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Repair and Rehabilitation of RCC Structures

[1] Ms. Sangam S. Talekar [2] Mr. Melito M. Pudtado [3] Asst. Prof. Naveen U.G
[1][2][3] Girijabai Sail Institute of Technology, Karwar

Abstract:- **The repair and rehabilitation can be proposed to an existing structure to increase the probability, so that the structure will survive for a long period of time and this can be accomplished through the addition of new structural elements and strengthening of existing structural element using "Retrofitting" method .The repair and rehabilitation of the structure involves, inspection methods, assessments, monitoring, concrete durability, seismic strengthening, general repairs and laboratory studies of various materials.**

The problems faced in the recent years, commonly, durability problems, poor performance, repair failures and significant user costs for repairs, calls for advanced repair using simpler methods. It is necessary to consider the recent advancement in structural repair from the view point of extending the serviceability of the structure of the structure under repairs.

In this paper the sounding test conducted using "Rebound hammer", is discussed, which indicates the surface hardness measured on graduated scale. The measured value is designated as "Rebound number". The formation of moderate cracks developed on structure is assessed. The surface cracks were cleaned and brushed to develop the bonding strength between the old concrete and surface preparation using bonding agents called "Nitto-bond".

Keywords:-- **Retrofitting, Non-destructive repair, Rehabilitation.**

I. INTRODUCTION

The term rehabilitation in broad sense implied restoring the structure to its original condition. Technique developed for rehabilitation may also be used for modifying a structure to meet new functional or other requirements. In general, structures may need rehabilitation for one of the following

1. Normal deterioration due to environmental effect.
2. New functional or loading requirements entailing modifications to a structure.
3. Damage due to accidents.

Repair and rehabilitation engineering is a specialized field, which calls for skills and abilities beyond design and construction engineering. The systematic approach to deteriorate a structure is necessary and there should be a balance between technology management and economics. The first task when a structure shows sign of cracking, spalling or any other sign is to determine whether the damage is structural or non-structural. The engineer in-charge of rehabilitation should have qualities of an investigator, structural designer, material technologist and awareness of application techniques.

The repair and rehabilitation of the structures include the following-

1. Inspection methods, assessment, monitoring, maintenance of structures.
2. Concrete durability, fatigue issues in bridges, laboratory studies, dynamic testing and analysis.
3. Seismic strengthening.
4. General repairs.

The repair and rehabilitation methods involve the attachment of new materials to existing structures or applying protective coating to the structures. Research in rehabilitation includes the prevention of corrosion of steel which is the most important structural member used in the construction. Research in design, behavior and analysis of reinforced building and bridge construction includes studies in materials, components and complete structural systems. Materials studies have included normal and high strength concretes, effects of materials ageing and materials deterioration on component properties; bond between concrete and steel reinforcement, and use of headed reinforcement.

II. ADVANTAGES OF REPAIR AND REHABILITATION OF CONCRETE STRUCTURES

- Strengthening of existing structure.
- Cost effective.
- Less workmanship.

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- It is economic.
- Service life of the structure is increased.
- Safety against the structure is pre-dominantly achieved.

III. MATERIALS USED

1. Nitobond.
2. Fine aggregates.
3. Coarse aggregates.
4. Chicken mesh.
5. Cement.
6. Water proofing compound.
7. Water.

Nitobond:-
Nitobond is based on solvent-free epoxy resins containing pigments and fine fillers. It is supplied as a two-part material in pre-weighed quantities ready for onsite mixing and use.
Coloured components, white base and green hardener, provide visual evidence that adequate mixing is achieved.

- Can be applied to dry or damp surfaces
- High mechanical strength
- Good positive adhesion
- Can be applied where a substrate/repair barrier is required
- Standard and slow set grades

Fine aggregates:-
Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter.

Coarse aggregates:-
Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

Chicken mesh:-
Chicken wire with flexibility structure for plaster - no injury. Chicken wire has specific properties for plastering use. As its special physical and mechanical properties, chicken wire is perfectly suited for reinforcement plastering in construction, reinforcement waterproofing etc,.

Cement:-
A building material made by grinding calcined limestone and clay to a fine powder, which can be mixed with water and poured to set as a solid mass or used as an ingredient in making mortar or concrete.

Water proofing compound:-
"Water resistant" and "waterproof" often refer to penetration of water in its liquid state and possibly under pressure, whereas damp proof refers to resistance to humidity or dampness. Permeation of water vapour through a material or structure is reported as a water vapour transmission rate.

Water:-
Portable water free from salts was used for the mixing of the concrete.

IV. METHODOLOGY

Methodology:

A) Field testing:
- Non-Destructive
- Destructive

B) Laboratory testing:

4.1 Field Testing.

Non-Destructive:-
Numerous testing options are available to assist in completing the field-condition survey. The most common method of nondestructive field testing is through a process called sounding. Sounding involves striking the concrete surface and interpreting the sound produced. Solid concrete will produce a ringing sound, while concrete that is spalled, delaminated, or contains voids will produce a flat or hollow sound. Sounding can be accomplished using a variety of tools. Sounding of small areas and vertical or overhead structural elements is best achieved by using a hammer or steel rod. A steel chain can also be dragged over the surface under evaluation. This method is best suited for slab surfaces where large areas can be tested in a reasonable amount of time. Nondestructive evaluations can also be accomplished using ultrasonic methods. Two common approaches include a pulse velocity meter and an impact echo system. The pulse velocity meter can detect defects such as the depth of cracks and loss of bond. The impact echo system can detect the thickness of a thin concrete section, locate a crack within the concrete, and locate voids or defects such as honeycombing. Should the approximate size and location of the embedded reinforcing steel be desired, non-destructive testing methods include ground-penetrating radar and magnetic testing using a pachometer. While both systems result in identifying the size and

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location of embedded reinforcing, the ground-penetrating radar also provides a three-dimensional representation of the concrete, identifying the differing layers of reinforcing.

Some of the non destructive methods are as follows,

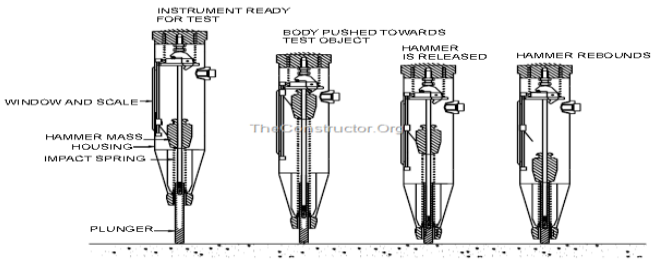
- Rebound hammer method
- Magnetic particle testing (MT)
- Liquid penetrant test (PT)
- Radiographic testing (RT)
- Ultrasonic testing (UT)
- Visual testing (VT)
- Leak testing (LT)
- Laser testing methods (LT)

Rebound hammer method

The operation of rebound hammer is shown in the 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 hit concrete surface to rebound back. The extent of rebound, which is a measure of surface hardness, is measured on a graduated scale.

This measured value is designated as Rebound Number (rebound index). A concrete with low strength and low stiffness will absorb more energy to yield in a lower rebound value.

Fig. 4.1 Rebound Hammer



- To find out the likely compressive strength of concrete with the help of suitable co-relations between rebound index and compressive strength.
- To assess the uniformity of concrete.
- To assess the quality of concrete in relation to standard requirements.
- To assess the quality of one element of concrete in relation to another.

Rebound hammer test method can be used to differentiate the acceptable and questionable parts of the structure or to compare two different structure based on strength.

Destructive:-

Destructive testing methods include exploratory openings, coring, and pull-out testing. Exploratory openings can reveal conditions such as depth of cracks, delimitation, reinforcing size, and pattern and coating information. Cutting an opening in the area of a previous repair will reveal information about the preparation, application, and performance of the repair. Corings will determine conditions similar to exploratory openings but on a limited scale. Corings can provide insights into depths of cracks, depths of delamination, and reinforcing sizes. A core can also be sent to a laboratory for petrographic analysis. Pull-out testing can determine the bond strength between a coating and the concrete substrate or between two cementitious materials. The application of this test when used for determining coating bond is covered by ASTM D 4541, Standard test method for Pull-Off Strength of Coatings Using Portable Adhesion Testers- The test method calls for bonding a plug to the surface coating. The area around the plug is then cut away to isolate the bond area. The testing apparatus is set over the plug and attached to the plug. A force is applied through the testing apparatus until the plug is pulled from the substrate. Review of the plug will reveal the type of failure (i.e., failure in the topping, along the bond line, or in the substrate). An approximation of the bond strength can be determined through a reading on the apparatus; however, this value is a qualitative answer, since different apparatus types will yield different results.

The type of destructive methods are as follows,

- Tensile testing.
- Bend testing.
- Impact testing.
- Nick break testing.
- Hardness testing.
- Core cutter test.

Core cutter test

Cores are usually cut by means of a rotary cutting tool with diamond bits. In this manner, a cylindrical specimen is obtained usually with its ends being uneven, parallel and square and sometimes with embedded pieces of reinforcement. The cores are visually described and photographed, giving specific attention to compaction, distribution of aggregates, presence of steel etc. the core should then be soaked in water, capped with molten sulpher to make its ends plane, parallel, at right angle and then tested in compression in a moist condition as per BS 1881: Part 4: 1970 or ASTM C 42-77. The core samples can also be used for the following:

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1. Strength and density determination
2. Depth of carbonation of concrete
3. Chemical analysis
4. Water/gas permeability
5. Petro-graphic analysis
6. ASHTO Chloride permeability test

4.2 Laboratory testing:-

Three common laboratory tests that provide concrete property information include the chloride ion content test, depth of carbonation test, and concrete petrography.

Chloride ion content is determined by an analyzer that measures the amount of chloride ion in a prepared sample. The sample is prepared from pulverized samples of concrete taken directly from the field or prepared in the laboratory from a solid sample. The application of this test is covered by ASTM C 1218 – Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.

Depth of carbonation is determined by applying phenolphthalein to the sample. The phenolphthalein reacts with the alkaline cement paste to turn the paste a pink color. Due to its lower pH, the carbonized concrete does not change color, allowing the thickness of the carbonized layer to be measured.

Petro-graphic analysis involves cutting a concrete sample into thin layers and observing them under a microscope. The aggregates and cement paste are examined for conditions such as mix proportions, type of aggregate, air content, presence of deleterious chemicals, alkali-silica reaction, freeze/thaw action, and depth of carbonation.

V. TEST CONDUCTED

1) CEMENT
   - Initial Setting Time of Cement
   - Specific Gravity of Cement
   - Standard Consistency of Cement
   - Slump Test

2) COARSE AGGREGATE
   - Moisture Content of Coarse Aggregates
   - Specific Gravity of Coarse Aggregates by Pyconometer

3) FINE AGGREGATE
   - Fineness Modulus of Fine Aggregates
   - Moisture Content of Fine Aggregates
   - Specific Gravity of Fine Aggregates by Pyconometer

VI. PROCEDURE

A. Preliminary investigation
B. Compressive strength of the structure (column) using rebound hammer
C. Preparation of the site
   - Removal of concrete cover
   - Removal of fine powdered material of concrete using brush
   - Scaffolding
D. Application of nittobond
   - Tools for plastering
   - Material
   - Mortar
   - Situation mix thickness
   - Mixing of ingredients of plaster
E. Rough plastering of the surface
F. Wrapping of the column using chicken mesh
G. Form work
H. Preparation of the concrete mix
   - Batching
   - Mixing
I. Concreting
   - Placing
   - Compaction
J. Removal of the form work
   - Precautions
K. Plastering of the surface
L. Curing

Compression test using “Rebound Hammer”

VII. CASE STUDY

- ***Retrofitting of earthquake damaged building at Gujarat.***

The Bhuj 2001 earthquake provided eye opening information on the state of construction practice followed in India. It is notified that majority of buildings in India are not designed as per any IS Code practices; especially for sesmic design and are highly vulnerable to strong seismic ground motion. In this case study we have taken some of the columns as shown in fig. of tenth floor of Manasi Appartment.

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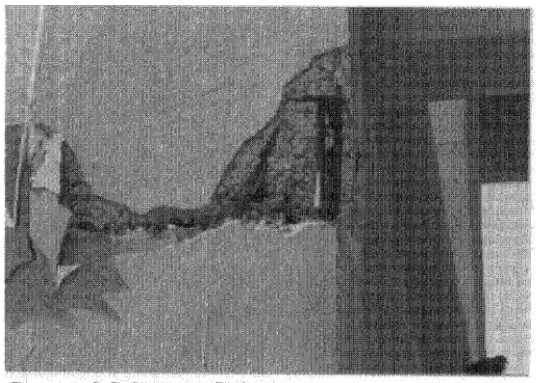
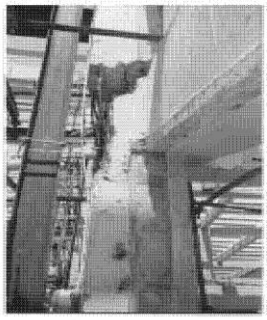


Damaged Column at Gujarat



Damaged Column beam joint

Surface preparation

Assesment Of Structure:-

After general assesment and visual inspection; non destructive/ partial destructive test is carried out. From these tests they have collected information about the cracks, voids, chloride sulphade content. We have also investigated the soil profile of the ground.

VIII. CONCLUSION

Through proper evaluation, design and installation, concrete repairs can be made that performed as well as the surrounding material. A comprehensive evaluation will identify the areas that require repair as well as assist in identifying possible sources of the damage. By understanding the extent and source of the damage incurred, a suitable repair using the most appropriate materials can be designed. Only through proper preparation and execution will a repair be successful. Many of the repair materials used have specific requirements that must be carefully followed to produce a quality repair.

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