Case Study on Repair and Rehabilitation of Damaged Residential Building
Rishabh kalal¹, Mahipal singh jhala², Pradeep salvi³, Akanksha singh⁴

Abstract—Information regarding this paper discusses the Review of Repair and Rehabilitation of residential building. In current scenario of Building Research, Repair and Rehabilitation plays a vital role as it serves important in building applications. It acts as an inevitable solution in maintaining the Integrity of Structures. Repair and Rehabilitation of buildings has become a concern of greater importance over the world. The major defects reported are discussed and a suitable and economical solution for a particular defect is identified by a trade off between cost, lifetime and adaptability of the solution. Some guidelines for the selection of testing materials for repair work like, non-destructive test (NDT), jacketing, grouting, Epoxy resins, Quick-setting cement mortar has been discussed in this paper. The selection of materials for the repair is generally depend on many factors like requirement of repair and the financial resources, the suitability of materials and their applicability in the repair of damaged part of structures. For the successful repair, strengthening and restoration of damaged structures use of innovative and standard repair materials with good workmanship and appropriate technique, and proper control on quality during implementation are the only key factors.

Keyword—NDT tests, jacketing, grouting, Rehabilitation, Epoxy resins.

I. INTRODUCTION

For the maintenance of reinforced concrete structures buildings, it requires periodic inspection. In that case there is very little awareness in civil engineers and other discipline. As a result, many of the times due importance is not given to the repair and maintenance of the building.

But now a day it has become necessary to give more attention towards the repair and maintenance of old and damaged building structure. Hence, in depth requirement has been generated for structural repair, restoration and strengthening of RCC structures. New and innovative techniques have been developed in the repairs of concrete structures. In India there are large numbers of old existing buildings which are deteriorated because of their use, their age and may be due to fully consumption of their design life. For such a deteriorated structures it requires repair with proper material and proper technique. The cost of repair for any deteriorated building structures could be in lacs of rupees. To avoid any kind of accident of such deteriorated buildings, repair works should be carried out at regular time so that the building will be serviceable up to its full serviceable life.[1]

Repair and Rehabilitation technique is also used to modify a structure to meet new functional and other requirements. Many structures may need Repair and Rehabilitation for one of the following reasons

1. Deterioration due to Environment effect.
2. New functional or loading requirements entering modifications to a structure.
3. Damage due to accidents.

The basic process flow employed in Repair and Rehabilitation includes identification of the building that should be rehabilitated, history of the building, preliminary survey which includes preliminary tests that are performed, identification of problems, and suitable solution for the problem which should be feasible to the building topography conditions.[1]
II. REPAIR AND REHABILITATION OF RESIDENTIAL BUILDINGS- CASE STUDIES

Reported case studies of Repair and Rehabilitation in heritage buildings are prescribed below. The reason for the problem is cited and the solutions existing to resolve the problem are also provided[2]

2.1 Preliminary Investigation

By the physical point of view buildings shows various problems such as cracks in masonry walls, crack in concrete slab, collapse of column portion and roof leakages. These are caused due to poor load distribution, poor waterproofing, seepage of water and water logging, cracks in the outer brick surface and decay of bricks in the inner surface. The visual inspection necessitated the need for detailed evaluation for design of the rehabilitation design.

2.2 Detailed investigation

Non-Destructive Methods

The objective of a non-destructive test is to obtain an estimate of properties of material by measuring certain quantities which are empirically related to it. To make a strength estimation, it is necessary to know the relationship between the result of the non-destructive test and strength of material.

The accuracy of interpretation of results depends directly on the correlation between strength of material and measured quantity. Thus, the user of NDT should have an understanding of what quantity is measured by the test and how this quantity is related to the strength of material. Test methods range widely in reliability and complexity. Hence, appropriate experience is necessary in selection of the proper tests and correct interpretation. The following NDT techniques are generally employed[2]

2. Ultrasound pulse Velocity tests for establishing quality of concrete.
3. Pull out test.

2.2.1 Rebound Hammer Method

The operation of rebound hammer (also called Schmidt’s Hammer) is illustrated in fig. when the plunger of rebound hammer is pressed against the surface of concrete a spring controlled mass with a constant energy is made to hits concrete surface to rebound back. The extend of rebound which is a measure of surface hardness, is measured on a graduated scale. This measured value is designated as rebound number. A concrete with low strength and low stiffness will absorb more energy to yield in a lower rebound value.
This method is explained in IS:13311 (part2):1992. Principle of test; When the plunger of the rebound test hammer is pressed against the surface of the concrete the spring controlled mass rebounds and the extent of such rebounds depends upon surface hardness of the concrete. The rebound is then be related to the compressive strength of concrete.[3]

Factors affecting the Rebound Number

a. Mix characteristics:
   1. Cement type
   2. Cement content
   3. Coarse aggregate type

b. Angle of inclination of direction of hammer with reference to horizontal

c. Members characteristics
   1. Mass
   2. Compaction
   3. Surface type
   4. Age, rate of hardening and crushing type,
   5. Surface carbonation
   6. Moisture condition
   7. Stress state and temperature

Table 1.
Quality of concrete from rebound values comparative hardness

<table>
<thead>
<tr>
<th>Average rebound</th>
<th>Quality of concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;40</td>
<td>Very good</td>
</tr>
<tr>
<td>30-40</td>
<td>Good</td>
</tr>
<tr>
<td>20-30</td>
<td>Fair</td>
</tr>
<tr>
<td>&lt;20</td>
<td>Poor/delaminated</td>
</tr>
<tr>
<td>0</td>
<td>Very poor/delaminated</td>
</tr>
</tbody>
</table>
2.2.2 Ultrasonic Pulse Velocity

This method is explained in IS 13311 (part 1):1992, which involves measurement of the time of travel of electronically generated mechanical pulses through the concrete.

The ultrasonic pulse velocity method could be used to establish:

a) Homogeneity of concrete
b) Presence of cracks & voids
c) Changes in structures of the concrete
d) The quality of the concrete in relation to standard requirement
e) The values of dynamic elastic modulus of the concrete

The principles behind the Ultrasonic Pulse Velocity is that the pulses are generated by an electroacoustical transducer, when pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of different material phase within the concrete. A complex system of waves is developed which include longitudinal, shear and surface waves. The receiving transducer detects the onset of longitudinal waves which is the fastest. Because the velocity of the pulses is independent of the geometry of the material through which they pass and depends only on its elastic properties. When quality of concrete in terms of density, homogeneity and uniformity is good, higher velocities are obtained. In case of poorer quality of concrete lower velocities are obtained.[3]

Table 2. In general the velocity criterion are as shown in table

<table>
<thead>
<tr>
<th>Pulse velocity(km/sec)</th>
<th>Concrete quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4.5</td>
<td>Excellent</td>
</tr>
<tr>
<td>3.5 to 4.5</td>
<td>Good</td>
</tr>
<tr>
<td>3.0 to 3.5</td>
<td>Medium</td>
</tr>
<tr>
<td>Below 3.0</td>
<td>Doubtful</td>
</tr>
</tbody>
</table>

Factors affecting the pulse velocity

i. Surface condition and moisture content
ii. Temperature of concrete
iii. Micro cracks in concrete
iv. Water cement ratio
v. Age of concrete
vi. Presence of steel reinforcement
vii. Type of aggregate
Table shows the guidance for qualitative assessment of concrete based on UPV test results. To make a more realistic assessment of the condition of surface concrete of a structural member, the pulse velocity values can be combined with rebound number.

Table shows the guidance for identification of corrosion prone locations by combining the results of pulse velocity and rebound numbers.

<table>
<thead>
<tr>
<th>SL.NO.</th>
<th>Test results</th>
<th>Interpretations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High UPV values, high rebound number</td>
<td>Not corrosion prone</td>
</tr>
<tr>
<td>2</td>
<td>medium range UPV values, low rebound number</td>
<td>Surface delamination, low quality of surface concrete, corrosion prone</td>
</tr>
<tr>
<td>3</td>
<td>low UPV, high rebound number</td>
<td>Not corrosion prone, however, to be confirmed by the chemical tests, carbonisation, pH</td>
</tr>
<tr>
<td>4</td>
<td>low UPV values, low rebound number</td>
<td>Corrosion prone—requires chemical and electrochemical tests.</td>
</tr>
</tbody>
</table>
2.2.3 Pullout (lok) test.

The fundamental principle behind pull out testing is that the test equipment designed to a specific geometry will produce results (pull-out forces) that closely correlate to the compressive strength of concrete. This correlation is achieved by measuring the force required to pull a steel disc or ring, embedded in fresh concrete, against a circular counter pressure placed on the concrete surface concentric with the disc/ring.

The LOK-TEST system is used to obtain a reliable estimate of the in-place strength of concrete in newly cast structures in accordance with the pullout test method described in ASTM C900, BS 1881:207, or EN 12504-3. A steel disc, 25 mm in diameter at a depth of 25 mm, is pulled centrally against a 55 mm diameter counter pressure ring bearing on the surface. The force $F$ required to pullout the insert is measured. The concrete in the strut between the disc and the counter pressure ring is subjected to a compressive load. Therefore the pullout force $F$ is related directly to the compressive strength.

![Fig.4 lok test insert](image)

### III. LITERATURE REVIEWS

S.Raja Subramaniam et al. (2016)[1] gives information regarding this paper discusses the Review of Repair and Rehabilitation of Heritage Buildings. In current scenario of Building Research, Repair and Rehabilitation plays a vital role as it serves important in building applications. It acts as an inevitable solution in maintaining the Integrity of Structures.

Varinder.K.Singh et al. (2013)[2] estimated detailed investigation of the buildings with rebound hammer test, ultrasound pulse velocity test and core tests, carbonation test and chloride tests have indicated that there is lot of variation in the compressive strengths of concrete in beams as well as columns.

Hand Book “Repairs and Rehabilitation of RCC Buildings”(CPWD) et al. (2011)[3] is a organisation practising in construction and maintenance of building for a cover a century. it give the investigation works carried out by this unit including remedial measures suggested & adopted for deteriorated buildings. A variety of case included to facilitate the readers to imbibe a better understanding off the subject.

Shital Pardeshi et al. (2017)[4] developed innovative techniques of the structural repairs have many advantages. Some guidelines for the selection of materials for repair work like fiber reinforced polymer. Epoxy resins, Quick-setting cement mortar has been discussed in this paper. The selection of materials for the repair is generally depend on many factors like requirement of repair and the financial resources.

### IV. EXPECTED OUTCOMES

The underlying concepts in the three operations are stated below:

4.1 REPAIRING

The main aim of repairing is to bring back the aesthetics of the building so that it starts working and the functioning of building precisely. It includes the following:

(i) Patching up of defects such as cracks and fall of plaster.
(ii) Repairing doors, windows, replacement of glass panes.
(iii) Checking and repairing plumbing services.
The behaviour of old existing buildings is affected by their structural inadequacies, degradation of material due to age of the building, and the structural or non structural change carried out during the life of the structure such as making new doors and windows, construction of any part which induces dissymmetry in the plan and elevation, etc. The possibility of substituting the old buildings with new earthquake resistant buildings is generally neglected because of social and economical reasons, historical and artistic view. The complete replacement or rehabilitation of old buildings in the given area could also result in destroying a number of social and human links.

Strengthening means an improvement in the building structure over the original strength of the building. After the damage and evaluation of the building it indicates that the strength available in the structural members before the damage was insufficient and only restoration of strength in the structure alone will not be sufficient for the future damages may be due to same or different reasons.

Generally the objectives of strengthening the structure are as below:

i. To increase the strength of building, by providing extra reinforcement or by increasing the number of walls and columns.

ii. To eliminating some features that are sources of weakness or that producing concentration of stresses in some of members. e. g. asymmetrical distribution of resisting members, large openings in walls without a proper peripheral reinforcement.

iii. To avoid the possibility of brittle failure by proper reinforcement and connection in between of resisting members.

iv. To providing strengthening materials like epoxy, extra reinforcement and FRP to strength the damaged building.[4]

4.3 Strengthening Of Existing Buildings

The behaviour of old existing buildings is affected by their structural inadequacies, degradation of material due to age of the building, and the structural or non structural change carried out during the life of the structure such as making new doors and windows, construction of any part which induces dissymmetry in the plan and elevation, etc. The possibility of substituting the old buildings with new earthquake resistant buildings is generally neglected because of social and economical reasons, historical and artistic view. The complete replacement or rehabilitation of old buildings in the given area could also result in destroying a number of social and human links.

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V. CONCLUSIONS

- There should be keen observation where we will apply protective coatings.
- It is essential to carry out the periodic maintenance of structures.
- Each repair technique and repair material is suitable only for the its particular application for which it is prepared.
- Honey combing and bug hole like surface defects requires immediate repairs.
- To restore the durability and serviceability of building the damaged part of structures should be repaired on priority basis however; structures affected by corrosion of reinforcement need special treatment to care of corrosion besides restoration of strength.
- Before repairs & rehabilitation of damaged structures it is essential to carryout detailed condition assessment of the building with non destructive and destructive tests so that suitable remedial measures and repair techniques could be employed.

REFERENCES


Hand Book on “Repairs and Rehabilitation of RCC Buildings” (2011) (published by CPWD, Govt. of India, New Delhi