Survey on Automatic Bridge Monitoring System

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***Abstract*- The Survey addresses during heavy rainfall the overflow of river and flood occurs, there may be possibility of huge damage of roads and bridges. The travelling and transportation will be affected. In paper we are highlighting some of the papers related to the title viz., their technologies, basic block diagram, tools used, sensors used, advantages and disadvantages etc.…**

Keywords: **Water level Sensor, Arduino Nano, Wi-Fi Module, Vibration Sensor, LCD display.**

1.INTRODUCTION

Bridges are our everyday means of traveling for everyone. These bridges are present in various surrounding conditions which can be extreme as well as some slow harm causing factors. The extreme conditions causing harm or degrading the bridges condition can be flooding of water waves, scorching heat, earthquake frequencies, etc. Similarly, the low harm causing factors can be highly loaded vehicles passing more often on through the bridge, Surplus usage of bridge, ignorance of timely maintenance of bridge, etc. We can see that some bridges in our surrounding are old and safe to use conditions, while there are also some bridges which are newly built but still unsafe due to some ignored factors. This is because the health of any bridge depends on the elements and conditions considered while constructing this bridge. Every bridge has some places where a human inspector can't reach because these places are out of human reach. There needs a monitoring system which can keep an eye or track of the health at such places of bridge. IoT system for bridge health monitoring can be a way through which the bridges can be looked after without any human intervention. An IoT system consisting of various hardware and software components along with some cloud storage system can be used over the bridge surface for this problem. The module built can be used to collect various kinds of data regarding the structure (in this case 'bridge'). This collected data can be analyzed and if at all the system catch holds of any anomalies, then the concerned authorities would receive the alert notification. This kind of system would reduce many human errors caused during inspection of bridges. An early stage of damage may reduce its maintenance cost and time to be spent on it. The notification sent by the system can result in taking necessary actions towards safety measures. The system would be used for monitoring the bridges remotely without any human interference. The real-time data collected by the system would result in early and effective outcomes or avoiding future harm to many lives.

2.SURVEY CARRIED OUT

Paper [1] deals with Arduino Nano ref. fig.1., which controls the interface between the different components of the system i.e. sensors, motor driver, LCD Display, Wi-Fi Modem. The power supply is given to Arduino Board which is smaller in size and has a microcontroller. The board is connected to the Opto- Coupler, LCD Display, LAN interface and Motor Driver. Here we have used LCD 16x2. The opto-coupler is connected to the sensors i.e. water level sensor, angle sensor, crack detection sensor, vibration sensor to have interfacing between two or more devices. The function of opto- coupler is to prevent high voltages from affecting the system receiving the signal. Here for angle sensor we are using accelerometer and for crack detection we are using wire mesh. Thus, when the sensors sense some harm or detect values above the threshold value, it sends signals to the Arduino Board through opto-coupler. The program installed in the Arduino will start to execute and according to the flow of the program it will send the signals to the respective components. Arduino Board sends warning signal to the motor driver. The motor driver has been attached to a boom barrier which blocks the vehicles from moving ahead to prevent accidents from happening. All sensors get the real time value and send it to the server and android through the Wi-Fi modem to the cloud. The analyst is already logged in to the android device and analyse the data that was sent to the control room by the system. It sends the data to the user. User can see the data who has been already registered in the database and can see this data. This data will help the user to see the details of the bridge. These data can be helpful to avoid accident from happening and all that data will be display on the LCD so that the coming vehicles could see the information from not so far distance and inform the other passage vehicles.

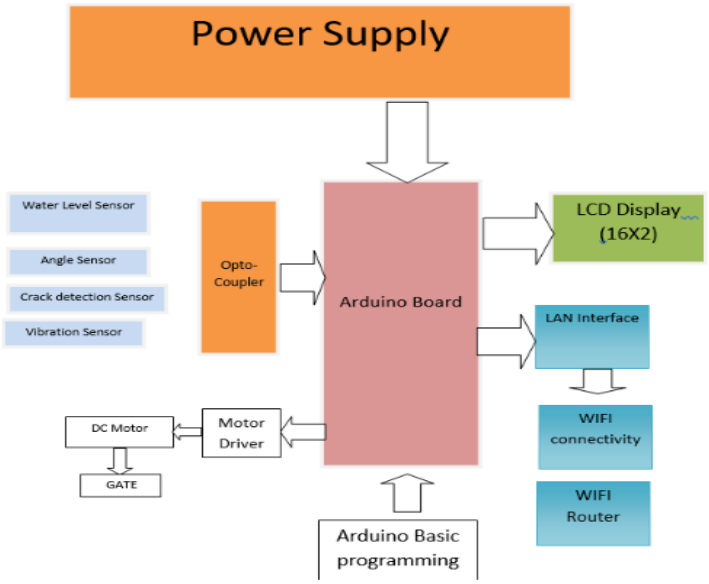

Figure 1: Arduino Board with components connected

In [2], Now a days, natural disaster is happening mostly in all over the world. This is because of change in natural conditions. These types of disasters will destroy the many structure like bridges and this will damage the life. Hence to always monitor the conditions on bridge we use the system called bridge monitoring system. Bridge monitoring system will help to know the current natural conditions on bridge like wind speed, temperature, weight etc. and inform us. According to the readings of different sensors the system will compare the obtained values with critical values and will alert the people before any disaster

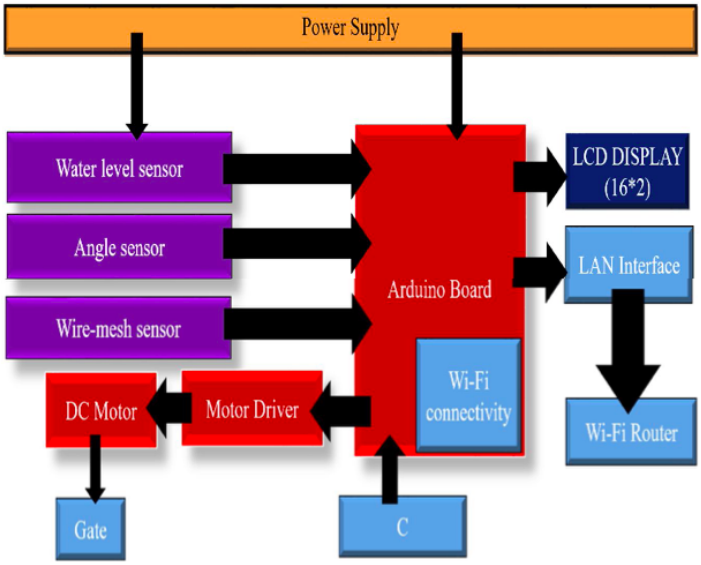

Figure 2: Working Model Block Diagram [2]

The public or government can use this bridge monitoring system for bridge monitoring which will provide bridge condition as well as safety to public. In this system we are going to design login interface using which user can login to system. If user fails to login then emergency option is provided by our system. Arduino is to be connected with sensors using TCP/IP protocol and by using Wi-Fi module it will send real time monitor data to cloud server as well as to system server for backup purpose, in case of failure of cloud server . The above block diagram(Figure 2) shows the working of their project. Firstly, the sensors take inputs from environment and surrounding in the form of float values. Then these inputs are given to Arduino Nano to perform operations of comparation with respect to the values that are set as maximum values. The Wi-Fi module helps the Arduino by providing Wi-Fi connection. Then after comparison the values are passed on to the cloud services so that these values will be stored to the cloud storage. And if these values are more than maximum values ,then the output in the form of binary digits i.e. (1=yes and 0=no) are sent to motor driver module which allows the motor to close the gate ,in an emergency case. Side by side Power supply is connected to all these components. These float values are displayed on the Led screen as a message for public .A LED is connected to power supply to indicate that a power supply is still working.

In Paper [3] , an loT based Bridge Safety Monitoring System is developed using the wireless technology. This system is composed of monitoring devices installed in the bridge environment including the communication devices connecting the bridge monitoring devices and the cloud-based server, and a cloud-based server that calculates and analyzes data transmitted from the monitoring devices. This system can monitor and analyze the conditions of a bridge and its environment, including the water level force levels nearby, vibration and other safety conditions. The detected data are transmitted to the server and database for users to have real-time monitoring of the bridge conditions with the help of mobile telecommunication devices. Many bridges in cites are at the river bank which are mostly not in good conditions as they had been constructed long years ago which need to maintained on regular basis. Due to heavy load of vehicles, high water flow, heavy rains these bridges may get collapse which in turn leads to disaster. So, these bridges require continuous monitoring. So, this paper proposes a system which consists of a weight sensor, vibration sensor, water force sensor, Wi-Fi module, and ARM microcontroller This system detects the load of vehicles and if the value rises above threshold, it generates an alarm, then the concerned authority can assign the task to the employees for maintenance

Arduino Uno consists of 14 digital inputs/output pins, each of which provide or take up 40mA current. Some of them have special functions like pins 0 and 1, which act as Rx and Tx respectively, for serial communication, pins 2 and 3- which are external interrupts, pins 3,5,6,9,11 which provides PWM output and pin 13 where LED is connected. The light rays passing through the LCD would be rotated by the polarizer. which would result in activating/highlighting the desired characters. The power supply should be of +5v, with maximum allowable transients of 10mv. To achieve a better/suitable contrast for the display the voltage at pin 3 should be adjusted properly. The ground terminal of the power supply must be isolated properly so that voltage is induced in it. The module should be isolated properly so that stray voltages are not induced, which could cause a flicking display. A servo consists of a Motor (DC or AC), a potentiometer, gear assembly and a controlling circuit. First, we use gear assembly to reduce RPM and to increase torque of motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output.

Now an electrical signal is given to another input terminal of the error detector amplifier. Now difference between these two signals, one comes from potentiometer and another comes from other source, will be processed in feedback mechanism and output will be provided in term of error signal. This error signal acts as the input for motor and motor starts rotating. Now motor shaft is connected with potentiometer and as motor rotates so the potentiometer and it will generate a signal. After sometime the position of potentiometer reaches at a position that the output of potentiometer is same as external signal provided. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer, and in this situation motor stops rotating.

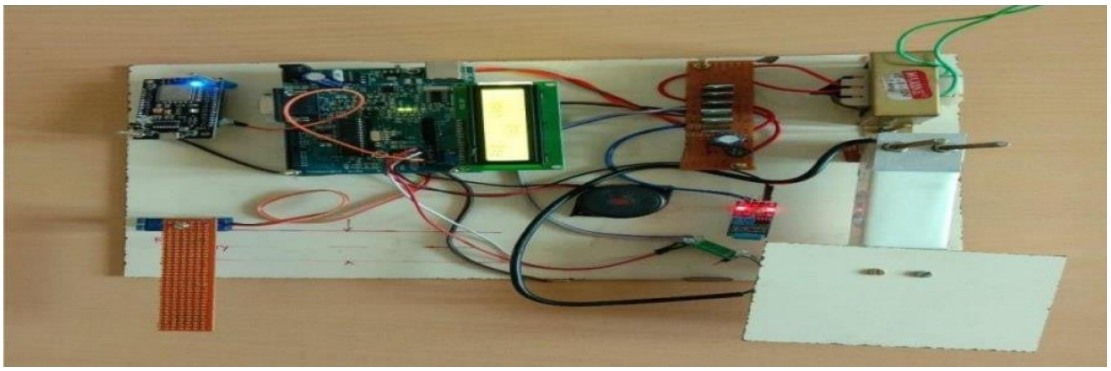

Figure 3: Log and WSN Technology [3]

In this Paper the system ref. Fig. 3 is developed by log and WSN technologies. In the proposed system, the hardware module consist of a weight sensor, vibration sensor, water force sensor, Wi-Fi module, and ARM microcontroller. This system detects the load of vehicles and if the value rises above threshold, it generates an alarm. If the value rises above the particular value, it sends the notification message and the values are displayed in the LCD display. Then the barrier gate is used to close the entry way if anything happens in the bridge for that we used the DC Motor to close the gate.

[4] As Maharashtra faced recent devastating flood in Kolhapur, Sangli and Satara there arise a need of efficient flood monitoring systems. Flood are the most damaging natural disaster , on the occasion of heavy flood ,it can destroy the community and killed many peoples. . The government would spend billions of to recover the affected area . It is important to develop a flood control systems a mechanism to reduce the flood risk .Providing a quick feedback on the occurrence of the flood is necessary for alerting resident. Flood forecasting and the issuing of flood warnings are effective ways to reduce damage. The proposed system will be good because it has better coordination of monitoring and transmission technologies which are adaptable to flood conditions. This system would be beneficial to the community for decision making and evacuation planning.

The proposed system of paper [4] ref. Fig. 4 was implemented using Raspberry pi. The Raspberry Pi receives Information from connected input sensors, processes the data . Raspberry pi will send the values measured by sensors to cloud.

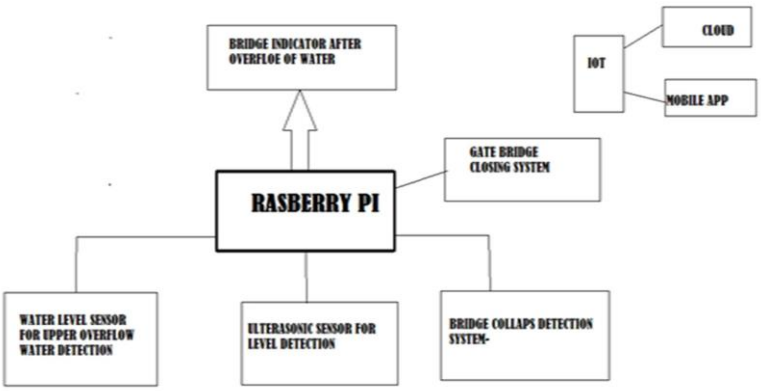

Figure 4: Proposed Model [4]

Flood happen everywhere in the world, they can be completely disturbing the peoples and the economy of the country. The system is much advantaged for protecting lives of humans and animals. The proposed model is utilized for monitoring of the water level, flow in rivers and the same can be used for measuring level at dam or on river bridges. The measured value are regularly updated on cloud which is very much useful to send flood alerts to consist authority and people for faster action. The project mainly constitutes a wireless sensor to monitor water condition. The parameters measured using sensors are processed using raspberry pi. This information transferred from corresponding node to alerting system. Cloud (API) is used as a data logger The alert management system can be used to observe, record and send a message to the people before disaster knockouts.

Android application in system, minimize the impact natural phenomenon can leave. That is why creating a android application specifically to monitor flood condition can greatly help those who are travelling or on who's their way to somewhere. Notify peoples about the condition of the roads ahead of time will lessen the hassle of their travel, and it will decrease accidents caused due to floods.

[5] Monitoring the bridge is very important as a poor bridge may lead to many accidents. Therefore, it needs a system to monitor the strength or stability of the bridge to avoid any failures. Cracks may occur due to accidents or overload in the bridges which will be identified by the mems sensor. The bridge monitoring system is significant for monitoring bridges or flyovers. The aim is to develop an IOT based bridge monitoring system that will automatically detect the cracks and checks if there is an increase in vibration. Different sensors are used for monitoring. It also monitors the light in the bridge which is very important especially during nighttime. It also checks if the heat of cables in bridges increases which may cause fire and also checks the fire.

According to the ref. [5], they used a mems sensor to detect cracks. Mems sensor works by measuring the angle, so even if a small crack occurs there will be a change in angle. Even if there is a slight change in the angle it will indicate us the next second which will be quicker and better. The vibration sensor senses any vibration in the bridge. Normally all kinds of accidents cause some vibration. So, vibration sensor monitors the occurrence of vibration. LDR sensor is used to monitor the bridge lights. Here temperature sensor is also used to monitor the heat in the bridge, as an increase in heat of cables in the bridge can lead to fire accidents, and a fire sensor is used to detect fire, ref. fig.5.

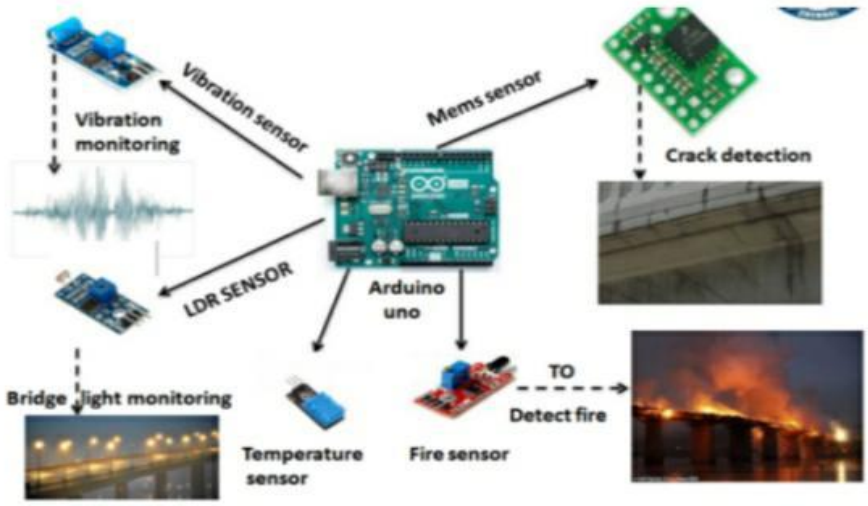

Figure 5: Arduino UNO with mems, LDR, temp, fire and vibration sensors

Is bridge really important? what happens if there is the absence of a bridge in a heavy traffic area? Yes, there is a need for the bridge without which there will be severe consequences. Bridge is very important as poor bridge leads to many accidents. Therefore, it needs a system (ref. fig.5) to monitor the health of bridge which is being one of the diagnostic tools that prevents the causes from progression and avoid any failure. It identifies the crack that occurs due to accidents or overload in the bridge. It is significant for monitoring bridges and flyovers and it automatically detects the cracks and if checks and if any increase in vibration. It also monitors the light in the bridge especially during nighttime and checks if the heat of cable in the bridges increases if may cause fire and also checks the fire.

According to [6] the occurrence of bridge collapse in India has become a normal news that someone comes across. The bridges are inspected mostly visually and these inspections are carried out once or twice a year. The real time condition of the bridge is unknown and sudden changes may happen due to environmental conditions or many other reasons which result in the changes in current condition of the bridge. The bridge monitoring system with the help of Internet of Things (IoT) sensors could provide the real time condition of the bridge. Fig. 6 is capable of providing real time monitoring of the features of the bridge which contribute in safety of people and transport. This system output will be helpful for maintenance authorities to make decisions regarding maintenance and repairing budgets.

The Internet of Things is the technology used for evaluating the real time condition of the bridge. Fig.6 consists of sensors like vibration sensor, water level as sensing devices. The sensors will detect the vibration and water level. Android application using Android Studio for users to access condition of bridge.

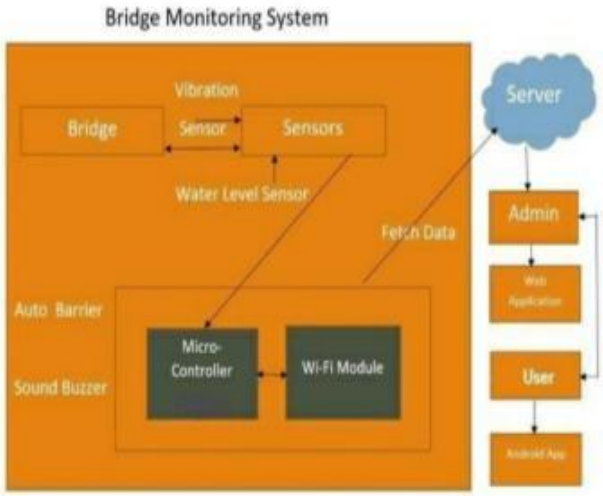

Figure 6: Bridge Monitoring System

Bridges often suffer structural damage due to aging and lack of proper maintenance also because of various external factors that affect the bridges. The bridges in rural areas have probably more risk for water flooding on it as the bridges are of less height and hence near to the flow of water. Similarly, the bridges in urban areas tend to have risks related to the traffic that is load on the bridge or cracks on the bridge. The most common objective of the proposed system is to obtain the real time feedback and to obtain the real time condition of the bridge.

The Internet of Things i.e. IoT is the trending technology which have explosive growth of devices connected and controlled by the internet through mobile application or web application. This results in improved efficiency, economic benefits, and reduced human exertions. IoT is a system of interrelated computing devices, which can transfer data over internet without requirement of human to human or human to computer interaction.

Traditional embedded systems, sensors, real time analytics, automation all contribute to enable Internet of Things into the consumer market. This proposed system application would give and retrieve data within short amount of time thus making it real-time application. Alerts will be provided to the officials and a buzzer for indicating a calamity. If status of any parameter is beyond the specified limit, then it will generate the alarm. Bridge condition can be monitored by the users as well through the android application. The data is collected from sensors, processed by controller & data is transferred over wireless modules using any of the routing protocol. The system basically focuses on vibration detection and water level detection. The system collects the sensors data from a bridge and evaluates the bridge health status using a logic-based system.

In [7], Bridge safety monitoring system using IoT is developed using the Wireless technology. With the help of advancements in sensor technology have brought the automated real-time bridge health monitoring system. This system will help prevention in disaster management and recovery. IoT-based bridge safety monitoring system is developed using the Wireless Technology. By the use of wireless sensor nodes, various types of data can be collected like vibration, water level and Bridge weight. These data would also be useful for monitoring and surveillance. The main moto of this paper is to develop a system that can prevent accidents or structural disasters of flyovers and bridges. This study gives the survey of various techniques used to monitor the conditions of the

bridges and proposed a system for monitoring continuous structures and an ultrasonic sensor for monitoring the water level in the river to avoid traffic from a bridge in flood conditions using Kalman's Filter algorithm. In case of emergency situations, the gates of the Bridge will be automatically closed. The obtained data are transmitted to the server and database for admins to have real-time monitoring of the bridge conditions via mobile telecommunication device.

The Monitoring devices ref. fig.7., like water level vibration sensor and weight sensor are continuously monitoring the structural health of bridge. If water level is increased or weight is too high and if bridge is being vibrated then barriers with servomotor will close and at the same time, status of bridge condition is directed to the monitoring Centre.

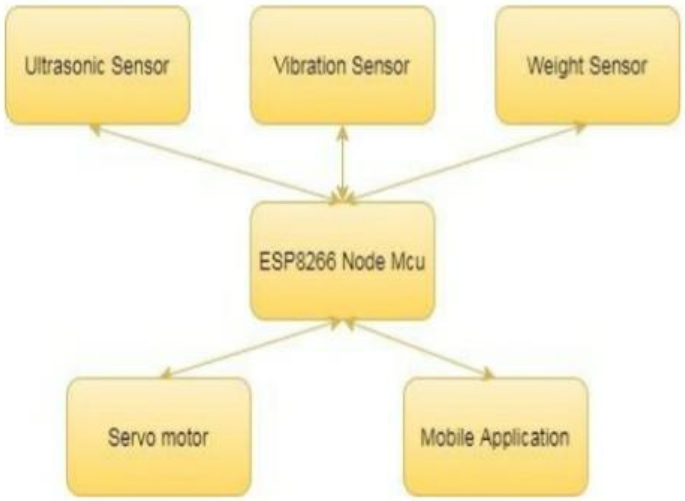

Figure 7: Monitoring Devices with Node MCU

It has a technology called MBM (Monitoring Based Maintenance) that enables maintenance engineers to monitor the condition of the bridge in real time. The components that which are used to detect the strain, acceleration, cracks etc. The System includes the desktop application which is useful for the engineers working in the bridge department to monitor the current position of bridge. There are three important chunks in the system i.e. Vibration Sensor, weight sensor and River water level sensor, which sends the details of bridge strength to the Management Center. All the collected environmental data sent to the server system.
So that as per situation Management Center takes immediate action for bridge safety and security. For example if water level increases beyond the default settled water level then system alerts the management center and barriers of bridge will automatically close by management center.

Now a day it is very essential to monitor, the bridges in our country or state as there were incidences happen earlier. The reason behind these incidents as there is no such type of system, which will give information to the peoples if the bridge is not in good condition when sudden situations may occur like flood, earthquake. It means that the bridge is not in safe condition. When this kind of situation arises, bridge may be collapse, which causes much kind of losses like accidents, human deaths, etc. This happens because there is no efficient system in existence, which will provide notification about conditions about current condition of bridge when bridge is not in safe mode.

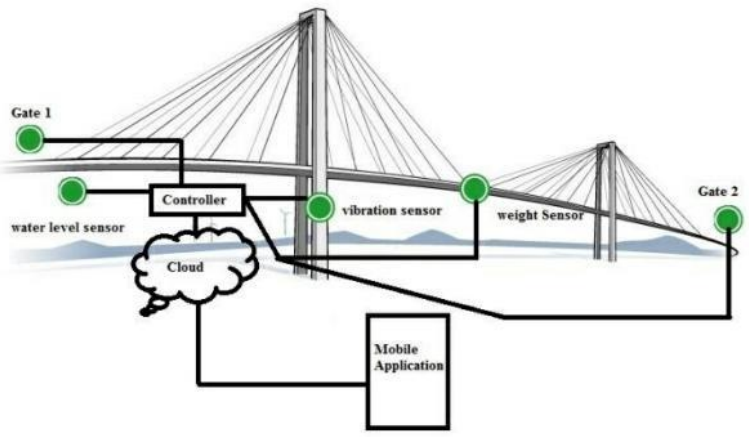

Figure 8: **System Setup**

In the existing systems, Zig-Bee technology was used which is cost consuming and quite time consuming, but this system used the TCP/IP protocol which is suited for all types of bridges. Bridge health condition monitoring in real time is very popular issue. The sensor technology is continuously and condition monitoring has never been accurate and easier before. With the help of wireless technology and water level sensor, smart system is developing for securing bridges. Fig. 8., checks the water level and the position of bridge for safety purpose. In the emergency conditions like earthquake, flood, etc. the facility of broadcasting the message is added. This System is unique in its ability to monitor the bridge environment, it transmits environmental data through wireless communication and sends alerts to the bridge management staff i.e. Monitoring Centre in real time for prompt action also to user's.

In [8] the Bridge Health Monitoring using IoT now-a-days due to incidents of bridges or change in deflection of the bridge structure, or bridge piers severely damaged by moisture, or by excess variation in vibration are frequently reported annually. Different disasters and damaged sites require different professional disaster rescue knowledge and equipment so as to realize optimal rescue results. However, lack of data about the damage site can impede information management at the rescue center and operation, leading to poor rescue efficiency or maybe preventable causalities. Generally, to perform SHM, firstly, data must be collected using sensors. The different types of sensors Fig. 9., are often used by SHM to generate the signals traveling through solid configurations. Later, this data is collected from the sensors and must be analyzed by applying different signal processing techniques, because a minor variation within the system is triggered by various factors like noises, temperature changes, environmental effects, might cause significant changes within the response from the sensors, concealing the potential signal changes due to structural defects.

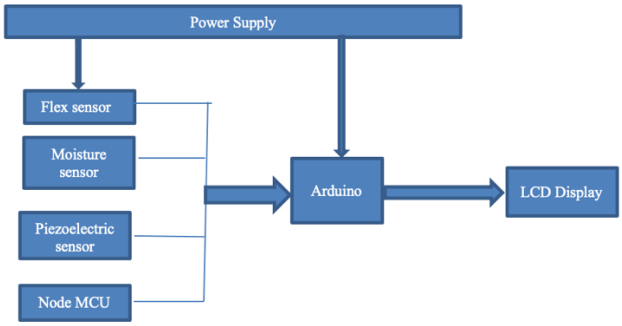

Figure 9: **SHM**

[9] In Development of a Bridge Management System the rapid development of the economy and the advancement of urbanization, China's bridge construction has reached its crescendo ref. fig. 10. Bridges play an important role in the transportation system by supporting economic and social development and are therefore regarded as one of the most important and indispensable infrastructures. According to the statistics, there are currently more than 800,000 road bridges in China, ranking first in the world , which gives severe pressure to their maintenance. However, at the present stage in China, people still mainly focus on construction but not maintenance. During the long-time operation of the bridges, bridge structures suffer different levels of damages caused by loads and environmental effects, which then reduces the structures' reliability and shortens their expected service life-time. For example, severe rust and breakage of the boom can result in bridge collapse, such as the destruction of the Yi Bin south gate bridge in China. There are also many similar cases of bridge defect or even destruction accidents, and the main cause is the lack of maintenance.

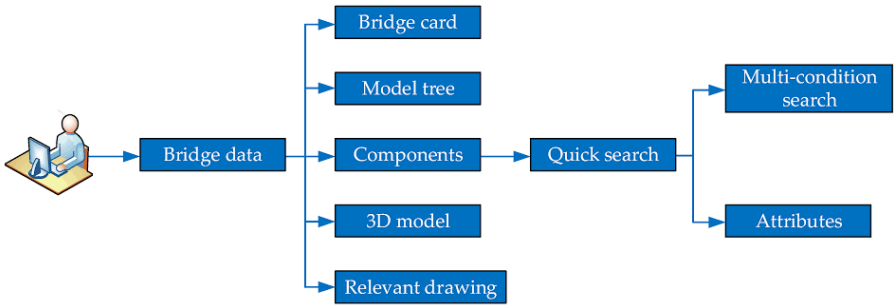

Figure 10: Bridge-Urbanization

With the development of the Chinese transportation industry, the number of bridges has increased significantly, but this results in high pressure of structural maintenance and management. Bridge management system (BMS) is critical for efficient maintenance and ensured safety of bridge structures during long-term operation. Building information modelling (BIM) is an emerging technology with powerful visualization and informatization capability, making it an ideal tool for developing modern management systems. This paper introduces the development of a bridge management system based on the BIM technology.
The BIM-based system mainly includes four parts: data collection system, data center, model layer, and evaluation system. The framework of the system is shown in Figure 11, which displays the connections and the relationship between the different modules

of the system. The data center plays a significant role in the system, which consists of four layers: cloud resource layer, access layer, storage layer, and application layer. The cloud resource layer provides computing services by renting existing mature cloud computing resources for implementing various functions of the data center. The access layer provides a unified interface for the import of different types of data. The storage layer provides centralized storage of all bridge management-related data. The application layer includes the implementation of various user-oriented functions such as data query, data management, and database management tools. The data center obtains static and dynamic data of bridges from scattered data resources through the data acquisition system of bridge maintenance. The dynamic data collection system includes two parts: the front-end collection program and the background management program. The front-end collection program is mainly the mobile APP software, which is responsible for real-time collection, input of maintenance data, and uploading information to the background management program. During the process, the background management program is responsible for managing the collected data and generating reports.
The bridge automatic analysis and evaluation system relies on the data center to obtain various types of data required for bridge condition assessment, bridge data statistics, and in-depth analysis. Through the calculation and the analysis of relevant models and algorithms, output evaluation, statistics, and analysis results are obtained and submitted to the data center. Also, the evaluation results would be presented in the bridge model. The model layer is one of the important distinguishing points of the BIM-based bridge maintenance management system compared with the traditional systems. Because the system is based on the three-dimensional model for operations, it can make many maintenance services more intuitive and vivid. Considering that the size of the model is huge and takes up too much memory, the model is then transformed into a lightweight model to better display in the portable terminals. The model layer correlates the information such as inspection, evaluation, and maintenance reinforcement in the database with the component of the bridge, thus different information can be displayed through the model. Therefore, the model layer part effectively connects the data layer part and the functional layer part together and plays a central role in the whole system framework.

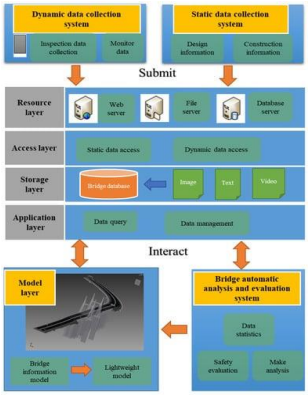

Figure 11: Framework

In [10], the objective of the system ref. Fig. 12 is to continuously monitor the bridges, sense the environment and send the data to web application through the server, generate the alert with the help of buzzer and auto-barrier if load of vehicles and level of water in river crosses its threshold value. The sensors and the LCD are interfaced with the Arduino UNO. The sensors used are Flex and Water level. The Flex sensor measures the angle of tilt of the bridge as well as cracks. The value is set so that if there is any sort of tilt or little crack and if it crosses our set value then the crack is detected. The water level sensor will be placed below the bridge and within the gaps. When the water touches the sensor, it will give alertness to the Arduino UNO. Then the alarm will beep. An LCD is kept so that if there is any danger and if the system finds the fault, then the LCD will display “DANGER”. Servo motors are also there to closed the roads so that no vehicle reach the bridge. It is placed before the bridge. A buzzer is also used to spread alertness when the danger is detected. The wi-fi modem is used to send the data to the server. In this research work used “THINGSPEAK” where we can see the reading of the sensors.

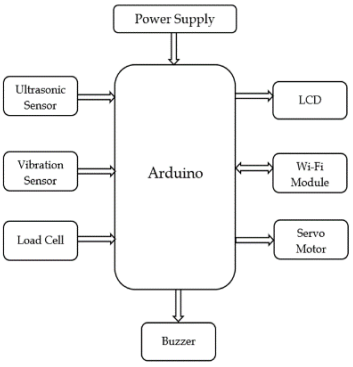

Figure 12: WIFI Module with Arduino UNO

3.CONCLUSION:

We have gone through several papers on bridge monitoring system. By doing so we got to know more knowledge about Bridge. Our aim is to implement "Automatic Bridge Monitoring System" by considering almost all parameters with respect to Bridge in further coming academics. This paper may help for researchers who are working on the same problem.

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