BUILDING COLLAPSE ALERT SYSTEM USING IOT

A PROJECT REPORT

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ABSTRACT

Nowadays, "Structural Health Monitoring" (SHM) is developing into an essential study topic to improve human safety and lower maintenance costs of structurally complex structures as a result of the development of modern technologies in the civil engineering area. This entails the process of discovering and detecting interior cracks and damages in the infrastructures well in advance so that a preventive cure can be applied before it crumbles as a result of ageing, a natural disaster, or any other cause that was caused by humans. However, the bulk of SHM systems now in use have trouble functioning in a real-time context due to their lack of portability and resilience. Also, the technology for remote and continual monitoring is still not fully integrated. As a result, we have proposed a portable and reliable Internet of Things-based SHM solution (IoT). A concrete beam, a metal structure, a slab, a bridge joint, gusset plates, a beam-column joint, etc. can all be used to mount our suggested device. It can also use a Wi-Fi module to send raw data to cloud storage for upcoming research and analysis. Flex sensors are used by this device to track even the smallest bending from the surface to which it is attached.

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LIST OF ABBREVIATION

BCAS	Building Collapse Alert System
DMP	Digital Motion Processor
IDE	Integrated Development Environment
INMIC	International Multitopic Conference
IOT	Internet Of Things
IP	Internet Protocol
I2C	Inter-Integrated Circuit
LED	Light Emitting Diode
MEMS	Micro Electro Mechanical Systems
MIT	Massachusetts Institute of Technology
MPU	Microprocessor Unit
SHM	Structural Health Monitoring
TCP	Transmission Control Protocol
WSN	Wireless Sensor Networks

CHAPTER 1
INTRODUCTION

1.1 OBJECTIVES

The main objectives of Building collapse alert system using IOT include

- To build a structural health monitoring of buildings, in order to avoid the building collapsation and identify the building health conditions.
- To remotely control the structural health monitoring system based on non destructive testing.
- Detecting the building collision at an early stage only and altering the building based on the structure.

1.2 OVERVIEW OF BUILDING COLLAPSE ALERT SYSTEM

The core idea of BCAS is the process of establishing a damage detection for engineering structures such as buildings, bridges etc. It enables us to know the current condition of the structure. Significant building collapses of this nature occur not only in India but also all over the world, particularly in developing nations.

A bridge's collapse is typically unpredictably unpredictable, but when it does, it frequently causes numerous injuries and fatalities. Bridge disasters can cause property damage worth billions of dollars in addition to a in addition to a number of fatalities and serious injuries. Between 1980 and 2012, there were approximately 1254 bridge failures worldwide, each affecting a different region. 907 of the 1062 destroyed bridges in the United States were caused by structural failures brought on by poor materials. According to reports, the walkways collapsed as a result of poor design.

We have developed a system that provides a dependable method of monitoring metal beams, gusset plates, concrete joints, beam-column connections, concrete joints, and bridge joints in order to identify problematic structures and notify the public for a safe evacuation. A bridge joint, a slab joint, a frame joint, a metal structure joint, etc. can all be examined with our portable "Structure Analyzer" device.

The gadget utilizes worked in Bluetooth LE capacities to convey information to a cell phone application while estimating point and breaking down twists where it is put. An integrated 6-axis accelerometer and gyroscope measures the inclination by keeping track of the angle in the X, Y, and Z planes. The gadget utilizes worked in Bluetooth LE capacities to convey information to a cell phone application while estimating point and breaking down twists where it is put. An integrated 6-axis accelerometer and gyroscope measures the inclination by keeping track of the angle in the X, Y, and Z planes.

Between 1989 and 2000,225 failures were discovered in a survey of construction breakdowns in the US (including both partial and whole collapses), resulting in a total death toll of 97 people [1]. 3161 people died in collapse-related incidents in 2011, the most in ten years [2]. The three worst building collapses, in 2013 in Mumbai, 2013 in Thane, and 2014 in Chennai, each claimed 200 lives.

Monitoring of structures is important, it was deployed to predict and detect the damage at the early stages to ensure the safety of the structure. There are many methods for monitoring the structure, the sensors used for detecting and monitoring the structure by ultrasonic waves, vibrations, electrical impedance, acoustic waves, echo sound, and heat-dissipation.

In order to identify problematic structures and notify the public for a safe evacuation, we have devised a system that gives a dependable way of monitoring metal beams, gusset plates, concrete joints, beam-column connections, concrete joints, and bridge joints. Our portable "Structure Analyzer" gadget can be used to inspect a bridge joint, a slab, a frame, a metal structure joint, etc. This device uses built-in Bluetooth LE capabilities to communicate data to a smartphone app while measuring angle and analyzing bends where it is placed.

In addition, this device makes use of flex sensors to monitor even thesmallest joint bending away from its mounting point. When there is a deformation, the system sounds an alarm and illuminates a red led to notify the occupants. Prior to being moved to the versatile application, the underlying processor processes every single crude datum. The following is a list of the novelties of the suggested method

(i) It is measured how inclined and bent walls, bridge joints, and beam-column jointsare as a result of disorting, internal crack, or outside stresses earthquakes.

(ii) To trigger an alarm and turn on a red led to alert nearby residents or the general public of excessive deformation so they can flee or take safety actions.

(iii) Constructing a trustworthy, mobile device system that can be easily managed via a user's smartphones and function freely Early detection of buildingcollapse using IoT (Internet of Things) is an emerging technology that aims to prevent catastrophic events like building collapses.

The pressure on the building may be monitored in the sensor and statistics may be shared with the controller. aside from building, as any basement can crack via flexing as monitored via the flex sensor, it can also be a basement bending to analyze and share the facts with the controller, permit the controller, as all smart sensors are, get the information by means of returning the assignment as an LED indication through the parallel motion of a sound alarm and an external utility tracking machine.

Then the outside load of the building, as monitored with the aid of safety at the land basement, may be sensed via a smart sensor as a pressure sensor.

The idea is to use sensors and other IoT devices to monitor various parameters of a building, such as structural integrity, temperature, humidity,and air quality. By collecting and analyzing data from these sensors, it is possible to detect early warning signs of potential structural failures and take preventive actions before a collapse occurs. IoT-based early detection systems for building collapse can be used in a variety of applications, such as in high- rise buildings, bridges, and other large structures. They can also be used in areas that are prone to earthquakes, hurricanes, and other natural disasters.

The key components of an IoT-based early detection system for building collapse include sensors, gateways, and cloud-based platforms. The sensors are placed at various locations throughout the building and collect data on structural integrity, temperature, humidity, and other parameters. The gateways collect data from the sensors and transmit it to a cloud-based platform, where it is analyzed using machine learning algorithms and other techniques.

The platform then provides real-time alerts and notifications to building owners, managers, and emergency responders if any abnormal patterns or warning signs are detected. Overall, early detection of building collapse using IoT has the potential to save lives, prevent catastrophic events, and improve the safety and resilience of buildings and infrastructure.

The monitoring of the smart sensors and suitable timing of the facts sharing to the controller within the hardware communication. The hardware communicates with the cloud using MQTT protocols, then cloud to the utility can be communique protocols may be HTTP. The smart sensor is as vibration sensor can be a bit shaken to get the information to be shared through the main controller.

1.3 DIRECT BENEFITS

The implementations of building collapse using IOT for the following direct benefits.

- Energy Efficiency & Sustainability
- Cost-Effective Condition-Based Monitoring
- Speed and Responsiveness
- Reduction of Manual Labor
- Improved Performance Management

1.4 INDIRECT BENEFITS

In addition to the direct benefits, the implementations of building collapse using IOT also provides the following indirect benefits.

- Technical complexity
- Security and privacy
- Connectivity and power dependence
- Integration
- Higher costs (time and money)

1.5 ORGANIZATION OF THE REPORT

Chapter 1 gives the overview of autonomous maintenance system and its direct and indirect benefits.

Chapter 2 summarizes the review of related background pertaining to autonomous maintenance system.

Chapter 3 outlines the system implementation including problem statement, overview of digital autonomous system and proposed methodology.

Chapter 4 deliberates the results of the proposed system and givesinference about the results.

Chapter 5 discusses the conclusion and future outlooks.

CHAPTER 2
LITERATURE REVIEW

2.1 RELATED BACKGROUNDS

Haroon Malik ,Khurram S. Khattak, Tousiq Wiqar, Zawar H. Khan, Ahmed B. Altamimi, [1] presented a Low Cost Internet of Things Platform for Structural Health Monitoring**.** Different sensors are included into SHM systems to sense the aforementioned parameters. The choice of sensor is influenced by price, power consumption, size, and measurement frequency, which can range from 0-300 Hz [2,3,4]. Piezoelectric, Micro Electro Mechanical, and other types of accelerometers can be used to detect anomalous vibrations in the structure caused by external sources. The advantages of wireless SHM over wired SHM have increased due to decreased installation and maintenance costs, technological breakthroughs, and declining prices for compute units, sensors, and cloud platforms. The WiFi module, which is main power-consuming module in the SHM sensor node, is used to communicate sensed parameters to the cloud server. A free and open source cloud platform called ThingSpeak has been utilised to store, analyse, and analyse data in order to come up with preventative measures against structural issues.

Noel et al. [2] have presented a comprehensive Survey Covering SHM using wireless sensor networks (WSNs), outlining algorithms used in damage detection and localization, network design challenges and future research directions. According to the poll, wireless SHM systems are a better option than wired SHM systems since they require less installation and maintenance. Despite the fact that wireless SHM systems' rapid data collecting presents special network design difficulties.

With sampling frequencies up to 100 Hz, each node is gathering data on structural health-related factors like vibration, stress, and load, among others. Either directly or by forwarded packets from other sensor nodes, sinks receive the sensed data from the sensor nodes. In-depth discussions of various strategies for network architecture to effectively manage bandwidth restrictions have been conducted.

Jeong et al. [3] presented an IoT platform tailored to engineering applications and adopts an information modeling approach to facilitate data interoperability, integrating engineering information with sensor data. The management and exchange of semi-structured information models as well as the vast volume of sensor data are supported by database schema and online interfaces. The suggested platform has three fundamental levels that facilitate data storage and retrieval: the communication layer, the mapping layer, and the storage layer. IoT-driven sensor ecosystem that efficiently and continually assesses the structural health of public infrastructures.

Chanv et al. [4] proposed IoT based sensor unit measuring vibration, strain, moisture using Arduino Uno as compute platform. For storing and processing data Wi-Fi is utilised to transmit data to the cloud platform ThingSpeak. Users have access to the data that has been stored on the cloud platform, and alerts for preventive measures are sent whenever a sensed parameter crosses a certain threshold. Data analytics (powered by cloud computing technologies) can offer analytics and guidelines for historical and prospective structure monitoring. Despite the advantages, IoT-based solutions are complex and require ongoing technical work to function well.

Sabato et al. [5] analyzed and reviewed use of MEMS based accelerometers for structural vibration monitoring. Progress in Micro Electro-Mechanical Systems (MEMS), wireless data transmission has extended and enhanced WSNs role in realization of low-cost SHM systems. Girolamil et al. presented a low-cost system that provide structural modal analysis from a number of synchronized MEMS accelerometers distributed along the structure. Modal analysis is the study of dynamic properties and the assessment of vibration when subject to external excitations. The suggested system is based on a gateway that is in charge of data transmission to the cloud platform from sensor nodes connected to it through a CAN bus and data collecting from those nodes. Validation of the suggested solution based on the condition of a civil structure that is used by the general public. The two key issues are: 1) synchronised data sampling from remote nodes, and 2) capture of signals at frequencies typical of more expensive piezoelectric sensors. Security and privacy issues [12, 13] must be addressed in such mobility-driven and linked systems to support solutions that may be adopted with confidence.

Liang et al. [6] addressed the sensor failure problem in a largescale sensor network and proposed a self-diagnostic and self reconfiguration reasoning method for SHM, which was verified by performing experiments in a real-world monitoring platform with an aluminum plate and actuator/sensor bonding. On the other hand, Park et al. addressed the challenges of using an older baseline signal for SHM. A technique of using instantaneous baseline signals was proposed to compare with the real-time signal for making the SHM decision. For signal analysis Wavelet transform and CC techniques were use.

Hera et al. [7] analyzed the data provided by American Society of Civil Engineers task group for a four-story building on their proposed SHM technique. This method used wavelet analysis to find damage by looking for spikes in the wavelet information. The location of the damaged area was identified using the spikes' spatial distribution patterns [15]. [1] studied damage detection using the Gabor Wavelet transform. In [16], uncertainty was dealt with employing a model-based SHM and Bayesian Probabilistic theory, where structural models were found using modal data. They did not test their proposed system on actual hardware, hence it was unknown how well this method performed in real-time. Furthermore, a big scale damage is not well served by this strategy [16]. Jiang et al. in [17] also took the system's unpredictability into account. A Fuzzy Neural Network (FNN) system utilised the structure vibration response's retrieved modal parameters as inputs, and three separate FNN configurations' outputs were used as inputs by a data fusion centre. The uncertainty of the modal data was reduced by utilising the fusion.

CHAPTER 3
SYSTEM IMPLEMENTATION

3.1. PROBLEM IDENTIFICATION

The Building Collapse Alert System using IoT (BCAS) involves a complex system of sensors, data collection, and analysis. Several problems may arise during the working of such a system, including

Sensor malfunction: IoT sensors are prone to failure due to environmental factors such as temperature, humidity, and power supply. Sensor malfunctions can lead to false alarms or missed alerts, which can be dangerous.

Data accuracy: Data collected by sensors needs to be accurate to detect early signs of building collapse. Faulty or inaccurate data can lead to false alarms or missed alerts, which can be dangerous.

Real-time monitoring: Real-time monitoring of data is crucial to detect early signs of building collapse. Delayed or intermittent monitoring can lead to missed alerts, which can be catastrophic.

False alarms: IoT systems may generate false alarms, which can lead to unnecessary evacuations or disruptions. It is important to reduce the number of false alarms to ensure the system is taken seriously when an alert is raised.

Monitoring ageing infrastructure that has been in operation longer than it should have been owing to weather, corrosion, and other factors is essential. For instance, one in nine bridges in the United States is still in service today with an average age of 42 years. New solutions must be developed in order to prolong the operational life of structures and stop collapse owing to the ensuing costs to people and the economy.

3.2 OVERVIEW OF BCAS

Building collapse alert system using IoT is used with the Internet of Things (IoT) technology in the field of structural engineering and civil infrastructure. This technology isaimed at detecting any signs of structural defects in buildings in real-time, in order to prevent building collapse and enhance public safety. The early detection of building collapse involves the installation of a network of sensors in the structure, which are capable of collecting data related to the building's structural integrity, such as as flexing of pillars, force, vibrations, and other physical parameters. This data is then transmitted to thecloud platform, where it is processed and analyzed using machine learning and artificial intelligence algorithms.Figure 3.1 shows Block Diagram of BCAS.

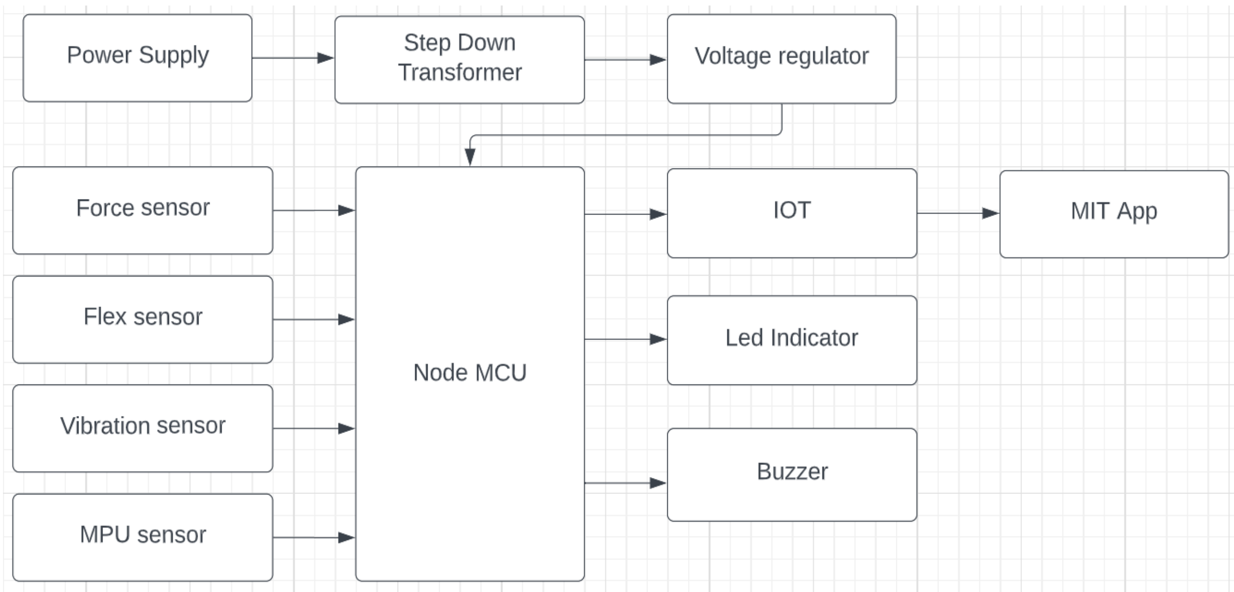

Figure 3.1 Block Diagram of BCAS

The key objective of this technology is to identify any warning signs of a potential building collapse, such as cracks, deformation, or changes in the physical parameters of the building. The system can then generate alerts and notifications, which can be sent to the relevant stakeholders, including building managers, engineers, and emergency services, to take appropriate action.

Early detection of building collapse has the potential to significantly enhance public safety by providing an early warning system for structural defects in buildings. It can also reduce the risk of costly and catastrophic building failures, which can haveserious consequences for both the public and the environment. Despite these challenges, building collapse alert using IoT is an exciting area of research and development, and has the potential to transform the field of structural engineering and civil infrastructure.

3.2.1 IOT MIT Application

MIT App Inventor is a web-based platform developed by the Massachusetts Institute of Technology (MIT) that allows users to create mobile applications for Android devices. It is a visual drag-and-drop programming tool that enables users to build fully functional mobile apps without requiring extensive programming knowledge or experience.

These blocks can be customized to perform specific tasks such as displaying text, playing sounds, and accessing device sensors like the camera and accelerometer. App Inventor's drag-and-drop interface makes it easy for users to create mobile apps without requiring extensive programming knowledge.

Real-time debugging on linked devices via Wi-Fi or USB is made possible via the MIT AI2 Companion software. Additionally, a "on computer" emulator for Windows, MacOS, and Linux is available for usage by the user.

Users can test their app in real-time on their connected Android device as they build it. App Inventor has a large and active community of users who share resources, provide support, and collaborate on projects.

Users can modify and extend the platform to suit their needs. MIT App Inventor is a powerful and particularly well-suited for students and beginners who are interested in learning about mobile app development.

3.2.2 Database Management

The Firebase real-time database is a NoSQL cloud-hosted database that allows developers to store and sync data in real-time between clients and servers. Any changes made to the data are immediately synchronized across all connected clients and servers in real-time. Firebase provides offline support, so users can still access andmodify data even when they are offline. Changes made while offline are automaticallysynced when the user comes back online.

The Firebase real-time database can be easily integrated with other Firebase services, such as authentication and cloud messaging, as well as with other third-party services, the Firebase real-time database is a powerful and flexible tool for building real-time applications that require fast and reliable data synchronization between clients and servers.

3.3 METHODOLOGY INVOLVED IN BCAS

A sensor, or a unit made up of a MEMS sensor (Micro Electro-Mechanical System) with an integrated 3-axis accelerometer and gyroscope, was used to achieve this feature. (MPU6050). If the sensor is measuring acceleration, velocity, displacement, etc., then more than two sensors are interfaced on the ESP8266 (node MCU).

These two sensors, the flex sensor (bending sensor) and the force sensor, are external objects that can be forced by the pressure sensed by the sensor, which is interfaced by the node MCU. The main functional unit in the Control Module is the ESP8266 (Node MCU).

This module manages the node's MCU's external input sensors and output devices. This module uses Internet access to control the devices. So this module appears to be a WiFi module. Otherwise, the output devices are interfacing with the ESP8266.

These output devices are buzzers (piezoelectric type), which are audio signaling devices like alarms and sound indicators. Then, unless output devices are part of the device's IoT application, output in this process will indicate LED light. The sensors will detect the pressure on the building the flexing state of the main pillars and also the vibration caused by human or natural calamities.

The sensors are fitted in their positions and it is all connected to the microcontroller where every reading is noted in there it means the values are get stored, the microcontroller is connected via WIFI to the device above in that the MIT app inverter for the particular BCAS is installed, output devices are part of the device's IoT application. The values that sensors are sending is transmitted through the microcontroller and received by the IOT application where the sensors values are get updated. IoT-based early detection systems for building collapse can be used in a variety of applications, such as in high- rise buildings, bridges, and other large structures. They can also be used in areas that are prone to earthquakes, hurricanes, and other natural disasters. Figure 3.2 shows the flow of BCAS.

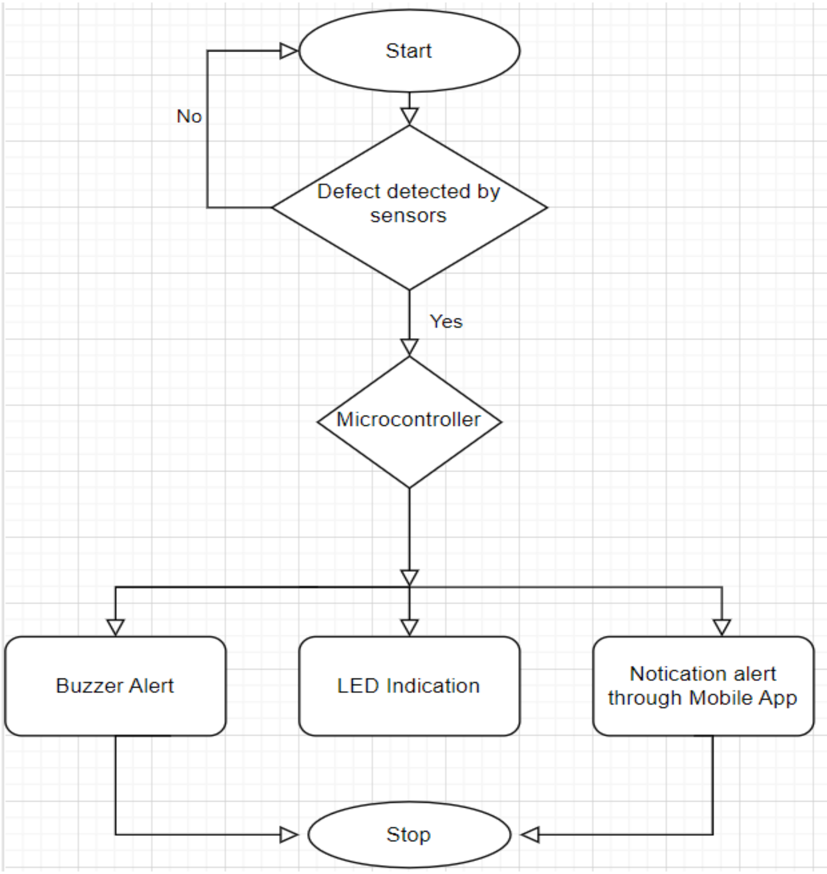

Figure 3.2 Flow of BCAS

3.4 HARDWARE REQUIREMENTS

The proposed system's hardware unit comprises of ESP 8266, flex sensor, force sensor, MPU sensor, LED, buzzer and voltage regulator, step down transformer.

3.4.1 ESP8266

Figure 3.3 Node MCU

The ESP8266 is a highly popular and affordable Wi-Fi module that can be used in a variety of IoT applications. It was developed by the Chinese manufacturer Espress if Systems, and it has become a popular choice among hobbyists, makers, and engineers for building Internet-connected devices. The ESP8266 is a microcontroller with a built-in Wi-Fi module, which makes it easy to connect to the internet and communicate with other devices. It has a low power consumption and a small form factor, making it ideal for use in portable and battery-powered devices. A low-cost, open-source System on a Chip prototype board is the ESP8266 (SoC). Figure 3.3 shows the ESP8266.

3.4.2 Flex Sensor

Figure 3.4 Flex sensor

A flex sensor is a type of sensor that measures the amount of bend or deformation in a material. It is made up of a thin, flexible strip of material that is coated with a conductive material on both sides. When the flex sensor is bent, the distance between the two conductive layers changes, causing a change in resistance. This change in resistance can be measured and used to determine the degree of bend in the sensor.

Flex sensors are commonly used in a variety of applications, such as in robotics, medical devices, gaming controllers, and musical instruments. Figure 3.4 shows the flex sensor.

Usually attached to the exterior, this sensor's resistance can be adjusted by twisting the exterior. These sensors can be used in robot whisker sensors, door sensors, and the Nintendo power glove, among other products. They are also a key ingredient in creating alert stuffed animals.

3.4.3 Force Sensor

A force sensor is a type of sensor that measures the force applied to a particular object. It is commonly used in applications that require precise measurements of force, such as in robotics, manufacturing, and healthcare. Force sensors can be used to detect and measure force in a variety of directions, including tension, compression, and shear. Force sensors come in various forms, including load cells, piezoelectric sensors, and strain gauges. Several physical principles are built around the idea of force. When force is applied to an object with mass m, the object's velocity is altered.Figure 3.5 shows the Force sensor.

Figure 3.5 Force sensor

Thrust, drag and torque are only a few of the many terms that relate to force. No acceleration is visible when the distribution of force within the item is balanced.

3.4.4 MPU Sensor

A 3-axis accelerometer and 3-axis gyroscope are features of Micro Electro-Mechanical Systems (MEMS) dubbed the MPU6050. The accelerometer in an MPU sensor measures linear acceleration, such as changes in speed or direction, while the gyroscope measures rotational motion, such as changes in orientation. The magnetometer measures magnetic fields and can be used to determine the device's orientation relative to Earth's magnetic field. Figure 3.6 shows the MPU sensor.

Figure 3.6 MPU sensor

It is now simpler for we may measure a system's or an object's acceleration, velocity, direction, displacement, and many other motion-related variables. The (DMP) Digital Motion Processor in this module is also strong enough to perform difficult calculations without using the time of the Microcontroller. An MPU (Motion Processing Unit) sensor is a type of sensor that combines multiple sensors, such as accelerometers, gyroscopes, and magnetometers, into a single package. MPU sensors also have built-in processing capabilities, which can offload some of the processing tasks from the main microcontroller, reducing power consumption and improving performance. It has an I2C interface to communicate with the host controller. It is also called Gyroscope or Triple axis accelerometer.

3.4.5 Buzzer

A buzzer is an aural signaling device that can be mechanical, electromechanical, or piezoelectric. Buzzers and beepers are commonly utilized as timers, alarm clocks, and to confirm human input such mouse or keyboard clicks. The suggested system makes use of the ESP8266 low-cost Wi-Fi module. Figure 3.7 shows the Buzzer.

Figure 3.7 Buzzer

With the help of this little module, micro-controllers may join a Wi-Fi network and establish straightforward TCP/IP connections. A buzzer is an electronic component that produces a loud, continuous or intermittent sound. It is a simple and low-cost component that is commonly used in a variety of applications, such as in alarms, timers, and electronic games.

Buzzer components typically consist of a coil of wire and a diaphragm, which is a thin piece of metal or plastic that vibrates when an electrical current is applied to the coil. As the diaphragm vibrates, it produces sound waves that create an audible sound.

It can operate from 3V to 12V and hence can be used in a wide range of systems. The buzzer also has mounts so that it can be installed easily with screws.

3.4.6 LED

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current flows through it. Figure 3.8 shows the LED.

Figure 3.8 LED

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current flows through it. When current passes through an LED, the recombined electrons and holes result in light.

LEDs limit the direction that current can travel in and prevent it from going in the other direction. Light-emitting diodes have highly doped P-n junctions.

An LED is enclosed with a transparent cover, as seen in the image, to allow the light that is emitted to escape. LEDs have many advantages over traditional lighting technologies, such as incandescent bulbs and fluorescent tubes, including higher energy efficiency, longer lifespan, and better durability. They are widely used in a variety of applications, such as lighting, displays, and electronics.

In BCAS, two LED’s (Red and Green) are used to indicate the structural health of building. Whenever any abnormal condition detected, the LED will blink. The LED symbol is simply a diode with the addition of two tiny arrows to indicate light output.

3.4.7 Vibration Sensor

A vibration sensor is an electronic device used to detect and measure vibrations or oscillations in a physical system. These sensors are commonly used in industrial applications to monitor machines, equipment, and structures for signs of damage or wear and tear. Figure 3.9 shows the vibration sensor.

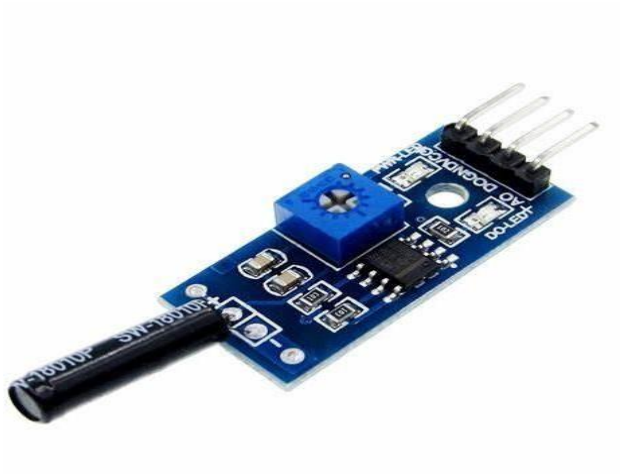

Figure 3.9 Vibration Sensor

Vibration sensors can be designed to measure various types of vibrations, such as acceleration, velocity, and displacement. Acceleration sensors measure the rate of changein velocity over time, while velocity sensors measure the speed of movement at a specificpoint.

Displacement sensors measure the distance a vibrating object moves from its resting position. The sensitivity of the SW420 Sensor can be controlled by an onboard potentiometer and LM393 Comparator IC. The vibration sensor is a close type switch by default.

The induced eddy currents cause the high-frequency oscillator circuit that supplies the excitation signal for the sensor coil to become loaded.

3.5 SOFTWARE REQUIREMENTS

With this procedure, we can first set up the Arduino IDE program. The following import libraries in Software are Firebase ESP Client Library and ESP8266 Community. The actual ESP8266 board then uses the Arduino IDE software to upload the program IDE software to both the device and the software are referred to as "Arduino". After that, the Firebase Cloud Storage will be able to transmit useful data.

Using a third-party application development website that MIT App Inverter can design, the data can then communicate with the Firebase Database. MIT App Inventor is a cloud-based platform that allows users to create mobile applications for Android devices without needing any prior coding experience.

The physical ESP8266 board interacts with Firebase cloud storage to deliver data for the created application. This physical board can interact with the MPU6050, the Flex sensor, and the Force sensor.

Arduino IDE (Integrated Development Environment) is a software program that is used to write, compile, and upload code to an Arduino board. It provides user friendly interface that makes it easy for beginners and experts a like to program the board.

The software provides syntax highlighting for C++ code, making it easy to read and identify different elements of the code. The Arduino IDE includes a c library with many pre-written functions and examples that can be used in you projects. The software allows you to select the board and the port that the board is connected to, making it easy to program multiple boards.

It requisites for software Verify that the software is current between each installation of the Arduino IDE. following which, we may import the esp8266 community, which is required for the esp8266 package. In order to save and apply a preference, a json file can be used.

3.6 MERITS OF PROPOSED SYSTEM (BCAS)

The implementation of BCAS in an industry organization will lead to the following advantage for the organization.

- Early detection of building collapse can save lives and prevent injuries. If the building is evacuated in time, people can be moved to safety before the collapse occurs.
- Early detection can also help prevent property damage. If the collapse is detected early enough, there may be time to prevent or minimize damage to the building and its contents.
- IoT sensors can provide real-time monitoring of the building's condition, allowing for continuous assessment of potential risks and enabling proactive maintenance and repair.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 EXPERIMENT RESULTS

The procedures in installing flex Sensors include surface preparation, rough cleaning, smoothing, washing with metal conditioner, and neutralizer. The surface cleaning, flex sensors are attached using adhesive tapes to the bridge surface's row-column junctions. This system's direct sensing method is used from the surface on which it is installed.

Flex sensor resistance will alter in response to the flex sensor's deformation. Flex value is altered as a result of the change in resistance. The ESP8266 receives this flex value as the sensor output for the purpose of gathering raw data and conducting analysis.

The Bend sensors also read angles between 0 and 90 degrees. Hence, it is for obtaining outcomes up to 180 degrees. To warn users or residents, a buzzer gets fitted and a red LED is fastened to the Node MCU. Every time there is a significant skew, deformation, or bending relative to their beginning position, the buzzer will make an alert and led will blinking.

The vibration sensor which detects vibrations, collisions in structure level vibration sensor is used in detecting Collisions, Burglary protection alarm systems, Vibration alert systems.

A piezoelectric buzzer and a force-sensitive resistor work together to create a potent force warning circuit, how to combine the FSR and buzzer using the ESP8266. For this kind of circuit, Node MCU board programming code is required. This is a straightforward project that makes use of a piezoelectric buzzer and a force sensitive resistor (FSR).

The buzzer will turn on and play an alarm to signal that a force has been detected from the sensor when a force is applied to the Node MCU board- controlled FSR's sensor pad, As the MPU6050 uses I2C for communication, connecting it to an Arduino is rather straightforward. The connections made with Arduino are displayed in the following circuit diagram. We will receive the three fundamental parameter.

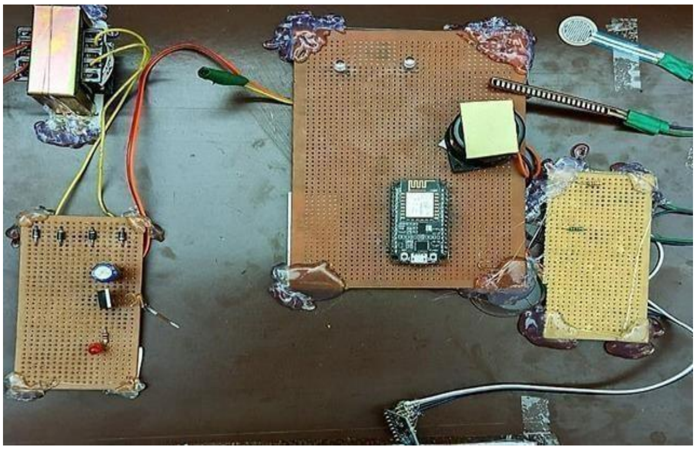

Figure. 4.1 Hardware Setup

Roll, Pitch, and Yaw. You can gauge a car's motion in terms of forward, backward, left, and right movements. Yet, it won't be seen as the same situation when it comes to drones or other flying objects. Yaw, pitch, and rolls are some of the different terms used on flying control boards. The roll axis of the drone is the axis that extends from front to back. Roll motion describes the rotation around this axis. The pitch axis is the axis that moves from left to right. Pitch motion refers to the rotation around this axis.

The yaw axis refers to the drone's axis that extends from top to bottom. Yaw motion refers to the rotation around this axis. In a nutshell, we may state that Rotation about the front-to-back axis is referred to as rolling. Figure 4.1 shows the Hardware setup.

The output from all the sensors are displayed through a LED Blink. If any parameter sensor, then red color LED will blink, which indicates some abnormalities are found in structures, else green color LED will blink, whichindicates the healthy condition of structure. The results of force sensor, flex sensor, MPU sensor as shown below.

4.1.1 Force Sensor Output

Several physical principles are built around the idea of force. When force is applied to an object with mass m, the object's velocity is altered. Thrust, drag,and torque are only a few of the many terms that relate to force. No acceleration is visible when the distribution of forces within the item is balanced. The introduction ofthe Force Sensor, a sensor that can assist in monitoring force, is a result of technological advancement. It measures the load or compression on a object. The actuation force is 0.2N. The range of Sensitivity is up to 20N. Figure 4.2 shows the force sensor output.

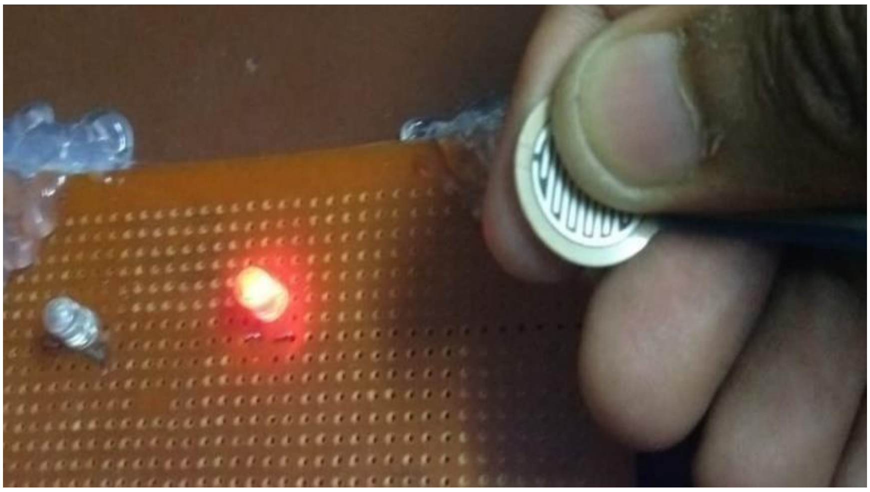

Figure 4.2 Force sensor output

The output may vary depend upon change in resistance according to the pressure applied to the sensing area.

4.1.2 Flex Sensor Output

Flex sensors gauge how much deflection or bending has occurred Flex sensor used to gauge how much bending or deflection has occurred is the flex sensor. Usually attached to the exterior, this sensor's resistance can be adjusted by twisting the exterior. These sensors can be used in robot whisker sensors, door sensors,and the Nintendo power glove, among other products. They are also a key ingredient in creating alert stuffed animals. Figure 4.3 shows the flex sensor output.

,

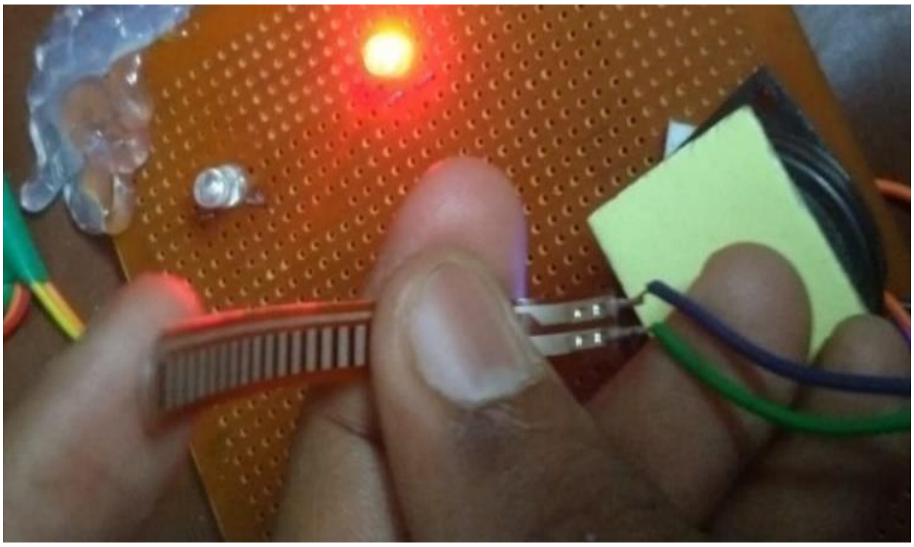

Figure 4.3 Flex sensor output

The two output leads on the flex sensor function as a variable resistor. That instance, depending on how much the sensor is bent, the resistance between two pins changes. It is frequently combined with another resistor to create a voltage divider circuit, which produces a variable voltage dependent on the sensor's changing resistance.

4.1.3 MPU Sensor Output

Micro Electro-Mechanical Systems (MEMS) called the MPU6050 have a 3-axis accelerometer and a 3-axis gyroscope. This makes it easier for us to measure a system's or object's acceleration, velocity, orientation, displacement, and many other motion-related parameters. The module's 16 bit analogue to digital converter circuitry for each channel ensures extremely accurate conversion of analogue values to digital values. This module has the ability to simultaneously record the x, y, and z channels. Moreover, this module contains a (DMP) Digital Motion Processor, which is strong enough to do complex calculations and free up the Microcontroller's time. Figure 4.4 shows the MPU sensor output.

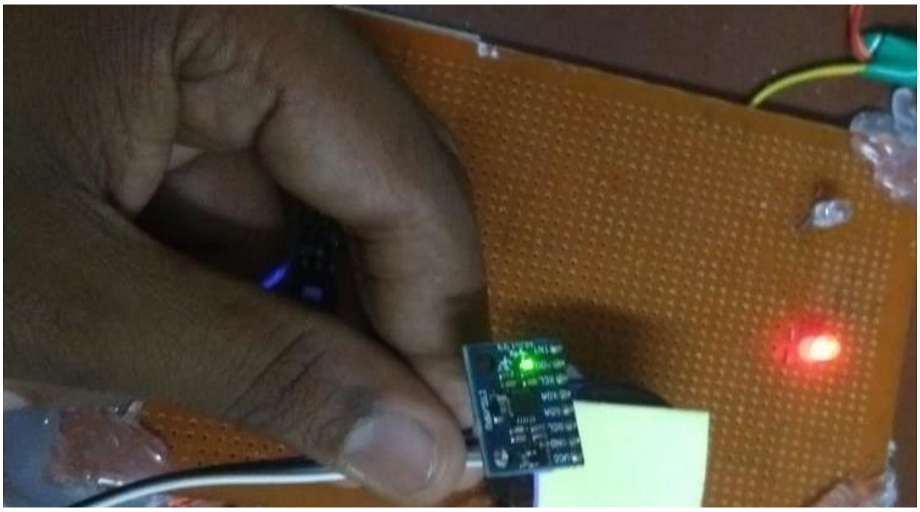

Figure 4.4 MPU sensor output

The sensitive module additionally has a VDDIO, an internal temperature sensor, and an additional I2C interface for non-inertial sensor data transmission. It measures acceleration, orientation, velocity, displacement or any other motion-related parameter. The MPU sensor measures the object’s velocity, displacement, acceleration in three dimensions (X, Y, Z).

4.1.4 Vibration Sensor Output

The Vibration Sensor Module is works on the principle that when the movement or vibration occurs, the circuit will be briefly disconnected and output low. Figure 4.5 shows Vibration sensor output.

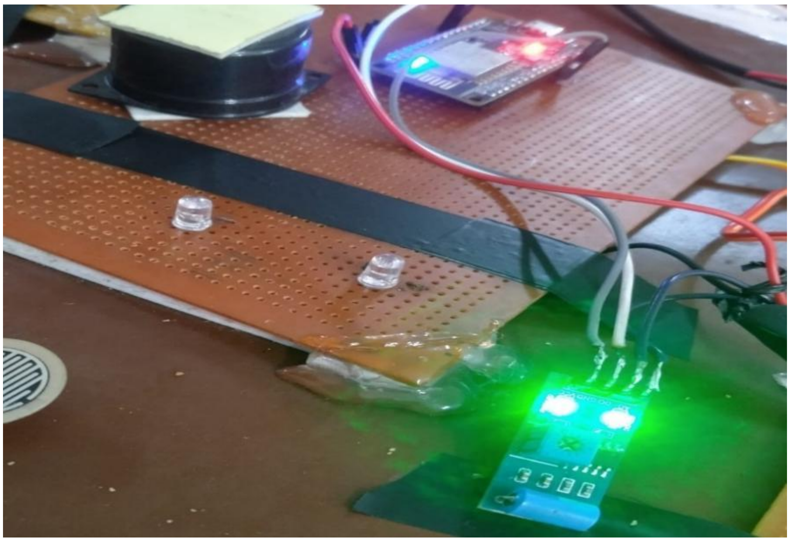

Figure 4.5 Vibration sensor output

The sensitivity of the sensor can be selected based on the application. The module has a fixed bolt for easy installation. Therefore, it is crucial to understand the range of vibration amplitude levels to which the sensor will be subjected during measurements.

4.1.5 IOT MIT Application Output

MIT App Inventor is a web application that helps users build Android applications with block-based programming. It can also create apps for the Internet of Things (IoT) and connected devices. With App Inventor, users can simply select, drag and drop functional blocks onto the web-browser based platform to create their own Android mobile applications.Figure 4.6 shows the MIT Application result.

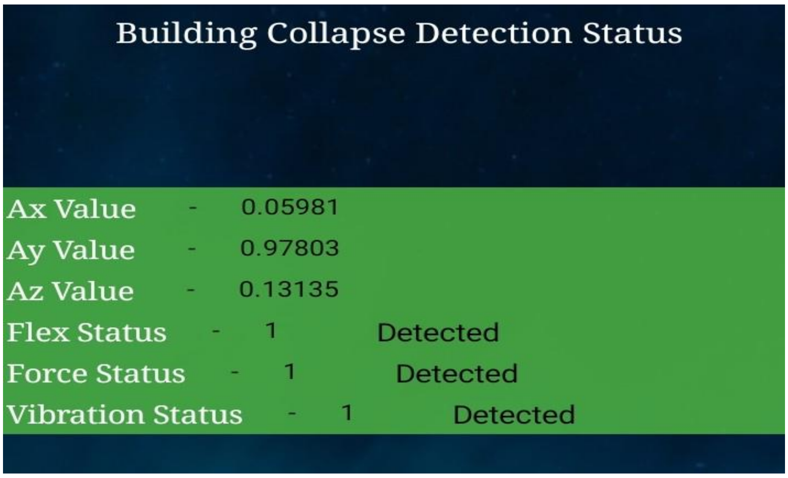

Figure 4.6 MIT Application Result

The sensed sensor values and the status of system are updated in IOT MIT app.

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

People are experiencing severe issues associated to the increase in liquid increasing investments in civil infrastructure have led to content in wall and infrastructure ageing. As a result, timely actions can be done to prevent accidents. Based on cloud data, this method aids the government in providing citizens and bridges. To enable them to respond appropriately before it collapses.

Future IoT-enabled gadgets or sensors will allow us to monitor somemore sophisticated structural parameters, increasing safety. Because Arduino may combining them together, there are various ways to add few more sensors so that you can measure more factors, such as interior fractures etc.

The system's prototype is more robust, mobile, and more user friendly than the technologyin use today since it can be used to a wide range of structures, such as bridges, tall walls, electric poles.

Technology from the Internet of Things genuinely becomes a part of daily life. In fact, technology can link the globe and make it possible for people to communicate with one another. This technology has the potential to save lives in some situations. For instance, disaster management enables us to save many lives when both natural and man-made disasters result in the loss of life and destruction of a significant portion of the environment.

Smart sensors and monitoring systems have made it feasible to identify potential structural problems in buildings and take a action before a collapse takes place. The immediate notification message alert are useful in taking precautions to avoid a major collapse.

In conclusion, a crucial component of building safety is the application of IoT in the early detection of building collapse. Smart sensors, wireless networks, cloud-based monitoring, and AI algorithms have made it feasible to continuously monitor a building's health and identify any structural problems before they become serious enough to cause a collapse. The use of BIM and predictive maintenance can both assist in seeing possible problems and resolving them before they become serious.

In general, IoT integration for building safety is a quickly developing topic with encouraging prospects. It is a crucial component of contemporary building design and construction because it has the potential to save lives and avoid substantial damage to buildings. We can anticipate seeing more sophisticated and efficient solutions in this area as technology advances, ensuring the security of buildings and the safety of their occupants.

IoT devices play a crucial and distinctive role in disaster management and lessen the impact of disasters. In this survey article, the function of IoT in disaster management is presented along with IoT-based disaster management of various calamities and comparisons between several current disaster management technologies. It demonstrates the implementation of certain IoT application examples, such as the early-warning system for earthquake and fire detection. There are numerous sensors are available to measure the various parameters of structural health of building, bridges etc., It describes the whole application, IoT architecture, and focuses on the study of different disasters.

Numerous research for IoT disaster management programmes are covered in this study. IoT-enabled disaster management systems are used for early-warning systems by integrating information analytics and computational tools since the IoT makes it possible for diverse devices to be connected.

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5.2 FUTURE SCOPE

Upcoming Internet of Things (IoT)-enabled devices or sensors will let us keep an eye on certain more advanced structural factors, improving safety. Because Arduino boards may be combined with one another, there are various ways to add more sensors so that you can measure more factors, such as interior fractures, piling problems, etc. The prototype of this system is more robust, mobile, and user-friendly than the existing technologies since it can be used to a wide range of structures, such as enormous walls, electric poles, metal structures other than buildings, and bridges.

It's a new style that's catching on in the building and construction sector. Thermostat, humidity, vibration, and structural integrity are just a few of the factors that IoT-enabled devices may track and collect data on in real-time. Artificial intelligence (AI) and machine learning (ML) algorithms can be used to analyze this data in order to find potential problems before they grow into larger ones, enabling preventative maintenance and repairs.

Now a days develop a technology in IoT System. We can Building collapses monitoring using IoT. our future Scope as develops on building develops on the inbuilt connect to the Smart sensors. The data can send by cloud storage by make own decision by like an Artificial Intelligence to make own alert by safety measuring then safety low as alert by living all building people send alert notification in GSM and Internet access by shown notification in the System. The use of IoT for early building collapse detection is a rapidly developing trend.

APPENDIX 1

SOURCE CODE OF BCAS

```
#include <Wire.h>
#include <ESP8266WiFi.h>
#include <FirebaseArduino.h>
#define FIREBASE_HOST "flexsensorproject-default-rtdb.firebaseio.com"
#define FIREBASE_AUTH
"L5ihhxFe1HB96YHDdhtMmdvYzXFQ920K6XrP0V1s"
#define WIFI_SSID "node"
#define WIFI_PASSWORD "12345678035"
const uint8_t MPU6050SlaveAddress = 0x68;
const uint8_t scl = D6;
const uint8_t sda = D7;
const int flexSensorPin= D2;
const int forceSensorPin= D8;const
int buzzerPin= D1;
const int redLedPin = D3;
const int greenLedPin = D4;
const uint16_t AccelScaleFactor = 16384;
const uint16_t GyroScaleFactor = 131;
const uint8_t MPU6050_REGISTER_SMPLRT_DIV   = 0x19;
const uint8_t MPU6050_REGISTER_USER_CTRL    = 0x6A;
const uint8_t MPU6050_REGISTER_PWR_MGMT_1  =  0x6B;
const uint8_t MPU6050_REGISTER_PWR_MGMT_2   =  0x6C
```

```
const uint8_t MPU6050_REGISTER_CONFIG        =   0x1A;
const uint8_t MPU6050_REGISTER_GYRO_CONFIG = 0x1B;
const uint8_t MPU6050_REGISTER_ACCEL_CONFIG = 0x1C;
const uint8_t MPU6050_REGISTER_FIFO_EN       =   0x23; const
uint8_t MPU6050_REGISTER_INT_ENABLE        = 0x38;
const uint8_t MPU6050_REGISTER_ACCEL_XOUT_H =  0x3B;
const uint8_t MPU6050_REGISTER_SIGNAL_PATH_RESET  = 0x68;
int16_t AccelX, AccelY, AccelZ, Temperature, GyroX, GyroY, GyroZ;

void setup() {
        Serial.begin(115200);
        Wire.begin(sda, scl);
        MPU6050_Init();
        pinMode(flexSensorPin, INPUT);
        pinMode(forceSensorPin, INPUT);
        pinMode(buzzerPin, OUTPUT);
        pinMode(redLedPin, OUTPUT);
        pinMode(greenLedPin, OUTPUT);
        WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
        Serial.print("connecting");
        while (WiFi.status() != WL_CONNECTED)
        {
        Serial.print(".");
          delay(500);
        }
         Serial.println();
```

```
        Serial.print("connected: ");
        Serial.println(WiFi.localIP());
        Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
}
int n = 0;

void loop() {
        double Ax, Ay, Az, T, Gx, Gy, Gz;
        Read_RawValue(MPU6050SlaveAddress,
        MPU6050_REGISTER_ACCEL_XOUT_H);
        Ax = (double)AccelX/AccelScaleFactor;

        Ay = (double)AccelY/AccelScaleFactor;

        Az = (double)AccelZ/AccelScaleFactor;

        T = (double)Temperature/340+36.53;

        Gx = (double)GyroX/GyroScaleFactor;

        Gy = (double)GyroY/GyroScaleFactor;

        Gz = (double)GyroZ/GyroScaleFactor;

        boolean AxValue = (Ax > 0.20) || (Ay > 0.25) || (Az < 0.80);

        int flexSensorValue = digitalRead(flexSensorPin);
        Firebase.set("Flex", flexSensorValue);
        int forceSensorValue =   digitalRead(forceSensorPin);
        Firebase.set("Force", forceSensorValue);
```

```
if(flexSensorValue || forceSensorValue || AxValue)
{
  digitalWrite(buzzerPin, HIGH);
  digitalWrite(redLedPin, HIGH);
  digitalWrite(greenLedPin, LOW);
}
else
{
  digitalWrite(buzzerPin, LOW);
  digitalWrite(redLedPin, LOW);
  digitalWrite(greenLedPin, HIGH);
}
Firebase.setFloat("Ax", Ax);
Firebase.setFloat("Ay", Ay);
Firebase.setFloat("Az", Az);
Serial.println(flexSensorValue);
Serial.print("Ax: "); Serial.print(Ax);
Serial.print(" Ay: "); Serial.print(Ay);
Serial.print(" Az: "); Serial.print(Az);
delay(1000);
}

void I2C_Write(uint8_t deviceAddress, uint8_t regAddress, uint8_t data)
{
        Wire.beginTransmission(deviceAddress);
        Wire.write(regAddress);
```

```
Wire.write(data);
Wire.endTransmission();
}
void Read_RawValue(uint8_t deviceAddress, uint8_t regAddress){
Wire.beginTransmission(deviceAddress);
Wire.write(regAddress);
Wire.endTransmission(); Wire.requestFrom(deviceAddress,
(uint8_t)14); AccelX = (((int16_t)Wire.read()<<8) | Wire.read());
AccelY = (((int16_t)Wire.read()<<8) | Wire.read());
AccelZ = (((int16_t)Wire.read()<<8) | Wire.read());
Temperature = (((int16_t)Wire.read()<<8) | Wire.read());
GyroX = (((int16_t)Wire.read()<<8) | Wire.read());
GyroY = (((int16_t)Wire.read()<<8) | Wire.read());
GyroZ = (((int16_t)Wire.read()<<8) | Wire.read());

}
void MPU6050_Init(){
delay(150);
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_SMPLRT_DIV, 0x07);
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_PWR_MGMT_1,0x01);
```

```
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_PWR_MGMT_2, 0x00);
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_CONFIG,0x00);
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_GYRO_CONFIG, 0x00);
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_ACCEL_CONFIG, 0x00);
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_FIFO_EN,0x00);
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_INT_ENABLE, 0x01);
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_SIGNAL_
PATH_RESET, 0x00);
I2C_Write(MPU6050SlaveAddress,
MPU6050_REGISTER_USER_CTRL,0x00);

}
```

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LIST OF PUBLICATION

[1] Mr. S. Balamurali, Aravind M, Chandramohan S, Kailesh K, Karthick K, “Building Collapse Alert System Using IOT”, 8th International Conference on Science Technology Engineering and Mathematics (ICONSTEM2023), 6th April 2023.

Abstract—"Structural Health Monitoring" (SHM) is developing into an essential study topic to improve human safety and lower maintenance costs of structurally complex structures as a result of the development of modern technologies in the civil engineering area. This entails the process of discovering and detecting interior cracks and damages in the infrastructures well in advance so that a preventive cure can be applied before it crumbles as a result of ageing, a natural disaster, or any other cause that was caused by humans. However, the bulk of SHM systems now in use have trouble functioning in a real-time context due to their lack of portability and resilience. Also, the technology for remote and continual monitoring is still not fully integrated. As a result, we have proposed a portable and reliable Internet of Things-based SHM solution (IoT). A concrete beam, a metal structure, a slab, a bridge joint, gusset plates, a beam-column joint, etc. can all be used to mount our suggested device.

CONFERENCE CERTIFICATES

Building Collapse Alert System using IOT

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Abstract **"Structural Health Monitoring" (SHM) is developing into an essential study topic to improve human safety and lower maintenance costs of structurally complex structures as a of the development of modern technologies in the civil result engineering area. This entails the process of discovering and detecting interior cracks and damages in the infrastructures well in advance so that a preventive cure can be applied before it crumbles as a result of ageing, a natural disaster, or any other cause that was caused by humans. However, the bulk of SHM systems now in use have trouble functioning in a real-time context due to their lack of portability and resilience. Also, the technology for remote and continual monitoring is still not fully integrated. As a result, we have proposed a portable and reliable Internet of Things-based SHM solution (IoT). A concrete beam, a metal structure, a slab, a bridge joint, gusset plates, a beam-column joint, etc. can all be used to mount our suggested device. Before providing the data to a smartphone app for real-time viewing using Bluetooth Low Energy, this gadget analyses bends and calculates inclinations where it is installed (BLE). It can also use a Wi-Fi module to send raw data to cloud storage for upcoming research and analysis. Flex sensors are used by this device to track even the smallest bending from the surface to which it is attached. Each set of unprocessed data is put through an internal processor.**

Keywords— ***Flex sensor; buzzer; Internet of Things (IOT); Arduino; Structural Health Monitoring (SHM)***

I. INTRODUCTION

With the growth of the civil engineering sector, there are numerous structures everywhere we look. Some of them

components have been specified for three reasons: (1) ease of use when formatting individual papers, (2) automatic compliance to electronic requirements that facilitate the concurrent or later production of electronic products, and (3) conformity of style throughout a conference proceedings. Margins, column widths, line spacing, and type styles are built-in; examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

Between 1989 and 2000,225 failures were discovered in a survey of construction breakdowns in the US (including both partial and whole collapses), resulting in a total death toll of 97 people [1]. 3161 people died in collapse-related incidents in 2011, the most in ten years [2]. The three worst building collapses, in 2013 in Mumbai, 2013 in Thane, and 2014 in Chennai, each claimed 200 lives. [3]

Significant building collapses of this nature occur not only in India but also all over the world, particularly in developing nations. A five-story commercial building collapsed on April 24, 2013, in the Savar upazila of Bangladesh's Dhaka district, in what has come to be known as the "Savar Building Collapse" or "Rana Plaza" disaster.