LAPORAN KERJA PRAKTEK

EARTHQUAKE-RESISTANT SMART BUILDINGS

International Course Program (ICP)

Disusun Oleh :

Dharma Putra Syarma

(238110031)

TEKNIK SIPIL

FAKULTAS TEKNIK

UNIVERSITAS MEDAN AREA

2026

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LEMBAR PENGESAHAN

PROJECT REPORT

EARTHQUAKE-RESISTANT SMART BUILDINGS

Diajukan untuk memenuhi salah satu tugas pada
International Course Program (ICP)

Oleh :

Dharma Putra Syarma 238110031

Medan, 25 September 2026

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BERITA ACARA DAN NILAI SEMINAR KERJA PRAKTEK

Pada hari ini 25 September 2026 telah diselenggarakan Seminar Kerja Praktek Program Studi Teknik Sipil Untuk Tahun Akademik 2025/2026 atas:

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NIM	: 238110031
Program Studi	: Teknik Sipil
Jenjang Pendidikan	: S1
Judul Kerja Praktek	: Earthquake-Resistant Smart Buildings
Tempat Seminar	: Fakultas Teknik

Tanda Tangan Pembawa Seminar :_____

Nilai Pembawa Seminar : 85 (A)

Seminar **Kerja Praktek** bersasngkutan disetujui/tidak disetujui dengan catatan perubahan seperti yang tercantum pada table berikut ini :

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Saran	*Tika Ermita Wulandari, ST. MT* *Ka. Prodi*
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Medan, 25 September 2026

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CHAPTER I
INTRODUCTION

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1.1 Background

Earthquakes are natural hazards that can cause significant damage to buildings, infrastructure, and human life. The effects of an earthquake on a building depend on several factors, including the intensity and characteristics of ground motion, building configuration, structural system, material properties, construction quality, and site conditions. Therefore, earthquake-resistant building design is an important aspect of structural engineering, particularly in earthquake-prone regions such as Indonesia. In Indonesia, seismic design requirements for buildings are regulated through SNI 1726:2019, which provides requirements concerning seismic hazards, design criteria, structural systems, and expected performance of buildings and other structures (Badan Standardisasi Nasional [BSN], 2019).

Traditional earthquake-resistant building design primarily focuses on providing sufficient strength, stiffness, ductility, and appropriate structural detailing so that buildings can withstand seismic loading. However, structural safety does not end when a building has been designed and constructed. During an earthquake, a structure may experience vibration, displacement, deformation, and other changes in structural response. Therefore, continuous monitoring of structural behavior can provide additional information regarding the condition of a building before, during, and after an earthquake (Çelebi & Kaya, 2022).

Structural Health Monitoring (SHM) is a technological approach that involves measuring structural responses using sensors and analyzing the resulting data to assess structural condition. The U.S. Geological Survey explains that SHM can measure structural response in near real time and can be used to assess structural conditions following severe loading events, including earthquakes (U.S. Geological Survey [USGS], 2026). Parameters such as interstory drift, vibration characteristics, natural frequency, and permanent deformation can provide information about possible changes in structural performance (Çelebi & Kaya, 2022).

The development of microcontrollers and sensor technology has made it possible to develop relatively simple and economical structural monitoring prototypes. Arduino Uno, for example, is a microcontroller board based on the ATmega328P and provides digital and analog input/output capabilities that can be used to connect sensors and actuators (Arduino, 2026). When combined with an

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accelerometer or inertial measurement unit (IMU), an Arduino-based system can be used to detect changes in acceleration and vibration.

One sensor that can be used for this purpose is the MPU6050, which integrates a three-axis accelerometer and a three-axis gyroscope. Arduino-based implementations of the MPU6050 demonstrate that the sensor can be interfaced with an Arduino Uno through the I²C communication protocol to obtain acceleration and rotational data (Arduino Project Hub, 2021). Although a low-cost prototype cannot replace professional seismic instrumentation, it can be useful as an educational and experimental platform for understanding the basic principles of sensor-based structural monitoring.

Modern structural monitoring is increasingly associated with intelligent technologies, including the Internet of Things (IoT), wireless communication, artificial intelligence, and automated data processing. Recent reviews indicate that intelligent technologies can improve the ability to collect, process, and interpret structural-health data (Ghahremani et al., 2023). IoT-based structural monitoring can also support the transmission of sensor information to centralized or cloud-based systems for further analysis (Rahul et al., 2023).

Based on these considerations, this work practice project develops a prototype entitled **"Earthquake-Resistant Smart Buildings."** The project focuses on the integration of an Arduino microcontroller and vibration sensor into a simplified smart-building monitoring system. The prototype is intended to detect vibration or acceleration associated with simulated earthquake movement and provide an immediate warning through indicators such as LEDs and a buzzer. The system represents the monitoring component of a smart building and is not intended to replace the structural design requirements specified by applicable building codes.

1.2 Objective of the Project

The objectives of this project are:

1. To understand the basic principles of earthquake-resistant buildings and structural health monitoring.
2. To study the application of sensors for detecting vibration and movement in building structures.
3. To design and construct an Arduino-based earthquake monitoring prototype.

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4. To integrate an MPU6050 accelerometer/gyroscope with an Arduino Uno microcontroller.
5. To develop a program capable of reading sensor data and identifying vibration conditions based on predefined criteria.
6. To provide a simple warning mechanism using LEDs and/or a buzzer when the detected vibration exceeds a predetermined threshold.
7. To evaluate the performance of the prototype through controlled testing.
8. To understand the potential application of low-cost sensing technology as part of a smart-building monitoring system.

1.3 Benefits of the Project

The project provides several benefits.

1.3.1 Academic Benefit

This project provides practical experience in combining civil engineering concepts, structural monitoring, electronics, sensors, and programming. It helps students understand that modern structural engineering increasingly involves interdisciplinary technologies such as sensing, data acquisition, and intelligent monitoring.

1.3.2 Technical Benefit

The prototype provides an example of how an accelerometer can be integrated with a microcontroller to monitor vibration. It also provides practical experience in circuit assembly, sensor calibration, programming, data acquisition, and system testing.

1.3.3 Practical Benefit

The developed prototype can serve as an educational model for demonstrating the basic concept of smart structural monitoring. Sensor-based monitoring can provide information about structural response that may complement conventional inspection methods (USGS, 2026).

1.3.4 Future Development Benefit

The prototype can be further developed by adding wireless communication, data logging, cloud monitoring, multiple sensors, GPS, advanced accelerometers, or machine-learning algorithms. Such developments are consistent with the broader

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direction of intelligent Structural Health Monitoring (Ghahremani et al., 2023; Rahul et al., 2023).

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CHAPTER II
LITERATURE REVIEW

2.1 Earthquake-Resistant Buildings

An earthquake-resistant building is a structure designed to maintain an acceptable level of performance when subjected to earthquake loading. Earthquake-resistant design does not necessarily mean that a building will remain completely undamaged during a major earthquake. Instead, the structural system is designed to satisfy specified performance objectives by providing adequate strength, stiffness, ductility, and structural integrity.

In Indonesia, seismic building design is governed by SNI 1726:2019, entitled *Tata Cara Perencanaan Ketahanan Gempa untuk Struktur Bangunan Gedung dan Nongedung*. The standard establishes requirements related to seismic hazard, site classification, design criteria, structural systems, and seismic effects that must be considered in building design (BSN, 2019). The standard remains listed as applicable by the Indonesian National Standardization Agency (BSN, 2026).

Earthquake-resistant design is generally based on the assumption that the structure will experience dynamic lateral forces generated by ground motion. Structural components must therefore be proportioned and detailed to resist these effects. In addition to strength, ductility is important because it allows structural components to undergo controlled deformation while maintaining load-carrying capacity.

2.2 Structural Health Monitoring

Structural Health Monitoring is a systematic process of collecting and analyzing information about structural behavior. According to USGS, SHM uses sensors and other measurement technologies to observe structural responses, including responses associated with severe loading events such as earthquakes (USGS, 2026).

A typical SHM system consists of several major components:

1. Sensors.
2. Data acquisition hardware.
3. Data processing.

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4. Communication systems.
5. Data storage.
6. Analysis software.
7. Warning or decision-support systems.

For earthquake monitoring, accelerometers are particularly important because they measure ground or structural acceleration. More advanced building-monitoring systems can use multiple accelerometers installed at different floors to determine structural response characteristics, including interstory movement and modal parameters (Çelebi & Kaya, 2022).

2.3 Seismic Vibration and Acceleration

An earthquake produces ground motion that causes a structure to vibrate. The structural response depends on the characteristics of the ground motion and the dynamic properties of the structure.

Acceleration is commonly expressed in units of m/s^2 or in terms of gravitational acceleration, (g). The acceleration measured by a sensor can be analyzed to identify changes in vibration. For a simplified monitoring prototype, a threshold can be established so that the system activates a warning when the measured acceleration exceeds the selected value.

2.4 Accelerometer Sensors

An accelerometer is a sensor capable of measuring acceleration along one or more axes. In structural monitoring, accelerometers can be installed at selected locations to measure building motion. Professional seismic monitoring systems may use highly sensitive accelerometers and multiple sensors distributed throughout a building. USGS examples show that building arrays can use multiple accelerometers on individual floors to capture horizontal and vertical structural responses (USGS, 2012).

The MPU6050 is a commonly used low-cost IMU that combines a three-axis accelerometer and a three-axis gyroscope. Arduino Project Hub provides examples of connecting an MPU6050 module to an Arduino Uno and obtaining acceleration and gyroscope measurements through the I^2C interface (Arduino Project Hub, 2017).

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2.5 Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P. According to Arduino's official technical documentation, the Uno R3 provides 14 digital input/output pins, six analog inputs, a 16 MHz clock, 32 KB of flash memory, 2 KB of SRAM, and 1 KB of EEPROM (Arduino, 2026).

The Arduino Uno is suitable for a prototype because it can receive data from sensors, process the information according to a programmed algorithm, and control output devices such as LEDs and buzzers. The basic function of the Arduino system in this project can be represented as : Sensor → Arduino → Data Processing → Threshold Evaluation → Warning Indicator

2.6 Internet of Things in Structural Monitoring

The Internet of Things enables physical devices to communicate and exchange information through digital networks. In structural engineering, IoT technologies can connect sensors, data acquisition systems, communication devices, and data-processing platforms.

Recent research indicates that IoT, wireless sensor networks, cloud computing, and machine learning are increasingly being considered for Structural Health Monitoring applications (Rahul et al., 2023). Intelligent SHM research also highlights the growing integration of IoT and artificial intelligence with conventional structural monitoring techniques (Ghahremani et al., 2023).

In the current project, the prototype does not necessarily require an internet connection. However, its architecture can be expanded in the future by adding an ESP8266, ESP32, Wi-Fi module, or other communication technology.

2.7 Smart Building Concept

A smart building uses sensors, control systems, communication technologies, and data processing to improve building operation, safety, efficiency, and monitoring.

For earthquake-related applications, a smart building can incorporate structural sensors capable of detecting vibration and transmitting information to a monitoring system. The data can then be used to support rapid post-event assessment. USGS describes advanced building monitoring systems in which seismic sensors and computer-based calculations can rapidly provide information concerning the

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condition of monitored structures after an earthquake (USGS, 2026). Therefore, structural monitoring can be considered one component of a broader smart-building system.

2.8 Previous Applications of Seismic Monitoring

Seismic instrumentation has been applied to buildings for decades. USGS has documented building instrumentation programs using sensors to record structural responses during earthquakes and ambient vibration conditions (Çelebi, 2000). Research and monitoring programs have also used dense accelerometer arrays in multi-story buildings. For example, USGS describes instrumentation of the Millikan Library and other buildings to investigate seismic-wave transmission and structural response (USGS, 2026).

These applications demonstrate that sensor-based structural monitoring is not merely a theoretical concept. However, professional systems use more sophisticated instrumentation, synchronization, signal processing, data acquisition, and analysis than the simplified prototype developed in this work practice.

2.9 Conceptual Framework

The conceptual framework of this project is:

Earthquake/Vibration → Structural Movement → Sensor Detection → Arduino Processing → Threshold Evaluation → Warning Output → Structural Condition Information

The prototype focuses on the sensor detection and warning stages. It does not independently determine whether a building is structurally safe or unsafe. Such a determination requires engineering assessment using appropriate structural models, inspection procedures, instrumentation, and applicable standards.

CHAPTER III
METHODOLOGY

3.1 Time and Place of Implementation

The work practice project was conducted during the period determined by the work practice schedule. The activities consisted of literature study, component preparation, circuit design, prototype assembly, testing, and analysis.

The project location can be written as :

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Place : University of Medan Area

Implementation Period : January - February 2026

3.2 Tools and Materials

The tools and materials used in the project were selected according to the requirements of the prototype.

3.2.1 Tools

The main tools included:

1. Soldering iron.
2. Cardboard box.
3. Paper glue.
4. Tire rubber.
5. Plastic
6. Cable
7. Battery.
8. Solar power panels.

3.3 Procedure

The project procedure was divided into three main stages :

1. Literature study and design.
2. Model implementation.
3. Testing.

3.3.1 Literature Study and Design Stage

The first stage consisted of reviewing literature concerning earthquake-resistant structures, seismic vibration, accelerometers, Structural Health Monitoring, smart buildings, Arduino microcontrollers, and IoT-based monitoring. Relevant technical requirements were identified from scientific publications, technical documentation, and applicable standards. SNI 1726:2019 was considered as the main Indonesian reference for earthquake-resistant building design (BSN, 2019). After the literature review, the monitoring system was conceptually designed. The system consisted of an MPU6050 sensor, Arduino Uno, warning indicators, and a prototype building model.

The design process included :

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1. Determining the monitoring concept.
2. Selecting the sensor.
3. Selecting the microcontroller.
4. Designing the circuit.
5. Determining the sensor connection.
6. Developing the warning logic.
7. Preparing the Arduino program.
8. Preparing the test procedure.

3.3.2 Model Implementation Stage

The second stage involved physically assembling the prototype.

The MPU6050 was connected to the Arduino Uno using the I^2C communication interface. For a typical Arduino Uno configuration, the sensor's SDA and SCL lines are connected to the corresponding I^2C pins. The power and ground connections are also connected according to the requirements of the sensor module.

The warning indicators were connected to digital output pins. An LED was used to represent a visual warning, while a buzzer was used to represent an audible warning.

The MPU6050 sensor was positioned on the prototype building model so that movement of the model could be detected by the sensor.

The Arduino program was then uploaded to the microcontroller. After uploading the program, the Serial Monitor was used to observe the sensor data and verify whether the system was receiving acceleration measurements.

3.3.3 Testing Stage

The third stage consisted of controlled testing of the prototype.

Testing was conducted by applying different levels of controlled movement to the building model. The purpose was to determine whether the sensor could detect the movement and whether the warning indicators responded according to the programmed threshold.

The testing procedure consisted of :

1. Prepare the props : Use a manual vibrating table or an automatic vibrating table based on a motor and microcontroller.
2. Create a Miniature : Design a symmetrical model using materials such as popsicle sticks, cardboard, or wood.

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3. Aplly a Sprcial Structure : Add diagonal bracing to the walls of the miniature or build a solid foundation to compare its strength.
4. Start the Simulation : Gently shake the base of the table from side to side, then gradually increase the shaking intensity to determine the point of failure or the resilience of the miniature structure.

The testing in this project represents a prototype-level functional test. It should not be interpreted as a certified seismic qualification test for a real building.

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CHAPTER IV
CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Based on the literature review, design process, prototype implementation, and system concept, the following conclusions can be drawn:

1. Earthquake-resistant buildings require appropriate structural design based on seismic loading, structural strength, stiffness, ductility, and applicable building standards. In Indonesia, SNI 1726:2019 provides the principal requirements for earthquake-resistant design of buildings and other applicable structures (BSN, 2019).
2. Structural Health Monitoring provides an additional approach for observing structural response. Sensors can be used to collect information concerning vibration, acceleration, deformation, and other structural parameters (USGS, 2026).
3. Arduino Uno can be used as the main microcontroller in a low-cost structural monitoring prototype. Its ATmega328P microcontroller and available input/output interfaces allow it to communicate with sensors and control warning devices (Arduino, 2026).
4. The MPU6050 can be integrated with Arduino Uno to detect acceleration and movement. The sensor provides three-axis acceleration data that can be processed to obtain a resultant acceleration value.
5. The prototype demonstrates a simple monitoring process consisting of sensor measurement, Arduino-based data processing, threshold comparison, and warning activation.
6. The prototype represents an educational and experimental implementation of smart-building monitoring. It should not be considered a replacement for professional seismic instrumentation, structural inspection, or engineering assessment.
7. The integration of sensors, microcontrollers, communication systems, and data analysis represents an important direction for the development of intelligent Structural Health Monitoring and smart buildings (Ghahremani et al., 2023; Rahul et al., 2023).

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4.2 Recommendation

Several improvements are recommended for future development. First, the prototype should use a higher-quality accelerometer or professional seismic sensor if the system is intended for engineering-scale monitoring. Professional seismic monitoring requires sensors with suitable sensitivity, frequency response, dynamic range, and calibration.

Second, several sensors should be installed at different locations or floors of the prototype building. Multiple sensors would allow comparison of movement between floors and provide more information regarding structural response.

Third, the system should be equipped with data logging so that acceleration data can be stored and analyzed after testing. A micro-SD module or cloud-based database can be added for this purpose.

Fourth, wireless communication can be introduced using an ESP32, ESP8266, or another IoT communication device. This would allow sensor data to be transmitted to a monitoring dashboard.

Fifth, signal-processing techniques should be developed to reduce noise and distinguish earthquake-related movement from normal environmental vibration.
Sixth, future research can investigate natural frequency, damping, interstory drift, and modal response. These parameters are important in more advanced structural health monitoring systems (Çelebi & Kaya, 2022).

Finally, the prototype should be validated through controlled laboratory experiments and, if intended for practical engineering use, through comparison with calibrated professional instrumentation. Any threshold used for real building safety decisions should be established using engineering analysis, applicable standards, sensor calibration, and validated structural-response criteria rather than an arbitrary prototype threshold.

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