International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
Research Symposium on
"Advancements in Engineering, Science, Management, and Technology"
Volume 5, Special Issue 04, April-2019.

Structural Health Monitoring: A Review

Danish Yousuf [1], Ms. Afreen[2]

[1]*PG student, Department of Civil Engineering, Sharda University,*
[2]*Assistant Professor, Department of Civil Engineering, Sharda University,*

Abstract— Structural health monitoring is a process of accessing the condition of a structure. It is a damage detection process of structures comprising civil, aeronautics and mechanical infrastructure. Unlike traditional techniques which required destructive approach, this new and improved process enables load monitoring and damage detection in real-time without changing the integrity of structure. This paper presents the various techniques used along with addition of modern sensors. New and improved ways of crack detection, strength evaluation and curing process monitoring are gaining attention among researchers.

Keywords— Sensors, Ultrasonic, Piezoelectric, Damage, Monitoring.

I. INTRODUCTION

In today's world of growing infrastructure, a system is needed to continuously check the structures for any integrity change. Any physical change in a structure can lead to a failure of member(s) which can eventually lead to the failure of structure. In order to avoid those disasters, a system which continuously monitors a structure for any change is needed in order to avoid loss of life and property. This can be achieved through Structural Health Monitoring (SHM).Structural Health Monitoring aims to assess the integrity of structures. It uses various sensors for collecting the information about the structure and the data is then processed and results are drawn. Structural responses are collected in either passive (ambient) or active (external) mode using different methods [2, 3, 7-12]. The sensors are either embedded or they are attached using proper adhesive [1, 5]. Various researches have been carried out using different kinds of sensors and different approach for damage identification and localisation on different materials e.g. concrete, steel, aluminium etc. It is also helpful for remotely checking extensive frameworks, e.g. buildings, bridges and dams, and prominent mechanical frameworks, e.g. air ship, shuttle, ships, seaward structures and pipelines where execution is basic yet on location observing is troublesome or even inconceivable.

II. SENSORS USED

The sensors that can be used in SHM are either embedded in structure or surface mounted using proper adhesive. The sensors should be light, cheap and should not cause any structural hindrances. Some of the sensors generally used in SHM are:

1.1 Strain Gauge sensors

A Strain gauge (sometimes referred to as a Strain gage) is a sensor whose resistance varies with applied force. It converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured. These sensors are surface mounted over areas to be monitored and provide reliable data [5]. These sensors are generally used for load monitoring over a member(s).

1.2 Fiber optic sensors

Fiber optic sensors are also used for measuring strain like strain gauges. They are resistant to electromagnetic interference and robust hence can survive harsh environments. They can be integrated over a large span up to few kilometres due to low light attenuation. They can also be used for moisture detection in concrete.

1.3 Piezoelectric sensors

Piezoelectric sensor generates electric current when stress is applied and vice-versa. It converts mechanical stress in electric current and applied current into vibrations. These sensors are used for ultrasonic emission and reception having very good sensitivity on both sides. A single piezoelectric sensor can be simultaneously used both as emitter and receiver hence used in Electro-Mechanical Impedance (EMI) method [4, 2]. They come into variety of shapes and types e.g. Piezoelectric active wafer sensors (PAWS), Piezoelectric patches, Piezoelectric discs etc. These are becoming new choice of researchers from past decade owing to their excellent sensitivity, dual nature and low cost.

1.4 Thermal sensors

Thermal sensors or temperature sensors measure the temperature (heat) of an object. They are generally used for the evaluation of porosity, moisture and density variation.

Apart from these sensors other different types are also used e.g. acceleration sensors, displacement sensors, cameras, laser sensors, radiography sensors etc.

The sensors are employed over a structure to form a network and the collective data is then sent to a computer where it is analysed. The sensors can be wired together and with other equipments or connected wirelessly. Wireless approach is new to the field and is gaining attention. It reduces the cost and also helps in maintaining and surveying easily.

III. TECHNIQUES USED

Various methods are used in SHM for detection of cracks and evaluating other properties like the EMI (electro-mechanical Impedance) method and Wave propagation method. In EMI method, a piezoelectric sensor is used as both transmitter and receiver (transducer) for ultrasonic signals and the results are measured in terms of electrical impedance. Another method known as Wave propagation method uses a separate emitter and receiver for generating and detecting ultrasonic signal and the results are measured by studying the change in the waveform and wave parameters. Table 3.1 shows various non-destructive techniques (NDT) used today

Table 3.1 showing various NDT techniques used [11]

No.	TECHNIQUES	EVALUATION
1	Visual	Surface defects and cracks
2	Ultrasonic	Internal cracks and discontinuities
3	Eddy current	Surface and internal cracks in electrically conducting materials
4	Acoustic emission	Only qualitative gauge of how much damage is contained, initiation of cracks or failure of member
5	Infrared thermography	Density variation, moisture, porosity
6	Radiography	Internal and surface discontinuities, geometrical defects
7	Magnetic particle methods	Surface and internal defects in magnetic materials
8	Liquid penetrant	Open surface defects

IV. PROCESS OF SHM

The whole process of SHM requires many steps and needs to go through many stages before actually being implemented. The process consists of three main steps as:

4.1 Operation evaluation

This is the first step which involves setting up the project and planning the cost, mode of SHM, equipments used, labour, type and number of sensors, placing and network of sensors and other equipments etc.

4.2 Data acquisition

After the setup has been finished and everything is in place, the setup is then started and data is acquired by sensors. The data is the then collected from whole network and sent to a computer for analysis.

4.3 Data Processing

The collected data is analyzed using special softwares and equipments. Assessment of damage requires a comparison between two states of structure. Hence a skilled person is used to identify the damaged and undamaged part of a structure.

V. **Conclusion**

1. In modern world, SHM is a must tool for the viability of structures.
2. New techniques and sensors are detecting damage at microscopic level.
3. Ultrasonic methods are proving very helpful especially in steel structures.
4. Piezoelectric materials are being introduced owing to their relatively lower price and better performance.
5. Frequency has an important role in damage detection, higher the frequency, higher will be the damage sensitivity but lesser screening area and vice-versa (generally150-400KHz).
6. Research shows EMI technique is better for sensing near field damage.

REFERENCES

[1] L. Han, X.D. Wang, Y. Sun "*The effect of bonding layer properties on the dynamic behavior of surface-bonded piezoelectric sensors*" May. 2018.

[2] Suresh Bhalla and Chee-Kiong Soh "*electro-mechanical impedance technique for structural health monitoring and non-destructive evaluation",* March 2008.

[3] Carino, N. and Sansalone, M.*, "Pulse–echo method for flaw detection in concrete,"* July 1984.

[4] Constantin E. Chaliorisa, , Chris G. Karayannisa , Georgia M. Angelia , Nikos A. Papadopoulosa , Maria J. Favvataa , Costas P. Providakis *"Applications of smart piezoelectric materials in a wireless admittance monitoring system (WiAMS) to Structures—Tests in RC elements*,", Mar. 2016

[5] S T Quek, Q Wang, L Zhang and K H Ong, "*Practical issues in the detection of damage in beams using wavelets*", Oct 2001.

[6] Lin, Y. and Su, W.-C.*, "Use of stress waves for determining the depth of surface-opening cracks in concrete structures,"* Sept. 1996.

[7] Popovics, J., Song, W. J., Ghandehari, M., Subramaniam, K., Achenbach, J., and Shah, S., *"Application of surface wave transmission measurements for crack depth determination in concrete,"* Mar. 2000.

[8] Ramamoorthy, S. K., Kane, Y., and Turner, J. A., *"Ultrasound diffusion for crack depth determination in concrete,"* Feb. 2004.

[9] Sansalone, M., Lin, J.-M., and Streett, W. B., *"Determining the depth of surface-opening cracks using impact-generated stress waves and time-of-flight techniques,"* Mar. 1998.

[10] Seher, M., In, C.-W., Kim, J.-Y., Kurtis, K. E., and Jacobs, L. J., *"Numerical and experimental study of crack depth measurement in concrete using diffuse ultrasound,",* Mar. 2013.

[11] Jason Maximino C. Ongpeng J., *"NON-DESTRUCTIVE TESTING USING ULTRASONIC WAVES IN REINFORCED CONCRETE,",*Oct. 2015.

[12] Fabricio G. Baptista, Danilo E. Budoya, Vinicius A. D. de Almeida, and Jose Alfredo C. Ulson "*An Experimental Study on the Effect of Temperature on Piezoelectric Sensors for Impedance-Based Structural Health Monitoring*" Jan 2014.