# Structural Monitoring using Smart Materials and Internet of Things (IoT)

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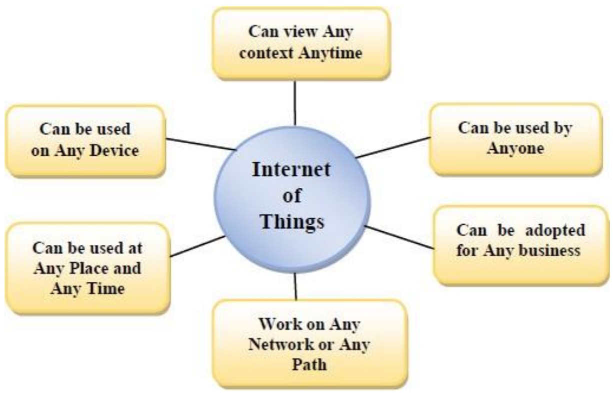
***Abstract*—In construction industry maintenance should be given utmost importance and focus. For continuous monitoring of maintenance, Internet of Things (IoT) can be used. IoT can be used to monitor the structure from anywhere. Structural health monitoring using IoT is the latest technique employed all over the world, especially the buildings exposed to harsh environments. Sensors are used to collect the data from the structure from which we can identify the deterioration and suggest the method to rectify. Cloud computing technique is also employed in this regard. A simple signal processing technique helps to interact with buildings. This paper presents the state of art survey about current research and implementations put into practice.**

***Keywords— IOT, Internet of Things, Cloud computing, Sensors.***

## I. INTRODUCTION

Internet of Things (IoT) is the hot-topic of research. While IoT is in its peak with Communication Engineering and Information Technology, it is still in its infancy with applications to Civil Engineering structures. Structural Health Monitoring (SHM) is the evaluation of structure to detect, locate and assess the damage. SHM has become challenging task with the increase in development and construction of structures along with the complexities involved in them. The demand for SHM has also increased due to increase in the necessity to ensure safety of the structures as well as the human lives associated with it. Each structure is often unique regarding its material, shape, and its behavior often change due to their age, usage or environmental factors. Key structures such as bridges, power utilities, nuclear power plants and dams particularly require continuous monitoring and provide necessary maintenance in time. A more effective SHM should provide monitoring results in real-time and online; immediate response can be carried out to avoid further loss and damage of the structure and detailed structural behavior data can be used in design or study in the future. Computer application in the construction industry is minimal. A tool to study the safety and serviceability of concrete structures is scarce. For studying the real-time behavior of concrete structures, IoT becomes vital. Fig. 1 depicts the consents of the inhabitants and possessions that can be linked at any given time, at any place, with any person, using some network plus some broadband utility. The Ambient Intelligence, insidious computing and omnipresent computing concepts are basically adopted in the IoT

*Fig 1. Consents of IoT [13]*




## II. LITERATURE REVIEW

A complete real-time SHM platform is integrated with the IoT system. The proposed platform consists of Pro-Trinket, NRF module, Wi- Fi module and Raspberry Pi 2. Fig 2 shows the proposed IoT platform.

The data is be stored in the cloud and can be checked remotely from any mobile device. The system has been validated using a real test bed in the lab. Results show that the proposed platform has a 1% error for the damage location and a 9% error for the damage width detection.

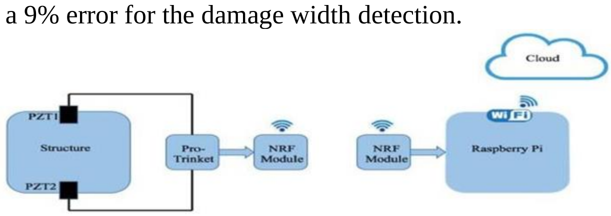



*Fig 2. Proposed IoT platform.*

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Several attempt has been made to implement IoT to monitor deflection of Bridge decks using piezoelectric sensors. This process could make the whole system "self-sufficient for energy generation and utilization". The findings could pave a positive way of approach for the successful practical implementation of IoT to monitor bridges and also make it "self-sufficient" by adopting to an Alternate Energy Conversion system. Fig. 3 shows the Flow Diagram for IoT of Bridge Deck.

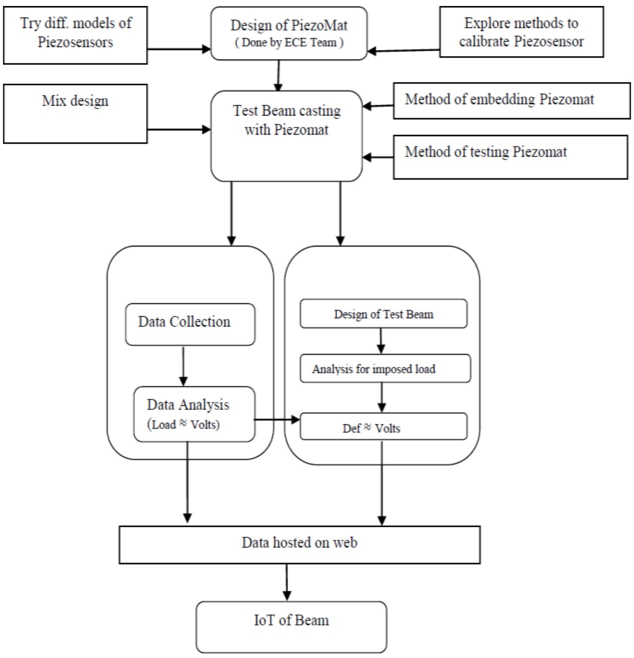


*Fig 3. Flow Diagram for IoT of Bridge Deck [2]*

The findings contribute to research and development and when put to practical use, will enable practicing Civil Engineers to monitor and manage projects through IoT.Data collected by Arduino Uno is also given to the visual studio for locally storing data and visualizing data on the bar chart form as shown inFig.4.

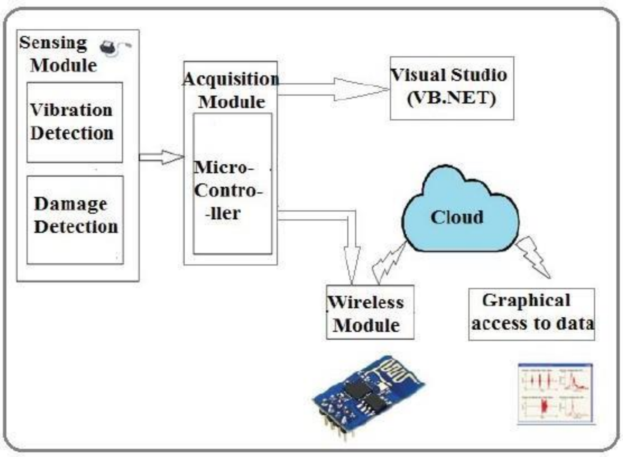


*Fig. 4. Block diagram of proposed system*

This system helps government to issue early warning of any unwanted critical condition for resident based on cloud data. So that, they can take a legal action earlier before it collapses. In future, we can also monitor some more advance parameter of building using IoT enabled devices or sensors for enhancing safety. Prototype of system can be used for various applications like environment health monitoring system, greenhouse monitoring systemetc.

Sensors are smart since they are not only able to measure the physical quantities of interest but elaborate them and are able to transmit the information through the internet to take decisions.

The architecture of an IoT-SHM system (Fig. 5) can be schematized by: Smart Object (SO) sensors; gateway; remote control and service room (RCSR); and the open platform communications (OPC) server.

The advantages of the IoT paradigm in implementing the SHM monitoring system are highlighted with several actual examples, with the aim to boost the effort of scientific research in this direction. Among several application scenarios, particular importance is the monitoring of building materials through acoustic emission. This is a technique that will have great potential for development of IoT-SHM and allow systems with reduced battery consumption to continuously monitor existing and new structures

Image processing technique involved in multipath ultrasonic guided wave imaging is used for complex structures, inhomogeneous and anisotropic materials. This technique gives an improved image quality using fewer sensors. It takes maximum advantage of using a large number of echoes and reverberations to perform localization and damage detection. This system helps not only to increase the performance but also to reduce complexity and cost. Vibrational sensors and video cameras used together in Wireless Sensor Networks (WSN) send distributed data interpretation to detect the local data trends like normal vibrations, abnormal vibrations, and structural tilts.

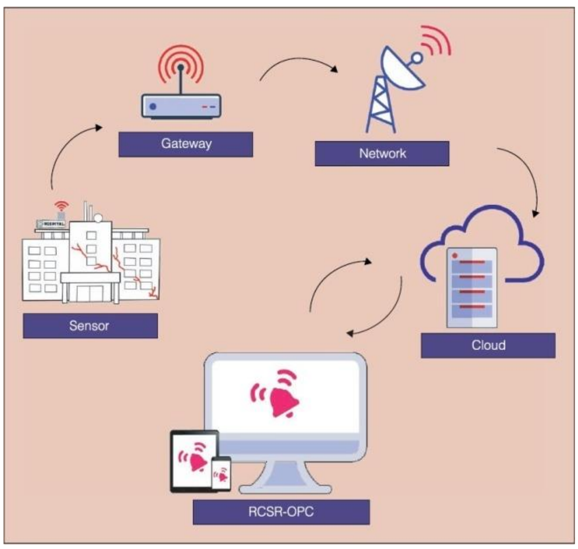


*Fig5. Scheme of an IoT-SHM system*

Fiber optical sensors are used in Fiber Bragg Grating (FBG) to detect the dynamic loads on bridge decks. Vibration based SHM systems have become an area of focus in recent studies, as it is used to detect damage that cannot be visually detected and damage hidden within the internal areas of the

structure. The vibration of the structure changes along with the stiffness of the body when it is damaged and this can be detected by using vibrational SHM.
Signal processing is the key component of any SHM. The data obtained through data acquisition systems are not accurate as there are vibrational and environmental effects which influence the output data. The errors in the output data can be removed by using Principal component analysis (PCA) and Hilbert-Huang Transform (HHT) with EMD for data processing and analyzing data to detect structural health problems.

The Wavelet Spectral Finite Element (WSFE) method is very efficient for wave motion analysis and best suitable for inverse problem solving but will have "wraparound" problem. Samaratunga has proposed WSFE model which eliminates the wraparound problem and is best suitable for 2D finite structures with transverse cracks [30]. A wavelet based approach is also helpful in finding the damage from wavelet decomposition of response data. Location of the damage can be detected by patterns in the spatial distribution of spikes. Even with the existence of all these systems, we lag to integrate the data with the Internet. Tracking of data is also as important as sensing the health of the structure.

## III. CONCLUSIONS

The IoT-Structural health monitoring system is well adapted to application scenarios such as smart houses and smart cities, boosting on one side safety for humans and goods and on the other side reducing the costs of periodic monitoring. Both of these features introduce the capability of the monitoring system to implement criteria for providing a prognosis about the residual life of the structure or to optimize its maintenance.

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