INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

www.ijprems.com
editor@ijprems.com

Vol. 03, Issue 06, June 2023, pp : 65-68

e-ISSN : 2583-1062

Impact Factor : 5.725

A REVIEW PAPER ON DETECT DAMAGE IN CONCRETE BEAMS SUBJECTED TO IMPACT LOAD THROUGH THE UTILISATION OF PIEZOELECTRIC SENSORS

Chowdhary Mamta Chuman[1], Sitender[2]

[1]M. Tech Scholar, Ganga Institute Of Tech. & Management, Jhajjar, India

[2]Assistant Professor, Ganga Institute Of Tech. & Management, Jhajjar, India

ABSTRACT

Since engineers often struggle with the challenge of identifying concealed damage, structural health monitoring combined with damage detection and evaluation of its severity level in non-accessible reinforced concrete members utilising sensors becomes vital. Applications of piezoelectric sensors, magnetostrictive sensors, fibre optic sensors, and self-diagnosing fibre reinforced composites are just a few examples of smart sensing technologies that have important capabilities for monitoring various physical or chemical parameters related to the health and, consequently, long service life of structures. Piezoelectric and magneto-restrictive sensors, in particular, may function as both sensors and actuators, making SHM an active monitoring system.This essay analyses a number of academic works that have examined the investigation of the flexural behaviours of reinforced concrete beams using both sensors and traditional methods. Examined are three typical flexural behaviours: concrete cracking, deflection, and strain, among other things.

Key Words: Structural Health Monitoring, Flexural Behaviour, Damage detection, beams, sensors

1. INTRODUCTION

There have recently been a variety of experimental methods developed that protect reinforced concrete infrastructure against complete and unexpected breakdowns and lower the cost of inspection. Real-time damage detection and structural health monitoring (SHM) approaches are the main goals of this methodology. The goal of SHM is to provide effective techniques for the ongoing inspection and identification of different flaws in structural elements used in civil engineering. Furthermore, SHM is increasingly crucial in RC structures where shear processes dictate failure modes that are brittle and abrupt. A catastrophic collapse might result from even small incipient shear damage to weak shear critical RC components, such as beam-column junctions, short columns, and deep beams. Failure of the whole structure or some of its components may be caused by inaccessible areas of the structure, the existence of invisible hair fractures, and material degradation in particular areas of the structure. It may be possible to extend their lifespan and avoid unexpected failure scenarios via early damage prediction. Structural Health Monitoring (SHM), which attempts to create automated systems for the continuous monitoring, inspection, and damage detection of structures with minimal manpower required, must be installed in civil structures in order to maintain structural integrity and safety. In order to carry out the best maintenance on the structures and assure safety and a long service life, an efficient SHM system can identify different problems in real time and online and monitor strain, stress, and temperature. A typical SHM system is made up of three main parts: a sensor system, a data processing system (which includes data gathering, transmission, and storage), and a health assessment system (which includes diagnostic tools and data management). Incorporating a degree of robust and dependable structural sensing capabilities is the initial stage in setting up this system. Therefore, the initial part of the SHM system, the sensing system made up of intelligent materials and sensors, is the major focus of this article. Fibre optic sensors (FOS), piezoelectric sensors, magnetostrictive sensors, and self-diagnosing fibre reinforced structural composites are just a few examples of smart materials/sensors that have the vital ability to sense various physical and chemical parameters relating to the health of the structures.

2. LITERATURE REVIEW

S TejaswiJ Eeshwar Ram “BEHAVIOUR OF RCC BEAMS IS FLEXIBLE. This research examines the flexural behaviour of RCC under different constraints. Simple supported beams of under-, balanced-, and over-reinforced sections are taken into consideration for the experimental study. This study's major goal is to determine the relationship between a simply supported beam's loading and corresponding deflection under a point load. In the current investigation, the flexural behaviour of the material in different fibres and the stress-strain behaviour of concrete and steel are used as a basis.

C. G. Karayannis M. E. Voutetaki, Constantin E. Chalioris, Costas ProvidakisThe study is titled "DETECTION OF FLEXURAL DAMAGE STAGES RC BEAMS USING PIEZOELECTRIC SENSORS (PZT)". In this work, the analytical potential of piezoelectric sensors for the detection of flexural damage condition in the lower portion of the

mid-span region of a simply supported reinforced concrete beam is explored. Examined are two frequent flexural damage severity levels: (i) concrete cracking that extends from the concrete's lower exterior fibre up to the steel reinforcement; and (ii) reinforcing bar yielding that takes place at greater degrees of bending tension and follows the flexural cracking. Furthermore, it is found that, in comparison to the other sensors, the piezoelectric sensor that is applied closest to the flexural damage exhibits better overall sensitivity to structural damage in the full frequency range for both damage states. However, at the top values of the root mean square deviation index, the observed sensitivity of the other sensors increases significantly.

V.P Roshan Ahamed1, Priyanka Dilip. P- ""Experimental And Analytical Analysis Of Flexural Behaviour Of Reinforced Concrete Composite Beams"In This Study, A Partial Replacement Of concrete below the neutral axis with light-weight concrete is explored based on an experimental and analytical examination. Lightweight composite beam experimental models were cast and put through a 600kN UTM test. The experimental and analytical data were then evaluated and discussed after modelling light weight concrete tensile layer in reinforced concrete prisms utilising a continuum-based finite element model test in ANSYS 16.1.

R. Regupathi- "The experimental effort for the damage assessment of concrete reinforcing beam using embedded and surface-bonded piezoelectric transducers is based on the electromechanical admittance approach. DAMAGE DETECTION OF REINFORCEMENT CONCRETE BEAM USING EMBEDDED PIEZOCERAMIC TRANSDUCERS. The experimental findings demonstrate unequivocally that reinforced concrete (RC)beam deterioration may be detected by piezoelectric lead zirconate titanate transducers as early as the testing phase. As a result, the utilisation of these sensors for structural health monitoring and concrete fracture detection using the electromechanical admittance methodology may be seen as being very promising.

James Chilles, Ian Paul Bond- "Design Of An Embedded Sensor, For Improved Structural Performance" This article describes how to incorporate thin sensors with sizable in-plane dimensions into composite materials. Finite element analysis was used in conjunction with the experimental investigation to help understand the experimental data by identifying the load routes within various embedment configurations. The findings demonstrate that sensors may be included into composite constructions without significantly reducing mechanical performance by using careful selection of sensor materials, shape, embedding position, and embedding process.

Mustaqqim Abdul Rahim1, Abdul Naser Abdul Ghani2, Muhammad Arkam Che Munaaim1, Zuhayr Md Ghazaly1, Ngah Ramzi Hamzah3 & Zulhelmi Zulkeflee- "Flexual Behaviour Of A Reinforced Concrete Beam Embedded With Lightning Protection Cable" The goal of this study is to look at the flexural strength of concrete beams that have lightning protection cables installed in them after high electric current equipment provoked lightning strikes. As a consequence, the extra reinforcement provided to the structure beam boosted its flexural strength without affecting the beam's structural performance.

Youyuan Lu, Jinrui Zhang, Zongjin Li, Biqin Dong- "Using a PIEZOELECTRIC SENSOR that is based on embedded cement, monitor corrosion in reinforced concrete beams. In this work, embedded cement-based piezoelectric composite sensors and the acoustic emission (AE) approach were used to monitor the corrosion activities of reinforcement in concrete beams with or without cracks under accelerated corrosion circumstances. The beam with cracks deteriorated significantly sooner than the case without cracking, causing in early degradation. It was discovered that cement-based piezoelectric sensors have excellent performance in AE detection.

M. Sun,1 W. J. Staszewski,2 and R. N. Swamy- "Structural Health Monitoring Technologies For Civil Engineering Structures Using Smart Sensing" This study provides a critical analysis of the use of smart materials and sensors for the SHM of civil engineering constructions. The assessments of laboratory and field research of intelligent materials and sensors in civil engineering constructions are the main emphasis.

Theeran KS, Jayaguru C- "Rc Frame Structural Health Monitoring With Smart Sensors" The main goal of this study was to characterise the health of concrete using impedance using the electromechanical interaction between the underlying PZT structure. The technology being suggested is termed electromechanical impedance (EMI), and it uses embedded self-sensing, also known as Smart Sensing Aggregates (SSAs), which are piezo-impedance transducers, to detect structural health. In this study, numerical methods for calculating the damage index are demonstrated for the outcome analysis. The following will be followed by a thorough examination of SHM of structural systems employing SSAs.

Zhi Zhou and Zhenzhen Wang- "An experimental investigation of "The Flexural Behaviour Of Reinforced Concrete Beams Strengthened By An Intelligent Cfrp Plate With Built-In Optical Fibre Bragg Grating Sensors" The new end-anchored self-sensing CFRP plate assembly with an integrated optical fibre Bragg grating (FBG) sensor is proposed in this work. The experiments' secondary goal was to better understand the failure process and flexural behaviour of reinforced concrete beams (RC beams) using post-tensioned CFRP plates while taking into consideration various

strengthening techniques, initial damage, and the dead load before strengthening. The results of the experiments demonstrated that the developed CFRP plate with integrated FBG sensors can be used to reinforce RC structures as well as provide a useful method for tracking the full-range behaviour of the CFRP plate with the superior self-sensing capability demonstrated in the demonstration test.

Arooran Sounthararajah, Leslie Der Zhuang Wong, Nhu H.T. Nguyen, Ha H. Bui- "Utilising distributed fibre optic sensors, evaluate the flexible behaviour of concrete pavement material beams. The purpose of this study is to assess the accuracy and dependability of a distributed fibre optic sensing method for flexural strain assessment in cemented pavement material (CPM) beams. On CPM beams fitted with distributed fibre optic sensors (DFOSs) and a linear variable differential transducer (LVDT), static and dynamic four-point bending tests were carried out. Additionally, the development of the strain

Nobuhiro Okude1 , Minoru Kunieda2 , Tomoki Shiotani3 And Hikaru Nakamura- ""Rc Beams' Flexual Failure Behaviour With Rebar Corrosion And Damage Evaluation By Acoustic Emmission" The flexural failure behaviour of RC beams with varying weight losses of 0, 5, 10, and 30% owing to corrosion is experimentally investigated in this work. The deteriorating concrete beams' loading tests were also observed for AE. According to the analysis, such discovered AE signals with lower frequency seem to be caused by corrosion-related de bonding behaviour.

ZHU Jinsong1,2, GAO Change1, HE Liku- "Concrete Structures: Piezoelectric-Based Crack Detection Techniques: Experimental Studythe viability of an active crack detection method based on wave propagation was investigated for non-destructive testing (NDT) of concrete structures with embedded and surface-bonded piezoelectric ceramic (PZT) patches. In the experimental investigation, both the lateral and thickness modes of the PZT patches are used to evaluate the progression of cracked damage intentionally induced on the plain concrete beam. The findings show that for surface-bonded PZT patches and embedded PZT patches, respectively, the magnitude of the sensor output decreases with an increase in the number and severity of fractures.

Lei li, Qingbin li , and Fan zhang -"Behaviour Of Smart Concrete Beams With Embedded Shape Memory Alloy Bundles "This work examines the behaviour of smart concrete beams with embedded shape memory alloy (SMA) bundles. The recovery force caused by SMA bundles is considerable and manageable, the deflection caused by the SMA bundles in the middle span of the beam is approximately 0.44 mm, and the average capacity of each beam to withstand overload is around 2.98 kN, according to experimental data. Also established is a correlation between activating/inactivating time and SMA temperature. The conclusion is that, from an economic or technical standpoint, SMA may be employed in civil engineering constructions.

Narayanan1, K. V. L. Subramaniam- ""Defect Assessment In Concrete Structures Using Piezoelectric Based Sensors" The formation and evolution of internal damage in concrete structures may be continually monitored with the use of PZT (Lead Zirconate Titanate) smart sensors, which are based on piezoelectric technology. Investigated for increasing degrees of damage are variations in the resonant behaviour of the observed electrical conductance derived from the electro-mechanical (EM) response of a PZT bound to a concrete substrate. Before cracks become obvious, changes in the conductance resonant characteristic may be seen in EM conductance tests. It is shown that the conductance signature at resonant peaks' root mean square deviation is a reliable indicator of the extent of substrate degradation. The results provided here serve as a foundation for creating a sensing technology for continuous monitoring of concrete structures utilising PZT patches.

Weijie Li1, Qingzhao Kong, Siu Chun Michael Ho, Ing Lim, Y L Mo and Gangbing Song- "Feasibility Study Of Using Smart Aggregates As Embedded Acoustic Emission Sensors For Health Monitoring Of Concrete Structures" In this work, the viability of employing smart aggregates (SAs), a class of embedded piezoceramic transducers, as AE sensors for the maintenance of concrete structures is examined. The capacity of embedded SAs to identify and assess the damage to the concrete structure was compared to that of conventional surface-mounted AE sensors. The findings supported the viability of utilising embedded AE sensors in smart aggregates to monitor structural degradation in concrete.

M.R. Esfahania, M.R. Kianoushb, A.R. Tajaria- "Flexual Behaviour Of Reinforced Concrete Beams Strengthened By Cfrp SheetS" This study examines the flexural behaviour of carbon fibre reinforced polymer (CFRP) sheet-enhanced reinforced concrete beams. Examined is the impact of the reinforcing bar ratio on the reinforced beams' flexural strength. The study's findings suggest that the maximum value, max, stated in ACI 440.2R-02 and ISIS Canada's design recommendations overestimate the contribution of CFRP sheets to boosting the flexural strength of beams with small values.

Vishesh Kakwani ,Siddharth Patel, Mohammed Tohfafarosh Sunil- Jaganiya "Utilising piezo ceramic-based smart aggregate, monitor the health of structures. This research develops a novel piezoceramic-based method for assessing the structural health of diverse constructions. The PZT's piezoelectric characteristic is employed for damage

detection and structural health monitoring. For compressive and seismic stress monitoring, a ceramic-based piezoelectric material called PZT (Lead Zirconate Titanate) and piezoceramic-based disc are utilised. As a result, the actuator and sensor will alternately employ the two attributes. The findings will be put to use for classification and damage assessments.

Haichang Gu, Yashar Moslehy, David Sanders, Gangbing Song and Y L Mo- The term "Multi-Functional Smart Aggregate-Based Structural Health Monitoring Of Circular Reinforced Concrete Columns Subject To Seismic Excitations" In this study, the health of concrete columns exposed to shaking table excitations is monitored using the smart aggregate, a newly invented multi-functional piezoceramic-based device. The amplitude of the dynamic seismic response can be used to estimate acceleration level, according to experimental results. Damage statuses at various locations were also assessed using a damage index matrix, and the first modal frequency derived from the white noise response decreased as damage severity increased.

Yee Yan Lim, Kok Zee Kwong, Willey Yun Hsien Liewand Chee Kiong Soh- "Non-Destructive Concrete Strength Evaluation Using Smart Piezoelectric Transducer—A Comparative Study" The strength of mortar with various mixes was evaluated in this research using a semi-analytical model of surface bonded piezoelectric (lead zirconate titanate) based wave propagation (WP) approach. Following that, the electromechanical impedance method and other common techniques, including the ultrasonic pulse velocity (UPV) test and the rebound hammer test, were used to compare the performance of the WP technique. The WP approach performed as well as its traditional equivalents, according to the results. To confirm the applicability of this approach on heterogeneous concrete specimens, a second investigation was eventually done. With its intrinsic capacity to provide autonomous, real-time, online, and remote monitoring, the WP methodology has the potential to displace its traditional equivalents by offering a method for the monitoring of concrete strength that is more efficient.

3. CONCLUSIONS

A recent innovation with significant promise for SHM of civil engineering constructions is smart materials and sensors. While others are being tested in a lab setting, some of them are now being used in the field. The SHM system must have all-encompassing skills to identify damage locations and levels. However, much research to date on smart sensor/smart material applications in SHM of civil engineering has been focused on the fundamental sensing capabilities of smart sensors. That example, although certain structural defects may be tracked directly using sensor data, others can only be indirectly identified through specialised diagnostic techniques. Typical civil engineering structures are enormous. As a result, several sensors are available to enable buildings to perceive their state of health. Even though many problems remain unanswered, SHM technology is developing and new innovations are developed every year. In this work, we discovered how to use sensors to apply SHM methodologies to civil infrastructures and components, thereby improving on current techniques.

4. REFERENCES

[1] Hou Z., Noori M. and Amand R. St. (2000) ‘’Wavelet- Based Approach for Structural Damage Detection’’, Journal of Engineering Mechanics, Vol. 126, No. 7, pp. 677-683.

[2] M. Quirion and G. Ballivy, “Laboratory investigation on Fabry-P´erot sensor and conventional extensometers for strain measurement in high performance concrete,” Canadian Journal of Civil Engineering, vol. 27, no. 5, pp. 1088–1093, 2000.

[3] K. P. Chong, “Health monitoring of civil structures,” Journal of Intelligent Material Systems and Structures, vol. 9, no. 11, pp.892–898, 199 Minoru Kunieda, Keitetsu Rokugo.(2006) “Recent Progress on HPFRCC in Japan Required Performance and Applications” Journal of Advance Concrete Technology, Vol 4, pp. 19∼33

[4] Lim, Y. M., Li, V. C.(1997). “Durable repair of aged infrastructures using trapping mechanism of engineered cementitious composites” Journal of Cement and Concrete Composites, Elsevier 19(4), pp. 373∼385

[5] P. L. Fuhr, D. R. Huston, M. Nelson et al., “Fiber optic sensingof a bridge inWaterbury, Vermont,” Journal of Intelligent Material Systems and Structures, vol. 10, no. 4, pp. 293–303, 2000..

[6] J.Michels and J. Sena-Cruz, “Structural strengthening with pre stressed CFRP strips with gradient anchorage,” Journal of Composites for Construction, vol. 17, no. 5, pp. 651–661, 2013.

[7] Li Z, Zhang D and Wu K (2002) Cement-based 0–3 piezoelectric composites. Journal of the American Ceramic Society, 85(2): 305–313.

[8] R. El-Hacha and M. Gaafar, “Flexural strengthening of reinforced concrete beams using prestressed, near-surface mounted CFRP bars,” PCI Journal, vol. 56, no. 4, pp. 134 151, 2011.

[9] Qin L, Lu Y and Li Z (2010)” Embedded cement-based piezoelectric sensors for AE detection in concrete”, Journal of Materials in Civil Engineering ASCE 22(12): 1323–1327.