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Case Studies of Rehabilitation / Repair of Reinforced Cement Concrete Structures

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Abstract: ***Reinforced cement concrete (RCC) as a construction material has come into use for the last one century. In India, RCC has been used extensively in the last 50- 60years.During this period, we have created large number of infrastructural assets in terms of buildings, bridges, sports stadium etc., which are lifeline for the civilized society. These have been created with huge investment of resources. We cannot even dream of recreating such assets out of limited national resources. It is there more essential to maintain them in functional condition. Since, deterioration of RCC is a natural phenomenon and has started exhibiting in large number of structures, a systematic approach is needed in dealing with such problems. Identification of the causes of deterioration and consequent repair/rehabilitation strategy at optimum cost needs a scientific evaluation and solution. It has been observed that the deterioration phenomena of RCC are not realized by majority of practicing 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.***

Keywords: Delamination, Deterioration, Rehabilitation, Repair, Retrofitting, Spallin.,

I. INTRODUCTION

As the human body becomes deteriorated upon ageing after a certain period of time, then there is important that problem can be remedied by taking necessary actions and preventive steps at the appropriate time. This is exactly the case with buildings. As time passes, the condition of buildings also becomes deteriorated due to various factors. Rehabilitation of structures is a multi-disciplinary activity. The concerned engineer or the concerned faculty should know the design aspects, environmental factors, construction procedure, and about building materials and the other things. The rehabilitation of existing structures is a more complicated, difficult as well as sophisticated task than new construction. Thus, some numbers of non-destructive, partially destructive and destructive techniques in the existing RCC structures are used for evaluation of concrete structure and to predict and analyze the cause of deterioration of the concrete. To overcome the ill effects caused by these deteriorated buildings Repair and Rehabilitation works are carried out from periodic time. Many of the existing structures were designed with the help of codes that have since been modified and upgraded. Concrete constructions require proper care in the form of regular maintenance. If buildings remain for several years with im proper attention and negligence then, various factors like water clogging, paint peeling, plaster break- off, fungus and other organic growth, cracking and creeping of external surfaces will affect the structure.

II. ANALYSIS OF THE PROBLEM AND SOLUTION ON THAT

Based on the results of various tests and field observations and inspection , it will be possible to find the actual causes of the problem and suggest suitable remedial and proper action. Various alternative as well as different methods of solutions may be looked into taking into account of the safety, economical, and time required for the work. The most suitable method among the alternatives which are explained below. There is large number of products available in the market. As such there is a requirement with general guidelines and standard evaluation techniques, which should enable users to make the best use of products available.
The Repair and Rehabilitation of structures include the following:

A. Inspection methods, evaluation and assessment , monitoring, maintenance of structures.
B. Concrete durability, fatigue issues in bridges, laboratory studies, dynamic testing & analysis
C. Seismic strengthening
D. General repairing work

III. REASONS BEHIND THE STRUCTURES FALL DOWN

1) *Operational and execution Errors:* Failures can occur after occupancy of a facility at that time of construction as the result of owner/operator errors. These may include alterations, changes made to the structure, change in use, negligence in overloading and improper maintenance.

2) *Errors while Designing:* In these failures include errors in concept that lack of structural accuracy, failure to consider of a load or combination and calculations of loads, deficient in connection details, manual calculation errors, insufficient knowledge of computer software, improper detailing problems including selection of incompatible materials, failure to consider maintenance requirements and durability, inadequate or inconsistent specifications for materials or poor quality of work.
3) *Development of site Errors:* Failures can be obtain by result from bad judgment of land use or site selection decisions. Certain sites are more vulnerable to failure. The most obvious examples are site location i.e. where it is located which means it is located in regions of significant seismic activity, in coastal regions, or in flood plains. Other sites problems related to their specific soil as well as geometrical conditions such as expansive soils or soil layer permanently frozen 2 or more years in cold regions.

IV. REPAIR MANAGEMENT BEFORE EXECUTION

The decision of repair or replacement of a structure or its member can be taken only after based on the results consideration when the structure is established based on the technical & economic evaluations. Before repairing of structure repair management should be done properly for avoiding any causes. There are Three several stages are to be recognized while taking up a repairing work. The first stage includes proper documentation of damage structure, damage type and extent, opinion or proper suggestion of repaired structure and recommendations on repair methodology. The second stage involves preparation of detailed drawings of structure, sketches, execution as well as working guidelines and notes if any, required material and quality works specifications and tender document. Guidelines prepared for execution of the job should be practically possible and flexible so as to encourage the inventiveness of the contractor executing for the work. The third stage is actual execution of repairing work. This is a specialized kind of job and those who have the potential expertise and knowledge of using resources in terms of tools and plants should be engaged. The supervising engineer should have a good understanding and knowledgeable of the procedures and give an proper supervision. Different types in terms of techniques and repairing materials are available for executing repair jobs or work.

Areas where repair/rehabilitation work can be done:

A. Repairing, removing, replacement and maintenance of mechanical supports area, sanitary treatment plant and commonly in pipelines duct.
B. Repairing if any and modificational changes to diffuser ports, aeration systems i.e. ventilation and other, and pipelines etc.
C. Repair of RCC members like columns and beams etc.
D. Proper Installation and maintenance of dewatering objects.
E. In case of foundation repairing Pile restoration and wood pile concrete encapsulation can be apply.
F. Anode installation for cathode protection.
G. Repair and replacement of trash-rack as well as garbage and waste products materials.

V. IMPORTANT FACTORS TO BE HELD ON FOR SELECTION OF REPAIR METHODS:

Following are the factors to be considered for selection of repair methods:

A. Repairing Type and extent of distress
B. Location of distress and damages
C. Due to Environmental exposure if any
D. Availability of skilled manpower
E. Availability of time and access for repairing work.
F. Appearance or safety measures
G. Cost impact.

There are some repair Stages for reinforced cement concrete structures:
1) Removal of Damage Concrete and proper Surface Preparation
2) Fixing suitable and appropriate formwork
3) Application of Bonding coat and then repairing work

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VI. METHODS FOR REPAIRING AND REHABILITATION OF RCC STRUCTURE

A. Shotcrete

There are two types of shotcrete are as follows,

1) *Wet Mix Shotcrete:* Wet mix Shotcrete is a method that includes premixing of all necessary ingredients including binder, water, aggregates and admixtures for making of concrete .The premixed repair materials are deposited into a concrete pump which transports the mixed materials to an exit nozzle where compressed air is present. The repair material is delivered onto the surface with the help of compressed air. Different suitable Admixtures can be used to achieve durability. Air entrainment admixture is required for freeze thaw resistance.
2) *Dry Mix Shotcrete:* Dry mixing includes premixing of binders and aggregates which are fed into particular mechanical feeder or gun where the premixed materials delivered into a hose.

The mix is carrying with compressed air from a nozzle with high velocity connected to the hose having a water ring outfitted to it. This mix is injected to the repairing area or spot. It resultant hardened properties are increased such as flexural, compressive strengths and more durability of conrete.

Problems carried out with Dry mix Shotcrete: –

Presence of voids due to encapsulated rebound and

Due to improper curing, it causes Shrinkage cracking and also due to high cement concrete.

B. Removal of damage Concrete and Surface Preparation

Pervious preparation of concrete surfaces, exposed reinforcement should be inspected or observed for access clearance, cross-sectional area and as well as location. Reinforcing bars must be exposed if the remaining concrete is unbounded from the reinforcing steel. Removal procedure must be continued till it completely expose the bar if more than half of a reinforcing bar perimeter has been exposed. For completely exposed reinforcing bars, a minimum average clearance of 25 mm or nominal maximum size of aggregate plus 5mm, whichever is greater, must be provided between the reinforcing bar and surrounding concrete based on IS code specifications . A structural engineer or the structural agency should be consulted if the cross-sectional area of an individual bar has been reduced by 15 percent or more or if two adjacent bars have been reduced by 10 percent or more.

C. Form Work

If repairing work are carried on vertical or overhead surfaces like column and beam etc. and if the repair material is likely to sag, at this stage formwork will be required. Previous to installation of formwork, the concrete surface must be inspected properly for any surface contours that could result in air being trapped during concrete placement or pumping of material. If air is likely to get trapped in concrete, then concrete must be removed to change the contour, or vent tubes must be installed. Formwork should be properly secured to the concrete with expansion anchors of standard makes etc.

D. Injection of Epoxy

In its easy 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 force to the head. For small quantities of repairing material small hand-held guns are usually used which are the most economical. They can maintain a steady pressure which minimizes chances of damage to the surface seal and other area. For big jobs power-driven pumps are often used for injection at repairing sites. The injection pressures are adjusted by the width and depth of cracks and the viscosity of resin and seldom exceed 0.10Mpa. The low pressure for fine cracks is a common in using to increase the injection pressure during the course of work to overcome the increase in resistance against flow as crack is filled with material.

E. Reinforcement Cleaning and Anti corrosive Coating

All concrete sticking to the rebars was removed by with the help of light hammering and manual chipping for removing of concrete . Specially wire brush was used to remove unwanted oxide and agents from steel surface completely. One coat of rust remover was applied on the steel rebars. The average rate of rust clear coating on the steel bars came out to be about 3.86 sq. m per litre only. This are much lesser than the claim in the technical brochures and the guidelines. Precautionary measures was also taken that the backside of the bars also gets coated with the rust remover.

The rust remover material or the products was allowed to act for 24 hrs and then steel bars were rubbed with wire brush to remove the rust.

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VII. EVALUATION OF STRUCTURE

A. Non-destructive Testing

Non-destructive testing method can be applied to both old and new structures. For new structures, this applications are likely to be used to determine for quality control or the solution of doubts about the quality of materials or construction works. A number of non-destructive evaluation (NDE) tests for concrete structure are available to find out strength and quality of concrete. Some of these tests are very useful in evaluation of damage to RCC structures due to corrosion, chemical attack, and fire etc. The 'non destructive' term is used to indicate that it does not impair the intended performance of the structural member being tested/investigated. The testing of existing structures is usually related to an evaluation of structural integrity or adequacy. Non-destructive testing methods can be used in those situations as a preliminary to subsequent coring.

B. Core Sampling and Testing

While rebound hammer, and ultrasonic pulse velocity tests give indirect evidence of concrete quality, a more direct evaluation on strength can be made by core sampling and testing method. Cores are usually cut by means of a rotary cutting tool with diamond bits. In this process, a cylindrical specimen is obtained and it is usually with its ends being uneven, parallel and square and sometimes with embedded pieces of reinforcement.

The strength of a test material depends on its shape, proportions, and size. The influence of height/diameter (H/D) ratio on the recorded strength of cylinder is an established fact. Strength of cores has to be related to the standard cylinder strengths i.e. for H/D ratio of 2. Thus, core should preferably have this ratio near to 2. For values of H/D between 1 and 2, a correction factor has to be applied. Cores with H/D less than 1 yield unreliable results and BS 1881: Pt 4: 1970 prescribes a minimum value as 0.95.. The general rule for fixing the core size, besides the H/D ratio, is the nominal size of stone aggregate and the dia should be not less than 3 times the maximum size of stone aggregate. For diameter of core less than 3 times the size of stone aggregate, an increased number of cores have to be tested. The core samples can also be used for the following:

1) Determine the Strength and density
2) To find out Depth of carbonation of concrete
3) Evaluate the Chemical analysis
4) Determine Water/gas permeability.

C. Chemical Tests

Chemical analysis of concrete can provide extremely useful information regarding the cause of causes of failure of concrete structure or members .The tests most frequently carried out to determine below points,

1) Depth of carbonation
2) Finding the Chloride content
3) Cement content ratio
4) Presence of Sulphate content
5) Different Types of cement
6) Determination of Alkali content

VIII. CONCLUSION

Repair and Rehabilitation is necessary to save hazardous failure of structural members due to deterioration. It is recommended for old buildings which have some indications like cracks, corrosion of embedded materials, etc. Therefore timely, properly maintenance of structures is required. After analyzing the problem of structure, we can apply the appropriate and suitable various repair methods which are described above. The repair/ rehabilitation of damaged structure should be carried out urgently on the important basis to avoid further deterioration and losses with required time so that the life of the structure and the people related depend on the structure is not jeopardized.

Each and every problem should be properly and carefully analyzed and then the apply appropriate repair methods.

Structural rehabilitation and repair is more challenging then new concrete construction. It requires special kind of considerations for evaluation and analysis of damage, selection of proper as well as suitable material, technical specifications which is very important, and techniques for repair and quality control measures of material and workmanship. Therefore sufficient time and cost on that should be made for durable rehabilitation work.

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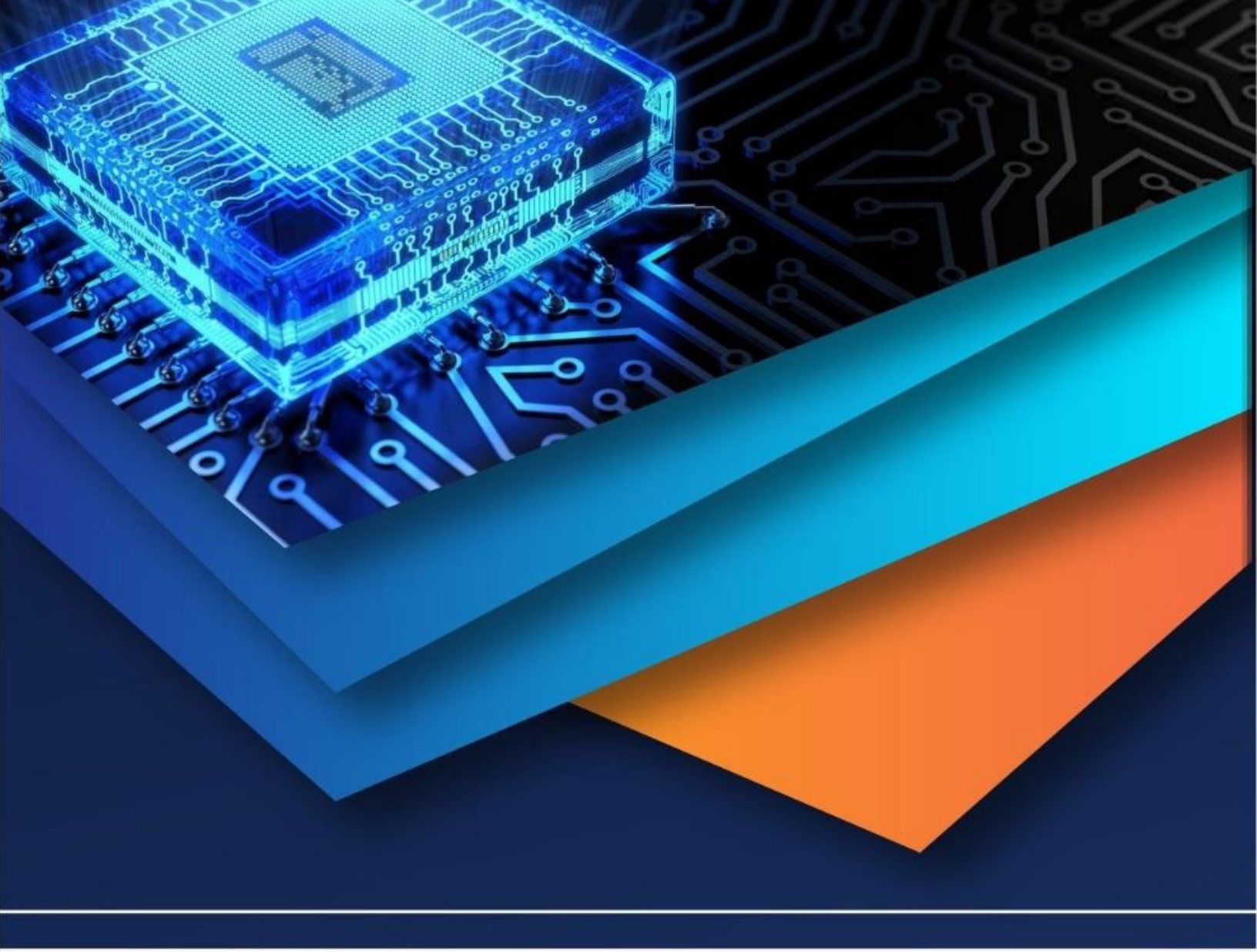

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