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Retrofitting of RCC Apartment Building –A Case Study

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ABSTRACT

In the job of retrofitting of structures, first of all the visual inspection is being done to decide whether structure is liable to retrofit or not. If liable, then using proper techniques, the structure is retrofitted. Next to it various techniques of retrofitting are collected which can be used to retrofit the various structures such as building, ESR, bridge, etc. On average 75% of human life is being spend in buildings and hence it becomes prime importance to retrofit the building by using various techniques such as concrete jacketing, steel jacketing, FRP sheet wrapping, addition of concrete, steel plating, strengthening with wire mesh etc. The whole structure is rested on the foundation and hence come into the picture dominantly curing the settlement and action of seismic forces on the foundation. For this reason base isolation of structure is necessary and achieved by using the technique. In this Paper case studies were observed and some measures to retrofit the same are suggested of, Apartment building. (Building, Concrete, Jacketing, Retrofitting)

1.1 GENERAL

The retrofitting is define as the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes. Earthquake creates great devastation in terms of life, money and failures of structures. Earthquake Mitigation is an important field of study from a long time now. Seismic Retrofitting is a collection mitigation technique for Earthquake Engineering. It is of utmost importance for historic monuments, areas prone to severe earthquakes and tall or expensive structures. To avoid demolition of structure like religious places. To increase the life of damaged structure. It is newly research topic and advantageous to all the existing structures which are liable to retrofit. It is painful to demolish the whole the structure which has been damaged due to various reasons. It has been proved as a boon for existing structure. The structures which are deteriorated are liable to retrofit. This work includes different techniques of retrofitting and provides solution at a glance. These studied approximate techniques are used to retrofit the different structures. Using this study, the measures to retrofit the different structure are suggested which are the part and parcel of this case study. Buildings and other structures have a certain useful life, which depends on the specifications adopted. The large number of monuments, which are cherished heritage structures have stood well over a period of time. But some of these have shown signs of distress due to age, aggressive natural environment/industrial pollution etc. Further distress gets aggravated due to over loading misuse of buildings. A few buildings have also failed due to faulty design of construction. Thus, repairs and rehabilitation of buildings are of vital importance. Reinforced cement concrete (RCC) as a construction material has come into use for the last one century. In India, RCC has been used

ISSN: 2454-9665

extensively in the last 50-60 years during this period. Human created large number of infrastructural assets in terms of buildings, bridges, sports stadium etc. which are life lines for the civilized society. These have been created with huge investment of resources and cannot even dream of recreating such assets out of limited national resources. It is therefore essential to maintain them in functional condition, since deterioration of RCC is a natural phenomenon and has started exhibiting in large number of structures; a systematic approach is needed in dealing with such problems. Identification of the causes of deterioration and consequent repair/rehabilitation strategy at optimum cost needs a scientific evaluation and solution. Initially, the structures deteriorate slowly due to cyclic temperature variations, overloading and physical causes and aggressive chemical attack due to environment etc. Later on, if not paid due attention, these deteriorate rapidly and fail to meet the functional requirement for its designed service life. Various causes of deterioration like original construction defects, chloride induced corrosion, carbonation of concrete, sulphate attack, cracking due to thermal gradient, plastic shrinkage cracks and foundation settlement etc

1.2 CAUSES OF FAILURE OF RC BUILDINGS

These are the several causes of failure of RC buildings the reinforced building are considered as engineered construction. These building are normally designed following a detailed structural analysis for dead loads, live loads and seismic loads. In order to withstand the effect of earthquake, reinforced concrete buildings are required to be designed for both strength and ductility. The buildings often get damaged in earthquake because of lack of good design and faulty detailing practice.

1. Lack of good design in planning lateral load resisting system such as moment resistant frames, frames with shear walls or with infill walls, and the joints.
2. Poor quality of construction materials and technology.
3. Inadequate detailing of reinforcement in beams, columns, beam-column joints, particularly from ductility considerations.
4. Inadequate diaphragm action of roofs and floors.
5. Sudden reduction in all column reinforcements at some point along the height.
6. Inadequate treatment of non-structural components like infill masonry walls, staircases, water tanks on roofs, etc.
7. Inadequate anchorage of bars at the ends, particular those ordinarily in compression, but subject to tension under reversed earthquake force direction.
8. Inadequate splicing of reinforcement in columns and beams.

2. LITERATURE REVIEW

D. Choudhuri. (1992), Bracci et al. (1997) [1] – have investigated that many of the structural failures during earthquakes in the early 1970s were due to inadequate shear strength and/or lack of confinement in concrete columns. Hence, early column strengthening procedures are typically involved increasing in the concrete column's cross-section. The main problem with this approach is that it often unacceptably increases the dimension

ISSN: 2454-9665

of the column, rendering the retrofit impractical. The use of thin carbon fiber composite sheets avoids this problem and has consequently gained acceptance over the past 10 years. It was noted that steel and composite jacketing was particularly useful for correcting inadequate lap splice problems and that anchor bolts can be used to improve confinement away from the corners of rectangular columns (e.g., Priestley et al. 1994; Saadatmanesh et al.1997). Nevertheless, concrete jacketing of concrete columns has been shown to be very effective in improving strength and ductility and converting strong-beam weak-column buildings into buildings with a strong-column weak-beam mechanism.

R.S. Aboutaha.et al. (1999) [2] - has done a study to investigate that the Concrete jacketing involves addition of a thick layer of RC in the form of jackets; using longitudinal reinforcement and closely spaced ties with seismic detailing method increases both strength and ductility. But the composite deformation of existing and the new concrete requires adequate dowelling for the existing column. Also the additional longitudinal bars need to be anchored to the foundation and should be continuous through the slab. The disadvantage is that the size of column increases. Steel jacketing refers to encasing the column with steel plates and filling the gap with non-shrink grout. The jacket is effective in passive confinement. That is, lateral confining stress is induced in the concrete as it expands laterally. Steel jacketing is a very effective method to remedy deficiencies such as inadequate shear strength and inadequate splices of longitudinal bars at critical locations.

A. Mukharji, M.V.Joshi.et al. (2002) [3] – have studied that the Fiber reinforced polymer (FRP) is a composite material and can be classified based on the material of the fiber which can be glass, carbon or aramid. Glass has been the fiber for economic reasons. FRP has desirable physical properties like corrosion and fatigue resistance and high tensile to weight ratio. FRP sheets are thin, light and flexible enough to be inserted behind service ducts, thus facilitating installation in retrofitting of column. There is no significant increase in the size. The main drawbacks of FRP are the high cost, brittle behavior and fiber resistance.

A. Seth et al. (2002) [4] - has done a study to investigate that the Concrete is added to increase the strength or stiffness of beam. There are some disadvantages in this traditional retrofit strategy. First, addition of concrete increases the size and weight of the beam. Second the new concrete requires proper bonding with existing concrete. In beam soffits the bleeding water from the new concrete creates weak cement paste at the interface. Third the effect drying shrinkage must be considered as it induced tensile stresses in the new concrete. Instead of regular concrete, fiber reinforced concrete can be used for retrofitting. The use of high performance fiber reinforced concrete, like slurry can be applied while the structure infiltrated mat concrete leads to increase of strength and energy adsorption capacity.

3. METHODOLOGY

3.1 SCIENTIFIC STEPS OF RETROFITTING

It is obvious that the best solution can be reached if the problem is approached in cool and scientifically rational manner in the following successive steps.

1. Detailed examination of the seismically weak building.
2. Analysis of the state of the building and noting the deficiencies.

ISSN: 2454-9665

3. Development of alternative strengthening strategy.

4. Examination of technically feasibility of implementing each alternative, as well as its cost estimate and selection of the optimum solution.

5. Final retrofitting design.

4. CASE STUDY.

Type of structure: - G+4 Storied R.C.C. framed structure

- Location: - Mauli Krupa chambers, plot no 19 sector, Airoli, New Mumabi

General

The building is located in Airoli, New Mumbai. This structure is farmed structure design was done by 4th storied with parking at ground level. But because of increasing dead load the building lower most columns was deteriorated and foundation also get damage. The roughly information collected at site then main causes of column and foundation failure is the water tank leakage exactly over the column. The leakage water corroded the reinforcement in the structure. The beam also exposed steel and not capable to take more load.

Visual Observation

1) The lower most columns in apartment building are exposed reinforcement totally.
2) Concrete cover on reinforcement was mostly less than specified.
3) The column concrete cover is less.
4) The foundation can deteriorate due to the ground water or soil containing aggressive chemicals.
5) Many occasions settlement of soil damage the foundation.
6) Faulty design of footing and workmanship also causes the failure.
7) The beam steel bars are shows unsafe or insufficient to carried load
8) Improper methods of compaction to the concrete.
9) Higher ground water table in the locality.

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	Photo. Excavation around the footing
 	Photo. Column support by Jack Photo. Column bars paint epoxy material (a)
	Photo. Column bars paint epoxy material (b)
	Photo. Strengthening of beam

ISSN: 2454-9665

c) Recommended Repair Methods

➢ ***Strengthening of Foundation***

Stepwise sequence of methodology to be adopted is given here under.

Step1] Excavating around the footing.

Step2] Cleaning and roughening the concrete surface.

Step3] Installing dowels at 25-40cm spacing in both directions using an appropriate epoxy material.

Step4] Fastening the new steel bars with the dowels using steel wires. The diameter and number of steel bars should be according to the design.

Step5] Coating the footing surface with a bonding agent in order to achieve the required bond between old and new concrete.

Step6] Pouring the new concrete before the bonding agent dries. The new concrete should contain a non-shrinkage material.

Step7] If the bearing area of footing has to be increased without strengthening of the column then the soil pressure on the extended foundation area has to be
transferred to the existing footing.

Step8] Transfer of soil pressure to existing footing is difficult to excavation is required below the existing footing. The building has to be properly supported and settlement of foundation has to be avoided.

➢ ***Column Steel Jacketing***

Stepwise sequence of methodology to be adopted is given here under.

Step1] Removing the concrete cover.

Step2] Cleaning the reinforced steel bars using a wire brush or a sand compressor.

Step3] Coating the steel bars with an epoxy material that would prevent corrosion.

Step4] Installing the steel jacket with the required size and thickness, according to the design, and making opening to pour through them the epoxy material that would guarantee the needed bond between the concrete column and the steel jackets.

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Step5] Filling the space between the concrete column and the steel jacket with an appropriate epoxy material.

Step6] In some cases, where the column is needed to carry bending moment and transfer it successfully through the floors, one should install a steel collar at the neck of the column by means of bolts or a suitable bonding material.

- ***Strengthening of Beam***

Stepwise sequence of methodology to be adopted is given here under.

Step1] Removing the concrete covers, roughing the beam surface, cleaning the reinforced steel bars and coating them with an appropriate material that would prevent corrosion.

Step2] Making holes in the whole span and width of the beam under the slab at 15-25cm.

Step3] Filling the holes with cement mortar with poor viscosity and installing steel connectors for fastening the new stirrups.

Step4] Installing the steel connectors into the column in order to fasten the steel bars added to the beam.

Step5] Closing the added stirrups using steel wires and the new steel is installed into these stirrups.

Step6] Coating the concrete surface with an appropriate epoxy material that would guarantee the bond between the old and new concrete, exactly before pouring the concrete.

Step7] Pouring the concrete jackets using low shrinkage concrete.

5. THE RESULTS AND DISCUSSION

In third case study the visual observation of the building is done at some places of brickwork. Cracking which results when an excessive amount of water is lost from the plaster in the first hours after application is known as plastic shrinkage cracking. In this structure totally external plaster is removed before retrofitting. The polymer jacketing should be done for column. For plastering first cutting of old plaster the mortar of the patch, where the existing plaster has cracked, crumbled or sounds follow when gently tapped on the surface, is first removed. The patch is to be cut out to square or rectangular shapes at position where repairing is needed. The edges of cut plaster are made under cut to provide a neat join. Then new plaster material should be placed. In the fourth case study because of increasing dead load the buildings lower most columns is deteriorated and foundation also gets damaged. The rough information collected at site the main cause of column and foundation failure is the water tank leakage exactly over the column. The leakage of water is corroded during the reinforcement in the structure. The beam is also exposed steel. The column has concrete jacketing at one place. The increase of cross sectional area is not permitted, so the discussion about the steel jacketing for one column, and check feasibility of steel jacketing is possible. The foundation can deteriorate due to the ground water or soil containing aggressive chemicals. On many occasions settlement of soil damages the foundation.

Result Case Study.

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Table. Types of defects in concrete, suitable methods

Sr. No.	Problems	Methods
1	Column reinforcement exposed	1. Concrete jacketing 2. Steel jacketing 3. Fiber reinforced polymer sheet wrapping 4. Prestressed wire wrapping
2	Beam reinforced exposed	1. Addition of concrete 2. Steel plating 3. FRP wrapping 4. Use of FRP bars 5. External prestressing

a) ***Recommended conclusion***

1) When the bearing area of footing is not sufficient
2) The size of the footing should be increased
3) The forces on the foundation increase.
4) The column has not more cover place so steel jacketing is preferable.
5) The leakage water corroded the reinforcement in the column, water leakage problem solved before retrofit.
6) The steel bars in the beam are unsafe and insufficient to carried applied load.
7) Stability of the area, particularly for building on retained earth or hilly area.

CONCLUSION

The crack inspection forms the primary most important aspect. It in fact defines the entire rehabilitation program to be adopted. Study of cracks is done visually. Hollowness identification forms the next important aspect of investigation, tapping of with proper hammer to locate the limits of the zone of hollowness. The formation of proper bond between the old and new material is essential for the success of the system.

The following conclusion can be write on the basis of studied the various case studies on the residential building.

1. FRP, RC Jacketing and Steel Jacketing can be used to improvement the strength of the buildings.
2. RC jacketing is a very effective strengthening technique, leading to values of resistance and stiffness of the strengthened column considerably higher than those of the original column.
3. Column jacketing increases the overall building stiffness, but that is accompanied by an increase in the seismic forces induced in the building.
4. Plaster mesh is designed for better grip on the plaster wall and spalling of concrete at celling to supporting the plaster layer. It protects the finished surface from cracks and improves the mechanical strength of plaster.
5. In high rise building where bottom story kept open in such type of cases steel and RCC bracing should be used for stabilize the structure.

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6. Polymer modified cement slurry to be injected through nipple to improve water proofing at roof surface crack for existing terrace.
7. The combination of fly ash, sand, and epoxy has resulted in a cohesive, flow able and consistent mixture for repaired joints.
8. The cracking in piers can be reduced by providing the additional horizontal band, preferably at sill level.

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REFERENCES

1. Aboutaha, R.S., Englehart, M.D., Jirsa, J. O. and Kreger,M.E. (1999)," Rehabilitation OF Shear Critical concrete by Use of Rectangular Steel jackets" ACI Structural Journal, American Concrete institute, January-February, Vol.96, No.1, pp. 68-78.
2. ACI Committee 440.2R02. (2002). Guide for the Design and Construction of Externally Bonded Systems for Strengthening Concrete Structures, ACI, Michigan, U.S.A.
3. Aguilar, J., Juarez, H, Ortega, and Iglesias.J (1989)" The Mexico earthquake of September 19, 1985. Statics of damage and retrofitting techniques in R/C building affected by the 1985 earthquake". Earth. Spectra, EERI, 5(1), 145-52.
4. Bhandari N. M. and Dwivedi A. K."Repair Materials and Techniques for Retrofitting" Workshop on Retrofitting of structure, Oct 10-11-2004 IIT Roorkee, pp. 86-105.
5. Biggs, J. M., H. S. Suer and J. M. Louw, "The Vibration of Simple Span Highway Bridges," *Journal of Bridge Engineering*, American Society of Civil Engineers, Vol. 96, No. EM5, October, pp. 593–620.
6. Bracci, J. M., Reinhorn, A. M. and Mander, J. B., "Seismic Retrofit of Reinforced Concrete Buildings Designed for Gravity Loads: Performance of Structural Model", ACI Structural Journal, American Concrete Institute, November-December 1995, Vol. 92, No. 6, pp. 711-723.
7. Fib Task Group 9.4. (2001) externally bonded FRP Reinforcement for RC Structures, fib Bulletin 14, Lausanne, Switzerland.