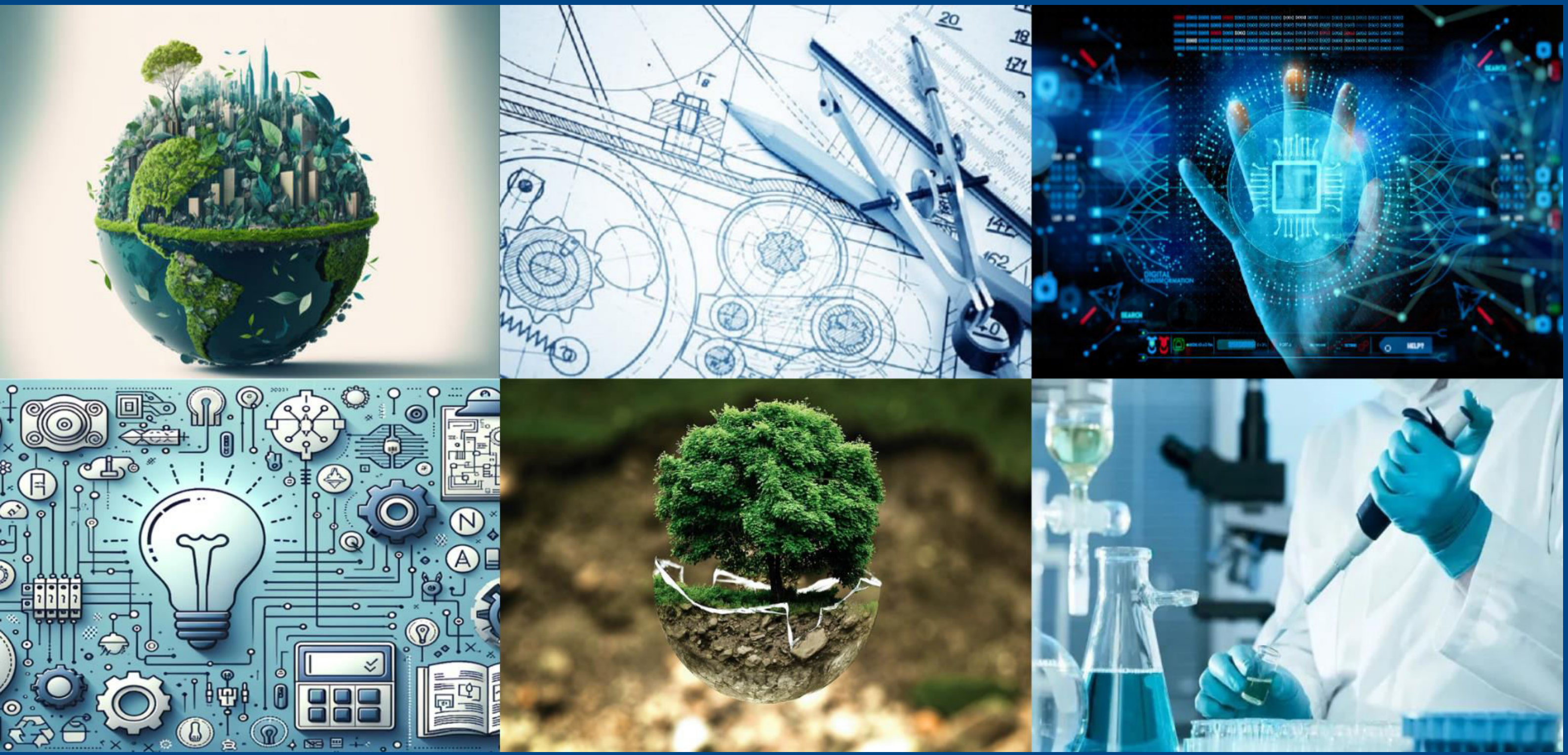
ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.206

Volume 8, Issue 5, May 2025

© 2025 IJMRSET | Volume 8, Issue 5, May 2025| DOI:10.15680/IJMRSET.2025.0805147

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Structural Health Monitoring Using (IoT) Internet of Things

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ABSTRACT: SHM paradigm is changing with IoT; real-time wireless sensors capture and transfer data directly to data processing centres, eliminating physical wiring. IoT integration enables more effective, continuous, and responsive structural monitoring in real-time.

Structural Health Monitoring (SHM) refers to the process of using various sensors, technologies, and data analytics to assess the condition of structures such as buildings, bridges, dams, and other critical infrastructure. The goal is to ensure safety, enhance performance, and extend the life of these structures by detecting issues like cracks, vibrations, and deformations in real-time.

With the rapid advancement of the Internet of Things (IoT), SHM has been revolutionized. IoT refers to the network of physical devices that are embedded with sensors and connected to the internet, allowing them to collect, exchange, and analyze data remotely. When integrated with SHM, IoT enables continuous monitoring of a structure's health with real-time data, facilitating early detection of problems and efficient maintenance.

In the future, as IoT technologies advanc and become more integrated with artificial intelligence (AI), the capabilities of SHM will expand, providing even more precise, automated, and predictive maintenance solutions.

I.INTRODUCTION

Structural health monitoring (SHM) is a process that monitors the condition of structures to detect and prevent damage, and to improve maintenance. The majority of SHM research conducted over the last 30 years has attempted to identify damage in structures on a more global basis. Computer application in the construction industry is minimal. A tool to study the safety and serviceability of concrete structures is scarce. For studying the real-time behavior of concrete structures, IoT becomes vital. Viren B. Chandanshive and Arbaz M. Kazi states that a large Network will develop by Internet of Things with number of wireless perceptible "things" interactive with one another and participating the developments. Fig. 1 depicts the consents of the inhabitants and possessions that can be linked at any given time, at any place, with any person, using some network plus some broadband utility. The Ambient Intelligence, insidious computing and omnipresent computing concepts are basically adopted in the IoT.

II.LITERATURE REVIEW

All the research paper gave a brief idea about the building concept and analysis method which can be implemented in our project and gives better results. 2.2.1 Literature Review:
Ahmad Zaki et al, 2024 Internet of Things (IoT) in Structural Health Monitoring: A Decade of Research Trends. In this study, SHM is important for safety and performance of civil structure by replacing wire sensors with real time wireless sensors that fastly transfer data. Structural Health Monitoring (SHM) is important for the safety and performance of

civil infrastructure. With IoT, the SHM paradigm is changing; real-time wireless sensors capture and transfer data directly to data processing centres, eliminating physical wiring. IoT integration enables more effective, continuous, and responsive structural monitoring in real-time. Although there are many publications in this field, few comprehensive surveys have conducted scientific analyses.

Anis Shafiqah Azhar et al, 2023 "Recent vibration-based structural health monitoring on steel bridges: Systematic literature review" In this study they found that the silver bridge took 46 life in 1976 do sudden collapse. So they suggested to provide SHM system to old ancient structure that 24/7 can monitoring on structure. The future of vibration-based methods is potentially tremendous as structure characterisation solution as it provides the state-of-the-art data-driven measures towards damage detection. However, the raise of SHM robustness has simultaneously raised the room for advancement towards achieving precise quantification and interpretation from vibration-based techniques. The room for advancements raised in this study has proven our one step forward to provide future studies of ways it can expand the vibration-based frontiers.

Sahar Hassani, et al, 2023 A Systematic Review of Advanced Sensor Technologies for Non-Destructive Testing and Structural Health Monitoring The article is motivated by the rapid developments in sensor technologies and data analytics leading to ever-advancing systems for assessing and monitoring structures.

Michela Rossi, et al, 2023 Structural Health Monitoring and Management of Cultural Heritage Structures: A State-of-the-Art Review In recent decades, the urgency to protect and upgrade cultural heritage structures (CHS) has become of primary importance due to their unique value and potential areas of impact (economic, social, cultural, and environmental). Structural health monitoring (SHM) and the management of CHS are emerging as decisive safeguard measures aimed at assessing the actual state of the conservation and integrity of the structure. Moreover, the data collected from SHM are essential to plan cost-effective and sustainable maintenance solutions, in compliance with the basic preservation principles for historic buildings, such as minimum intervention.

John mark payawal, et al 2023 Image-Based Structural Health Monitoring: A Systematic Review Structural health monitoring (SHM) has the potential to become a critical instrument in civil engineering. The majority of existing SHM systems include strain sensors and accelerometers.

Paul sargent, et al 2021 An overview of applications of renewable energy methods in the development of structural health monitoring systems In innovative technologies such as low power wireless sensor networks have further improved the efficiency and different qualities of SHM systems.

Lijia Long , Isaac Farreras Alcover & Sebastian Thöns, et al 2021 Utility analysis for SHM durations and service life extension of welds on steel bridge deck Optimization of the duration of Structural Health Monitoring (SHM) campaigns is rarely performed. This article provides a utility-based solution to posteriorly determine: i) optimal monitoring durations and ii) the extension of the service life of the welds on a steel bridge deck. The approach is illustrated with a case study focusing on remaining fatigue life estimation of the welds on the orthotropic steel deck of the Great Belt Bridge, in Denmark.

Riya bhandari et al 2020 Case study of structural health monitoring in india and its benefits SHM system improves the safety and reliability of the structures; reduce maintenance costs and also helps in extending the useful life of the structures.

Dimitris Diamantidis, et al, 2019 Implementing Information Gained through Structural Health Monitoring -Proposal for Standards With exception of a few issues such as design by testing, current standards do not include guidelines on the use and the quantification of value of additional information gained through Structural Health Monitoring (SHM). This contribution summarizes a recently developed draft of the guideline for practicing engineers in the framework of the EU-COST project 1402 and illustrates its application in engineering decision-making. Besides continuous and periodic monitoring, visual inspection, non-destructive evaluation and proof loading are included herein as a simple form of SHM. The guideline is independent of a type of structure, construction materials, loading, and of environmental conditions. It aims at a wide field of application including design of new structures, assessment of existing structures and type specific monitoring of a population of structures. The decision process related to the use of SHM is presented first together with relevant decision objectives and variables.

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III.METHODOLOGY OF PROPOSED SURVEY

METHODOLOGY

General:
Structural health monitoring (SHM) is the process of using damage detection and characterization techniques for critical structures like bridges, wind turbines, and tunnels. It is a non-destructive in-situ structural evaluation method that employs several types of sensors embedded or attached to the structure.

For the study of G+2 building using a different type of bracing system. For structure to resist vibration on building different types of bracing systems are provided. For modelling Reinforced concrete structure having a G+2 storied structure is considered. The floor height is kept constant at 1.5m and the size of the slab, column and beams are 30
3.2. Bracing System:

Bracing is a construction method used to stabilize the building structure against lateral forces. It increases the capability of building structures to withstand lateral load due to wind and earthquakes.
Bracing is essential in earthquake-resistant buildings to keep them standing. In a frame structure beams, and columns bear vertical loads, whereas the bracing bears horizontal loads.

What does bracing do?
Bracing provides one or more of the following functions:
- Control buckling of the main beams
- Load distribution
- Dimensional control

There are 5 types of bracing used in construction.

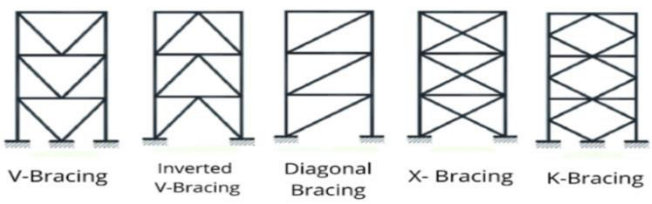

Fig. no. 3.2.1 Types of bracings

This type of bracing used in model,
1. Diagonal Bracing

Fig. no. 3.2.2 Bracing

3.3. Base of Model:
30X30cm Table with spring attached with 12V motor for vibration purpose.

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Fig. no. 3.3.1 12 Watts DC motor

3.4 Sensors used:

1. PWM DC Motor Speed Controller 12v 7.2v 6v 5v 3v 1.8v 2A

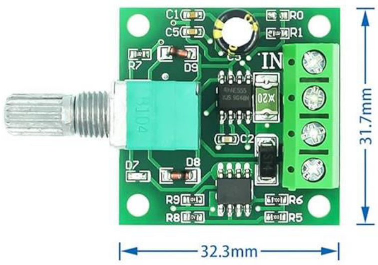

Fig. no. 3.4.1 PWM DC Motor speed controller

We can control the speed of the DC motor by simply controlling the input voltage to the motor and the most common method of doing that is by using PWM signal. PWM, or pulse width modulation is a technique which allows us to adjust the average value of the voltage that’s going to the electronic device by turning on and off the power at a fast rate.

2. DC 12V Power module multi output voltage conversion

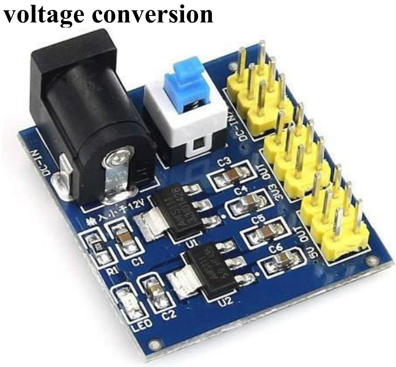

Fig. no. 3.4.2 DC12V module

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This DC-DC 12V to 3.3V 5V 12V Power Module Multi Output Voltage Conversion is also known as Buck Converter or also as Step-Down Voltage Converter. The module is capable of altering the output of the power supply before supplying it to the load so as to deliver the specified power to your load. The device is very flexible and easy to use.

3. NodeMCU ESP32 module

Fig. no. 3.4.3 NodeMCU ESP32

NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP32 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

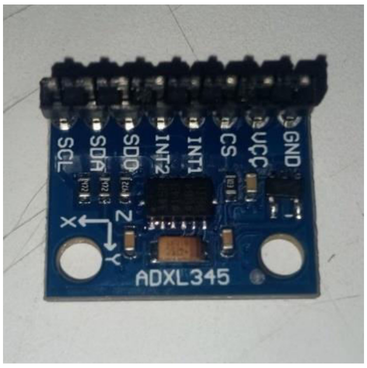

Fig.no. 3.4.4 Triple axle accelerometer board

4.Triple Axle Accelerometer Board

ADXL345 Tripple Axis Accelerometer Board is a small, thin, low-power, 3-axis accelerometer with a high resolution (13-bit) measurement at up to ±16 g. Digital output data is format as a 16-bit two's complement and is accessible through either an SPI (3- or 4-wire) or I2C digital interface.

3.5 Blynk IoT software:

Blynk is a comprehensive software suite that enables the prototyping, deployment, and remote management of connected electronic devices at any scale.
Blynk App is a versatile native iOS and Android mobile application that serves these major functions:

1. Remote monitoring and control of connected devices that work with Blynk platform.

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2. Configuration of mobile UI during prototyping and production stages.
3. Automation of connected device operations.

3.6 Process of Model:

3.6.1 Metal sheet cutting

Fig.no. 3.6.1 Metal sheet cutting

- Use Hacksaw (manual cutting)
- Good for small cuts.
- Hard work, but no sparks.
- Use Angle Grinder (with cutting disc)
- Best tool for cutting 3mm metal.
- Fast and powerful.
- Watch out for sparks and hot metal.
- Safety Tips:
- Always wear gloves, goggles, and long sleeves.
- Clamp the metal sheet tightly.
- Draw clear cutting lines first.
- After cutting, file or grind sharp edges.

3.6.2 Cutting of rod and measuring

Fig.no. 3.6.2 Cutting of rod and measuring

Measure and Mark the Pipe

Measure 1 foot (12 inches) from the end of the steel pipe using the measuring tape.
Mark the Cut Line: Use a marker or chalk line to mark a clear line around the pipe where you will make the cut. Make sure the line is straight and perpendicular to the pipe.

1.6.3 Welding of rods

Fig.no. 3.6.3 Welding of rods

Welding the Pipe to the Metal Sheet:
Set Up the Welding Machine: Adjust your welding machine to the appropriate settings for the material and thickness of the pipe and metal sheet. For steel, a MIG welder is commonly used because it provides strong, clean welds. A TIG welder is ideal for more precise work, while a stick welder can be used for thicker materials.

3.6.3 Ready model with vibration table

Fig.no. 3.6.3 Ready model with vibration table

- Materials and Components for the Project:
- Materials for the Mini Building:
- Metal Pipes: Steel pipes (or any other suitable metal) for the frame of the mini building.
- Metal Sheets: Steel or aluminum sheets to cover the walls, floor, and roof.
- Welding Supplies: For welding pipes and metal sheets together (as you've mentioned earlier, this could involve butt welding or other appropriate techniques).
- Structural Fasteners: Screws, bolts, or rivets for connecting parts

1.6.4 Vibration table with attach motor and sensor

Fig.no. 3.6.4 Vibration table with attach motor and sensor

1. Sensors: Devices that measure physical parameters (e.g., strain, displacement, temperature, etc.) of the structure.
2. IoT Devices: These are responsible for transmitting sensor data to a central server or cloud platform in real-time.
3. Data Processing and Analysis: The gathered data is analyzed using algorithms to detect anomalies, wear, or damage in the structure.
4. Alerts and Maintenance: Based on analysis, alerts can be triggered for maintenance or immediate action if potential issues like cracks or stress are detected.

By utilizing IoT, SHM systems can provide continuous monitoring, enabling early detection of structural issues and improving safety,

IV RESULTS AND DISCUSSION

In this project, we used the Internet of Thinking approach to monitor the health of the structure. Sensors were installed at important points to measure things like vibrations, temperature, and strain. These sensors were connected to the internet, and the data they collected was processed immediately using cloud computing and artificial intelligence.

The system worked very well. It was able to collect real-time data and quickly spot any unusual behavior in the structure. Most of the time, the structure showed normal performance. The vibration levels, strain measurements, and temperature changes stayed within safe limits. This means that the structure is still strong and healthy.

One of the major benefits of using the Internet of Thinking was the fast processing of data. Instead of waiting for engineers to manually check the structure, the system itself could analyze the information and send alerts if anything strange happened. This saved a lot of time and allowed for faster decision-making.

Overall, the results show that using the Internet of Thinking for structural health monitoring is very effective. It not only makes the monitoring process smarter and quicker but also helps to keep the structure safe over time. It is recommended to continue using this technology for regular monitoring and to upgrade the system as newer Al tools become available.

V CONCLUSION

In this project, we used the Internet of Thinking to monitor the health of the structure in a smart and efficient way. By connecting sensors to the internet and using artificial intelligence to process the data quickly, we were able to check the structure's condition in real time.

The system showed that the structure is safe and working as expected. It was able to detect small changes caused by things like weather and traffic, but no serious damage was found. Using the Internet of Thinking made it easier and faster to spot any problems without needing constant human inspection.

Overall, this method proved to be very useful for keeping the structure safe. It saves time, reduces costs, and improves the ability to catch early signs of damage. It is recommended to continue using and improving this smart monitoring system in the future to protect important structures and ensure public safety.

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