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Structural Health Monitoring Of River Bridge

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Abstract**:** *Bridges are extremely important part of society's infrastructure and reliable methods are necessary to monitor them and ensure their safety and efficiency. Bridges deteriorate with age and early detection of damage helps in prolonging the lives and prevent catastrophic failures. Most bridges still in used today were built decades ago and are now subjected to changes in load patterns, which can cause localized distress and if not corrected can result in bridge failure. One of the major causes of the structural health degradation is scour. There are other parameters like vibration of bridges, vibration near pier which also affects structural health of bridges. This proposed work consist the various existing scour monitoring techniques. This system consists of 8051 controller which uses IOT technology.*

Keywords-*Piezoelectric sensor, Scour, Structural health monitoring, Ultrasonic distance sensor, Vibration sensor, Wireless sensor networks,Intranet*

I. Introduction

For the effective bridge management the structural health monitoring (SHM) is used for the bridges. This monitors the structure of the bridges and identifies the damages on the bridges before it reaches critical level [1].

The structural monitoring includes the awareness of the outline of the structure like the limitations of the load that the structure can go through.This process involves the observation of a structure or mechanical system over time using periodically spaced measurements, the extraction of damage-sensitive features from these measurements and the statistical analysis of these features to determine the current state of system health [7]. By this method we can identify the issues on the structure of the bridge. The SHM includes different steps which are monitoring the structure, processing the data and sending the data to the control room [2].

The fact is that these bridges are monitored manually for every 5 years by the management system. Because of this random inspection for every few years it is difficult to get the bridge status in the required time. Due to lack of continuous monitoring bridge may collapse. In order to overcome this problem it needs a system which monitors the bridge status continuously and gives the proper alert to the operator at correct time.

II. Literature Survey

The idea of using structural health monitoring is not a new concept. It has been used at numerous sites worldwide. Various technological advancements have been proposed in several citations.

CláudiaNeves proposes that Sensor distribution is a critical part of any damage detection system. An enhanced configuration allows for accurate SHM information, improvement of the reliability and robustness of the system, minimization of the number of sensors and, thus, reduction of the investment in hardware. Typically, the very best configuration is the one that requires the least number of sensors to obtain the maximum SHM information [9].

Doebling, provides one of the most comprehensive reviews of the technical literature concerning the detection, location, and characterization of structural damage via techniques that examine changes in measured structural vibration response. Issues that were identified include the dependence of many methods on prior analytical models for the detection and location of damage. [10, 11].

Garibaldi, Marchesiello and Gorman (1999) describe a situation in which operation constraints of a bridge testing can obscure damage-detection results. The authors state that the bridge testing using traffic excitations suffers from a lack of sufficient instrumentation. When normal traffic is used as an excitation source, only exterior sides of the bridge's main span can be instrumented and other places that are rarely accessible unless a truck with a special crane is available [12].

III. Scour

Scour in watercourses and drainage paths causes significant damage to the environment and engineering infrastructure. In order to minimize the long term costs, infrastructure must bedesigned and

protected from scour. Scour is the transport of bed material by the flow of water and is present to some degreewhere the river bed or seabed is formed of granular material. Scour increases as flow rates increase and therefore the actual collapse of structures due to scour often occurs during periods of extreme flow, due to flooding. The scour occurs due to its different types and takes various forms. The loss can be majorwhich depends on the type of scour. Hence there is necessary to reduce such type of loss [3]. Scour monitoring can be completed by either fixed or portable instruments [6]. Fixed instruments are those that are installed and left at the bridge and typically involve a sensor for making the scour measurement, a powersupply and a data-logger.

Water usually flows at a greater velocity around piers and abutments making them susceptible to local scour. At bridge openings, contraction scour can occur when water accelerates as it flows through an opening that is narrower than the channel upstream from the bridge. Degradation scour occurs both upriver and downriver from a bridge over large areas. This gradually causes erosion of river bed.

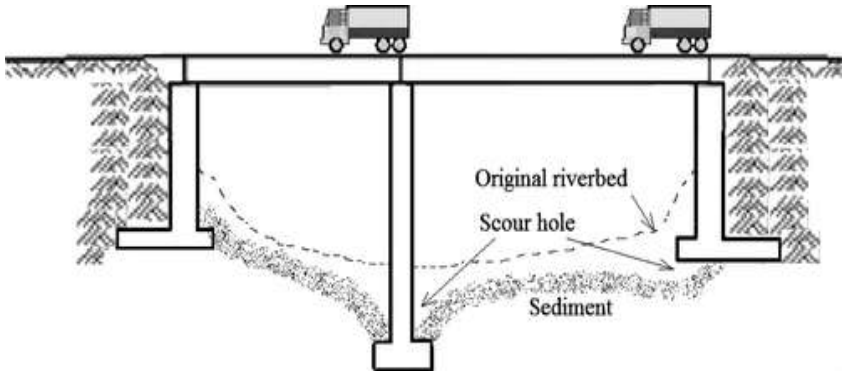

Fig.1 Bridge Scour

Preventing bridge scour is the major concern because scour is the erosion or removal of particles, sediment, dirt, rocks, from around the base of bridges, their abutment piers, and the opening. If this happens too often it can weaken the bridge's foundation and resultin bridge malfunction which can cause a catastrophic event, even loss of life [4]. Now, in order to prevent bridge failure it is essential to know how to calculate bridge failure. Bridge failure is calculated using two main components, contraction scour and local scour. Contraction scour occurs as water is forced through a narrower channel such as when water moves from the wider area of a river into the narrow area of a bridge opening. The local scour occurs around piers and abutments, soit happens locally in these areas [3]. And this occurs as water flows around them and washes away the soil particles of the river bed.

3.1 Scour Measurement

A) Ultrasonic Sensor-Ultrasonic sensors work on a principle similar to sonar which calculates distance between source and target by interpreting the echoes from ultrasonic sound waves. Ultrasonic ranging module HC – SR04 provides 2cm – 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit.

The basic principle of work

(1) Using IO trigger for minimum 10us high level signal,

(2) The Module is set to sends eight 40 kHz by default and detect whether there is pulse signal back.

(3) IF the signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time × velocity of sound (340M/S)/2

B) Vibration Sensor-Piezoelectric film type real-time scour monitoring sensor installed along the bridge pier is presented. The core idea of developing this scouring sensing system is based on the physical characteristic that output voltage can be generated as the piezoelectric film is deformed by the flowing media. Therefore, a sensing device can be constructed by mounting piezoelectric thin films along the rod at a fixed distance and inserting them into a guide rail beside the bridge pier. The piezoelectric film embedded in the soil of the riverbed is undisturbed and the output voltage is much smaller than the one disturbed by the water current. From the output signals of all the piezoelectric sensors with known locations along the depth of the pier foundation, one can trace the variation of the soil/water interface before, during and after a flood [5]. 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 [8].

C) Wi-Fi Module-Espressif Systems Smart Connectivity Platform (ESCP) is a set of high performance, high integration wireless SOCs, designed for space and power constrained mobile platform designers. It provides unsurpassed ability to embed Wi-Fi capabilities within other systems, or to function as a standalone application, with the lowest cost, and minimal space requirement. ESP8266EX offers a complete and self-contained Wi-Fi networking solution; it can be used to host the application or to offload Wi-Fi networking functions from another application processor.

IV. Proposed Methodology

As bridges and other structures such as buildings age, they naturally develop cracks, concrete deterioration, and steel corrosion that can impact the safety of the bridge or the structural integrity of the building. Wireless sensor network enables low-cost sensing of environment having low equipment cost, low installation cost, low maintenance cost, low duty cycle, low power consumption.

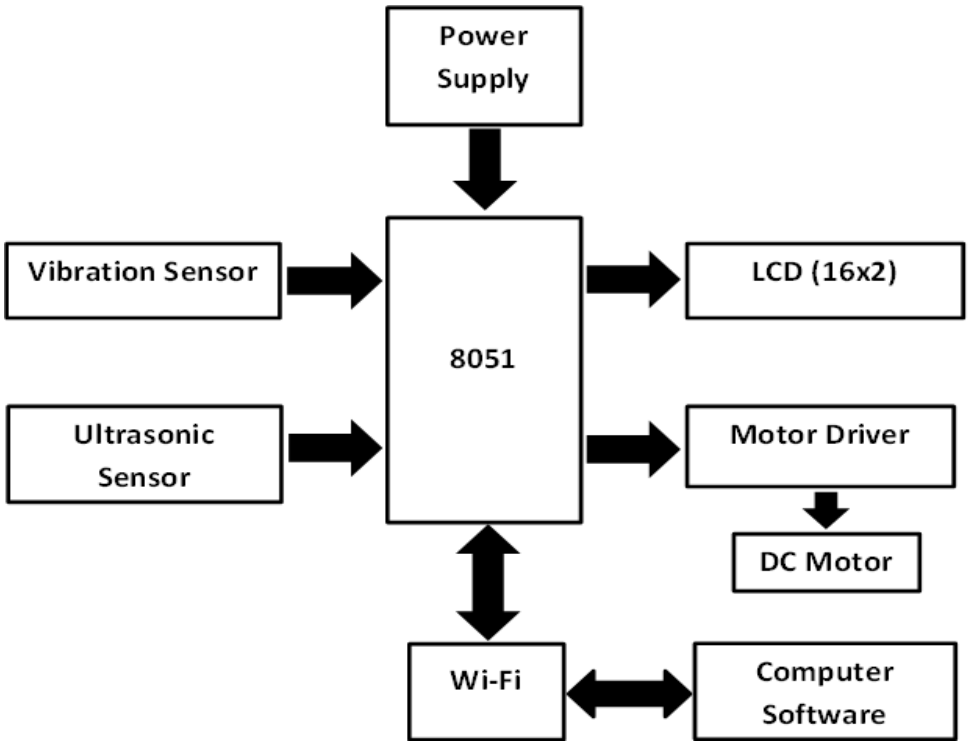

Fig.2 Block Diagram of SHM

We are using AT89C2051 for controlling all the actions

1. Vibration sensor is used to sense any vibrations or abnormal behavior in bridge. Vibration sensor will sense any vibrations or fluctuations in all co-ordinates of bridge.
2. Ultrasonic sensor is used to detect the height between surface and Bridge. If any reduction in height is detected, this input will be given to microcontroller.
3. If microcontroller gets input from vibration sensor or ultrasonic sensor, it will send alert notification through wi-fi module to an android app which is present at Authorized person. And the gate of the bridge will be closed.
4. The status of bridge will be displayed on LCD, so that all drivers can see the status of the bridge.
5. On Android app side, user can see the status of the bridge and status of gate i.e on / off. In emergency condition user will get notification, that vibrations or fluctuations are detected or height of bridge is reduced.
6. We are showing the energy generation concept also using piezoelectric devices and output of power generation will be shown on LED.

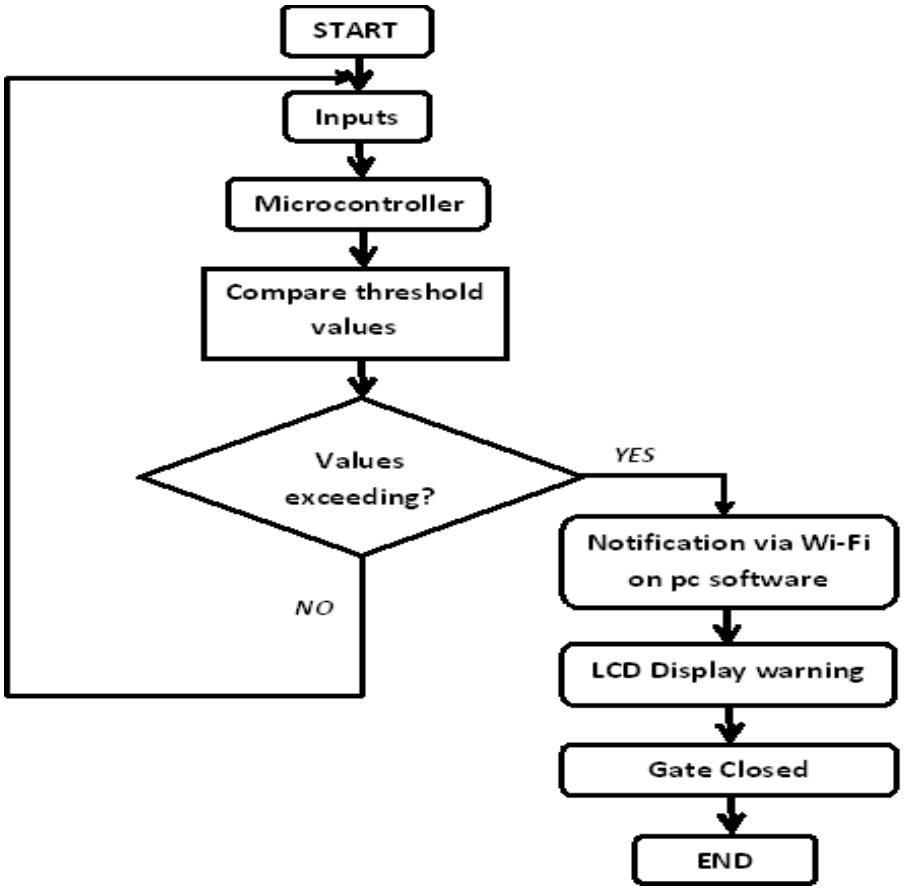

Fig.3 SHM Flowchart

V. Expected Results

In this system,IoT technology is used for the structural health monitoring of a river bridge. We measure several parameters that can lead to degradation of the structural quality of the bridge. Parameters like scour measurement, vibration measurement are monitored in real time using this system. Real time monitoring enables to take timely action (display warning on LCD screen and closing bridge entry) using IoT to prevent any major mishaps. Besides, electricity generation using piezoelectric sensors along the bridge's surface is also another feature of this project.

VI. Conclusion

The bridge scour monitoring is absolutely important for prior warning or signs of damage of bridge structure. The main objective of this paper is to ensure the structural health of bridge, its function and reduce the probability of bridge collapse during the scour. No single methodology or instrument can be utilized to solve the scour monitoring problems for all situations encountered in the field. Considering the wide range of operating conditions necessary, it is obvious that several instrument systems using different approaches to detecting scour will be required. In this paper, three kind of bridge monitoring devices are used such as ultrasonic distance sensor, vibration sensor, piezoelectric sensor. The cost effective IoT technology is used. Hence structural health monitoring of bridges is monitored by using this technology.

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