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Review of Structural Health Monitoring by using Sensors Technology

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Abstract: The rapid technical development of technology in the fields of sensors, data acquisition and communication, signal analysis and data processing has prepared SHM with great benefits. SHM often provides reliable data on the real conditions of a structure. Bridges, wind farms, nuclear power plants, geotechnical structures, historical buildings and monuments, dams, offshore platforms, pipelines, ocean structures, airplanes, turbine blades etc. may be objects for monitoring, just to mention some. The monitoring can be periodic or continuous, short-term or long term, local or global and the monitoring system can consist of a few sensors up to hundreds or even thousands of them depending on the demands of the monitoring object. As the area of the subject is numerous, this thesis principally brings up and discusses the subject from a civil engineering point of view. Cracking concrete, collapsing and deteriorating constructions are a not only phenomena that occurs in old structures.
Keyword: Sensors Technology, Piezoelectric Sensors, Applications, Structural Health Monitoring.

I. INTRODUCTION

Structural Health Monitoring (SHM) is an engineering implement that controls, verifies and informs about the condition or changes in the condition of a structure so that the engineers are able to obtain trustworthy information for management and decision making. SHM has become a well known and used tool in structural engineering in recent years in several countries all around the world. Shortened construction periods, increased traffic loads, new high speed trains causing new dynamic and fatigue problems, new materials, new construction solutions, slender constructions, limited economy, need for timesaving etc. are factors that demand for better control and makes SHM as a necessary tool in order to manage and guarantee the quality and safety for users.The number of sensors used in monitoring is endless. Different applications with various techniques, like electrical, optical, acoustical, geodetical etc are available. A variety of parameters like strain, displacement, inclination, stress, pressure, humidity, temperature, different chemical quantities and environmental parameters such as wind speed and direction can be monitored. Conventional sensors used for structural engineering, like strain gauges, accelerometers, inclinometers, load cells, vibrating wires, Linear Variable Differential Transformers etc. are able to measure most of these parameters and have a long experience in use.

Remote monitoring can sometimes be the only way to monitoring a structure, like for railway bridges and dams where the access is not always allowed. The reliability and durability of the sensors becomes significant when choosing the appropriate instrumentation. The fibre optic sensors allow for measurements that have been unpractical or too costly with the traditional sensor technology.Hundreds measuring points along the same fibre, as well as the distributed sensing, insensitivity for electromagnetic fields and also the fact that there is no need for protection against lightning are some of the advantages over the electrical-based counterparts. In the following, an overview of fibre optic sensors, microelectromechanical systems (MEMS), traditional technologies and geometry monitoring techniques is presented.

II. LITERATURE REVIEW

Literature review related to the structural health monitoring was carried out. The objective was to know the stability and the performance of different structural units in design. It was noticed that many researchers, engineers and consultants have worked extensively on non destructive tests, wired sensors as well as wireless sensors

III. PIEZOELECTRIC SENSORS

The technique based on electromechanical impedance (EMI) is considered one of the most promising methods for the development of SHM systems. This technique is simple to implement and uses small and inexpensive piezoelectric sensors. However, practical problems have made it difficult to apply this technique to real-world structures, and the effects of temperature have been cited in the literature as critical problems Regarding non-destructive ultrasonic inspection techniques, there are problems regardingthe reproducibility of the acoustic coupling, accessibility to the structure, and the weak signal-to-noise ratio in highly attenuating

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materials. The use of built-in or connected piezoelectric sensors overcomes some of these difficulties because they remain permanently connected to the structure, and these sensors can be used to monitor the integrity of a given component from its manufacturing phase to the end of its life cycle. At present, most works dealing with acoustic and ultrasonic processes have used piezoelectric transducers. Recently, there have been reports in the scientific community of the incorporation of piezoelectric sensors into composites and some metals. The techniques for the inclusion of piezoelectric sensors reported so far involve complex methodologies, so it is a scientific interest to look for easier ways to incorporate piezoelectric sensors into metal or composite structures. Therefore, Sections present a set of applications and methodologies that have been developed in recent years as a way to incorporate the sensors and ensure the monitoring of the integrity of metal and composite structural components.

The working principle of a piezoelectric sensor depends on "piezoelectric effect" of piezoelectric materials, first discovered by the Curie brothers in 1880. They found that, when an external force (pressure or tension) is applied in a specific direction of some dielectric crystals, the surface of both ends of the crystal will generate positive and negative bound charges of equal amount of electricity, and the density of bound charges is proportional to the magnitude of the applied stress, which is called the "positive piezoelectric effect". Subsequently, G. Lippman and the Curie brothers predicted and confirmed the existence of inverse piezoelectric effect in theory and experiment, respectively, that is, the material with piezoelectric effect will produce corresponding deformation under a certain electric field, and the deformation of the material will be restored when the applied electric field is removed.

IV. METHODOLOGY

Studying Literature Related To SHM and Smart Sensors
A throughout Study Of Working Of Piezoelectric Sensors
Piezoelectric sensors into composite structural components

Author	Methodology of Integrating Sensors	Measurement	Application
Wu etal.	Mounted on Reinforced Concrete	Damage	Reinforced Concrete Structures
Konka et al.	Open-Contact Moulding Processes	Stress Ultimate Strength -	Composite Structures
Tang et al.	Vacuum-Assisted Resin Transfer Moulding	Failure	Damage Prediction in Composites
Talakokula et al.	Mounted on Reinforced Concrete	Corrosion	Reinforced Concrete Structures.
Karayannis et al.	Mounted on Reinforced Concrete	Admittance Signatures	Concrete Beams' Cracking
Gopalakrishnan et al.	Mounted on Reinforced Concrete	Conductance Signatures	Reinforced Concrete Structures
Ahmadi et al	Mounted on Reinforced Concrete	Corrosion (Electro-Mechanical Impedance	Reinforced Concrete Structures
Sha et al	Encapsulation with Concrete, Epoxy Resin, and Curing Agent	Stress (Electromechanical Impedance)	Reinforced Concrete Structures
Huijer et al	Open-Contact Moulding Processes	Degradation Failure (Acoustic Emissions	Carbon Fibre-Reinforced Plastics
Gayakwad et al.	Mounted on Concrete	Damage (Electromechanical Impedance)	Concrete Structures
Wu et al.	Mounted on Reinforced Concrete	Strain	Concrete Structures

A. *Range Of Application*

1) Reinforced Concrete Structure.
2) Application In Civil Engineering.
3) Corrosion In Reinforced Concrete Structure.
4) Thin Dielectric Film For Composite Structure.
5) Self Sensing Carbon-Based Structural Material

B. *Installation of Sensors and Data Acquisition Systems*

Installation of the sensors and devices is performed according to the installation plan. The size of the installation team depends on the size of the project. The work to be done before actual installation is the following:

1) The sensors and devices to be installed are delivered, checked and quality controlled.
2) The persons installing the sensors are well-informed about the installation procedure and need even to have a good understanding for the sensor devises. When installing new complicated sensors like for example fibre optic sensors it is necessary to give the new personnel a short course about the sensors and installation procedure.
3) The necessary equipment is procured and if necessary tested.
4) Data acquisition systems are calibrated and the software is programmed and tested in the office.
5) A lot of practical details often delay the project and therefore it is good to check the following things: access and keys to the building site, safety regulations, other activities that might collide with the installation at the building site, access to electricity and facilities for the personnel etc.
6) Passage for the cables etc. is done beforehand if possible. This is especially important in new concrete constructions where the plastic pipes or such need to be concreted in beforehand. The work to be done in actual installation is following:
7) The sensors and devises are installed according to the installation plan and drawings
8) If any changes are made, they are noted so that the drawings can be revised
9) The installation procedure is described in detail in a diary and documented with photographs
10) The sensors are tested, measured and calibrated if possible or necessary
11) If there is a risk for damages, the sensors are protected or marked
12) The sensors are connected to the data logger for temporary or permanent measurement or if they are not to be used directly, they are protected or set in a safe place
13) If temporary measurements are performed during some stage of the construction the measurement equipment is protected against damage and marked clearly
14) In case of a new concrete construction an embedded sensors it is good to be present when concreting in order to supervise the survival of the sensors The work to be done after installation of the sensors and cables is following:
15) The sensors and devises are connected to connection boxes, main units etc. according to installation plan and drawings
16) The communication system is established
17) The cables are fixed temporarily or permanently on the cable rack
18) If any changes are made, they are noted so that the drawings can be revised 1.7. Aims of the present study
19) The installation procedure is described in detail in a diary and documented with photographs • The system is tested
20) The system and monitoring is verified by other systems, models or calculations Every project has unique requirements and therefore it is not easy to describe a procedure that covers all details. Good and very detailed planning saves time and thereby the costs for the installation and ensures qualified installation

V. CONCLUSION

Embedded sensors currently represent one of the main fields of sensing technology; therefore, the scientific community has focused its efforts on the development and optimizationof a set of technologies that ensure the continuous monitoring of structural integrity. SHM systems use a vast range of techniques; however, Fibre-Optic Sensors (FOSs) and Piezoelectric Sensors (PSs) have proven that, through the right technological processes, ESs can be incorporated into components or structures. The selection of smart sensors or the technology underlying them is fundamental to the type of monitoring that is intended to be performed, i.e., each embedded sensor is developed and optimised to monitor certain physical and mechanical properties in specific structures and perform under specific conditions. Regardless of the type of embeddedsensors or smart-sensing technology, there are limitations of use related to the physical, chemical, and mechanical limits of each. In this sense, with the correct selection of embedded sensors and technological process for its integration, it is possible to obtain structures or structural components that are reliable.

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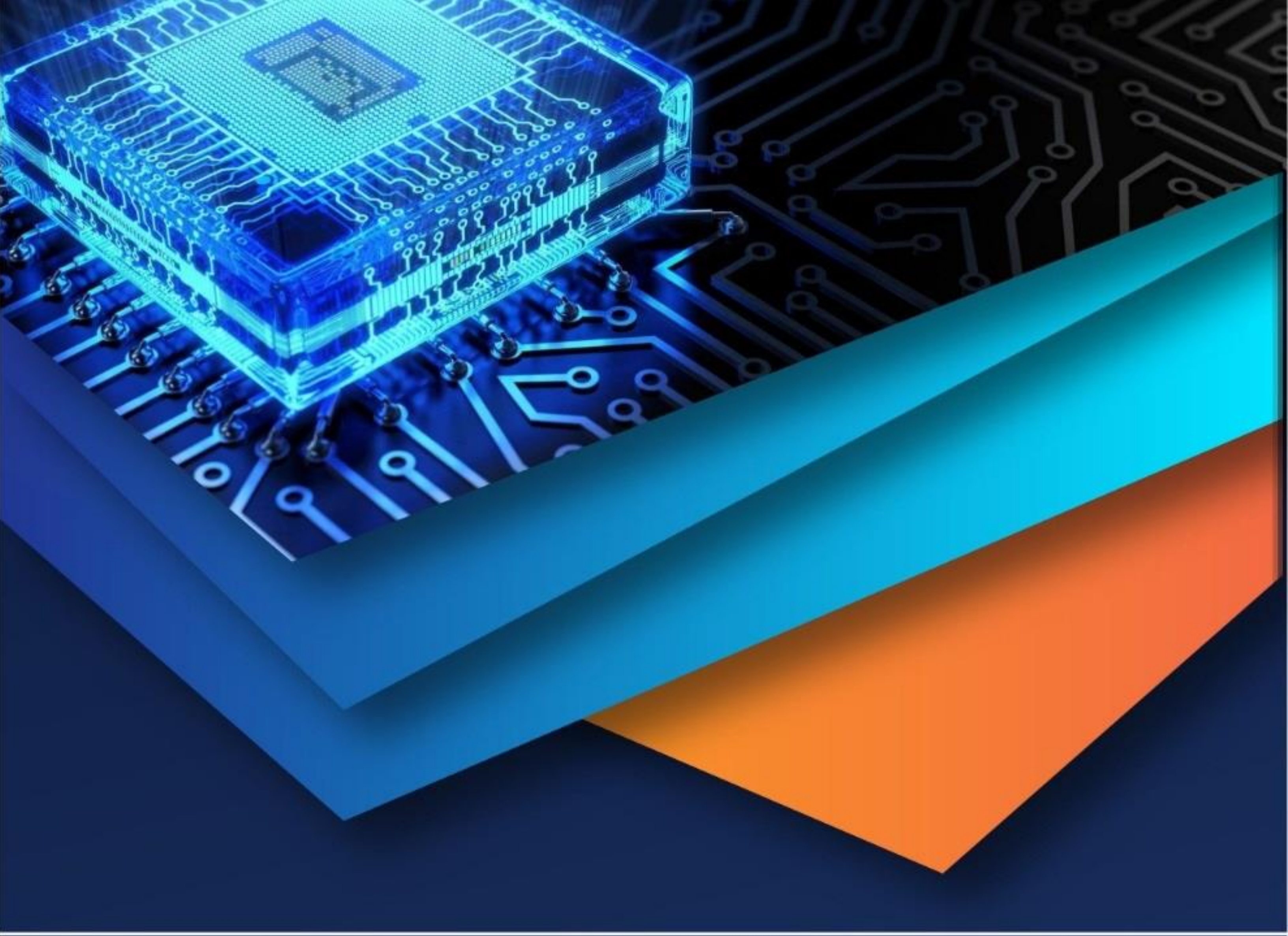

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