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Original Article

Development of a Monitoring System for Natural Hazard Resistant Building Using Arduino Microcontroller

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Abstract - *Having a safe and reliable home has become a major concern for every homeowner, in addition to facing the challenges of safety from natural hazards that may affect buildings and cause damage to infrastructure. The most common of these hazards are floods and earthquakes. This paper presents a building management system utilizing different sensors, a microcontroller and a smartphone mobile application. A model building considers structural aspects in hazard-resistant buildings, in addition to the integration of smart home components, to achieve a high level of comfort and security. The building is integrated with gyroscope sensors for movement detection to alert from possible earthquakes, moisture sensors for detecting water level rising to alert from flooding and an MQ-5 sensor for LPG gas detection to alert from possible gas leaks. When any of the sensors had been activated due to any possible dangers, the Arduino microcontroller sent an alert message via a smartphone application to residents and local relevant authorities to take the proper action. In addition to activating the integrated visual and auditable alarm system. The suggested prototype's testing findings demonstrate that the model's damping mechanisms allow it to endure a possible earthquake. Furthermore, when the moisture sensor detects that the building is submerged in water, electric actuators raise the building. When the aforementioned dangers are identified, the alarm system is also triggered, and a notification is issued through a smartphone app.*

Keywords - *Arduino, Microcontroller, Hazard, Moisture sensor, Gyroscope sensor, LPG leakage.*

1. Introduction

Protection from hazards is highly important to home civilians in addition to achieving a high level of safety and comfort [1]. The utilization of new technologies has become a major addition to the design and implementation of modern homes [2, 3]. The increasing advancement in communication technology and the increasing use of mobile applications in many aspects of life have made it easy to automate home appliances, as this provides convenience and allows users to control the appliances remotely and turn them on or off when necessary [4]. In order to create a cutting-edge disaster warning system that can identify natural calamities like earthquakes, landslides, and floods, a study proposes an Arduino-based disaster management system [5]. In disaster-prone locations, the proposed system seeks to increase response efforts and early warning capabilities. To track the shifting environmental conditions linked to these calamities, the system uses sensors for temperature, soil erosion, accelerometers, tilt, and rainfall. Home hazards include natural and non-natural hazards. Unlike non-natural hazards, natural hazards are unpredictable in terms of occurrence time and hazardous level [6]. The safety from non-natural dangers mainly related to humans, such as theft or misuse of different tools. It is also non-human related, such as failure of different systems in the homes, such as gas leaks, fire, and electrical contacts. Natural disasters impair access to critical services such as grocery stores, health care, schools, and daycare facilities. Furthermore, they may cause partial or entire interruption of numerous facilities, resulting in closures or complete shutdowns such as transportation system disruptions, evacuation orders, power outages, drinking water outages, and other critical services [6, 7]. In recent years, the term “smart home” has become increasingly popular among homeowners as well as home designers [2, 8]. The term smart is mainly related to the adoption of recent technologies that have the capability of monitoring and controlling different systems in the homes [9]. These designed technologies are also able to communicate by utilising different available communication systems to achieve the required duty [10]. A smart home system aimed to realize a safe and comfortable home, utilizing automation systems to increase safety, and provide additional benefits such as increased energy efficiency [11, 12]. In home automation, various devices are integrated to realize a system that remotely controls essential home functions and features automatically. The lighting, temperature, air quality, thermostats, motion, heating and ventilation are examples of the home systems to be controlled. The utilization of sophisticated, programmable controllers capable of capturing and processing critical inputs to the home system and implementing pertinent actions is essential for realizing a smart home [13]. In order to establish a real-time earthquake detection system that reduces possible hazards and provides early warnings, other implemented systems integrate networks of MEMS accelerometers with a variety of microcontrollers, including Arduino and ZigBee. Additionally, observed data is tabulated for further investigation using LabVIEW [14].

The use of commercially available microcontrollers greatly helps in developing smart and efficient residential systems. A smart home system combines sensors with a mechanical operating system to automatically deal with dangerous hazards and take proper action. These actions include warnings and alerts to building users and local authorities through massaging them using GSM or smartphone applications so that they can intervene and mitigate risks [15]. A study described the construction of a number of devices that use Arduino and Telegram to assess the ambient temperature and transmit information about it [16].

The devastating effects of floods on agriculture and the economy are addressed by an IoT-based flood monitoring and alert system created especially for Somalia. In order to improve readiness and lessen damage in flood-prone locations, this system gathers environmental data in real-time for early warning and response. A building site safety system is suggested that uses IoT and AI technology to collect site condition data and monitor and assess risks in real time. By predicting and preventing dangers, Artificial Intelligence (AI) improves safety, lowers accident rates, and boosts operational effectiveness in construction settings.

Today's smart home projects must have comprehensive system control to function effectively without human intervention. In the event of a system failure or risk, such as an LPG leak, the system must be capable of reporting the emergency and condition to the appropriate person. Furthermore, the system must be capable of detecting additional threats that pose serious risks to human life and public health. These dangers include unexpected seismic waves or floods, which cause significant damage, harming people and damaging property and infrastructure. The resolution of risks such as disasters and floods is beyond the capacity of individuals and even professionals. Consequently, it is imperative to establish a system that autonomously mitigates the consequences of these risks and potential disasters without the need for human intervention. Stringent and enforced precautions are implemented in regions located above earthquake epicenters worldwide to mitigate property and human losses. Buildings are equipped with seismic mitigation technologies that enhance their structural integrity and resilience, thereby reducing the impact of earthquakes and aftershocks [17]. Public and private buildings are subject to specifications and regulations that consider the general safety of residents and the adjacent area, and aesthetic and creative features that render them suitable for habitation and use.

The aim of this research lies in the integration of four technologies that can enhance the safety of a smart home: earthquake resistance, flood protection, and protection against LPG leaks, in addition to a smartphone application that can communicate with the homeowner and relevant authorities in the event of an emergency. As illustrated in Figure 1, a wiring diagram of the suggested solution is shown in order to provide a clear representation of the architecture of the system as well as the interactions that occur between its components.

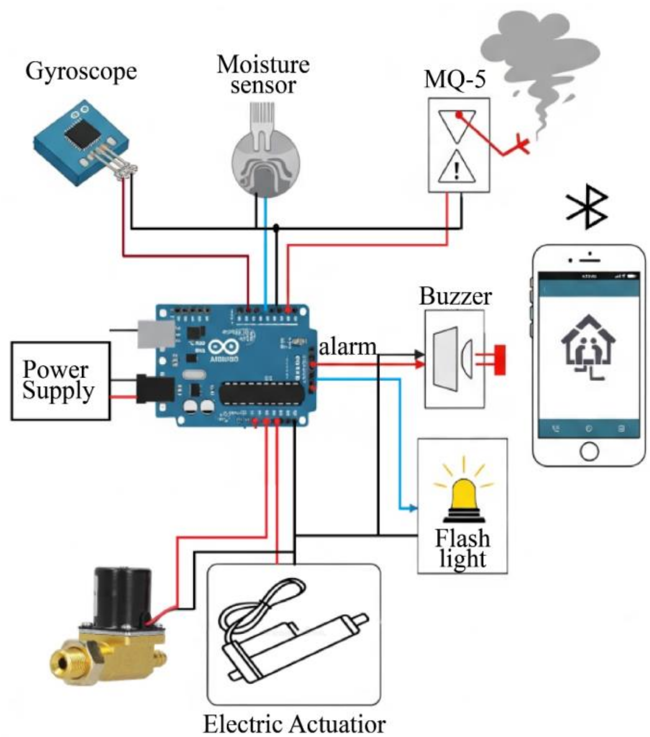

Fig. 1 Wiring diagram of the proposed system

2. Earthquake and Flood-Resistant

Two of the most frequent natural disasters that cause a great deal of damage and fatalities in metropolitan areas are earthquakes and floods. Cities' ability to withstand natural calamities can be evaluated through earthquakes and floods. A thorough resilience assessment framework that integrates earthquake and flood resilience indicators was created in response to the dearth of established techniques for evaluating resistance to both risks. After that, these indicators are divided into two categories-causes and effects-according to their relative relevance and ranking. According to the study, the "transportation and accessibility" group is believed to be most affected, while the "response capacity" group is believed to have the most impact on earthquake and flood resilience [18]. The major natural hazards that mostly cause high levels of damage and losses are earthquakes and floods. This research focuses on protecting residential buildings from these two hazards by adopting appropriate methods that mitigate their effects and reduce their losses. Some techniques can be related to the type of building design in terms of seismic response of regular and irregular buildings [19, 20].

Conventional regular buildings with a uniform structure have a predictable seismic response, uncomplicated and generally symmetrical shapes, and fixed dimensions. This predictability is a result of the building's homogeneous nature, which uniformly distributes seismic forces, thereby reducing the potential risk of failure. The seismic performance of regular and irregular structural elements is examined by [21]. Three irregular structures and one regular structure were the four building models created. Regular buildings fared better under seismic stresses, according to the investigation, which concentrated on important seismic metrics. Regular buildings exhibit a higher seismic resistance than irregular buildings, which have heterogeneous structures that differ in shape, mass, stiffness, height, or curvature. Consequently, irregular buildings are more susceptible to seismic forces as a result of the asymmetrical distribution of stresses, which can result in unforeseen behaviors, such as the concentration of forces in vulnerable areas or the twisting of the building. Consequently, the structure is susceptible to substantial destruction in the event of an earthquake.

Some other techniques can be related to the type of material used in the building during the design process. Therefore, many modern design codes emphasize the importance of elasticity in buildings, especially in areas of high seismic activity, to ensure that the building can undergo significant deformation before collapsing in the event of exposure to seismic activity. In ductile buildings, materials or structures are introduced that are capable of undergoing significant deformation before failure.

Thus, ductile building elements such as beams, columns and joints are able to bend and stretch, thus absorbing and dissipating the energy generated by the earthquake force and preventing the building from collapsing immediately. Meanwhile, the material or structure used is susceptible to breaking or failing suddenly in brittle buildings, as the deformation prior to failure is not noticeable or minimal. As a result, in brittle buildings, structural elements collapse without warning, resulting in sudden collapse and significant losses. Figure 2 illustrates the differences between the use of brittle and ductile materials in construction to resist external forces. The figure shows the response performance of ductile and brittle reinforced concrete buildings.

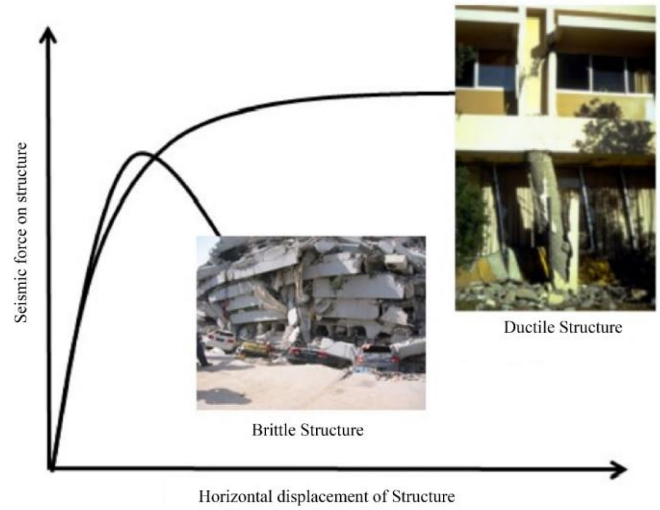

Fig. 2 Ductile versus brittle response [22]

2.1. Earthquake-Resistant Buildings

Earthquakes are processes somewhat similar to ruptures, where ruptures propagate longitudinally along tectonic faults. These ruptures produce seismic waves. The possible impact of the earthquake is determined by the final fracture area and propagation velocity. The intensity of these potential earthquakes depends directly on the nature and amount of energy dissipation associated with the rupture [23]. When huge blocks of rock rubbing against each other break and start to slide, the energy released in the Earth's crust starts to leak out, creating seismic waves. As a result of an earthquake, any sudden ground vibrations caused by seismic waves moving through rocks occur. The most frequent cause of earthquakes is geological fissures, which are the result of the relative movement of rock blocks. The majority of the Earth's crust's greatest tectonic plates are situated along significant fault lines. Faults are the result of movement caused by fissures in the Earth's crust. These cracks may be situated in locations that are either extremely vast or extremely small. An earthquake occurs when tension accumulates along the boundaries of the same tectonic plates and is abruptly released. Figure 3 displays the fundamental guidelines in an earthquake-resistant structure and contrasts them with those that apply above and below ground [24, 25].

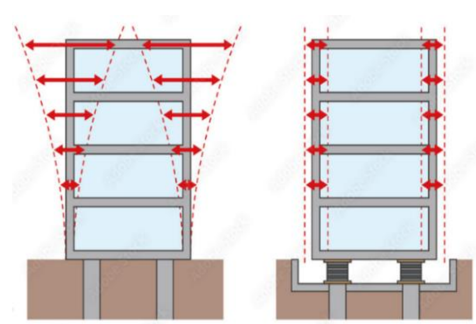

Fig. 3 Seismic isolated structure vs. Conventional earthquake-resistant structure [26]

2.2. Flood-Resistant Buildings

Natural disasters such as earthquakes, hurricanes and floods may lead to disasters due to the lack of a means to mitigate their effects on the building and the residents, so possible technologies must be harnessed to provide a good building that contains risk protection technologies to avoid accidents that lead to death or injury to people in addition to property losses. In certain countries, the risk of continuous flooding is a consequence of excessive rainfall, necessitating the development of strategies to safeguard homes and property.

Raising a building structure above its existing foundation and building a new foundation is a common project technique in coastal areas following hurricanes to raise a house to a certain height to protect it from flooding. Flooding can occur during heavy rainfall seasons, especially in low-lying areas, valleys, or areas near rivers, where rising and falling water can damage building parts. Raising the structure is one solution to this problem [27]. Floods also affect rural and agricultural areas, which negatively affect the agricultural economy and food security. Therefore, building a system of risk indicators helps in economic and social development, as well as in the economy and agricultural security [28, 29].

Floods typically cause widespread destruction, and with urban expansion due to population growth, the accompanying deforestation of wooded areas and the increasing proportion of paved surfaces that prevent the ground from absorbing rainwater easily. This, in turn, leads to a rapid rise in surface runoff of water levels. Another factor causing floods is climate change, which causes an increase in the frequency, extent, length, intensity and timing of weather events such as heavy rains and hurricanes [30]. Therefore, the idea of building flood-resistant housing using modern technology has become a necessity and one of the construction strategies to work on mitigating and reducing the impact of risks resulting from natural factors [31]. The most important of these risks is in the housing sector because it is an important aspect of human life due to the rising incidence and intensity of catastrophic disasters, especially floods, as housing can respond to and resist floods.

In this paper, the design of the proposed system prototype model will be based on an imitation and calculations of the weights that come from the external shape of the building and modifying it in proportion to reality. Thereafter, the right weight of the building is calculated, taking into account the estimated errors. The design utilizes springs to build anti-vibration to protect from earthquakes, and electric actuators installed on the base of the building to protect it from floods. Vibration sensors and gas leakage detectors are utilized along with the Arduino microcontroller to suit the function of the sensors. Communication between Arduino and the mobile is realized using Bluetooth. A smartphone mobile application is designed to remotely control the system.

3. System Components

The proposed system consists of many hardware parts, the most important of which are presented below:

3.1. Arduino Mega 2560

This microcontroller has 54 digital I/O pins, 16 analog I/O pins, 8KB of RAM, and 256KB of flash storage. It can be programmed in C++. Figure 4 shows the Arduino Mega microcontroller.

Fig. 4 Arduino mega 2560

3.2. Gyroscope Sensor

It is an instrument that detects changes in an object's rotating speed around an axis. When vibrating, this sensor will withstand any direction shift in accordance with the conservation of angular momentum concept. This resistance is measured in order to determine the rotational or vibrational speed. It contains a high-precision six-axis accelerometer chip that is used for motion tracking, orientation and position detection. Figure 5 shows the Gyroscope sensor.

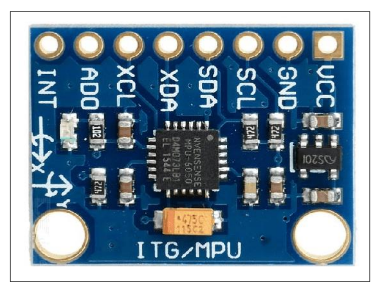

Fig. 5 Gyroscope sensor

3.3. MQ-5 Gas Sensor

This sensor is designed to identify gas leaks and can detect natural gas, methane, and LPG, as well as avoid alcohol noise and cigarette smoke. It responds quickly to gases and is highly sensitive to them. The MQ-5 gas sensor module is shown in Figure 6.

Fig. 6 MQ-5 gas sensor

3.4. Moisture Sensor

This sensor measures the amount of moisture or water in order to provide early warning about the presence of moisture or water around the building. This sensor reacts fast and has high sensitivity and accuracy. Figure 7 shows the moisture sensor.

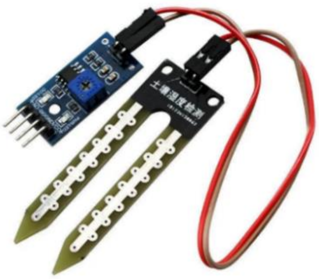

Fig. 7 Moisture sensor

3.5. Bluetooth Module HC-05

The HC-05 Bluetooth module can wirelessly connect with nearby devices that possess Bluetooth functionality within a maximum range of 100 meters. Data can be received or transmitted wirelessly by using the Universal Synchronous/Asynchronous Receiver/Transmitter protocol. Figure 8 shows the HC-05 Bluetooth module.

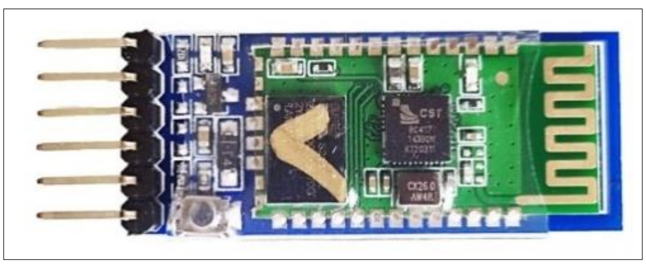

Fig. 8 Bluetooth module HC-05

3.6. Visual and Audible Alarms

Visual and audible alarms consist of a rotating warning light and a buzzer to alert residents of earthquakes or flooding.

3.7. Electric Actuator

It is a precision motion control device that converts rotational motion into linear motion. It has high torque and is small. Figure 9 shows an electric actuator.

Fig. 9 Electric actuator

3.8. Solenoid Gas Valve

It is an electromechanical valve that opens or closes the system's gas flow to regulate the flow of gases. Its features include quick response time, high dependability, extended lifespan, ease of use, and small size. Figure 10 shows the solenoid gas valve.

Fig. 10 Solenoid gas valve

3.9. Tension Springs

These are mechanical springs that, when pulled firmly, extend in length from their initial length by producing an extension force. In Figure 11, a tension spring is seen.

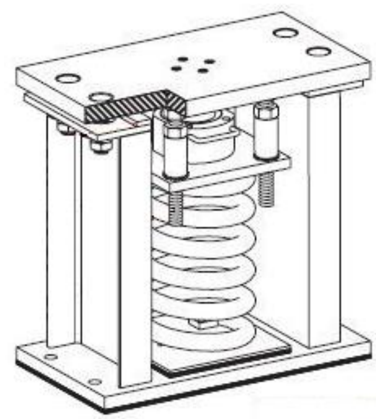

Fig. 11 Tension spring

3.10. Damper

It is a mechanical device that enhances stability by absorbing and damping vibrations. The mechanical damping factor is an indicator of the damper's ability to absorb and release energy during earthquakes.

Two types of dampers are used in this prototype: the first is the damper that relies on the compressed oil mechanism, and the second type is the use of rubber, as shown in Figure 12.

Fig. 12 Mechanical vibration damper

4. Methodology

To maintain pace with rapid technology development and use it in ways that benefit people and improve their lives in all areas, this project was designed with the primary goal of ensuring their safety and comfort, in addition to protecting amenities in cities and preventing huge losses caused by the collapse of buildings due to natural disasters such as floods and earthquakes.

The proposed system is characterized by its ability to absorb vibrations resulting from earthquakes, and it is also easy to install and modify. The main building foundations represent an important component in the design. It is based on connecting tension springs between the building structure and the foundations, with the need to attach vibration dampers (rubbers and mechanical dampers). The tension springs absorb a building's vibrations when it is exposed to earthquakes, while dampers work to reduce these vibrations.

The Arduino microcontroller is connected to sensors and a Bluetooth module to collect information about the stability of the building and to automatically deal with serious hazards and issue warnings. It will promptly alert residents and local authorities through a smartphone application so that they can intervene and mitigate risks. Figure 13 shows the block diagram of the proposed monitoring system, which contains gyroscope sensors mounted on the springs and dampers, MQ-5 gas sensors mounted near gas sources within the building, and a moisture sensor mounted around the building at a certain level.

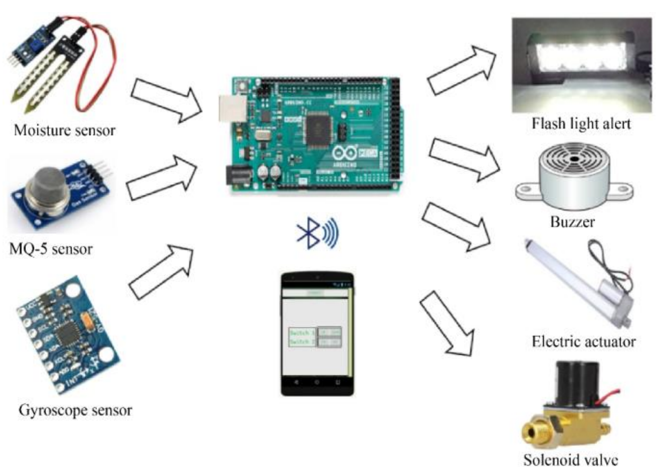

Fig. 13 Block diagram of the proposed monitoring system

The dimensions of the prototype were 45× 50× 100 cm³, and its weight was approximately 40 kg.

The base shear equation:

$$V = C_s \times W = 0.2 \times 392.4 = 78.48N$$

Where:

- V : Base shear (total horizontal force)
- W : Total weight of the structure = 40× 9.81= 392.4 N
- Cs : Seismic coefficient, which is normally between 0.1 and 0.3. Assuming it is average (Cs 0.2).

Without a damping system and tension springs, the structure undergoes significant deformation when the lateral shear force exceeds approximately 30% to 40% of the structure's weight (average 35%). Where:

$$F_{lateral\ shear} = 0.35 \times W \times DAF = 0.3 \times 392.4 \times 2 = 274.68\ N$$

This means that the structure begins to collapse when the lateral shear force is approximately 240-300 N. The Dynamic Amplification Factor (DAF) is a coefficient that measures the effect of dynamic loads on a structure compared to static loads. It is used to determine the increase in deflection or stress in a structure when exposed to sudden vibration compared to a static load of the same magnitude. Figure 14 shows the flowchart illustrating the functionality of the proposed system. The gyroscope sensors detect any vibrations resulting from earthquakes and send the data to the Arduino microcontroller, which in turn activates the warning lights and sound immediately and sends warning messages to residents and relevant local authorities via smartphone.

During an earthquake, the gas sensor detects LPG leaks and sends a signal to the Arduino microcontroller, which stops the solenoid gas valve from releasing LPG into the building and activates a ventilation fan to remove any residual gas. The prototype also features a safe capsule that can be used as a safe haven in the event of an earthquake. It is placed on the roof of the building and is fully equipped to provide food, water, and other personal needs for the duration of the hazard condition. During an earthquake, the system is powered by a PV system during the day or a UPS system at night in case of a power outage.

In the event of flooding, the building structure maintains its balance. When the water level around the building rises, a moisture sensor detects it and sends a signal to the Arduino microcontroller, which immediately turns on the warning lights and sound, sends warning messages to residents and the local authorities via smartphone, and activates an electric actuator placed under the building's foundation. The electric actuator lifts the building structure, lessening the impact of flooding and preventing the building from being submerged in water, which helps in resisting flooding.

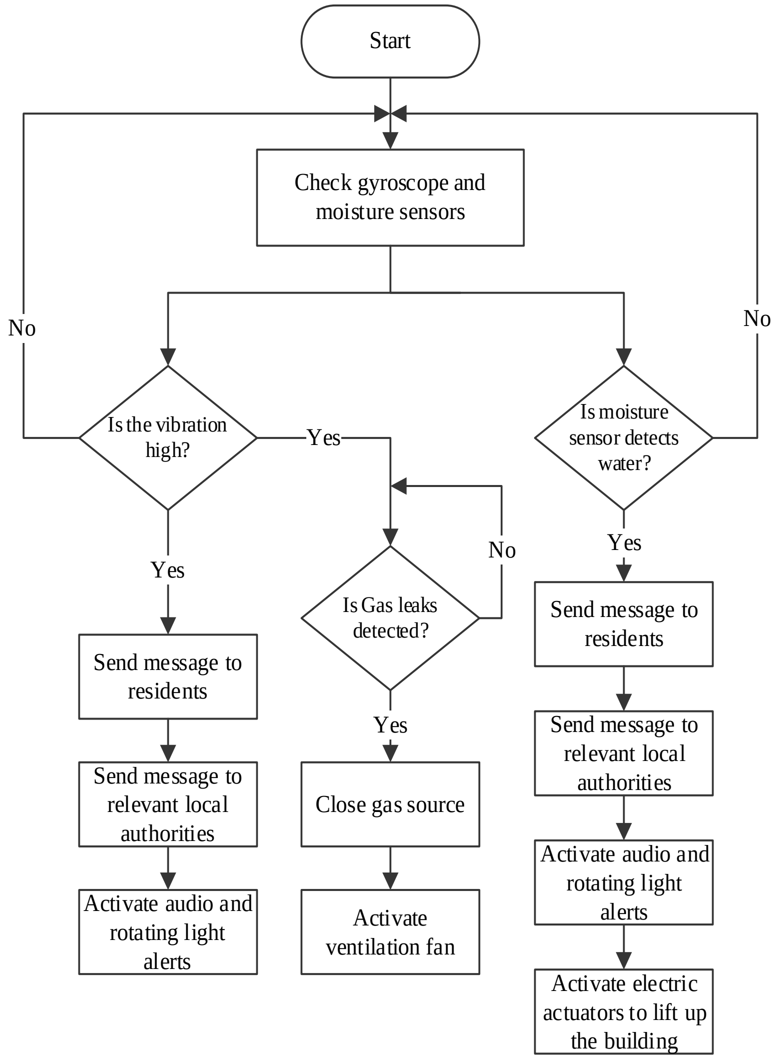

Fig. 14 Flowchart for the proposed system

The smartphone installs Tasker, an advanced Android app that automatically executes specific instructions upon receiving a specific command sent via Bluetooth from an Arduino board. The smartphone then responds to the Bluetooth message and opens an alerts app, built using MIT App Inventor, to remotely trigger an alarm when a hazard occurs. In the event of a potential earthquake, the gyroscope detects the vibration and sends a signal to the Arduino, which in turn sends Bluetooth commands to the app to display a text and audio message to alert users. When the moisture sensor is submerged in water to simulate a potential flood, the sensor detects this and sends a signal to the Arduino microcontroller, which in turn sends Bluetooth commands to the app to display a text and audio message about the flood to alert users.

5. Results and Discussion

With technological advancements, smart buildings have become resilient to natural disasters and can be controlled and monitored via mobile applications. The proposed model is designed because of the recent earthquakes that have occurred in the world, especially in regions that are always exposed to earthquakes. During earthquakes, buildings are subjected to horizontal forces and overturning moments. Hence, it should be taken into account when designing buildings to protect against earthquakes. Therefore, an earthquake-resistant structure with sufficient ductility is highly required. Thus, the developed design is proposed to achieve safety and stability against earthquakes through tension springs, rubber, and dampers. Accordingly, buildings that contain rubbers and dampers around and between tension springs should be moderate in cost and commitment, much less liable to structural damage.

Experiments were conducted without the presence of a damping system using a seismic shake table device with varying Peak Ground Acceleration (PGA) to find the lateral shear force at each PGA, and the result is shown in Table 1. Noting that the base shear force was found to be 78.48N, and the lateral shear force without a damping system and tension springs is equal to 274.68 N. The PGA is a measure of the ground shaking intensity at a particular place during an earthquake and is utilized in the development of structures to endure seismic forces.

Table 1. Seismic analysis experimental results without a damping system

PGA (g)	$F_{lateral\ shear}$ (N)	Prototype Situation
0.05	52	Safe
0.1	116	Near danger if shaking persists
0.2	245	significant deformation
0.3	660	collapse

When the same experiments were repeated with the presence of a damping system, the results were obtained as shown in Table 2.

Table 2. Seismic analysis experimental results with a damping system

PGA (g)	$F_{lateral\ shear}$ (N)	Prototype situation
0.05	4	Safe
0.1	7.3	Safe
0.2	18.7	Safe
0.3	41.5	Safe

As demonstrated in the final set of experiments with the existence of the damper system, the structure remains safe even when the PGA reaches 0.3g, which is equivalent to Richter 7. The results show concepts and techniques, such as the main use of rubber as an earthquake dampener due to its low cost, absorption efficiency, and superior performance. Consequently, using a tension spring is considered a new implementation in hazard-resistant buildings. Subsequently, the building prospered using a mechanical technique without the need to manipulate concrete.

One of the primary goals of a smart home with effective protection is to enhance the building structures' ability to withstand natural hazards by incorporating flood-resistant measures into the design. To this end, a flood-resistant technology was developed that elevates the entire building. The developed prototype is equipped with four electric actuators installed in the corner of the building under the foundations. The prototype is also equipped with sensors to detect soil moisture. When a flood occurs and the sensors detect submersion, a signal is sent to the microcontroller, which in turn commands the electric actuators to elevate the entire structure, as shown in Figure 15. The prototype was designed to lift the structure by approximately 10-15 cm using electric actuators. In real buildings, the amount of lift provided by electric actuators varies depending on the nature of the area in which the building is located. Therefore, the lifted height can be designed to be a few centimeters to meters, depending on the terrain.

Fig. 15 Electric actuators raised the prototype structure.

A comprehensive protection for the residents inside the building is considered through providing a capsule (designed to be like a bed) inside each flat. The capsule is made of solid and robust materials. However, it is employed in anticipation of any failure in the earthquake resistance system. Moreover, the capsule is supplied with the basic human needs for survival. Consequently, it could be utilized and implemented in a conventional building, which does not involve an earthquake-resistant system, to protect people from harm. The complete proposed system that shows the building's structure, mechanical dampers, and other system components is shown in Figure 16.

Fig. 16 Implemented proposed system.

As illustrated in the figure, the developed model is associated with a set of sensors, such as LPG for gas leak detection and moisture, as well as visual and audio alarm systems. In addition, the whole developed design is linked directly with the mobile application to send notification alerts to residents and relevant local authorities.

A comparison of the suggested system with other developed natural hazard monitoring systems is shown in Table 3. Compared to other systems, it is more comprehensive and versatile due to a number of unique advantages and combined characteristics. The suggested system includes dual hazard monitoring, in contrast to previous systems that can only monitor earthquakes or floods. Additionally, the suggested system combines humidity and gyroscope sensors to provide sensitivity to both ground motion and the presence of water. Other systems are less flexible in a variety of situations since they usually rely on single-purpose sensors. In terms of alerts, the suggested system combines several alert types, such as bells, flashlights, and app messages, offering multi-media alerts that enhance user responsiveness. Other systems, including SMS, bells, or an app, only use one alert method.

Table 3. Comparison of other developed natural hazard monitoring systems

Ref.	Controller	Sensors	Comm. Technology	Hazard Type	Alerts
[32]	Arduino	ultrasonic	WSN, cloud	Flood	App
[33]	Arduino Uno	Water level/rain	Wi-Fi, IoT	Flood	SMS
[34]	ESP8266	ultrasonic/MD0127	Blynk IoT, Telegram	Flood	Telegram messages
[35]	ESP32	laser sensor, cam	Blynk app	Flood	LED, buzzer, app
[36]	Arduino	accelerometer, vibration	NodeMCU IoT	Earthquake	Buzzer
[37]	Arduino Mega	accelerometer	GSM	Earthquake	SMS
[38]	ESP8266	Pendulum	IoT	Earthquake	App, buzzer
Purposed system	Arduino Uno	Gyroscope, moisture	GSM	Flood and Earthquake	App, buzzer, flashlight

A mobile application for the proposed system for alerting residents of earthquakes, floods, and LPG leaks was tested. Figure 17 shows screenshots of the earthquake and flood alerts on a user's phone during a test of the system's response.

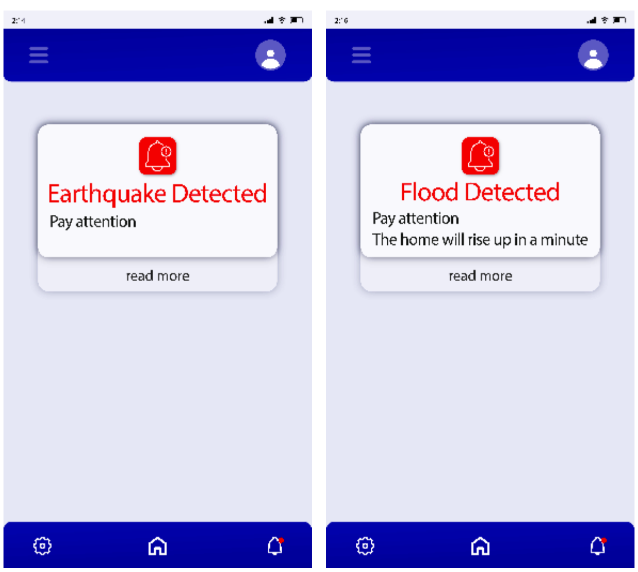

Fig. 17 Testing result screenshot of earthquake and flood detection

6. Conclusion

This paper presents a building structure that works against natural disasters such as earthquakes and floods. The proposed model is subjected to resisting horizontal forces and overturning moments in order to achieve safety and stability against earthquakes through tension springs, rubber, and dampers. Notably, using rubber as the primary element in the structure with the help of dampers offers benefits such as cost-effectiveness, high absorption efficiency, and better overall performance. Therefore, the building mechanically succeeded in maintaining balance without having to manipulate the concrete base. The outcome indicates that the building is stabilized in the presence of actual hazards by the damping system, which is composed of mechanical dampers, rubber, and tension springs.

At the same time, each flat is equipped with a capsule, resembling a bed, to ensure thorough protection for residents in the building. In addition, the established model has four electric actuators that are placed on the concrete base at the building corners.

In case of flooding, the entire model can be elevated by 10-15 cm using electric actuators. Finally, this research proves the ability of smart buildings that are resistant to natural hazards to withstand natural disasters, especially in areas exposed to seismic activity and floods.

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