Case Studies on Retrofitting of Government RCC Structures (Electricity Office)

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Abstract **- RCC as a construction material has come into utilization for the last one century. In India, Reinforced cement concrete has been utilized widely in the last 50-60 years. During this period, we have created enormous number of infrastructural resources in terms of bridges, buildings, sports stadium etc., which are lifeline for the civilized society. These have been made with gigantic speculation of resources. We cannot even think of recreating such resources out of limited national assets. It is, therefore, essential to maintain them in functional condition.**

The purpose of this project is to gain fundamental and practical understanding on concrete repairing and rehabilitation of the structures. The rapid urbanization has led to spreading of small RCC Buildings and has severely strained the resources in our country. Most recent constructions in the urban areas consist of poorly designed and constructed buildings. The older structures, even if constructed in compliance with relevant standards at that time, may not comply with the more stringent specifications of the latest standards. There is an urgent need to assess the seismic vulnerability of buildings in India, as an essential component of a comprehensive earthquake disaster risk management policy.

The main purpose of repairs is to bring back the architectural shape of the building so that all services start working and the functioning of building is resumed quickly. Repair does not pretend to improve the structural strength of the building & can be very deceptive for meeting the strength requirements of the next earthquake.

Rehabilitation is the restitution of the strength the building had before the damage occurred. This type of action must be undertaken when there is evidence that the structural damage can be attributed to exceptional phenomena that are not likely to happen again & that the original strength provides an adequate level of safety.

Index Terms **- Cement, concrete, Construction, civil engineering, demolished, design, development, jacketing, Rehabilitation, reduction, seismic strength.**

I.INTRODUCTION

RCC construction is generally expected to give trouble free service throughout its intended design life. However, these expectations are not realized in many constructions because of structural deficiency, material deterioration, unanticipated over loadings or physical damage. Premature material deterioration can arise from a number of causes, the most common being when the construction specifications are violated or when the facility is exposed to harsher service environment than those expected during the planning & design stages.

The existing buildings nearing its serviceability life & showing sign of breakdown does calls for technical intervention for enhancing their life & to avoid any accidental failure due to seismic event or other structural reason. Physical damage can also arise from fire, explosion – as well as from restraints, both internal & external, against structural movement. Except in extreme cases, most of the structures require Rehabilitation to meet its functional requirements by appropriate repair techniques.

Post the technical evaluation of such structures, the decision to repair or replace a structure or its component has to be taken. This has to be in compliance with economy, construction feasibility & as per latest trends and techniques.

The approach towards Rehabilitation of any building can be categorized in following steps & actions.

- Performing a Structural Audit of the building,

- Evaluating various retrofitting options, materials, feasibility and economy
- Performing structural calculations and capacity demand ratio for structural members,
- Suggesting retrofitting/construction system and getting the rehabilitation of the building done,
- Post retrofitting tests on the building.

II. RESEARCH BACKGROUND ON RETROFITTING OF RCC BUILDING

CPWD, New Delhi concluded in his studies that Buildings & 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.

S.S. Chandar Structural Engineer, Structural Department, MWH Global, Bajaj Brand View, Wakdewadi, Pune, Maharashtra, India. In 2014 expressed that the engineering which involves in modifying the existing buildings for structural behaviour without hampering its basic intent of use is termed as retrofitting.

Dr.Anand S. Arya, FNA, FNAE, FIE (Professor Emeritus, Dept. of Eq. Engineering, IIT Roorkee) Chairman, BIS Committee CED 39 National Seismic Advisor (EVR) Ministry of Home Affairs. In June 2006 stated that introducing new load bearing members including foundations to relieve the already loaded members. Jacking operations may be needed in this process. He also said that one of the strengthening methods includes adding new structural elements to an existing structure to increase the lateral force capacity. Shear walls & steel bracing can be added as new elements to increase the strength and stiffness of the structure.

Shamim A. Sheikh, David DeRose, & Jamil Mardukhi concluded in his studies that because the damage to the building was partly caused by excessive differential foundation settlement, enhancement in ductility was one of the main focuses in designing the retrofitting schemes, particularly in the case of beams showing signs of failure in shear. Another factor in the selection of the repair technique was the continued use of the structure for normal activities.

Hemchandra Chaulagain in his paper Assessment of seismic strengthening solutions for existing low-rise RC buildings in Nepal concluded that the RC jacketing of columns increases significant deformation capacity. It confirms that RC jacketing is a very effective strengthening technique, leading to uniformly distributed values of strength & stiffness of the strengthened column that are considerably higher than those of the original column. The measured hysteretic loops for the jacketed columns indicated good energy dissipation.

III. NEED FOR STRUCTURAL RETROFITTING:

During design & development of any structures many precautions & steps are taken to avoids any damages during serviceability life. But if any how damage caused then we need structural repairs & Rehabilitation.

The need of structural repairs can arise due to any of the following reasons:

- Faulty design of the structure.
- Low quality materials used.
- Improper execution and bad workmanship.
- Due to any side by construction or any adding & alterations in existing structures.
- Extreme weathering and or due to changes in environmental conditions.
- Changes in seismic zones, prompting seismic retrofitting for critical structures like healthcare facilities, define establishments etc.
- Improper use of structure. E.g. Increased loads etc.
- Changes in prevailing codes. E.g. changes in the minimum grade of concrete to be used.
- Due to any explosion or because of high degree of chemical attack.
- Ageing of the structure.

IV. ADVANTAGES OF STRUCTURAL RETROFITTING

- Strength: In case of lost strength, repairs should restore the strength.
- Economic: There are no detrimental effects on concrete & on other structural & non-structural elements.

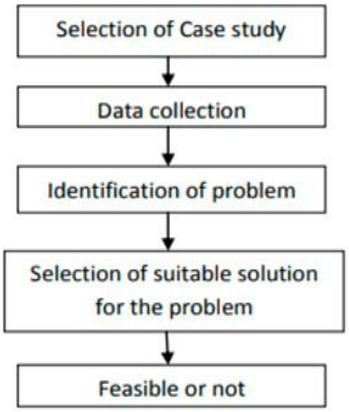
- Save environment: There is no uncovering of natural assets and less transportation. Also, less land is utilised.
- Save time: There is no hanging tight for material accessibility.
- Sustainable: Less outflow of carbon because of less smashing.
- Less Noise, Dust and Debris.
- Ideal for short term jobs.
- Reduce the impact of squander materials on environment in terms of dust particles, disposed etc.

V. DISADVANTAGES OF STRUCTURAL RETROFITTING

- Structural Repairs & Rehabilitation activities cannot be done during heavy rain or freezing conditions, since mortar will be severely affected.
- Repairs & Rehabilitation activities construction requires a good amount of time and adequate project planning. Depending on the type or Repairs & Rehabilitation activities, specialized manpower may be necessary.
- The stability of Repairs & Rehabilitation activities depends completely on their foundation. If any settling of the foundation occurs, cracks are likely and they must be repaired to prevent moisture infiltration and damage.
- Sometimes Structural Repairs & Rehabilitation activities involves heavy materials such as bricks, stone and concrete blocks. These cannot be transported in conventional vehicles, and in some cases they must be ordered from special catalogs, especially stones.
- Sometimes Structural Repairs & Rehabilitation activities involves of steel bars that may cause loss of historical material.
- Sometime because of dust respiratory problems arise in the workers involves in Repairs & Rehabilitation activities.

VI. TYPICAL STRUCTURAL RETROFITTING & STRENGTHENING TECHNIQUES

It is a general practice to have structural retrofitting to primarily restore or enhance either concrete or steel in the structure.



Flowchart-1: Process of Repair and Rehabilitation

The approach towards rehabilitation of any building can be categorized in following steps and actions.

- Performing a Structural Audit of the building,
- Evaluating various retrofitting options, materials, feasibility and economy.
- Performing structural calculations and capacity demand ratio for structural members,
- Re-design an existing structure using ETABS according to demand and analyzing the result with existing reports for ascertaining the seismic load carrying capacity of that structure.
- Suggesting retrofitting/construction system and getting the rehabilitation of the building done,
- Post retrofitting tests on the building.

There are primarily the following method used for the above said purpose.

1.Concrete

- Jacketing of beams, columns and increasing slab thickness.
- Rehabilitation of cover and loose concrete.
- Steel plates to enhance the strength of the structure.

2.Footings

- Extension of footings.

3.Steel

- Replacement of steel
- Fibre wrapping

VII. SEISMIC RETROFITTING TECHNIQUES

System strengthening and stiffening are the most common seismic performance improvement strategies adopted concurrently for buildings with inadequate

lateral force resisting systems. Typical systems employed by the authors during strengthening of earthquake-damaged buildings in India include the addition of new vertical elements, shear wall, braced frames & jacketing. Amidst all the retrofitting option, appropriate option can be selected on case-to-case basis after proper seismic evaluation and considering its merits & demerits, which are briefly discussed hereunder:

7.1 Shear Walls

The introduction of shear walls into an existing concrete structure is extremely effective method of increasing both building strength and stiffness. A shear wall system is often economical and tends to be readily compatible with most existing concrete structures. However, the addition of shear walls to an existing structure can have some adverse impacts, like addition of large number of shear walls to a building can result in a significant increase in building mass and therefore increase seismic forces and strength requirements. Shear walls may often result in significant architectural impact through the loss of windows and the introduction of barriers within areas of floor space and also tend to produce large overturning forces at their bases that may require supplemental foundation work, which is often expensive.

7.2 Braced Frames

Braced steel frames are another common method of enhancing lateral stiffness and strength of an existing building. However, it is not as popular in India as it is difficult to effectively attach braced frames to an existing RC frame. Typically, braced frames provide lower levels of stiffness and strength as that of shear walls, but they add far less mass to the structure and can be constructed with less disruption of services, less loss of light, and have a smaller effect on traffic patterns within the building.

7.3 Eliminating or Reducing Structural Irregularities

Irregularities related to distribution of strength, stiffness and mass result in poor seismic Performance. Often these irregularities exist because of discontinuity of structural members. Simple removal of such discontinuities may reduce seismic demand on other structural Components to acceptable levels. An effective measure to correct vertical irregularities such as weak and/or soft storey is the addition of shear walls and braced frames within the weak/soft storey. Braced frames and shear walls can also be effectively used to balance stiffness and mass distribution within a storey to reduce torsional irregularities.

7.4 Supplemental Damping and Isolation

Seismic isolation and supplemental damping are rapidly evolving unconventional strategies for improving seismic performance of structures. An overall response of base isolation is reduction in demands on the elements of the structure. This technique is most effective for relatively stiff buildings with low profiles and large mass compared to light, flexible structures. However, base isolation is technically complex and costly to implement. Energy dissipation helps in overall reduction in displacements of the structure. This technique is most effective in structures that are relatively flexible and have some inelastic deformation capacity. Again, this strategy is technically complex, but less costly compared to base isolation.

VIII. NEW APPROACHES FOR SEISMIC RETROFITTING

Immediately after the earthquake, the focus is drawn to repair the most vulnerable locations in the buildings by conventional repair cum strengthening schemes such as jacketing of ground storey columns, addition of shear walls etc. mainly governed by socio-economic considerations. However, these seismic retrofit schemes cannot be applied since one or more of the following conditions may often have higher priority in determining available repair scheme.

- Limit of construction space, period, & time
- Noise, vibration, dust during work
- Preservation of architectural & structural design
- Functional performance as well as structural performance
- Serviceability during construction

Among many new technological options viz. seismic isolation, supplemental energy dissipation, active control, high performance materials available for retrofitting, cost constraint restrict the use of these techniques in Indian context. However, recently developed seismic retrofit technique, ‘carbon fiber wrapping of structural members’ has been implemented successfully at number of multistoried

buildings during post rehabilitation work after Bhuj-earthquake despite of cost considerations. This enjoys edge over the conventional repairing techniques due to its speed of execution and durability. It is experimentally as well as analytically verified that the Carbon Fiber Wrapping around deficient columns and beams adds to confinement and thereby improve strength against flexure, shear and ductility.

8.1 Carbon Fiber Jacketing of RC Columns

The fiber wrapping system is a high strength hybrid woven fabric/epoxy composite made of E - glass & Kevlar / Aramid fibers embedded in an epoxy resin. This scheme basically aims at improving ductility of existing RC columns, which may fail in shear during an earthquake. The advantage of using carbon fiber jacketing is relatively easy for application; rapid execution; high strength to weight ratio; good resistance to corrosion and environmental degradation; tailor ability to adapt to any shape of the substrate concrete. However, the general methodology, design principles, and some test results for application of fiber wrap have been discussed elsewhere.

8.2 Base Isolation

This approach requires the insertion of compliant bearings within a single level of the building's vertical load carrying system, typically near its base. The bearings are designed to have relatively low stiffness, extensive lateral deformation capacity & may also have superior energy dissipation characteristics. Installation of an isolation system results in a substantial increase in the building's fundamental response period &, potentially, its effective damping. Since the isolation bearings have much greater lateral compliance than does the structure itself, lateral deformation demands produced by the earthquake tends to concentrate in the bearings themselves. Together these effects result in greatly reduced lateral demands on the portion of the building located above the isolation bearings. However, this is not being practiced in India for post-earthquake rehabilitation.

IX CONCLUSIONS

- Rehabilitation reduces the vulnerability of damage of an existing structure during a future earthquake. It aims to strengthen a structure to satisfy the requirements of the current codes for seismic design.
- In this respect, seismic repairs is beyond conventional repairs or even rehabilitation. The principles of seismic repairs refer to the goals, objectives & steps.
- The steps encompass condition assessment of the structure, evaluation for seismic forces, selection of retrofit strategies & construction.
- The applications include different types of buildings, industrial structures.

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