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IOT Based Automatic Crack Analysis for Structures Using Vibrations

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ABSTRACT

This paper presents a mechanism based on IOT-automation that can detect cracks in structures (Living Spaces and Flyovers).The system gathers information from the magnitude of vibrations produced by the structure using vibration sensors which relay information to a database for further data collection, analysis, and future reference. After the gathered data is analyzed, the concerned authorities are notified about the condition of the structure.

Keywords: IOT, Vibration Sensors, Database.

I. INTRODUCTION

The design of a structure is related to the type and amount of load it is meant to carry.

Under static load conditions, natural vibrations of the structure act as a restoring force a to keep the load in place. Under optimal conditions, these vibrations are low in magnitude, but are affected by various natural phenomena and structural defects. Cracks are usually the first visual signs of structural defect. Cracks develop whenever stress in a particular component of the structure exceeds the strength of that component. Since cracks are sometimes not visible on the exterior of the structure,

maintenance fails to record them, leading to a structural failure as the cracks grow undetected in size and number. The development of cracks directly relates to the magnitude of vibration that a building experiences instatic conditions. There is a lack of technology implemented for vibrational analysis to detect cracks in structures. Our system collects the data from these vibrations, and using a predetermined cut-off value based on the type of structure and load it undertakes, a prompt information report will be sent to the maintenance department. Inbuilt buzzers and LEDs will determine the location of the detected vibrational anomaly and subsequently, the location of the crack. Further, our system incorporates the concept of Internet Of Things technology to create a database for all structures making use of this system, allowing for future reference and accessibility of maintenance information.

II. WORKING AND CONSTRUCTION

Analysis of the natural vibration modes of the structure can be used to understand the behavior of the structure.

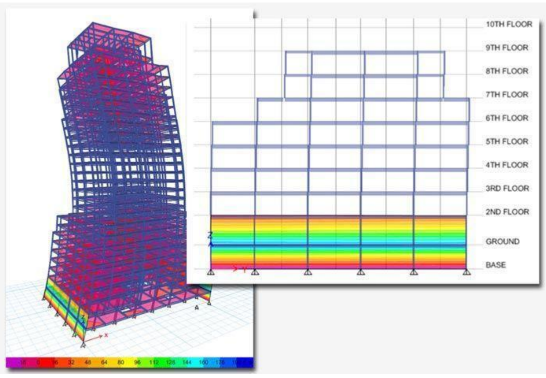

Figure 1. Eigen-Vector modal analysis which finds the natural vibration modes of the structure.

For the prototype our team constructed a miniature bridge of moderate structural strength. Connected Piezo Electric Sensors (a device that uses the piezoelectric effect, to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge.) which were used as vibration sensors for the experiment. Due to the application of a load, the magnitude of vibration in the structure changed, causing a change in pressure. An electric charge was then generated by the sensors, which was in turn relayed to an externally powered Arduino. Using Arduino IDE codes, we converted this signal into analytical data and it provided graphical representation of the recorded vibration. The graph is a representation of voltage generated by the piezo electric sensor v/s time. LEDs and Buzzers were connected to the Setup, which enhanced the effectiveness of maintenance and repair with accurate location of the anomaly. Further, we developed a mobile application which received a signal to send a text message to the concerned authorities when the magnitude of vibration crosses the predetermined threshold value. The message is sent to ensure that the authorities give proper attention proper attention to the condition of the structure.

Figure 2.1. The prototype model, with RC car used as Load.

The bridge was constructed in three phases.

1. 0% deformity was the first phase, representing ideal condition with almost no cracks.

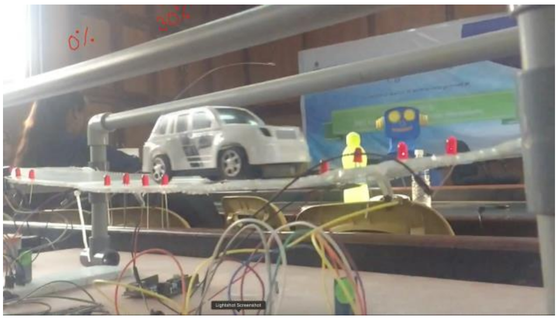

Figure 2.2: Phase 2, with 30% deformity. The presence of cracks is detected with the signal sent by the Piezo Electric Sensor. The Vibration travels to Phase 3(70% deformity) through the body of the structure. At Phase 3 The presence of increased deformity and cracks is detected even before load passes through the section. (As shown in **Figure 2.3)**

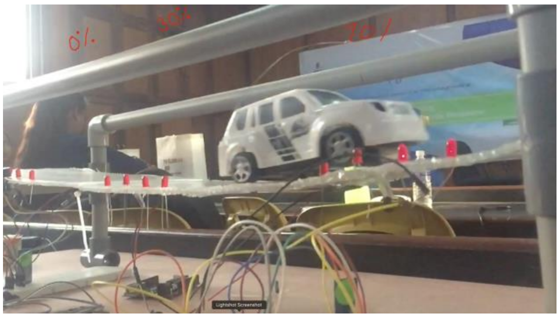

Figure 2.3. Phase 3, with 70% Deformity and cracks. The LED's light up and the Buzzer Signals Location of the vibrational Anomaly.

Once the maintenance crew has access to the aforementioned site, they can connect to the system easily via Bluetooth using the mobile app to receive accurate statistical data with all the generated values.

Components Used:

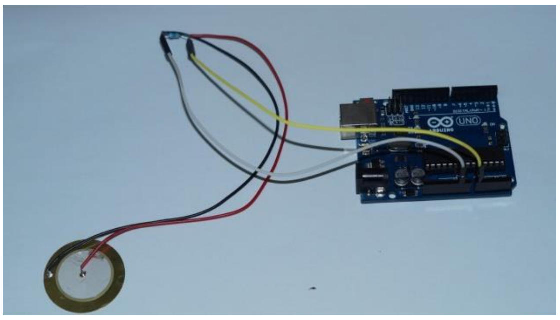

Figure 2.5. The Arduino (Externally Powered) with the Piezo Electric Sensor.

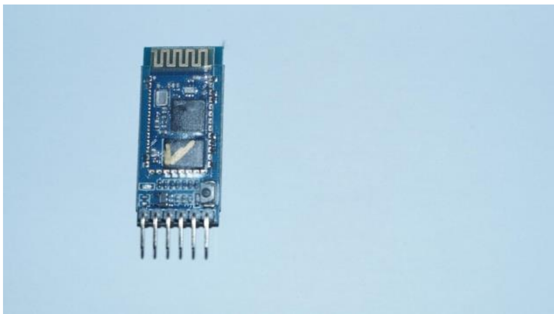

Figure 2.6. The Bluetooth Module

A bread board was used to make all the connections, along with LEDs and Buzzers.

III. RESULTS

The experiment proved successful with expected values at each phase. At peak values a message was sent to one of our phones.

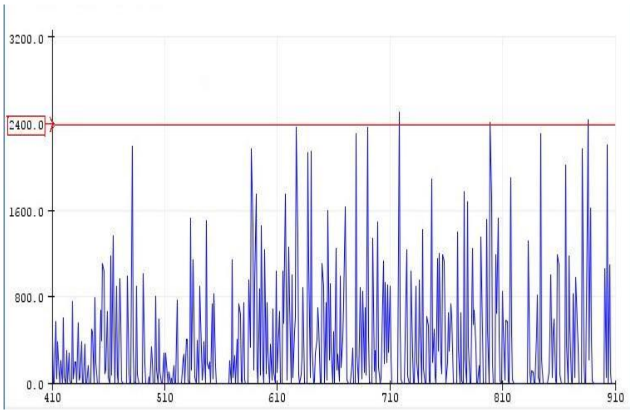

Figure 2.4. The data is presented in a graphical format where the cut-off value is shown in red. At this point, a text message will be sent to authorities regarding the condition of the structure.

Figure 2.5. Text message received after experiment.

Access to all the data was made through simple Bluetooth connection with the app.

IV. CONCLUSION

The design of this system aims to ensure coordinated and timely maintenance of structures with precise data collection and transmission for future reference. The database collected from multiple systems can be accessed and used for cost effective and efficient maintenance and repair of the structures. With further developments this system could be further improved to be self sustaining, wherein the Piezo electric sensors themselves generate the power required to run the Arduinos and the entire setup.

V. ACKNOLEDGEMENT

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