Filling the holes with appropriate epoxy material and inserting the connector into the hole.
- New vertical steel bars and stirrups should be added on the basis of designed dimension and diameters.
- To make strong bond between old and new concrete appropriate epoxy material should be coated before pouring the concrete.
- Before the epoxy material dries, new concrete should have poured in to the jacket. Concrete used should be rich concrete having low shrinkage consisting of small aggregates, sand, cement and additional materials to prevent shrinkage.



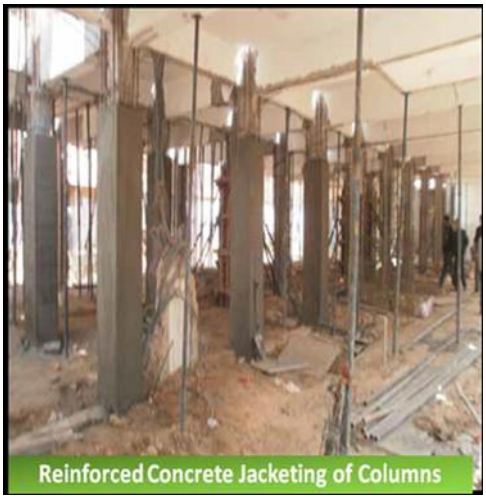


Figure 4: Jacketing of Column (Source MRB & Associates)

2.2.2 Steel Jacketing

Steel jacketing consists of four longitudinal angle profiles placed one at each corner of the existing reinforced concrete column and connected together in a skeleton with transverse steel straps. They are welded to the angle profiles and can be either round bars or steel straps. The angle profile size should be no less than L 50X50X5. Gaps and voids between the angle profiles and the surface of the existing column must be filled with non-shrinking cement grout or resin grout. In general, an improvement of the ductile behavior and an increase of the axial load capacity of the strengthened column is achieved. Local strengthening of columns has been frequently accomplished by jacketing with steel plates.

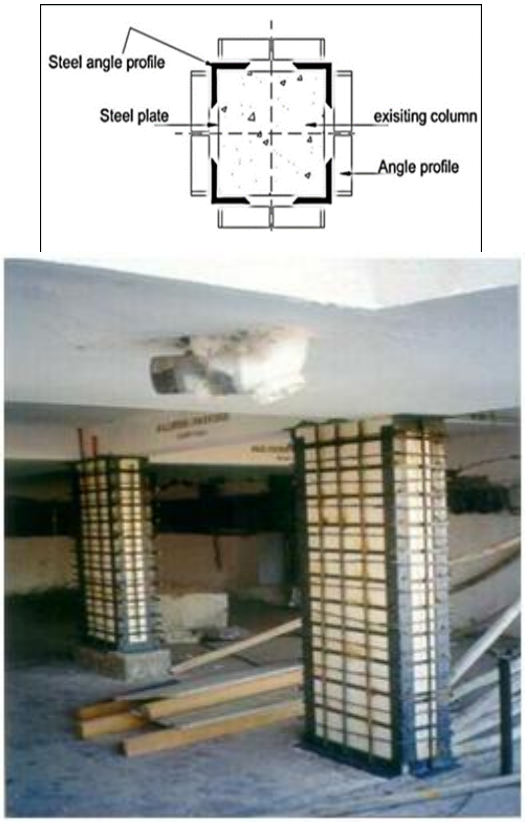


Figure 5*:* Steel Jacketing of column

3. Discussion and Conclusion

Many guidelines are used regrading seismic retrofitting and strengthening columns of existing school, office, hospital and apartment building. Unlike other techniques, RC jacketing method leads to increase in strength and stiffness of columns. The durability of the existing column is also improved. Due to all those reasons, RC jacketing of original column is one of the most frequent and popular technique used for strengthening or retrofitting of existing column to enhance structure performance.

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