

# Case Studies of Rehabilitation/Repair of Reinforced Concrete Structures

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**Abstract:** Concrete constructions and structures require proper care in the form of regular and proper maintenance. If buildings remain for several years without proper attention and poor caring then, then various factors causes like water stagnation, paint peeling, plaster break-off, fungus growth, cracking of external surfaces resulting its affect the building. Penetration of moisture into reinforced concrete components arises corrosion process and further damages the concrete cover and member. It has been observed that the deterioration phenomena of RCC are not realized by majority of practicing or less experience civil engineers. As a result, the factors considered necessary for durability of RCC buildings are many times not given due importance during construction and/or during maintenance. In the international scenario also, deterioration of RCC structure had been gaining attention of the practicing civil engineers for quite some time. They have accordingly, made certain up gradation in the field of protection, repairs, rehabilitation, strengthening and retrofitting of the existing RCC structures.

**Keywords:** Rehabilitation, Repair, Retrofitting, Structure.

## 1. Introduction

Generally, we are expected concrete construction is to give trouble free service throughout its intended design life. But, these expectations are not fulfilled or realized in many constructions because of some structural deficiency, material deterioration, unanticipated over loadings or physical damage in construction members. Premature material deterioration in structure can arise from a number of causes, the most common thing when the construction specifications are violated or when the facility is exposed to harsher service environment than those expected during the planning and design stages. Damages especially physical damage can also arise from fire, explosion as well as from restraints, both internally and externally, against structural movement. Except in extreme cases, many of the structures require restoration to meet its functional requirements by appropriate repair techniques. There are other factors that necessitate renovation. These are accidents, environmental factors, alteration to structures, etc. The construction work or some repairing work associated with already-constructed structures is called renovation. Some

people call the process of rehabilitation "Forensic Engineering." The role of the engineer is just like that of a doctor trying to diagnose the disease of a patient and then recommending corrective treatment. Maintenance of constructed structures includes preventive care, repairs, and rehabilitation. Rehabilitation of structures is a multi-disciplinary activity. The concerned engineer or experience engineer should know the design aspects, environmental factors, construction procedure, and about building materials. The rehabilitation or repairing of existing structures is a more complicated and sophisticated task than new construction.

## 2. Present Repair Practices - Overview

What are the aspects behind Repair of structures arise?

- The gap between Quality Planned and Quality achieved in past, present.
- We do take cube test but How far its significance is taken during progress of work how far is the correlation maintained with such results.
- There are some specifications and instructions for construction but they all remain on paper sometime due to lack of understanding or proper knowledge.
- The Periodic Inspections of building and maintenance procedure are not followed or maintained properly.
- Un-experienced engineer or someone else working can also affects the project.
- Buildings remains several years without any proper attention and lack of maintenance.

In Construction work, documents contain adequate specifications and instructions required to execute quality type works. However, they remain as written document without achieving the desired level of results, because of lack of understanding and knowledge of their significance by the field engineers as well as supervisor. Standard cube test results are taken as a measure of quality in the construction.

### 3. Preliminary Inspection/Survey

- Before start of the work collection of history of structure from client, owner, occupants, General public in building should be done.
- If any past records regarding maintenance of structure should be note as well as, previous repairs history and expenses done for the same.
- Collect all possible data and information regarding construction work.
- Apply Practical restriction and as well as safety concerns.
- Extent and quantum of survey work.
- Calculation of Time required for survey and execution.
- Consult immediate safety measures if required.

#### A. Information gathering

- Time Period of construction.
- Collection of Construction drawings, arch, structural etc.
- Knowing Exposure conditions.
- Designed and present use of structure.
- Gathered Previous information of changes.
- Note or Record of any structural changes if done previously.
- Record of 1st occurrence of defect.
- Get details of repairing work carried out previously.
- Gather Previous reports if any etc.
- Get details from owner. Collects also photographs.

### 4. Rational Approach to Any Repairs and Rehabilitation of Works

#### A. Identification of distressing

The success of repair activity depends on the identification and finding out the root cause of the deterioration of the concrete structures. If this cause is properly identified and find then satisfactory measures of repairs can be done for the improvement of strength and durability, which helps to extending the life of the structure, it is not difficult to achieve. Before attempting or starting any repair procedure it is necessary and important to have a planned approach to investigate the condition of concrete and reinforcement structure. While the diagnosis of damage or deterioration in some cases is reasonably straight forward, it may not be same in many cases.

### 5. Principles of Rehabilitation

- a) *Elimination of structure*: Remove the materials that causes damages to the buildings or structure. Obviously this is not easy matter practically, because of everything from the floor to the roofing may contain in building in various undesirable materials in the form of additives and admixtures and other materials.
- b) *Separation of members*: Something just can't be eliminated properly, but they still can be protected. Use sealants or foil

backed drywall to separate structures from damage causing sources or the materials.

- c) *Ventilation in structure*: High humidity air or extremely low humidity air resulting in causes to significant damage to concrete, plaster as well as brick walls.
- d) *Excessive arrangements*: Special gadgets or the products may be required to get access to that particular part of the structure where the repairing work is to be carried out. The access arrangements gadgets or products may be in the form of suspended platforms, scaffoldings, jacking arrangements, anchoring systems, etc.
- e) *Sequence of operation of work*: The process of rehabilitation and repairing has to carry out in such a manner that the safety of the structure should not be affect. Therefore, it is necessary to plan the operations properly and then execute the work accordingly.

### 6. Common Areas of Repair/Rehabilitation Work

- Repair, removal, replacement and maintenance in mechanical supports area, sanitary treatment plant area and generally in pipelines duct.
- Repair and modifications in some diffuser ports, aeration systems i.e. ducting and other resources, and discharge pipelines.
- Repairing work in columns and beams i.e. cracks and etc.
- Installation and maintenance of dewatering structures to avoid water clogging.
- Pile restoration and wood pile concrete encapsulation at foundation repairing work if any.
- Anode installation for cathode protection.
- Repair and replacement of trash-rack and debris screen for outlet of garbage's or waste material .

#### A. Types of repair work

- Brick Wall Repairing work
- Plaster Wall Repairing work
- RCC structure Repairing work

### 7. Methods of Repair and Rehabilitation for Slab/Wall Cracks

#### A. Epoxy Injection Methodology

This method used for repairs of cracks in massive structures like column, beams, concrete members etc., a series of holes (Usually 20mm in diameter and 20mm deep spaced at 150 to 300mm interval) intercepting the crack at a number of location are drilled. Epoxy injection method can be used to bond the cracks as narrow as 0.05mm. Epoxy injection is a highly specialized job and it is required a high degree of skill for satisfactory and proper execution. In simple and understanding form, the injection equipment consists of a small reservoir or funnel attached to a length of flexible tubing, so as to provide a gravity head. For the small quantities of repairing work, material that can use with small hand-held guns These are the

most economical way. They can maintain a steady pressure which reduces chances of damage to the surface seal. For big jobs power-driven pumps are often used for injection method.

### B. Routing and Sealing

Routing and sealing of cracks can be used in the conditions where required remedial repair and structural repair is not necessary in such conditions. This method particularly involves enlarging the crack along its exposed face and filling and sealing it with a suitable joint sealant. Cracks in building are of common occurrence. A building component develops cracks because when stress exceeds strength. This is a common and easy technique for crack treatment and is relatively simple in comparison to the procedures and the training required for epoxy injection. Cracks are of two types:

- **Structural:** Structural ones are due to faulty design, faulty construction or overloading which may endanger safety or buildings.
- **Non - Structural:** The non-structural cracks are due to internally reduced stress. Depending on width of crack they are classified into Thin (<1mm), Medium (1mm to 2mm), Wide (>2mm).

### C. Strengthening Concrete Columns

Strengthening of concrete columns is a process used to add or restore ultimate load capacity of reinforced concrete columns. This method is used particularly for seismic retrofitting, supporting additional live load or dead load that not included in the original design, to relieve stresses generated by design or construction errors, or to restore original load capacity to damaged structural elements. Jacketing i.e. reinforced concrete increases the member size significantly. This has the advantage of increasing the member stiffness and is useful where deformations are to be controlled. RC Jacketing provides a better solution for avoiding buckling problems in columns in a building if they are found to be slender.

There are several techniques which are used to strengthen reinforced concrete columns like reinforced concrete jacketing, steel jacketing, and FRP confining or jacketing. Design for strengthening/repair work is based on composite action between the old and the new work. The calculations of Strain compatibility may have to be carried out very carefully giving due accounts to factors. As the new jacket is to behave compositely with the parent member, the new jacket can take additional loads only with the increase in the stresses & strains in the old one.

### D. Overlays

Generally, in Slabs, it contained fine dormant cracks. This cracks can be repaired by applying an overlay of repairing material, such as polymer modified Portland cement mortar or concrete, or by silica fume concrete. Slabs with working cracks can be overlaid if joints are placed in the overlay directly over the working cracks. Suitable polymers materials including styrene butadiene or acrylic latexes. The resin solids should be

at least 15 percent by weight of the Portland cement, with 20 percent usually being optimum.

## 8. Structure Evaluation

### A. Rebound Hammer Test

The method Rebound hammer test of using the hammer is explained as, When the plunger of rebound hammer is pressed against the surface of concrete, a spring controlled mass with a constant energy is made to hit concrete surface to rebound back. The extent of rebound, which is a measure of surface hardness. It is measured on graduated scale. This measured value is indicated as Rebound Number or Rebound Index. A concrete with low strength as well as low stiffness will absorb more energy to yield in a lower rebound value.

It is a Non - destructive testing method of concrete. It is providing a convenient and rapid indication of the compressive strength of concrete. Rebound hammer is also known as Schmidt hammer. In schmidt hammer a spring controlled mass consist that slides of plunger within a tubular housing.

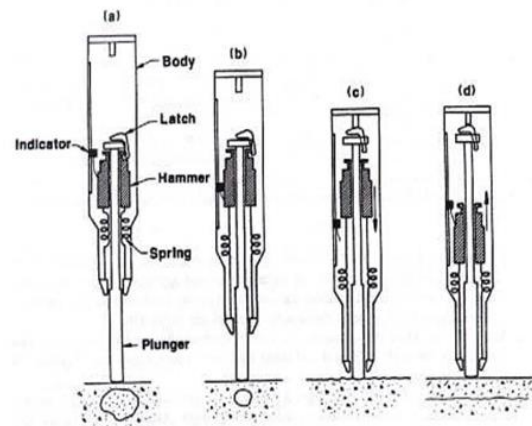


Fig. 1. Rebound hammer test

### B. Non-destructive testing

Non-destructive testing method can be applicable on both old and new structures. For new structures, the principal applications of this method are especially likely to be for determine quality control or the resolution of doubts about the quality of materials or construction works. There are number of non-destructive evaluation (NDE) tests for concrete members are available to determine in-situ strength and quality of concrete as well as materials. In this method some of tests are very useful in evaluation of damage to RCC structures subjected to corrosion, chemical attack, and fire and due to other reasons. The 'nondestructive' term indicates that it does not impair the intended performance of the structural member during tested/investigated. The testing of existing structures is usually related to an evaluation of structural integrity or adequacy. Non-destructive testing can be used in those situations as a preliminary to subsequent coring.

### 9. Conclusion

The Periodically and regular maintenance of RCC structures is essential and needful. Each and every problem should be properly analyzed and then apply suitable repair methods which are undertaken. Primary design of the building or the structure reflects its performance in long term manner. Each repair technique or method is suitable only for the particular problems for specially which it is meant for. Cost should not be significant factor in rehabilitation and repair of structure though it is a deciding factor. Due to moisture, wet walls losses its strength, so the mentioned repair works for bricks and plaster of walls is well recommended. Due to some adverse conditions cracks will form in walls and slab which disturbs the functioning of structure, so the earlier mentioned methods are very useful for repair of cracks and rehabilitation of structure. The early deterioration of concrete structure is also due to

improper and bad kind of maintenance. The water supply and drainage system should be kept so that there is no leakage/seepage on the walls and no clogging water on roofs due to overflow of water tanks or rains which acts as an enemy to the structural integrity of the buildings.

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