STRUCTURAL HEALTH MONITORING OF CONCRETE STRUCTURE USING NDT

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ABSTRACT

Structures are assemblies of load carrying members capable of safely shifting the superimposed loads to the foundations. Their main and most looked after things is the strength of the material that they are made of. Concrete, as we all know, is an integral material used for construction dedications. Thus, strength of concrete used, is essential to be 'known' before starting with any kind of analysis. In the recent past, various methods and techniques, called as Non-Destructive Evaluation (NDE) techniques, are being used for Structural Health Monitoring (SHM). The perception of nondestructive testing (NDT) is to obtain material properties of in place specimens without the damage of the specimen nor the structure from which it is taken. However, one problem that has been dominant within the concrete industry for years is that the true properties of an in-place specimen have never been tested without leaving a certain degree of damage on the structure. For most cast-in-place concrete structures, construction provisions require that test cylinders be cast for 28-day strength determination. Usually, demonstrative test specimens are cast from the same concrete mix as the larger structural elements. The rebound hammer test is classified as a hardness test and is based on the principle that the rebound of an elastic mass be determined by on the hardness of the surface against which the mass impinges. The energy absorbed by the concrete is correlated to its strength. There is no exceptional relation between hardness and strength of concrete but experimental data relationships can be obtained from a given concrete. However, the term "nondestructive" is given to any test that does not harm or affect the structural behavior of the elements and also leaves the structure in an satisfactory condition for the client. The use of the ultrasonic pulse velocity tester is introduced as a tool to monitor basic initial cracking of concrete structures and hence to present a threshold limit for possible failure of the structures.

Keywords - NDT, Structural Health Monitoring, Audit, Repair, Rehabilitation.

1. INTRODUCTION

To keep a high level of structural well-being, stability and performance of the infrastructure in each country, an efficient system for early and regular structural assessment is urgently mandatory. The quality declaration during and after the construction of new structures and after reconstruction processes and the characterisation of material properties and damage as a function of time and environmental influences is more and more becoming a serious worry. Non-destructive testing (NDT) methods have a large potential to be part of such a system. NDT methods in general are extensively used in several industry branches. Aircrafts, nuclear accommodations, chemical plants, electronic devices and other safety critical installations are tested frequently with fast and reliable testing technologies. A variety of advanced NDT methods are available for metallic or composite materials. In recent years, innovative NDT methods, which can be used for the assessment of existing structures, have become available for concrete structures, but are still not established for regular inspections. Therefore, the disinterested of this project is to study the applicability, performance, availability, complexity and restrictions of NDT. The purpose of establishing standard procedures for nondestructive testing (NDT) of concrete structures is to qualify and quantify the material properties of in-situ concrete without insensitively examining the material properties. There are many techniques that are currently being research for the NDT of materials today. This chapter focuses on the NDT methods relevant for the examination and observing of concrete materials.

1.1 Problem Statement

Many structural health monitoring systems depend on on point sensors, or sensors that obtain data about only one point, to monitor assets. The boundaries to point sensors are not about accurateness or dependability, rather it is about insight. Events that occur amongst critical points will be missed so structural response information will be lost. Using point sensors in SHM systems is limiting since these systems must use interruption to replication additional measurement locations. This practice leads to biased damage indices since true local information is lost. Another concern that faces many existing structural health monitoring systems is data standardization. This is the process of separating changes in sensor output caused by damage and changes caused by changing environmental conditions. Since most SHM systems do not constantly monitor, it is difficult to normalize the data—especially when point sensors are used to collect the information.

1.2 Objectives

1. To study and obtain the Calibration Graphs for Non Destructive Testing Equipment's viz., the Rebound Hammer and Ultrasonic pulse Velocity Tester and to study the outcome of reinforcement on the obtained results.
2. To examine 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.
3. To study the consistency of the concrete and the presence of cracks, voids and other imperfections
4. To study and change in the structure of the concrete which may occur with time and he quality of concrete in relation to standard obligation.

2. Structural health monitoring:

Based on the past concrete structure ultrasonic testing theory, a series of time-frequency investigates were carried out on ultrasound detection of concrete structures. Using the multiscale time-frequency of the S transform, S transform was lead into the data processing of ultrasonic testing of the concrete structures. The ultrasonic phase velocity was resulting based on the spectrum analysis. Then, S transform time-frequency analysis methods were recognized. From the study, several assumptions can be drawn by Juncai Xu and Hai Wei (2019) are as follows: The S-transform algorithm is humble and easy to implement. It perfectly transforms the ultrasonic time-domain signal into a time-frequency domain spectrum and has a significant recognition effect. In the faulty concrete structure, the energy spectrum of the S transform has significant differences from that of the intact concrete structure. The time-frequency energy spectrum can correctly test the presence of defects in the concrete structure based on the S transform. In the energy spectrum' risky area, the ultrasonic phase velocity's change with the frequency can be considered. In the case of the defective concrete structure, the ultrasonic phase velocity is slighter than that of the intact concrete structure. The proposed method requests to be further applied in actual data for non destructive detection. Future work will be conducted on successful the applicability of the method in practice. Saman Farhangdoust and Armin Mehrabi (2019) study included a comprehensive literature review with a focus on NDT methods applicable to health monitoring of ABC closure joints. The study absorbed on joint types relevant to precast concrete decks commonly used for ABC bridges, therefore, FRP (fiber reinforced plastic), timber (wood), and steel of any shape were excluded for the time being. The study resulted in classifying the most common closure joints in five general groups based on their features affecting the request of the NDT methods.

Lingzhu Zhou (2019) studied smart aggregate (SA) transducers, which can be used as both actuator and sensor, are employed to categorize the structural damage mechanism of basalt-FRP (BFRP) bars reinforced concrete beams. Time reversal method is accepted for increasing the signal-to-noise ratio (SNR), which is aimed at obtaining clear ampli- tude of focused signal.

Joyraj chakraborty (2019) presents the investigations on the opportunity of utilizing autoregressive model, where the velocity of ultrasonic wave in a medium is needy on the operational state. The goal is to use the model for localization of operational changes in the large concrete structure by means of embedded ultrasonic transducer networks. In this study, numerous static load tests and dynamic test on large reinforced concrete beams have been executed using embedded ultrasonic sensors.

Xinlin Qing (2019) paper delivers a brief indication of piezoelectric transducer-based SHM system technology developed for aircraft applications in the past two decades. The necessities for practical execution and use of structural health monitoring systems in aircraft application are then introduced. State-of-the-art techniques for solving some practical issues, such as sensor network integration, scalability to large structures, reliability and effect of environmental conditions, robust damage detection and quantification are deliberated. Development trend of SHM technology is also discussed.

Bin Wang et.al. (2019) research gives information of, electro mechanical impedance based method, an imperative technique in structural health monitoring, was assumed to detect the bonding damage of carbon fiber reinforced polymer plate-strengthened steel beam by using lead zirconate titanate (PZT) transducers.

The four-point bending test on the benchmark RC structure was used as a test of the excellence and sensitivity of the embedded sensors. It allowed assessment of whether any cracking and propagation that occurs with the embedded sensors can be distinguished. Various methods are used for the analysis of the ultrasonic signals this study is done by Joyraj Chakraborty in2019.

Study of Wongi S Na(2016) proposes a new concept of employing UAV for structural health monitoring of civil infrastructures, using a vibration-based NDE method. The concept exceeds the current limits of using a drone in combination with a visual examination method and image processing.

Review paper by Divya P. Goswami (2016)
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 repeat the main patterns exhibited with real data while improved controlling influencing parameters.

In this paper of Kazi Jabed Akram (2015) the effect of moisture on the electrical belongings such as impedance, capacitance, phase angle, dissipation factor of concrete is systematically studied. A fly ash brick has been taken in order to investigate the performance of the proposed methodology.

Kondapalli Harshada (2015) studied the objective of work is to take-out Structural Health Monitoring based on Non Destructive Testing. Various NDT methods can be used provisional upon the type & age of structure to check the integrity of structure. USPV, rebound hammer can be applied to newly constructed structures to check the quality of concrete, adequacy of cover before applying live load to the structures. Non-destructive testing of concrete structures yields valuable information for the engineer when investigating problems and can reveal unexpected or hidden descent. The repair of the structure is guided by the results of the testing.

Darshak kumar Mehta (2015) studies the method of conducting structural health monitoring varies extremely with the type and usage of structures which needs to be examined. Hence it is authoritative that the structure which needs to be investigated must be studied thoroughly before accepting a proper strategy to conduct structural health monitoring.

Dustin Pieper (2014) work focuses on the design and implementation of an embedded FSS sensor for detection of strain and buckling during displacement load testing of a novel steel-tube reinforced concrete column. Structural health monitoring is an essential characteristic of the transportation and infrastructure industries.

Won-Jae Yi (2013) says that Critical structures such as aircrafts, bridges, dams and buildings need periodic inspections to guarantee 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 exactness.

The concept of nondestructive testing (NDT) is to obtain material belongings of “in place” specimens without the obliteration of the specimens and to do the structural health monitoring. Ultrasonic pulse velocity (UPV) used organized with Schmidt Rebound Hammer (SRH) tests give a combined test method for health assessment by a suitable relationship 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 occurs between compressive strength, SRH and UPV is studied by Mohammadreza Hamidian (2011)

Structural Health Monitoring (SHM) can be unstated as the integration of sensing and intelligence to allow the structure loading and damage-provoking circumstances 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 appropriate reaction or correction actions. SHM sensing necessities 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 accessible for this application are reviewed; emphasizing the four most successful ones is reviewed by José Miguel
(2011)

In this paper, the operation of the non-destructive examination on composite structures has been investigated. The pitch/catch swept is used to identify the designed flaws of the laminated composite structures. Characteristics of the different types of defect are examined. The signal processing is applied to the collected data to excerpt the defect information. The smallest detectable defect size is found to be almost the size of the probe used. The results based on several defects are presented and compared. In this paper, the pitch-catch method in defect examination was presented. It has been shown that defects such as disbands, delaminations and voids may be modeled as a spring beneath which is the sound structure whose belongings are unaffected studied by Wai Yie LEONG (2009).

This paper presents the NDT&E of Indian Railways Road bridges. The various NDT&E methods developed are presented, and the findings are equally associated to highlight the efficiency of a specific method in a specific situation or for a specific persistence. In this study, various non-destructive condition evaluation methods have been studied and they have been used in the field testing of reinforced cement concrete bridge members. Based on the data collected by the authors by accomplishment numerous tests on four different sites, comparison have been made among various NDT equipment's obtainable for determining a particular parameter. Some of the NDT&E methods provided calculation of concrete weakening at relatively high speeds of data collection is studied by Amit GOEL.

3. Conclusion

Considerable engineering judgment is needed to properly evaluate a measurement. Misapprehension is possible when poor contact is made. For example, in some cases it may not be possible to recognize harshly corroded reinforcing bar in poor quality concrete. However, it is possible to recognize poor quality concrete which could be the cause of reinforcing bar problems. The poor quality concrete allows the entrance of moisture and oxygen to the reinforcing bars, and hence corrosion occurs. Presently the system is limited to penetration depths of 1 ft. Research is ongoing to improvement a system that can penetrate to a depth of 10 ft or more. When variation in properties of concrete affect the test results, (especially in opposite directions), the use of one method alone would not be satisfactory to study and assess the required property. Therefore, the use of more than one method yields more dependable results. For example, the increase in moisture content of concrete increases the ultrasonic pulse velocity but decreases the rebound number. Hence, using both methods together will decrease the errors produced by using one method alone to assess concrete. Attempts have been done to relate rebound number and ultrasonic pulse velocity to concrete strength. Unfortunately, the equation requires preceding knowledge of concrete constituents in order to obtain dependable and predictable results. The Schmidt hammer provides an inexpensive, simple and quick method of obtaining an indication of concrete strength, but accuracy of ±15 to ±20 per cent is possible only for specimens cast cured and tested under conditions for which calibration curves have been established. The results are affected by factors such as smoothness of surface, size and shape of specimen, moisture condition of the concrete, type of cement and coarse aggregate, and extent of carbonation of surface.

REFERENCES

1. Juncai Xu and Hai Wai (2019)," Ultrasonic Testing Analysis of Concrete Srucure Based on S Ttransform" Hindawi
Shock and Vibration, Volume 2019, Article ID 2693141, 9.

2. Saman Farhangdoust and Armin Mehrabi (2019), "Health Monitoring of Closure Joints in Accelerated Bridge Construction: A Review of Non-Destructive Testing Application" Journal of Advanced Concrete Technology Vol. 17, 381-404, July 2019 / Copyright © 2019 Japan Concrete Institute.

3. Lingzhu Zhou, Yu Zheng, Gangbing Song, Dongdong Chen, Yuxiao Ye (2019)," Identification of the structural damage mechanism of BFRP bars reinforced concrete beams using smart transducers based on time reversal method" .

4. Joyraj chakraborty, andrzej katunin (2019)," detection of structural changes in concrete using embedded ultrasonic sensors based on autoregressive model'. diagnostyka, 2019, vol. 20, no. 1.

5. Xinlin Qing, Wenzhuo Li, Yishou Wang and Hu Sun (2018), " Piezoelectric Transducer-Based Structural Health Monitoring for Aircraft Applications."

6. Bin Wang , Yongfeng Sun, Yunzhang Li and Chuan Zhang (2018) ," Debonding Damage Detection in CFRP Plate-Strengthened Steel Beam Using Electromechanical Impedance Technique."

7. Joyraj Chakraborty , Andrzej Katunin,
Piotr Klikowicz and Marek Salamak (2018), "Early Crack Detection of Reinforced Concrete Structure Using Embedded Sensors."

8. Wongi S Na and Jongdae Baek published in 2016 “Impedance-Based Non-Destructive Testing Method Combined with Unmanned Aerial Vehicle for Structural Health Monitoring of Civil Infrastructures.”

9. Divya P. Goswami1, Dr. Divya N.Parekh and Asst. Pro.Tushar J. Tuvar published in year 2016 “structural health monitoring of rcc structure using NDT under different exposure condition – a case study.”

10. Kazi Jabed Akram, Tarikul Islam and Akil Ahmed published (2015) “A Simple Non Invasive Technique for Structural Health Monitoring.”

11. kondapalli harshada and k. Sundara kumar (2015),” Non-destructive evaluation of structural health of a building using rebound hammer.”

12. Darshakkumar.V.Mehta, Mazhar A. Dhankot (2015) “application of non-destructive test for structural health monitoring-state of the art review.”

13. Dustin Pieper and Kristen M. Donnell and Omar Abdelkarim and Mohamed A. ElGawady published (2014) “Embedded FSS Sensing for Structural Health Monitoring of Bridge Columns.”

14. Won-Jae Yi, Spenser Gilliland and Jafar Saniie published (2013), “Wireless Sensor Network for Structural Health Monitoring using System-on-Chip with Android Smartphone.”

15. Mohammadreza Hamidian, Ali Shariati, M. M. Arabnejad Khanouki, Hamid Sinaei, Ali Toghroli and Karim Nouri (2011), “Application of Schmidt rebound hammer and ultrasonic pulse velocity techniques for structural health monitoring.”

16. Jose Miguel Lopez-Higuera, Senior Member, IEEE, Member, OSA, Luis Rodriguez Cobo (2011)“Fiber Optic Sensors in Structural Health Monitoring.”

17. Wai Yie LEONG, Liu Wei (2009) “Structural Health Monitoring: Subsurface Defects Detection.”

18. Civil Engineering Construction Review, August 1998 Edition (Non Destructive Testing of Concrete).

19. Concrete strength by combined nondestructive methods simply and reliably predicted Hisham Y. Qasrawi , Civil Engineering Department, College of Engineering, Applied Science University, Amman 11931, Jordan

20. Non-destructive testing of concrete material properties and concrete structures Christiane Maierhofer Federal Institute for Materials Research and Testing (BAM), D-12205 Berlin, Germany.

21. The use of USPV to anticipate failure in concrete under compression Hisham Y. Qasrawi ' and Iqbal A. Marie Civil Engineering Department, Faculty of Engineering, Hashemite University, Zarqa 13115, Jordan .

22.IS-1311 (Part-1): 1992 Non-Destructive Testing of Concrete -methods of test, Part-I, Ultrasonic Pulse Velocity.

22. IS 13311 (Part-2): 1992, Non-Destructive Testing of Concrete –methods of test, Part 2, Rebound hammer.

23. RDSO Report No.BS-53: Guidelines on use of ultrasonic instruments for monitoring of concrete structures.

24. Handbook on Non Destructive Testing of Concrete” (second edition) by V.M. Malhotra and N.J. Carino.