Construction Techniques for Retrofitting by Jacketing of RCC Member

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Abstract - There are number of structure in India that do not meet the lateral resistance i.e.- lateral strength, stiffness, lateral displacement or ductility of structure because of inadequate design or facing loss of strength due to deterioration of structural elements. Inadequate performance of this type of structures is a major concern from public safety standpoint. Therefore strengthening of buildings is required to increase, to resist lateral force acting on structures. The purpose of this paper is to present different techniques of retrofitting for RCC member in order to strengthen the structure for its functional continuity.

Keywords- Retrofitting, Repair, Rehabilitation.

I. INTRODUCTION

Strengthening of an existing structure is a need of a structure subjected to loss of strength due to deterioration or which have cross their anticipated life span. However when displacement or yielding of structure takes place, the strengthening of structures is an definite requirement.

The retrofitting of structure is nothing but strengthening or uplifting the performance of an existing structure. The retrofitting of structure is done in any one of the cases such as-if there is decrease in the strength of construction material due to decay, fire damage, settlement of foundation. If the quality of construction achieved is lower. Building designed to meet the modern seismic code but deficiencies exist in design/ or construction. It has been observed that majority of damaged building may be safely reused, if they are converted into load bearing structure by employing few retrofitting measures. It has often seen that retrofitting of building is generally more economical as compare to demolition and reconstruction even in case of severe damage. Therefore retrofitting of building is one of the most important aspects.

II. CONSIDERATION IN RETROFITTING OF STRUCTURES

The method of retrofitting depends on the horizontal and vertical load resisting system of the structure and the type of the material used for parent construction. It also depends on the technology which must be feasible and economical and also understanding mode of failure, structural behaviour and weak and strong design aspects carried out during damage surveys need to be consider while selecting the method of retrofitting. It includes the action for upgrading the seismic resistance of an existing building so that it become safe under the occurrence of probable future earthquake. The complete replacement of building is not possible due to number of social, cultural and financial problems. Therefore retrofitting of existing undamaged and /or damaged building is a definite requirement. It includes some of the action-

a. Modification of roof.
b. Strengthening of floor.
c. Modification in building plan
d. Adding shear wall or diagonal bracing.
e. Strengthening of foundation if found necessary
f. Adding to the section of beam and column by jacketing, etc.

Techniques to be used in Retrofitting of RCC structures

The response of unreinforced masonry structure to earthquake excitation differs substantially from the response of more modern structural systems. There are two ways to enhance the seismic capacity of existence structure. The first is a structural level approach of retrofitting which involves the global modification to structural system such as adding shear wall, adding bracing, wall thickening, mass reduction, supplemental damping, base isolation and adding infill wall. The second is member level approach of retrofitting or local retrofitting which deals with an increase of the ductility of component with adequate capacities to satisfy their specific limits states either by jacketing of wall or jacketing of column, strengthening individual footing, jacketing beam column joints.

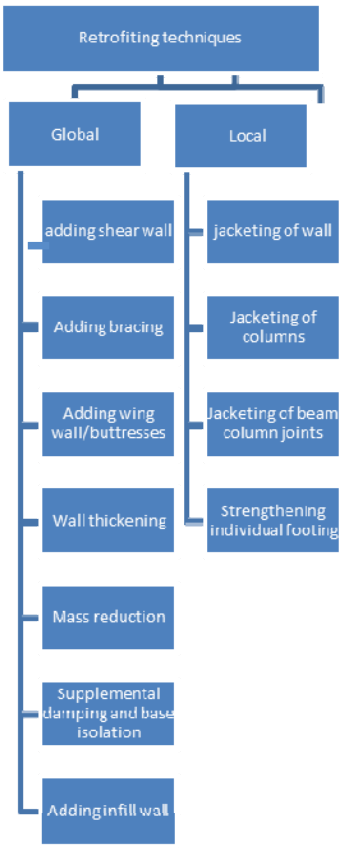


Fig.1. Global and Local Retrofitting Techniques.

III. STRENGTHENING OF RCC MEMBERS

In building problem occurs due to earthquake or due to age of structure. The formation of cracks, scaling and spalling will happen due to development of excessive stresses. Excessive deflection and yielding of steel occur due to the problem of overloading. De-colouration and erosion also occur due to chemical attacks. Steel erosion due to seepage of water

Different techniques of strengthening

A. Retrofitting for columns-

Reinforced Concrete Jacketing /Confinement- After 1985 earthquake in Mexico City jacketing is one of the technique that is widely used for the repair and retrofit of structures [5]. The main objective of jacketing of structure is to increase the seismic capacity of the structure. Jacketing is the most popularly used methods for strengthening of building column. The most common types of jackets are steel jacket, reinforced concrete jacket, fibre reinforced polymer composite jacket, jacket with tension material like carbon fibre, glass fibre, etc. The main purpose of jacketing is a) to increase the concrete confinement b) to increase the shear strength by transverse reinforcement c)to increase the flexural strength by longitudinal reinforcement.

Jacketing of column consist of adding concrete with longitudinal and with transverse reinforcement around the existing column. When jacketing is done as stated above, it is found that this type of retrofitting improves the axial and shear strength of column but the flexural strength of column and strength of beam column joint remain the same. It is also observed that jacketing is not successfully for improving the ductility [6].

Reinforced concrete jacketing is one of the methods of jacketing which can be employed as a repair or strengthening scheme. Before carrying out jacketing, damaged region of existing member should be repaired. RC jacketing provides a better solution for avoiding the buckling problems. Design for strengthening repair work is based on the composite action of the old and new work.

The minimum specification for jacketing column[7]

1. Strength of the new materials shall be equal or greater than those of the existing column. Concrete strength shall be at least 5MPa greater than the strength of the existing concrete.
2. 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.
3. Minimum jacket thickness shall be 100 mm.
4. Lateral support to all the longitudinal bars shall be provided by ties with an included angle of not more than 135°.
5. Minimum diameter of ties shall be 8 mm and not less than one-third of the longitudinal bar diameter.
6. 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.

Advantages of concrete jacketing.
1. To increase the shear & flexural capacity of Beam
2. To improve the compressive strength & Moment caring capacity of column
3. Ease in construction
4. Easily available material

Disadvantages of jacketing
1. The sizes of the sections are increased and the free available usable space becomes less.
2. Huge dead mass is added.
3. Requires adequate dowelling to the existing column.
4. Longitudinal bars need to be anchored to the foundation and should be continuous through the slab.
5. Requires drilling of holes in existing column, slab, beams and footings.
6. Placement of ties in beam column joints is not practically feasible.
7. The speed of implementation is slow.

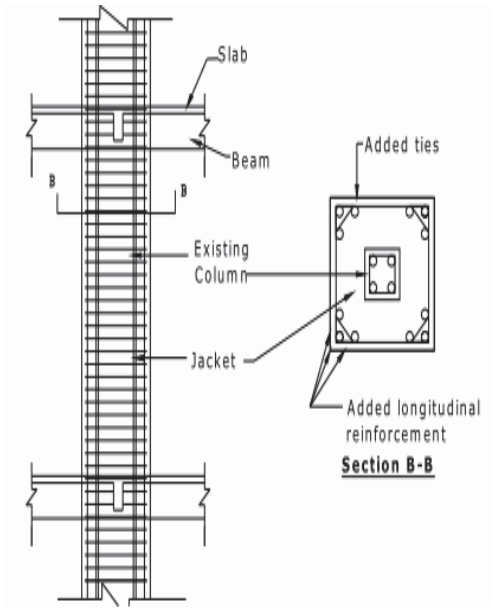


Fig.2. Column Jacketing [6].

Steel jacketing- In 1994 Northridge earthquake, the 1995 Hyogoken-Nanbu earthquake and the 2005 Kashmir earthquake have caused substantial damages to reinforced concrete bridge piers and buildings. Some of the major problems involved with the damaged reinforced concrete columns may be attributed to the poor transverse reinforcement detailing, which resulted in inadequate shear strength and flexural ductility of columns. Therefore, in order to prevent loss of human life and property from future earthquakes, methods to enhance the shear strength and ductility of existing reinforced concrete columns have to be developed [8],[9].

According to the dictionary of architecture and construction by C. M. Harris retrofit is: "the addition of new building material, building elements and components not provided in the original construction". Confining reinforced concrete column in steel jackets is one of the effective methods to improve the earthquake resistance capacity. As compared with conventional hoops or spirals, steel jacket has two more remarkable advantages; 1) to easily provide a large amount of transverse steel, hence strong confinement to the compressed concrete, and 2) to prevent spalling off of the shell concrete. Spalling of the shell concrete may be considered as the main reason for deterioration of bond and buckling of longitudinal bars of columns and is hardly prevented by conventional hoops [10]. The jackets provide a passive confinement to the concrete core and react against the lateral dilation of the column under compression, which delays the softening of the concrete and has shown to enhance both strength and ductility of the column [11]. Extensive work has been done in the experimental and analytical areas on concrete specimens of circular, rectangular and square columns retrofitted with steel jackets and fibre reinforced polymer [12].

Benefits of steel jacketing-

a. Steel jacketing is a cheapest way of retrofitting the existing damaged/weakened columns.

b. Retrofitted columns with steel jackets had better ductility and higher maximum load carrying capacity.

c. There is a significant increase in the axial strength and peak load strain of retrofitted column specimen with increase in the thickness of steel jackets.

d. The ultimate strain of the confined concrete increases due to jacketing. Increment in the ductility provides higher reliability of the confined columns.

e. Percentage increase in axial strength and ductility of circular column specimens retrofitted with steel jackets is more than that of square columns due to lack of stress concentration in the corners.

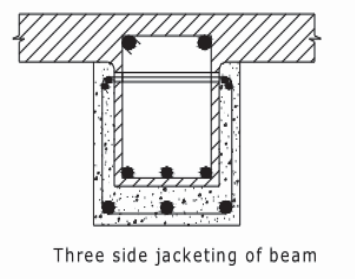
B. Retrofitting for RC Beams

Strengthening of reinforced concrete beams is required due to design errors, damage due to earthquake, accidents such as collisions, bad execution process, etc.

Retrofitting of deficient beam is recommended for several purposes as it gives continuity to the columns and increases the strength and stiffness of the structure.

Jacketing- Jacketing has been considered as one of the important methods for strengthening and repairing of RC beams. Jacketing of RC beams is done by enlarging the existing cross section with a new layer of concrete that is reinforced with both longitudinal and transverse reinforcement. Different researchers have employed various methods of jacketing for reinforced concrete RC elements [13]-[15]. The jacketing of RC beams can be done by using addition reinforcement and for connection between lateral and longitudinal reinforcement bar of old and new Z bars to be introduced before concreting, surface preparation plays important role before jacketing for superior performance of RC jacketed beam

While jacketing a beam, its flexural resistance must be carefully computed to avoid the creation of strong beam-column system. The jacketing of beam may be carried out under different ways [5]. The most common are one sided jacket, or 3- side and 4- side jackets.



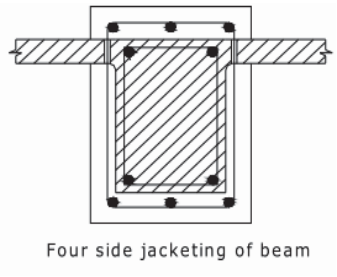


Fig.3. Beam jacketing [5].

Reinforcement details of beam jacketing[16].

Minimum width for jacket Longitudinal Reinforcement

• 8 cm if concrete cast in place or 4 cm for shotcrete.
• Percentage of steel on the jacket should be limited to 50 of the total area of the composite section.

Shear reinforcement

• Ignore the effect of existing shear reinforcement
• New reinforcement should have 135 hooks and at each corner of the tie there must be at least one longitudinal bar.
• The bar used for the tie should have at least 8 mm diameter
• Multiple piece ties can be used, as discussed before for columns.

Depth of jacketed beam

• Span/depth ratio
• Storey height
• Ductile behaviour

C. Retrofitting for slab

Strengthening of slab (insertion of new slab)- A rigid slab is inserted into existing walls plays an important part in resisting the mechanism of the building, keeping the wall together and disturbing the seismic forces among the walls.

Need of strengthening reinforced concrete slabs[17]

a) Repairing damaged/deteriorated concrete slabs to restore their strength and stiffness.
b) Corrosion of the reinforcement.
c) Limiting crack width under increased (design/service) loads or sustained loads.
d) Retrofitting concrete members to enhance the flexural strength and strain to failure of concrete elements requested by increased loading conditions such as earthquakes or traffic loads.
e) Rectifying design and construction errors such as undersized reinforcement.
f) Enhancing the service life of the RC slabs.

Steps to be carried out while insertion of new slab a) slab is cut and removed to distance of approximately 15 degree on each side of the crack. b) holes are drilled into the remaining slab c) reinforcing steel is bonded into the holes with epoxy d) a new plastic vapour barrier is placed e) new concrete is placed in old cracked slab areas.

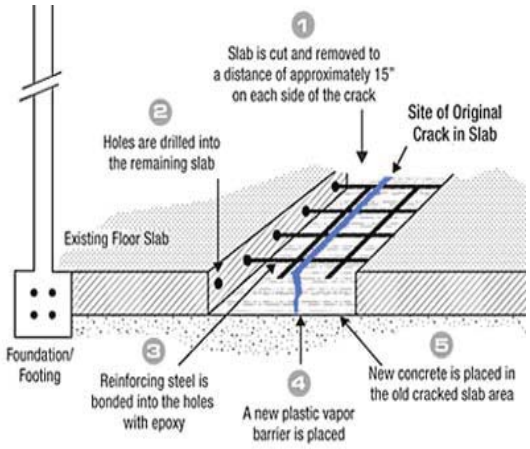


Fig.4. Construction techniques for retrofitting for slab.

D. Retrofitting for foundation –

Seismic retrofitting of important structures is essential in seismological active zones. Retrofitting is doubled in case of some buildings like school, hpospital, bridges, etc. Retrofitting of foundation is required in one of the following cases- (i) the change of loads on the foundation by strengthening the structure and (ii) the failure of foundation itself.

Strengthening of foundation is undertake by a) introducing new load bearing member including foundation to relieve already loaded member by jacketing method b) improving drainage to prevent saturation of the foundation soil to resolve any problem associated with liquefaction which may occur because of poor drainage c) providing apron to the building to prevent soaking of the foundation directly and drainage of water d)adding strong element in the form RC strip attached to existing foundation part of building.

IV. CONCLUSION

Retrofitting of seismically deficient building or damaged building is one of the most challenging task in civil engineering application. A large number of structures were constructed in the past by using older design codes, are structurally deficient according to the new designed code and requires a definite retrofitting. As replacement of such deficient structure is not possible because it incorporate huge amount of money and time. Hence strengthening is the possible way for improving structure load carrying capacity and extending their service lines.

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