BRIDGE MONITORING SYSTEM

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Abstract : In recent time maintenance of structures has gained its importance. Bridge collapsing being a major issue shows us the need to monitor its condition. In this paper we propose a continuous monitoring system to know its condition. A sensor network is deployed to capture data from the changing bridge environment, the data is stored and monitored. Further a web application is developed to display a messages over any unpleasant changes in bridge condition.

***Index Terms* - Structural Health Monitoring, Bridge Monitoring, Load, Structural bend, Vibrations, Flood Detection.**

I. INTRODUCTION

In many countries, a lot of bridges have exceeded their life span of 50- years. Old bridges cannot face to the severe nature disasters. In other words, these bridges in such countries are likely to suffer from severe damage due to aging or occurrence of natural disasters. Many bridges built on the river are subject to deterioration as their lifetime is expired but they are still in use. They are dangerous to bridge users. Due to heavy load of vehicles, high water level or pressure, heavy rains these bridges may collapse which in turn leads to disaster.

Bridges are important aspect of country's transport but are expensive to build and maintain. Sometimes minute fault inside the structure might affect whole body which would lead to collapse of the structure which might create a significant loss of property and human lives. To avoid these mishaps monitoring is necessary. Structural Health Monitoring (SHM) mainly aims to detect, locate and quantify damage happening to structure by the acquisition of data measured by sensors on the bridge. The SHM systems can also be used for other purposes, such as load estimation (e.g. traffic, wind), monitoring of construction and repair work, and to validate design assumptions regarding the static and dynamic behavior of the structure[2].

The government generally appoints an engineer who uses the method of visual inspection of structures for every 2-3 years. This method needs to be improvised. A new technology can be invoked with the help of different methods to deal with the bridges & structural monitoring in a more secure way[4]. Bridge monitoring system is necessary to understand the structural behavior and to pay a support for betterment of structural conditions . It helps in early damage detection which would reduce the cost of repair.

II. PROPOSED APPROACH

There are few major parameters those affect the structure's condition. The proposed system monitors four different parameters like load upon the bridge using a loadcell, detecting structural bend using a flex sensors, vibrations using accelerometer, water level detection using moisture sensor. All the sensor data is read to file and is further sent to a server using internet. The authenticated user shall login to the web page which shall display messages about the condition of the structure.

2.1 HARDWARE

Load Detection : We use a single point load cell to measure the load put upon the bridge [1]. The load cell is located under a platform that is loaded with a weight from above, that can be the pier of the bridge. The dead load is said to be neglected as it can be less in new structures but more in the older ones due to the factor called aging. The live loads such as traffic, human weight etc., is being measured.

Structural Bends : Flex sensors are sensors that change in resistance depending on the amount of bend on the sensor. They convert the change in bend to electrical resistance - the more the bend, the more the resistance value. These sensors can be positioned at desired spots over the bridge. Any sensitive area that can develop a structural bend due to damage must be recognized and the flex sensor placed in that position would help recognizing the bend in that part of the structure.

Vibration detection : Accelerometer ADXL335 is used to detect dynamic or damp free vibrations [5]. ADXL is a 3-axis accelerometer measuring X, Y and Z axis. The averaged measurement of all axis values would give a single dimensional output which would show major variations in its value upon major displacement in structure or any high vibrations.

Flood detection or Water level Monitoring : Moisture sensor with an onboard LM393 chip is being used. This sensor consists of a potentiometer using which the range of detection can be set. A digital output of either 0 or 1 is given out by digital output pin. The sensor uses an active low logic. The sensor consists of two probes that can sense the water level. The comparator compares the values given of both probes and gives out the larger one as the output. It has an option of both digital and analog output.

A Raspberry Pi processor is being used for all the data processing. As Pi consists of digital I/O pins, an ADC converter MCP3008 is being used for the conversion of all analog sensors. It has 8 channels of 10-bit analog input and the output ranges between 0-1023. Load cell amplifier HX711 works as an ADC as well which is being calibrated according to the application requirements.

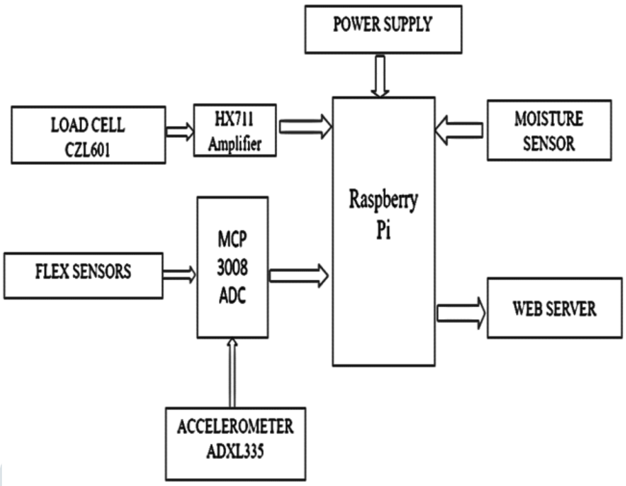

Fig 1: Block diagram of proposed system.

2.2 SOFTWARE

A web application is developed using JavaScript. The IP address of the network connected to raspberry pi is used a source link to the webpage[6]. The webpage allows the authenticated user to login to the page with user name and password. A brief systematic approach can be viewed in the form as a flow diagram shown below:

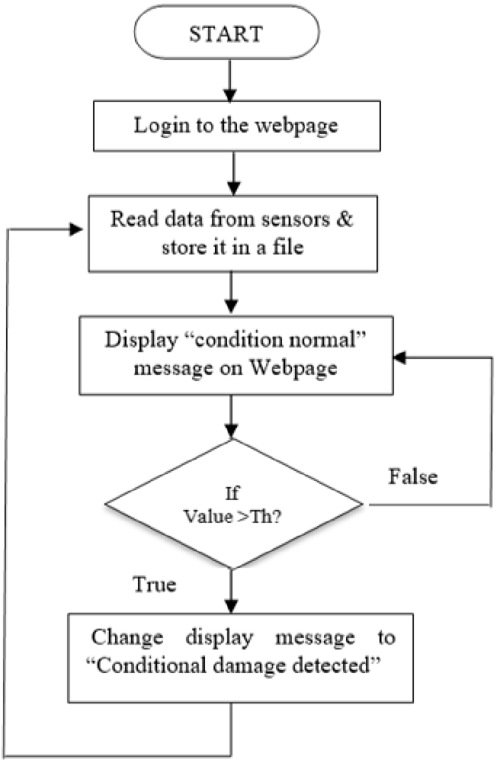

Fig 2: System Flow diagram where Th - refers to the threshold value.

By entering the page one can check out the messages displayed on screen, the display message would change over any undesirable changes in structures condition. One can even look at the values acquired by a particular sensor on the webpage. These values are continuously read into a file in the system which would give a detailed analysis of changes in the condition at different time.

III. OBSERVATION AND RESULTS

A Protype is built to show two different bridge conditions which can be seen on fig3. Here bridge1 (seen towards the left of fig3) is built to be shown as a stronger structure and bridge2 (seen towards the right of fig3) to present a weaker structure.

Fig 3: Implementation of bridge monitoring system.

Experimental observations of each different parameters were done and the observed results are shown below.

Load :

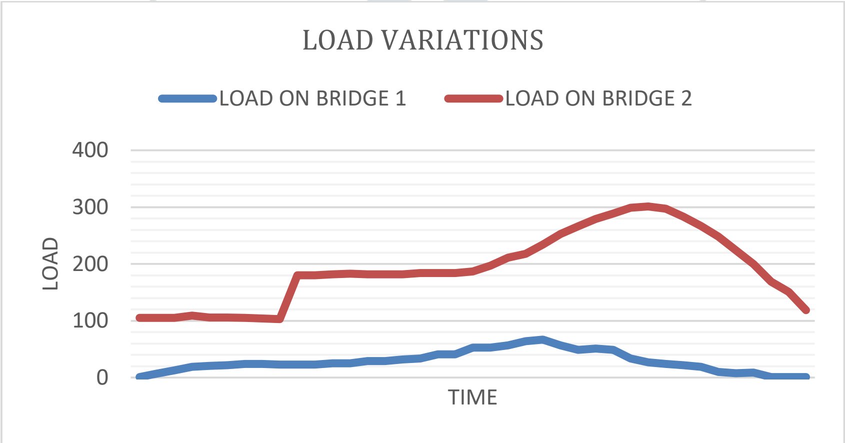

Fig 4: Representation of varying loads conditions on different structures.

Considering bridge 1 to be a strong structure and bridge 2 to be a weak or aged structure the load variations are being plotted in fig4. Two different structure carrying the same amount of load would give different values because the weak structure would give out more dead load value along with the applied load weight but not the strong structure.

Structural bend :

The used flex sensors vary with different bend resistance upon analyzing its characteristics and range of values a threshold is set with accordance to the need of the prototype. This shows that a weak structure would develop bends easily upon any vigorous environmental changes such as high wind speed, heavy load etc.

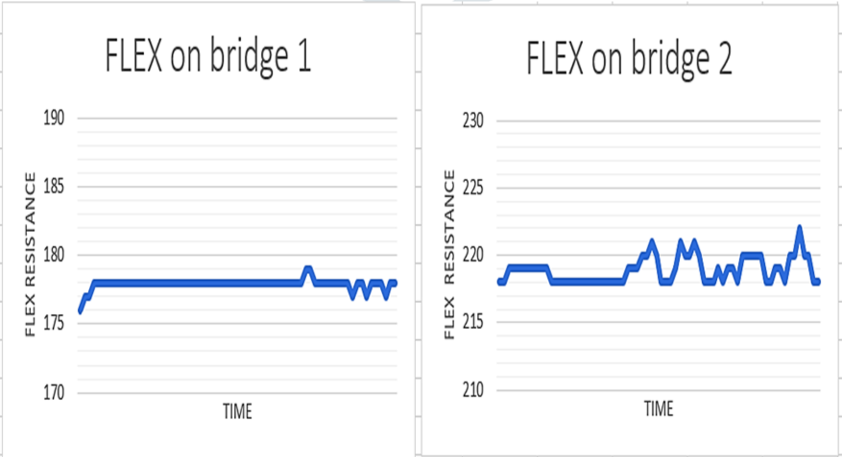

Fig 5: Variation in bend resistance of flex sensors.

Vibrations :

The measured values of ADXL sensor is taken as an average to indicate the data in 1- dimension. The sensor detects dynamic vibrations or displacements. On detection of such parameters the sensor value would vary largely but would stay constant under normal condition. This is shown in the graph at fig 6 below.

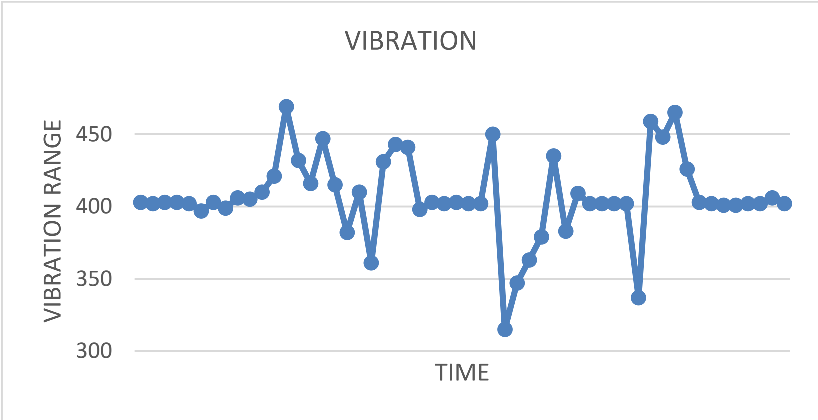

Fig 6: Accelerometer variations.

The rise in water level indicates the chances of flood, the message upon this condition is displayed on the webpage which is shown in fig7.

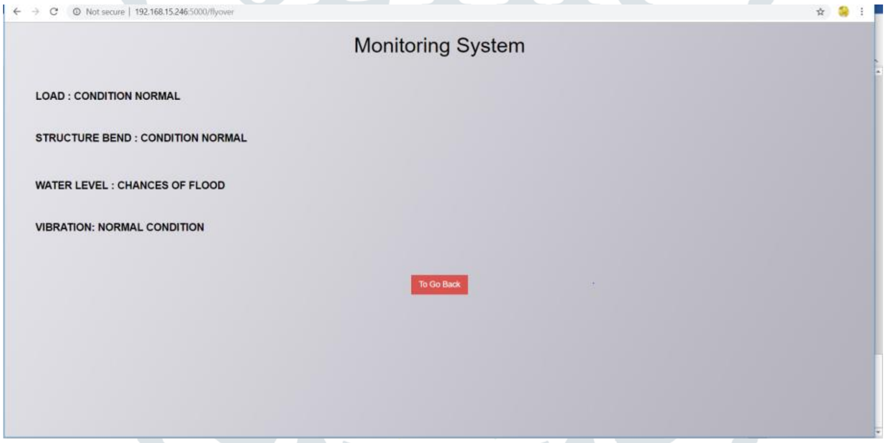

Fig 7: Webpage message display screen.

IV. FUTURE ENHANCEMENTS

Proposed system is a basic approach of bridge monitoring here we speak about data acquisition from one single node, many such sensor nodes can be deployed to monitor more than one structure at a time.

Storage of data plays a vital role in monitoring systems it also serves to be a limitation in the proposed system in order to overcome this change in the sensing subsystem processing subsystem, power subsystem and communication subsystem can be done [3]. Use of Adhoc networks, Cross layer design issues, Multichannel data collection, time synchronization and security issues of network are few areas to be looked upon for future work .

V. CONCLUSION

The proposed system enables continuous monitoring of various structural parameters through the deployed sensors. These parameters serves as a significance of bridge condition or health indicator of the structure. The system monitors the sensor values and judges whether the bridge is safe or not for travelling. This implementation is greatly useful for to provide the safety for human lives.

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