IOT-ENHANCED SEISMIC RESPONSE MONITORING OF STEEL STRUCTURES

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Introduction:

Many earthquakes are experienced on a regular basis and their devastation caused to the built environments highlights the need for understanding and promoting structural resilience. However, building with steel structures that are known to be strong, ductile and durable and are widely used in structures located in seismic risk areas, is quite important. Traditional approaches to seismic performance evaluation are usually static assessments or post-event evaluations which prevents them from providing real-time response to structural behavior during dynamic loading. The intersection of the IoT with the seismic resilience research field opens up new opportunities for observing, diagnosing, and improving the operability of steel constructions. The Internet of Things facilitates the installation of numerous sensors that have the capability to measure and record such parameters as acceleration, strain, displacement, and vibration. Together with sog called shake table studies that create conditions of earthquake, IoT systems allow to obtain the necessary information on the operational performance of structures. The present work is aimed at using such systems to assess and enhance the seismic resistance of steel constructions subjected to shake table test. Existing IoT sensors and data analytics will be used to

1. Provide essential feedback for structures during earthquakes

2. Characterize the evolution of damage and the failure mode

Objectives:

1. To record the response of steel frame subjected to seismic force.
2. To analyse the response of steel frame structure with diagonal braces when subjected to seismic force.
3. Getting the alert and updates about the performance through IoT.

Methodology:

The methodology of the project is defined as follows

Problem Identification: The project starts by determining the main problems that steel structures encounter during seismic activity. This could entail being aware of the failure sites, structural flaws, and difficulties with real-time monitoring during earthquake.

System Design: An Internet of Things-based system is created based on the issues that have been discovered. This entails choosing appropriate IoT devices (such as strain gauges and accelerometers), arranging sensor locations on the steel structure, and creating connection protocols for real-time data sharing.

Experimental Setup: The purpose of the shake table experiment is to replicate seismic conditions. In order to track reactions such as stress, strain, and displacement during these earthquake simulations, the Internet of Things sensors and gadgets are mounted on a scaled steel structure model.

Data Acquisition: IoT devices gather data on structural responses in real time while the shake table is being tested. Parameters such as vibration frequency, amplitude, and deformation brought on by simulated seismic activity are included in this data.

Data Analysis: Trends, important stress sites, and possible failure zones in the structure are found by analyzing the collected data. Meaningful insights can be extracted with advanced analytics, including machine learning and signal processing.

Seismic Resilience Assessment: The resilience of the steel structure under seismic loads is assessed using data analysis. The evaluation establishes if the structure needs further reinforcing or can sustain anticipated earthquake forces

Improvement Recommendations: Recommendations to improve the structure's seismic resistance are based on the resilience assessment. This could entail optimizing IoT monitoring systems, changing the structural architecture, or enhancing material qualities.

Reporting and Conclusion: The final step involves compiling the findings into a report. This includes the identified issues, system design, experimental results, and recommendations. The conclusion highlights the effectiveness of the IoT-enhanced system in monitoring and improving the seismic resistance of steel structures

Result and Conclusion:

The results of the study highlight how IoT technology has the ability to completely transform seismic resilience procedures. IoT-enhanced solutions facilitate improved designs for new construction as well as more efficient maintenance and retrofitting of existing structures by offering accurate and actionable insights. This is particularly important in metropolitan settings where transit hubs, bridges, and tall buildings are essential to everyday life and public safety. Real-time remote monitoring of these structures improves safety during seismic events, minimizes downtime during inspections, and lowers the expenses of post-event assessments and repairs. Furthermore, the fine grained information gathered by IoT sensors might enhance simulation models' accuracy, improving our comprehension of how steel structures react to seismic pressures. The difficulties in expanding IoT-based systems for wider uses should be the main focus of future studies. To guarantee interoperability across various sensor types and communication protocols, large-scale implementations necessitate improvements in standardization. To preserve sensor accuracy and longevity over time, environmental issues such high temperatures, moisture, and dust must also be addressed. Furthermore, the system's capabilities could be improved by integrating artificial intelligence (AI) technology, which would allow for automated decision-making both during and after earthquake events. Artificial intelligence (AI) systems are able to evaluate intricate information in real time, spot trends that could point to errors, and suggest quick fixes. In addition to improving structural safety, this integration would offer insightful information for emergency response and disaster management planning. This study's ramifications go beyond earthquake resilience to include more general uses in structural health monitoring and smart city projects. This research lays the foundation for safer and smarter built environments, where engineering and technology work together to reduce hazards and save lives. Future initiatives can guarantee that the built environment stays resilient and adaptable in the face of changing seismic dangers and urbanization issues by carrying on with the innovation and optimization of IoT systems. The potential for IoT to completely transform the way we build, monitor, and safeguard vital infrastructure in the contemporary world is highlighted by this vision of a technology driven approach to catastrophe risk management.

Expected Outcome of the project:

IoT-Integrated Monitoring System:

- An array of IoT sensors captures real-time data on critical parameters such as acceleration, strain, and deformation during simulated earthquake conditions.
- Wireless data transmission to a centralized system enables continuous monitoring and analysis.

Enhanced Seismic Resilience:

- Data-driven insights allow engineers to:
    - Identify structural weaknesses.
    - Validate and refine design assumptions.
    - Implement targeted improvements to enhance resilience.

Real-Time and Predictive Analysis:

- IoT technology facilitates adaptive responses by enabling:
    - Predictive modelling for damage anticipation.
    - Real-time decision-making during seismic events.

Applications Beyond Testing:

- Integration of IoT with shake table testing supports Structural Health Monitoring (SHM) post-tests, providing a long-term framework for:
    - Ongoing safety assessments.
    - Maintenance and repair planning.

Working Model vs. Simulation/Study:

Project involves a physical working model – The prototype of a multistorey structure.

Project Outcomes and Learnings:

The outcome of the project is through IoT the structure subjected to distress can be monitored and when the threshold value exceeds the limit the user can be alerted.

Future Scope:

The future scope of this project includes:

1. The structure can be analysed for different earthquake scenarios with the real data.
2. IoT can be applied to RC structures and response can be monitored.
3. Explore smart materials and adaptive systems responsive to environmental inputs.