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Efficient and Effective Vibration Monitoring System for Bridge Structure: A Case Study at Railway Over Bridge in Rural Area of Salem District

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Abstract - *The project aims about at developing the health monitoring system for Civil structures which is used to find the behaviour reactions in a continuous manner and also maintains to keep the structures as safety conditions. This system should interact and incorporate the real method of practice based on direct inspections and also combine the reaction of different sensors, installed on the rural area bridge structures. Development of the important parameter mechanism is taken due to frequent movements of the vehicles, as well as the changes in the structure's behaviour and safety. The developed monitoring system is going to be placed in two-way traffic lanes of Omalur railway bridge (SH307) located in rural area of Salem district. By this instrumentation, the vibration response can be predicted. Since the majority of the energy required for the sensor is bared by the developed solar panels and energy harnessed from human motion (piezo electric sensor) through pedestrian way, the system may lead to the era of energy conservation for future generation. The real time process is taking in an interdisciplinary manner with cost effective equipment method and also collected data is to be connected in the IoT clouding process. From the effective monitoring process, to detect the area of strength failures, crack locations, also to check the movement of load transforms in bridge structures. This project is focusing to give alert signal to specific areas of the bridge and higher authorities which can be monitored in control mode before it may collapse. The above monitoring system will pave the paths for Civil structures to enhance their life span in sustainable mode.*

Key Words: Sensors, IoT, Vibration, Warning signal.

1. INTRODUCTION

The bridge is a massive structure used for moving of vehicles and people from one to other places without going underneath, if any presence of water bodies, traffic, railway passages, etc. The bridge is one of the ancient aged concepts used for mankind's purpose which is brought into their needs. After the development of human activity, without technology and also material properties, they started to build the structures against natural calamities. The hard work of satisfaction of successfully crossing an obstruction from any land areas is built by a man with respective different shape and size of bridges, it a primitive of the ancients or modern availability material and equipment is used. The history of the oldest first arch stone bridge is built in Greece above 13th BC. Over the day by day improvements in civil, constructing of bridges take place to a developable area of conditions and society. The design of bridges is varied due to the area and the climatic condition is depended. The bridge is a foremost structure in civil Engineering which invested high cost and its mainly depend on human needs. The structure of the bridge is not much easier to construct than any other structure which means the handling of equipment's and machinery, also preparation of schedule, which mainly involves the area of location deals the various difficulties in working times of bridge construction. Different type of bridges is taking place in various method with the latest technology to improve the stability of the structure and quick installation of required strengthening materials such as post-tensioning wire in the deck to increase the lifetime performance with an easy method of bridge construction.

The part of bridge are placed in three main parts such as foundation (which stands the pier portion with the deep or shallow foundation for the load transfer from deck while moving of vehicles, external loads), substructure (used to holds the upper portions from the span of area is connected from both ends of abutments and it contains caps, bearings, piers, diaphragm, etc.) and superstructure (upper portion of structure which contains roadway with slab deck is resting on the girders from piers).

The few literature studies have been clearly reviewed about the bridge structures and its failure B veronica vaskova et al

[1] investigated the monitoring and failures of footbridges. Similarly, Shinae Jang et al [2] presented a paper about the structural health monitoring for bridge structures using smart sensors. Y. Kawwanob et al [4] proposed a suggestion

of health monitoring for road bridge shoes. Keishi Miyazaki et al [4] investigated the construction of a bridge over river Yamuna at ilahabad/Naini. Kavita Madditot et al [5] studied the Monitoring of Corrosions and Leakages in Gas pipelines and a Safety Technique using LabVIEW. Rudolf Aroch et al [6] investigated Structural Health monitoring of major Danube Bridges in Bratislava. Cristian-ClaudiuComisu et al [7] and AyahoMiyamotoa et al [8] Structural health monitoring system of bridges and A Vehicle-based Health Monitoring System for Short and Medium Span Bridges and Damage Detection Sensitivity. Viral K et al [9] presented Development of Smart Sensing Unit for Vibration Measurement by Embedding Accelerometer with the Arduino Microcontroller. S. Abinaya et al [10] presented a paper about Structural health monitoring using wireless sensor network. T.SR CH Murthy et al [11] and Diptanil Chaudhuri et al [12] investigated Smart Health Monitoring and Warning System Using IoT and Applications of Accelerometer as a Vibration Detector.

Nowadays all constructing structures must be monitoring the behavior of vibration, displacement, crack detections to increase the span of building and also give prediction failure for a clear view to take immediate repair instead of a major failure in the structure. Every constructed structure has their lifetime based on the designs and material used if any failure occurs due to disaster or mankind action which leads instability of the structure before it may collapse before attains its lifetime. In this case, a lot of problems will rise as people life, cost, things, and so on. Thus, an interdisciplinary activity must be included for the structural performance in the manner of a structural health monitoring system.

The structural health monitoring is a continuous process which is used to prevent the safety and maintenance of structure using smart sensors with the real-time-based method. The process of monitoring is one of the most important things which helps to study building performance. The concept of this process is mainly depending on an electronic device such as the part of sensor installation, collection of data in an interface of the data acquisition system, communication process, clouding and modelling system. From the above process, it relates to bridge structure to get the result and enhance the span of a lifetime. There are such parameters available to find the solution, which to detect the frequency range about the speed of vehicles and also find the displacement, vibration, crack failure, wind speed may use to rectified sudden behavior in bridges. An immediate result with proper action takes place the good maintenance in the structures.

2. EXPERIMENTAL SETUP

2.1 Preparation of Cloud setup

Internet of things is the symbolic representation as IoT, which is widely used for controlling the system through networking-based connection (internet). This is an advanced technique to operate the Wifi connected device from anywhere of world using internet connection. A specific electronic controller collects the data from sensors which can monitor using software or applications through storage capacity in network clouding method. This is the possible only way of using software and hardware by which is working under the process of coding programs to connect both software and hardware. Clouding data interlinks from the programs which are coded to the hardware devices.

One of the clouding IoT platform sources is ThingSpeak, it is free to open clouding services. It runs as some procedure to follow and then able to collect the data from the device. It can be stored data in graphical values as well as digital values with respect to time. Here, the project is to be compared from the standard process (LabVIEW and MyRio embedded device), which is an expensive and special power required as much comparing the cheap and less amount of power consumption for Arduino broad and its related codes. By the LabVIEW coding here the sensor data has been sent to IoT platform of Thingspeak. So that the data can be taken anywhere with mobile applications which gives immediate alerts to the specific monitoring of rural bridges

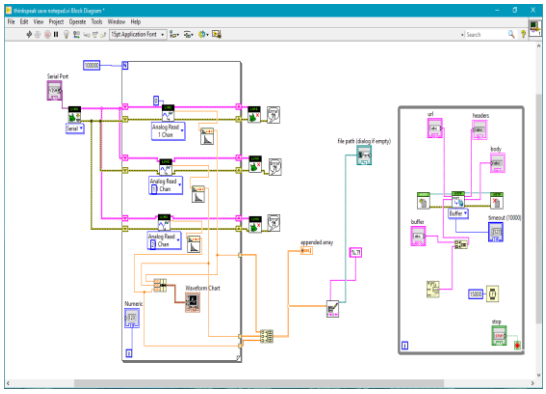

Fig -1: LabVIEW coding for cloud setup

2.2 Materials and circuit connection

i) The ADXL335 is a 3-axis sensing of accelerometer represent to X-axis, Y-axis, Z-axis which can detect the frequency with amplitude and time. This is cheap with thin sensor (4 mm × 4 mm × 1.45 mm) square shape dimension, takes up to low power of 350 μA (range of 3.3v to 5v). It can measure both the static and dynamic acceleration in the behavior of shocking, motion or vibration.

The Arduino Nano is a small, compact microcontroller which is used for interfacing software coding to activate the sensor and also to get collect data from the sensor to directly notice in the serial monitor of software. It requires up to 5v which is easy to access and effective in cost.

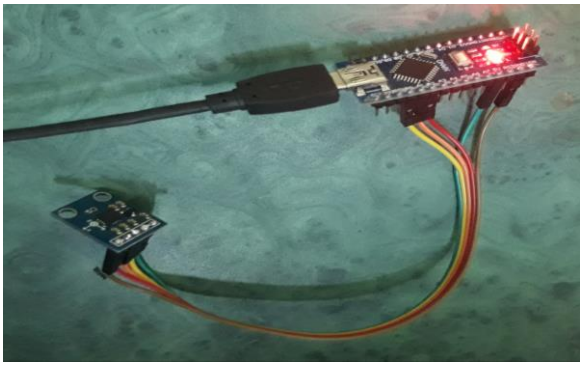

Fig -2.1: Circuit setup of Arduino Nano & ADXL 335

ii) MyRio is a real-time embedded evaluation board made by National Instrument. It requires LabVIEW software. It has dual-core ARM® Cortex™-A9 real-time processing and Xilinx FPGA customizable I/O (10 AI, 6 AO, 40 DIO) support for wireless programmable. Also, it has an on-board tri-axial accelerometer, onboard LED, onboard user control switch & USB interface used for camera/storage. The power consumption is from 6v to 16v maximum.

Fig -2.2: Circuit setup of MyRio-1900 & ADXL 335

3. STUDY OF VEHICLE SURVEY IN BRIDGE

This project area of the rural bridge has two lane roads. The passing of vehicles is taken during respective 7 peak hours. The total traffic recorded during the survey period (7hours) is 7719 vehicles excluding two wheelers.

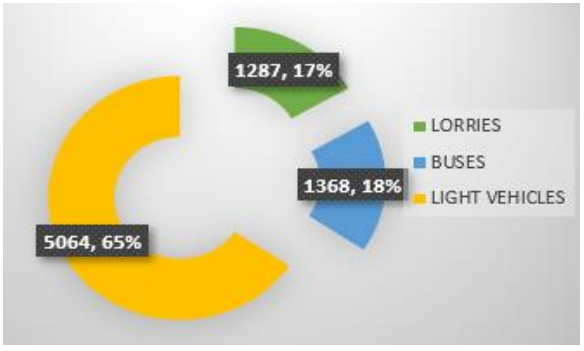

Fig 3: Survey of vehicles taken on study site

4. DETAILS OF BRIDGE

The rural area of Omalur railway bridge (SH307) has been constructed in 24.04.2007 by the Tamilnadu Government of Highway Department and Southern highway. It facilitates rapid flow of two-way traffic lanes and also nearly 1500 people living around the area of the bridge. The length is about 67 feet each span of bridge with carries 20 piers. This bridge is connecting wide areas including Dharmapuri, Sankari, Mettur, Erode. Before construction of this bridge, to cover the above areas about extra 4km to reach by another route of Omalur village road. Under the bridge, three tracked rails are used passing the trains in terms of which 10 cargo train carries thermal, coal, government goods, steels at the speed of 100 to 120 km/hr. And also passing 15 express trains at the speed 80 to 100 km/hr for daily routine.

The dimensions and structures of the bridge are shown in figure which is located in Omalur taluk, Salem district.

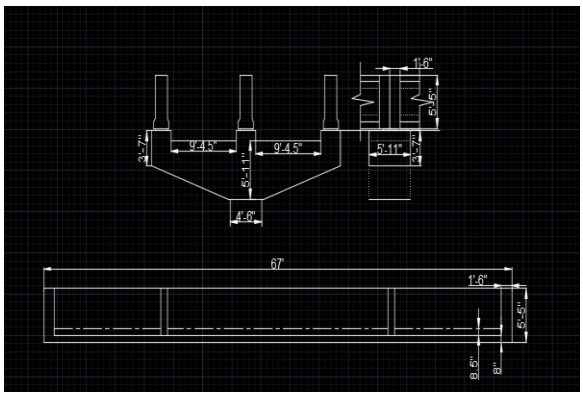

Fig -4.1: Dimensions of bridge

Fig -4.2: Structure of bridge under the railway track

5. TESTING PROCEDURE

The testing is done simultaneously in both data acquisition system and Arduino Nano using LabVIEW code. As per the above said materials and circuit connections the setup has been made and the result is taken as an output value for comparison simply by disturbing the setup. The process

after successful testing has been used for real time monitoring.

Fig -5: Monitoring setup

6. RESULT AND DISCUSSIONS

The MyRio-1900 is completely been circuited with ADXL-335 sensor and at the mean time the Arduino Nano is also been with ADXL-335 sensor circuited for identifying the exact output data.

The resultant graph represents the value of amplitude with respect to the time taken. For comparing the standard device (MyRio-1900) with cheap available Nano micro controller with code modification in LabVIEW is used to get the same value. The below graph shows that MyRio and Arduino Nano has been giving the same data with minor changes in value. The comparison value by graph has been shown below to verify that both are equal.

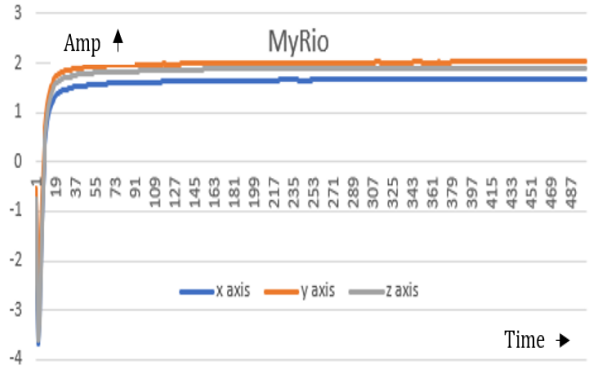

Fig -6.1: Frequency response using MyRio

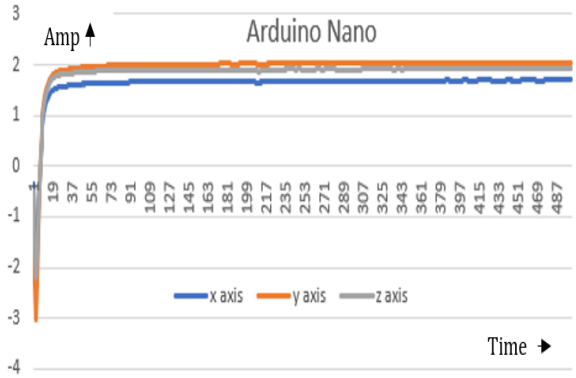

Fig -6.2: Frequency response using Nano controller

7. CONCLUSIONS

Plan to implement selected sensors for monitoring rural bridge, get results from LabVIEW

- To generate results from LabVIEW details about the bridge (e.g., natural frequency, amplitudes, accelerations and vibration modes).
- Consumption of energy generated by using solar panels.
- Create alert signals when damages happen in rural bridge.
- To pass the information to residents, users about condition of the bridge.

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