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Rehabilitation of Buildings

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Abstract

Repairs and rehabilitation engineering being a specialized field calls for skills and abilities far beyond the construction engineering and has to be a balance amid advanced technology and trends, management, feasibility and economy.

Experimental studies from past few earthquakes states, Most of the long-standing buildings that collapsed were found deficient to meet-up the requirements of present day seismic design standards. Frequent earthquakes continue shaking the land every now and then. Due to faulty construction practices, disinclination to seismic design compliance and the construction that has taken place in the past without seismic standards or awareness calls for the Rehabilitation of the existing structures showing signs of descent. This has to be done to save the lives and the economy.

The purpose of this paper is to present the process of rehabilitation, retrofitting characteristics and technical aspects of the major intervention methods. In addition, selected tests and feasible techniques as per the latest advances in the industry to be used for health assessment, retrofitting and rehabilitation are presented in depth with example calculations.

The paper will discuss following points in more detail.

- Scope of repairs and rehabilitation
- Health Assessment of the existing structures in adherence with latest tools.
- In depth Structural Audit and Condition assessment calcs for the structures with emphasis on load path and decapitation of seismic forces.
- Repairs and retrofitting methods and
- Post retrofitting evaluation for behavior of the structure.

Keywords: Retrofitting, Rehabilitation, Seismic, Audit,

1. Introduction

The existing buildings nearing its serviceability life and showing sign of breakdown does calls for technical intervention for enhancing their life and to avoid any accidental failure due to seismic event or other structural reason. The deterioration of the structures takes place due to Weathering action, Fire, Natural calamities like earthquake, Flood, Tsunami, cyclones, Soil and structure interaction (Settlement of soil or soil failure), defects in construction and many more. 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 and as per latest trends and techniques. 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,
- Suggesting retrofitting/construction system and getting the rehabilitation of the building done,
- Post retrofitting tests on the building.

2. Rehabilitation of Buildings

2.1 Structural Audit

Structural Audit forms a preliminary step towards rehabilitation of buildings. Health assessment/structural Audit of any existing structure, do determine whether its functionality is as per desired and acceptable. It ensures the existing structure is thoroughly inspected as per relevant codes, techniques and the serviceability of the structure is judged based on it. It is an activity where actual data related to civil structures is observed, measured, registered and conclusions are drawn. This is performed through all times by responsible designers, contractors and owners with almost identical objectives to check that the existing structures behave as intended. The Audit helps to understand critical areas to repair and enhance life cycle of building by suggesting preventive and corrective measures like repairs and retrofitting.

As per the Cooperative Housing Societies Bye-laws, structural Audit is also mandatory in India. It has to be performed once in 5 years for buildings aging between 15 to 30 years and every 3 years for buildings having age above 30 years.

Nondestructive tests which do not alter the original properties of the structural members are performed on the structure. The information on these tests is available in A.C.I. 228, IS 13311 (Part 1 & Part 2)1992. Few of the widely used tests, but not limited to, for estimation of strength of concrete in place are proposed below.

- Rebound Hammer test
- Ultra Sonic Pulse Velocity
- Probe Penetration

- Pull Out
- Break Off
- Maturity Method
- Core Testing (ASTM 42) IS 516 & IS 1199
- Infrared Thermography
- X-Ray & Gamma Radiometric Methods

Destructive tests that may be performed on the concrete are listed below.

- Gravimetric Technique (Weight Loss Method)

2.2 Approach towards Retrofitting of Buildings

The engineering which involves in modifying the existing buildings for structural behavior without hampering its basic intent of use is termed as retrofitting. It becomes necessary to improve the performance of structures including those facing loss of strength due to deterioration or which have crossed their anticipated lifespan. The realization of retrofitting depends on the authentic cause and measures adopted to prevent its further deterioration. This development includes repair, retrofit, renovation and reconstruction wherever required. A proper load path has to be analyzed by a structural engineer and a decision has to be taken if any additional member like shear walls, etc needs to be added. The engineering analysis, design and construction of any necessary retrofitting must be carried out bearing in mind the following aspects:

- Functionality aspect: The basic function/ operation of the structure should not be hampered.
- Structural safety Aspect: The susceptibility of the structure to an earthquake event has to be within acceptable standards.
- Importance Level Aspect: Historic buildings with immense archeological importance are sometimes beyond the cost factor for retrofitting. Such structures have to be rehabilitated without changing its elegance.
- Construction Methodology Aspect: The retrofitting has to be performed using latest construction techniques that have the minimal impact on usual functioning of the buildings.
- Economy Aspect: The entire cost of construction has to be practical and logical towards extended life of the structure.
- Skilled labor availability: The retrofitting practices need unusual construction method and is highly technical job and calls for utmost care to implement it. A very skilled workmanship must be provided to instrument the suggested measures.

2.3 Different Retrofitting options for Buildings

Based on the intensity of the repairs needed and calculations done, various retrofitting options listed below are used to enhance the structural strength. This is carried out under a strict supervision of a technical expert in the field.

- Replacement of structurally fragile concrete,
- Grouting and crack repair,
- Crack repairs and Patch repairs,
- Replacement of carbonated concrete near steel reinforcement,
- Cleaning and passivating corroded steel reinforcement,
- Concrete overlays with normal low or highly fluid concrete, latex modified concrete and corrosion protection such as jacketing, etc.,
- Re-alkalization of carbonated concrete,
- Electro chemical removal of chloride from concrete, and
- Water proofing / or protective coating.

2.4 Capacity calculations for existing structural members of a Building

The Moment of resistance without compression reinforcement for rectangular and T-sections based on the assumption of cl 38.1 and Annex G of IS 456-2000 for balanced section for Fe500, can be simplified as,

$M_u = 0.133 f_{ck} bd^2$

Where

fck= Characteristic cube compressive strength of concrete

Assuming M20 grade of concrete.

Staad-Pro Software is used to analyze the existing building of age 30 years and actual bending moment of the critical beams is obtained and presented below. Seismic, Wind and loading calculations was done as per latest code requirements.

Beam No.	**Section**	$M_u = 0.133 f_{ck} bd^2$ **kN-M**	**Actual Bending Moment in kN-M**	**Pass/ Fail**	**Capacity in %**	**Remark**
B1	230x550	185.06	221.07	Fail	83.71%	Requires retrofitting
B2	230x600	220.24	227.01	Fail	97.01%	Requires retrofitting
B3	230x550	185.06	112.3	Pass	>100%	Beam is Safe
B4	230x550	185.06	127.5	Pass	>100%	Beam is Safe
B5	230x550	185.06	145.8	Pass	>100%	Beam is Safe

2.5 Post Retrofitting tests and measures on the building

An independent assessment to check the stability of the strengthened structure is suggested post the rehabilitation work is done. A Live Load test using concepts of Sand bags or similar arranged all over the floor in order to replicate the Live Loading condition may be used. The structure has to be assessed for strength and serviceability cases of design.

3. Conclusion

Rehabilitation of structures embroils contribution of high end technology, advanced skills and calculations. This is a very responsible job to be done to save hazardous failure of structures due to deterioration. The success of this subject totally depends on gaining expertise in the field and day to day advancements. Rehabilitation is highly recommended for age-old buildings showing signs of decent and save human lives from failures.

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