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## A Review on Damage Detection by Using NDT and Its Repair

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**ABSTRACT:** Buildings and other structures have a certain useful life, which depends on the specifications adopted. The large numbers of monuments, which are cherished heritage structures have stood well over a period of time. But some of these have shown signs of distress due to age, aggressive natural environment/industrial pollution etc. Further, distress gets aggravated due to overloading and misuse of buildings. A few buildings have also failed due to faulty design or construction. The various causes of structural failure and the principles of rehabilitation of structures are discussed. In the proposed approach we used Damage Detection and Its Repairs and Rehabilitation Techniques in RCC Structures Using NDT 1) Half-cell potential meter 2) Resistivity meter For Corrosion Mapping 3. Ultrasonic Pulse Velocity 4. Rebound Hammer. In the structures, the cracks are generated due to different causes e.g. in some cases cracks are caused after the structure has been completed for a few years which results in shortening of life and strength of structure. The purpose of this paper is damage detection and its repairs and rehabilitation techniques in RCC structures using NDT. For corrosion mapping to justify the latest techniques, advanced materials and various requirements of repairing work to obstruct the deterioration which is necessary and economical than to reconstruct the building.

**KEYWORDS:** Building, Rehabilitation, Repair, Retrofitting, Structure, Half-cell potential meter, Resistivity meter, Ultrasonic Pulse Velocity, Rebound Hammer.

### I. INTRODUCTION

Most of structures while in service are subjected to aggressive influences of environment. These corrosive attacks on structures cause damage and lead to failure of the structural element or the whole structure. Corrosion causes deterioration of material and leads to destruction of structures, especially in coastal and industrial areas. Corrosion of steel is an electro-chemical phenomenon. Electro-chemical corrosion results because of the existence of different metals or non-uniformities in steel or non-uniformities in chemical or physical environment, afforded by the surrounding concrete. This thesis is worked with the comparison of three beams(M30(Normal), M30,M20).The experimental results have compared to the half-cell potentiometer readings and the % weight of loss of three beams were casted whose sizes were 750X150X100 mm respectively. The need to improve the ability of an existing building to withstand from weathering action, chemical attack, embedded metals, alkali-aggregate reactivity, fire, due to overload, seismic forces, etc. arises usually from the evidence of damage and poor behavior. These type of structures are deteriorated with use and time and might have passed their design life and require repair and rehabilitation. Therefore the solutions for RCC structure or structural elements are essential and for this different techniques are utilized. Strength assessment of an existing structure or any element of structures is essential to cover all the criteria in which maintenance is required. Thus, some numbers of non-destructive, partially destructive and destructive techniques in the existing structures are used for assessment of concrete structure and to predict the cause of deterioration of the concrete The old buildings in which ancient temples, monuments, heritage buildings and some residential buildings are included and need some maintenance of repair due to which the regain of strength, durability and stability of those buildings should be done. Hence, here some specifications are discussed about repair and rehabilitation of residential buildings. The purpose of this paper is Damage Detection and Its Repairs and Rehabilitation Techniques in RCC Structures Using NDT. In the recent past corrosion in concrete structures has been

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considered as major durability problems affecting the service life of concrete structures. Corrosion occurs when two different metals or metals in different environments are electrically connected in moist concrete. This paper represents a methodology for a systematic inside testing of corrosion in RCC structures.

## 1.1. Background

Repair The main purpose of repairs is to bring back the architectural shape of the building so that all services start working and the functioning of building is resumed quickly. Repair does not pretend to improve the structural strength of the building and can be very deceptive for meeting the strength requirements. The objective of any repair should be to produce rehabilitation – which means a repair carried out relatively low cost, with a limited and predictable degree of change with time and without premature deterioration and/or distress throughout its intended life and purpose. To achieve this goal, it is necessary to consider the factors affecting the durability of a repaired structural system as part of a whole, or a component of composite system. B. Rehabilitation Structural rehabilitation involves the upgrading or changing of a building's foundation in support of changes in the building's owners, its use, design goals or regulatory requirements. In every case it is determined that it is cheaper to rehabilitate the structure and make the building improvements instead of demolishing and constructing a new building in the allotted space. Retrofitting is 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.

## II. LITERATURE REVIEW

**Wongi S Na et al.** Unmanned aerial vehicles (UAVs), commonly known as drones, are a rising topic in remote sensing technologies for structural health monitoring. With technology advancement in cameras, the visual inspection method using drones is gaining much attention in the field of civil engineering. However, although visual inspection methods are feasible for finding cracks in structures, the limitations of image processing for finding internal damage or small defects cannot be ignored. To overcome this problem, a possible application concept of UAV, combined with a vibration-based non-destructive health monitoring method, is proposed. The idea is for the drone to temporarily attach the piezoelectric transducer onto a specific region where excitation and data acquisition occurs simultaneously. This eliminates the need for a structure to be covered with hundreds of sensors for monitoring, as this concept uses a single piezoelectric transducer for monitoring a structure. The proposed work offers new areas of research by converging UAV with a vibration-based method, as associated problems are required to be solved.

**Mohammadreza Hamidian et al.** The concept of nondestructive testing (NDT) is to obtain material properties of “in place” specimens without the destruction of the specimens and to do the structural health monitoring. Ultrasonic pulse velocity (UPV) used together with Schmidt Rebound Hammer (SRH) tests give a combined test method for health assessment by a suitable correlation between these two tests along with test by compressive testing machine. The structural health monitoring by NDT methods comprised of UPV and RSH were carried out in laboratory and site. The experimental investigation using NDT methods showed that a good correlation exists between compressive strength, SRH and UPV. The SRH offers method of achieving concrete strength with accuracy of  $\pm 15$  to  $\pm 20$  percent and the UPV method is a perfect instrument for both existing structures and those under construction with accuracy within  $\pm 20\%$ .

**Kazi Javed Akram et al** The efficiency of a parallel plate capacitor for the detection of moisture concentration in concrete structure is proposed in this paper. As the presence of moisture in the concrete structure deteriorate the health of the structure, therefore its presence should be correctly examined. In this paper, the effect of moisture on the electrical properties such as impedance, capacitance, phase angle, dissipation factor of concrete is thoroughly studied. A fly ash brick has been taken in order to analyze the performance of the proposed methodology.

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**Y. DONG et al.** The chapter begins by discussing the requirement for performance assessment of FRP rehabilitated structures by NDT/NDE methodologies. The general classification of NDT techniques are introduced, followed by the concept of structural health monitoring (SHM) as related to the real-time performance monitoring of the rehabilitated structures. It then explores the suitability of major NDT techniques for defect detection and assessment of FRP composites and FRP rehabilitated concrete structures. The NDT methods reviewed include visual inspections, acoustic emission testing, impact-echo methods, ultrasonics, radiography, ground penetrating radar, microwave based techniques, thermography, optical and laser techniques, and superconducting quantum interference methods. The chapter includes a brief introduction into the basic principles, methodologies, and types of fiber optic sensors, and their applications in FRP composite and FRP rehabilitated concrete structures. Smart structure systems with fiber optic sensors for real-time monitoring of FRP rehabilitated concrete structures are then discussed. A summary of the methods is provided at the end.

**Won-Jae Yi, et al.** Critical structures such as aircrafts, buildings, dams and buildings require periodic inspections to ensure safe operation. Reliable inspection of structures can be achieved by combining ultrasound non-destructive testing techniques with other sensors (for example, temperature sensor and accelerometers). In this study, we show that adapting wireless embedded systems to the task of structural health monitoring improves inspection productivity, increases mobility, and allows the aggregation of critical data to enhance inspection accuracy. To achieve this objective, we developed a customized system based on Reconfigurable Ultrasonic System-on-chip Hardware (RUSH) platform. RUSH collects and analyzes ultrasonic data to detect structural flaws such as cracks, voids, or fatigue. The collected data is then transferred through a Bluetooth transceiver to an Android smartphone referred to as Mobile Sensor Data Collector (MSDC), where the data is instantly displayed and forwarded to a central server for expert review over the Internet.

**Divya P. Goswami et al.** This review paper analyzes why and how nondestructive testing (NDT) measurements can be used in order to assess on site strength of concrete. It is based on (a) an in-depth critical review of existing models; (b) an analysis of experimental data gathered by many authors in laboratory studies as well as on site, (c) the development and analysis of synthetic simulations designed in order to reproduce the main patterns exhibited with real data while better controlling influencing parameters. The key factors influencing the quality of strength estimate are identified. Two NDT techniques (UPV and rebound) are prioritized and many empirical strength-NDT models are analyzed. It is shown that the measurement error has a much larger influence on the quality of estimate than the model error. It is based on the use of a prior double power law model, with only one parameter to identify. The analysis of real datasets from laboratory studies and from real size buildings show that one can reach a root mean square error (RMSE) on strength of about 4 MPa. Synthetic simulations are developed in order to better understand the role played by the strength range and the measurement error. They show that the number of calibration cores can be significantly reduced without deteriorating the quality of assessment. It is also shown that the optimal calibration approach depends on the number of cores

**Darshakkumar.V.Mehta et al.** The concept of non-destructive testing (NDT) is to obtain material properties “in place” specimens without the destruction of the specimens and to do the structural health monitoring. NDT using Rebound hammer, Ultra pulse velocity, Half-cell potential, core cutter, carbonation depth, rebar locator, Rapid chloride penetration test, electric resistivity meter test and vibration base analysis by data analyzer are very popular and highly effective in conducting structural health monitoring. The structure can be investigated by using a visual inspection, NDT, laboratory and field test performance. In this article a review of these tests have been provided to conduct effective structural health monitoring of a RCC structure

**Kondapalli Harshada et al.** The objective of work is to carry out Structural Health Monitoring based on Non Destructive Testing. For this we have considered a 5-storey educational building which is nothing but the R-Block of Usha Rama College of Engineering & Technology. It has an age of 8 years. There is a need for regular monitoring and maintenance of the structure for achieving increased life and service of the structure. In total there are 725 columns in R-Block. Each floor of the 5-floored structure consists of 145 columns. These are divided in to two parts, one as Part-

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A: 620mm x 260mm (112 no's) and the other as Part- B: 290mm x 290mm (33no's). All the columns were assessed. WTC-Model H Concrete Rebound Test Hammer is used in the present work. The range of compressive strength values measured on small columns vary from 20 to 45 N / mm<sup>2</sup> where as the range of compressive strength values measured on large columns vary from 20 to 50 N / mm<sup>2</sup>. Average compressive strengths in Ground floor for large columns and small columns are 43.38 N/mm<sup>2</sup>, 33.60 N/mm<sup>2</sup> respectively. Similar values were obtained for all the floors. The outcome of the project can be used as the basis for repair and maintenance works to be carried out for enhanced life and service of the structure

**Wai Yie Leong et al.** In this paper, the operation of the non-destructive inspection on composite structures has been investigated. The pitch/catch swept is used to detect the designed flaws of the laminated composite structures. Characteristics of the different types of defect are inspected. The signal processing is applied to the collected data to extract the defect information. The smallest detectable defect size is found to be approximately the size of the probe used. The results based on several defects are presented and compared.

**José Miguel López-Higuera et al.** Structural Health Monitoring (SHM) can be understood as the integration of sensing and intelligence to enable the structure loading and damage-provoking conditions to be recorded, analyzed, localized, and predicted in such a way that nondestructive testing becomes an integral part of them. In addition, SHM systems can include actuation devices to take proper reaction or correction actions. SHM sensing requirements are very well suited for the application of optical fiber sensors (OFS), in particular, to provide integrated, quasi-distributed or fully distributed technologies. In this tutorial, after a brief introduction of the basic SHM concepts, the main fiber optic techniques available for this application are reviewed, emphasizing the four most successful ones. Then, several examples of the use of OFS in real structures are also addressed, including those from the renewable energy, transportation, civil engineering and the oil and gas industry sectors. Finally, the most relevant current technical challenges and the key sector markets are identified. This paper provides a tutorial introduction, a comprehensive background on this subject and also a forecast of the future of OFS for SHM. In addition, some of the challenges to be faced in the near future are addressed

### III. SITE DETAILS

The aim of the project was to obtain the Calibration Graphs for Non Destructive Testing Equipment and to study the effect of reinforcement on the obtained results. These Non Destructive Instruments were then used to test the columns, beams and slabs of two double storied buildings viz., Hall No.2 and Hall no.7.

1. Name of the project :Sai Costruction
2. Location : Ambegaon , katraj Pune.
3. Owner : Sagar Gholap
4. Purpose of project: Industrial purpose.
5. Consultant: Mr. Aslam Shaikh.
6. Total Area of construction : 1,68,000 sq.ft.
7. Project highlights: 100% Green energy, STP Plant, Efficient natural light and ventilation.
8. Cost of the project: 25.4 crore.

#### 1. FACTORS INFLUENCING CORROSION

- Inadequate cover thickness
- Quality of concrete in the cover regions
- Environmental conditions
- Chloride level in concrete
- Presence of cracks etc.

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## 2. MATERIALS USED

- CEMENT
- OPC used.(53grade)
  
- COURSE AGGREGATE
- The sample of crushed aggregate passing through a20mm IS sieve & retaining on a 4.75mm IS sieve issued.
  
- FINE AGGREGATE
- Locally available sand passing through 4.75mm IS sieve & retaining 150microns sieve.
  
- STEEL PROVISIONS
- main bars - 10mm bars (Fe-415)stirrups - 8mm bars (Fe-415)

## 3. MIX DESIGN

- Method of design is Indian standard method
- Design mix ratio of M20 is 1:1.5:3
- Design mix ratio of M30 is 1:2:2.5For all the mixes w/c ratio is 0.55

## 4. BEAM DESIGN

- Minimum tension reinforcement:  $(A_{st} / b d) = (0.85 / f_y) > 0.34\%$  for mild steel ( $f_y = 250\text{N/mm}^2$ )  $> 0.20\%$  for HYSD bars ( $f_y = 415\text{N/mm}^2$ )
- Maximum reinforcement: 0.04 bD for both tension and compression reinforcement.
- Spacing between bars: Diameter of neither larger bar nor less than the normal maximum sizes of coarse aggregate plus 5 mm whichever is greater.
- Nominal cover: 25 mm nor less than the diameter of the bar.
- Curtailment: Refer clause 26.2.3 of IS 456-2000.
- Reinforcement in concrete will not corrode if the protective iron oxide film formed by the high alkaline condition of the concrete pore fluid with a pH around 13 is maintained. This film gets destroyed by chlorides or by carbonation, if moisture and oxygen are present, resulting in corrosion

## IV. CONCLUSION

Repair and Rehabilitation is necessary to save hazardous failure of structures due to deterioration. It is recommended for old buildings which have some signs like cracks, corrosion of embedded materials, etc. Therefore timely maintenance of structures is required. The selection of technique is used as per cost, location of site and other factors. Thus for proper maintenance, the techniques likewise Rebound Hammer Testing, Ultrasonic Pulse Velocity Evaluation, etc. are utilized. In Rebound Hammer 10 readings (rebound numbers) were obtained for each cube, at different locations on the surface of the specimen. The cube was divided into grid blocks of equal spacing and 10 points were marked at equal intervals for taking the Rebound Hammer test. The cubes were then given a load of 7 N/mm<sup>2</sup> (as specified by the IS CODE 13311) in the Compression Testing Machine and the Rebound Values were obtained. The cubes were then loaded up to their ultimate stress and the Breaking Load was obtained. Rebound numbers (rebound index), Mean Rebound Value, Standard Deviation, the Dead Load on the specimen at the time of testing, the Breaking Load, the Predicted Compressive Strength as predicted by the Rebound Hammer and the actual Compressive Strength as obtained by the Compression Testing Machine. 3 readings of Ultrasonic Pulse Velocity (USPV) were obtained for each cube. The cubes were then given a load of 7 N/mm<sup>2</sup> (as specified by the IS CODE 13311) in the Compression Testing Machine and the USPV were obtained. The cubes were then loaded up to their



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ultimate stress and the Breaking Load was obtained. The following table lists the USPV in each specimen with their mean velocity, the Dead Load, the Breaking Load and the actual Compressive Strength as obtained by the Compression Testing Machine. It seems that corrosion initiated after 40 hours on the basis of Half-cell potentiometer readings (For M20). By comparing all these NDT results without harming existing structure we recommend and suggest all necessary replacement, changes and repairs and get required strength to the structure.

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