Design and Implementation of Earthquake Detection and Alert System

by

Sadman-Uz-Zaman
ID: CSE2001019174

Saklain Ahmed
ID: CSE2002020074

Jannatul Nayem Mumu
ID: CSE2002020055

Md. Shakil Ahammed Tonmoy
ID: CSE2001019265

Supervised by
Arifur Rahaman

Submitted in partial fulfillment of the requirements for the degree of
Bachelor of Science in Computer Science and Engineering



DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
SONARGAON UNIVERSITY (SU)

May 2024

Design and Implementation of Earthquake Detection and Alert System

by

Sadman-Uz-Zaman
ID: CSE2001019174

Saklain Ahmed
ID: CSE2002020074

Jannatul Nayem Mumu
ID: CSE2002020055

Md. Shakil Ahammed Tonmoy
ID: CSE2001019265

Supervised by

Arifur Rahaman

Submitted in partial fulfillment of the requirements for the degree of
Bachelor of Science in Computer Science and Engineering



DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
SONARGAON UNIVERSITY (SU)
May 2024

APPROVAL

The project titled "**Design and Implementation of Earthquake Detection and Alert System**" submitted by Sadman-Uz-Zaman (CSE2001019174), Saklain Ahmed (CSE2002020074), Jannatul Nayem Mumu (CSE2002020055) and Md. Shakil Ahammed Tonmoy (CSE2001019265) to the Department of Computer Science and Engineering, Sonargaon University (SU), has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering and approved as to its style and contents.

Board of Examiners

Supervisor

Arifur Rahaman
Assistant Professor and Coordinator
Department of Computer Science and Engineering
Sonargaon University (SU)

Examiner 1

(Examiner Name and Signature)
Department of Computer Science and Engineering
Sonargaon University (SU)

Examiner 2

(Examiner Name and Signature)
Department of Computer Science and Engineering
Sonargaon University (SU)

Examiner 3

(Examiner Name and Signature)
Department of Computer Science and Engineering Sonargaon University (SU)

DECLARATION

We, hereby, declare that the work presented in this report is the outcome of the investigation performed by us under the supervision of **Arifur Rahaman, Assistant Professor** and **Coordinator,** Department of Computer Science and Engineering, Sonargaon University, Dhaka, Bangladesh. We reaffirm that no part of this project has been or is being submitted elsewhere for the award of any degree or diploma.

Countersigned

(Arifur Rahaman)
Supervisor

Signature

Sadman-Uz-Zaman
ID: CSE2001019174

Saklain Ahmed
ID: CSE2002020074

Jannatul Nayem Mumu
ID: CSE2002020055

Md. Shakil Ahammed Tonmoy
ID: CSE2001019265

ABSTRACT

The Earthquake Detection and Alert System (EDAS) proposed in this project aims to provide a robust and efficient solution for early earthquake detection and timely dissemination of alerts. With the increasing frequency of seismic events globally and their potential catastrophic consequences, there's a critical need for advanced systems capable of detecting earthquakes swiftly and alerting populations to take necessary safety measures. The EDAS leverages a network of seismic sensors strategically positioned in earthquake-prone regions. These sensors continuously monitor ground movements and detect seismic waves generated by earthquakes. Upon detecting anomalous seismic activity, the system employs sophisticated algorithms for event detection and localization, accurately determining the epicenter and magnitude of the earthquake. Once an earthquake is detected, the system initiates alert procedures through various communication channels, including mobile applications, SMS, sirens, and other public announcement systems. These alerts are disseminated rapidly to inform residents, emergency responders, and relevant authorities about the impending threat, allowing them to take proactive measures to mitigate risks and minimize damage.

ACKNOWLEDGMENT

At the very beginning, we would like to express my deepest gratitude to the Almighty Allah for giving us the ability and the strength to finish the task successfully within the schedule time.

We are auspicious that we had the kind association as well as supervision of **Arifur Rahaman**, Assistant Professor and Coordinator, Department of Computer Science and Engineering, Sonargaon University whose hearted and valuable support with best concern and direction acted as necessary recourse to carry out our project.

We are also thankful to all our teachers during our whole education, for exposing us to the beauty of learning.

Finally, our deepest gratitude and love to my parents for their support, encouragement, and endless love.

LIST OF ABBREVIATIONS

IoT	Internet of Thinking
IoS	Internet of Service
LCD	Liquid Crystal Display
LED	Light Emitting Diode
WSN	Wireless Sensor Network
GSM	Global System For Mobile Communication
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
EWS	Economically Weaker Section
EEW	Earthquake Early Warning
SSN	Social Security Number

TABLE OF CONTENTS

Title	Page No.
DECLARATION.....	iii
ABSTRACT.....	iv
ACKNOWLEDGEMENT.....	v
LIST OF ABBREVIATION.....	vi
CHAPTER 1	1-3
INTRODUCTION TO EARTHQUAKES DETECTION AND ALERT SYSTEM	
1.1 Introduction.....	1
1.2 Objectives of Project.....	2
1.3 Benefits of Project.....	2
CHAPTER 2	
UNDERSTANDING EARTHQUAKES AND EXISTING DETECTION SYSTEM	4-12
2.1 Introduction of Earthquakes.....	4
2.2 Causes of Earthquakes.....	4
2.3 Effects of Earthquakes on Human Lives in Infrastructure.....	6
2.4 Earthquakes Historical Documents.....	7
2.5 Existing Detection Technologies.....	8
2.5.1 Overview of Current Earthquakes Detection Methods.....	8
2.5.2 Case Studies of Successful Earthquake Detection and Alert Systems Around The World.....	11
2.6 Conclusion.....	12
CHAPTER 3	13-21
PROJECT BACKGOUND	
3.1 Introduction.....	13
3.2 Internet of Things-Concept and Definition.....	13
3.3 IoT Enabling Technologies.....	13
3.4 Required Equipment.....	14
3.4.1 Arduino Uno.....	14

3.4.2 Vibration Sensor Module 14
3.4.3 SIM8001 GSM Module..... 15
3.4.4 Battery Charging Circuit 16
3.4.5 16x2 LCD Display..... 17
3.4.6 LM2596 DC-DC Buck Converter Step Down Module..... 17
3.4.7 Mini Buzzer..... 18
3.4.8 Jumper Wire 19
3.4.9 3.7V Battery 19
3.4.10 Battery Case Holder..... 20
3.4.11 Vero Board 21
3.5 Conclusion..... 21

CHAPTER 4 22-25
HARDWARE IMPLEMENTATION OF THE PROPOSED PROJECT
4.1 Introduction 22
4.2 Working Process..... 22
4.3 Block Diagram of The Proposed Project..... 22
4.4 Flow Chart of The Proposed Project..... 23
4.5 Final View of The Project..... 24
4.6 Mobile Message View..... 25

CHAPTER 5 26-27
TEST AND RESULT
5.1 Project Testing..... 26

CHAPTER 6 28-29
CONCLUSION AND FUTURE WORKS
6.1 Conclusion 28
6.2 Future Works..... 28
6.3 Limitations..... 28
REFERENCES..... 30

LIST OF FIGURES

Figure No.	Title	Page No.
Fig.2.1	Tectonic Activity…….....	4
Fig.2.2	Fault Line…….....	5
Fig.2.3	Volcanic Activity…….....	5
Fig.2.4	Human Induced Activity…….....	6
Fig.2.5	Cumulative Storage…….....	8
Fig.3.1	Arduino Uno…….....	14
Fig.3.2	Vibration Sensor Module…….....	15
Fig.3.3	SIM8001 GSM Module…….....	16
Fig.3.4	Battery Charging Circuit…….....	16
Fig.3.5	16x2 LCD Display…….....	17
Fig.3.6	LM2596 DC-DC Buck Converter Step Down Module…….....	18
Fig.3.7	Mini Buzzer…….....	18
Fig.3.8	Jumper Wire…….....	19
Fig.3.9	3.7V Battery…….....	20
Fig.3.10	Battery Case Holder…….....	20
Fig.3.11	Vero Board…….....	21
Fig.4.1	Block Diagram of The Proposed Project…….....	22
Fig.4.2	Working Flow Chart of Earthquake Detection and Alert System….....	23
Fig.4.3	Final Project View Top…….....	24
Fig.4.4	Final View of The Project Turned On…….....	24
Fig.4.5	Mobile Message View…….....	25
Fig.5.1	Earthquake Detected…….....	26
Fig.5.2	Alert Message Received……..	27

CHAPTER 1
INTRODUCTION TO EARTHQUAKE DETECTION AND ALERT SYSTEM

1.1 Introduction

The Internet of things (IoT) brings an exciting new dimension to the world of field research, where researchers are able to access their data and insights in real time, wherever they are. This means that physical and chemical measurements can be made onsite or in the lab with a fraction of the effort that it would take if one were to rely on manual data collection. It also means that one can deploy a network of sensors across a region of interest and have them all communicate with each other to provide a comprehensive picture of what is happening in that area. This is particularly valuable for earthquake detection and alerting system, where changes in conditions can have serious consequences downstream. In recent years, the Internet of Things (IoT) has emerged as a transformative technology with diverse applications across various industries. One such application is in the realm of disaster management, where IoT can play a crucial role in enhancing the effectiveness of earthquake detection and alerting systems. By leveraging interconnected sensors, data analytics, and real-time communication capabilities, IoT enabled earthquake detection and alerting systems offer the potential to improve early warning capabilities, increase response efficiency, and mitigate the impact of seismic events on vulnerable communities. Traditional earthquake detection systems typically rely on standalone seismometers deployed in seismically active regions. While effective, these systems often face challenges such as limited coverage, scalability issues, and delays in data transmission and analysis. In contrast, IoT-based earthquake detection systems utilize a network of distributed sensors interconnected through wireless or wired communication protocols. These sensors continuously monitor ground vibrations and seismic activity, providing real-time data to centralized processing units. The key advantage of IoT-based earthquake detection systems lies in their ability to offer broader coverage and higher granularity of data. By deploying a dense network of sensors, these systems can capture seismic activity across a wider geographical area with greater precision. Moreover, IoT sensors can be easily deployed in remote or inaccessible locations, enabling monitoring in regions where traditional infrastructure may be lacking. Once seismic activity is detected, IoT-enabled systems employ advanced data analytics algorithms to analyze sensor data and assess the severity of the earthquake. Real-time processing enables rapid detection and localization of seismic events, allowing for prompt initiation of alerting procedures. Alerts can be disseminated through various channels, including mobile applications, SMS, email, and social media platforms, reaching individuals and communities in a timely manner. Furthermore, IoT technology facilitates the integration of additional data sources and sensor types, enhancing the capabilities of earthquake detection and alerting systems. For example, accelerometers embedded in smartphones or smart buildings can augment traditional seismic sensors, providing supplementary data for improved accuracy and reliability. Overall, IoT-based earthquake detection and alerting systems represent a significant advancement in disaster management technology. By harnessing the power of interconnected sensors and data analytics, these systems offer the potential to enhance early warning capabilities, improve response coordination, and ultimately save lives in earthquake-prone regions. As IoT continues to evolve, ongoing research and innovation in

this field will further enhance the effectiveness and resilience of earthquake detection and alerting systems.

1.2 Objectives of Project

- This project aims to develop an innovative Earthquake Detection and Alerting System using IoT that enhances early warning capabilities, improves disaster preparedness and response, and ultimately saves lives and mitigates the impact of seismic events on communities. To bring the benefit of technology to the user's hand.
- To establish channels for disseminating earthquake alerts to relevant stakeholders, including government agencies, emergency responders, and the general public, using methods such as mobile apps, SMS, email, and sirens.
- To provide timely alerts to individuals and communities.
- To minimize casualties and property damage.
- To improve emergency response coordination.
- To raise public awareness and preparedness.
- To facilitate orderly evacuation planning.
- To promote infrastructure resilience.
- To support scientific research and monitoring.
- To foster international cooperation in disaster risk reduction efforts.

1.3 Benefits of Project

- **Early Warning and Preparedness:** The primary benefit of an earthquake detection and alert system is early warning. By detecting seismic activity early, the system can provide warnings to communities, giving people crucial seconds or even minutes to take cover, shut down critical infrastructure, or evacuate buildings. This early warning capability significantly enhances preparedness and reduces potential casualties and damage.
- **Risk Reduction and Safety:** With advance notice provided by the system, individuals and organizations can take proactive measures to mitigate risks. For example, automated systems can trigger safety protocols in critical facilities (hospitals, power plants, transportation hubs) to minimize damage or disruption.
- **Enhanced Response Coordination:** An earthquake alert system improves coordination among emergency response agencies. Early warnings allow first responders to prepare and allocate resources more effectively, reducing response times and improving overall disaster management.
- **Infrastructure Protection:** Critical infrastructure, such as bridges, tunnels, and dams, can be equipped to automatically respond to earthquake alerts. This might involve shutting down systems to prevent catastrophic failure or activating emergency protocols to safeguard against damage.
- **Public Awareness and Education:** Implementing an earthquake detection and alert system can raise public awareness about earthquake risks and preparedness measures. This increased awareness can lead to better community engagement and understanding of seismic safety.

- **Economic Savings:** While the initial setup and maintenance costs of an earthquake detection and alert system can be significant, the system can ultimately save money by reducing the economic impact of earthquakes. This includes minimizing property damage, infrastructure repair costs, and disruption to businesses and services.
- **Data Collection and Research:** These systems can provide valuable data for scientific research and earthquake modeling. Continuous monitoring of seismic activity contributes to better understanding of fault lines and earthquake patterns, which in turn can inform urban planning and building codes.
- **Peace of Mind:** Beyond tangible benefits, having an earthquake detection and alert system provides peace of mind to residents and businesses in earthquake-prone regions. Knowing that there is a system in place to provide advance warning can alleviate anxiety and fear associated with earthquakes.

CHAPTER 2
UNDERSTANDING EARTHQUAKES AND EXISTING DETECTION SYSTEM

2.1 Introduction of Earthquakes

Earthquakes are natural phenomena that occur when there is a sudden release of energy in the Earth's crust, resulting in the shaking or trembling of the ground. These seismic events can range in intensity from barely noticeable tremors to devastating cataclysms, capable of causing widespread destruction and loss of life. Earthquakes are primarily caused by the movement of tectonic plates beneath the Earth's surface, although they can also be triggered by volcanic activity, human-induced factors such as mining or reservoir-induced seismicity, and other geological processes. Understanding earthquakes is crucial for assessing and mitigating their impact on society, as well as for developing effective early warning systems to minimize casualties and damage. Through ongoing research and technological advancements, scientists strive to unravel the complexities of earthquakes and improve our ability to predict, detect, and respond to these powerful natural events.

2.2 Causes of Earthquakes

The causes of earthquakes are primarily attributed to the movement of tectonic plates, although they can also result from other geological processes and human activities. Here are the main causes of earthquakes:

1. Tectonic Activity: Earthquakes primarily result from the movement of tectonic plates. As these large, rigid plates of the Earth's lithosphere interact at their boundaries, they generate stress and strain on the surrounding rocks, leading to earthquakes. This movement occurs due to the convective currents in the Earth's mantle.

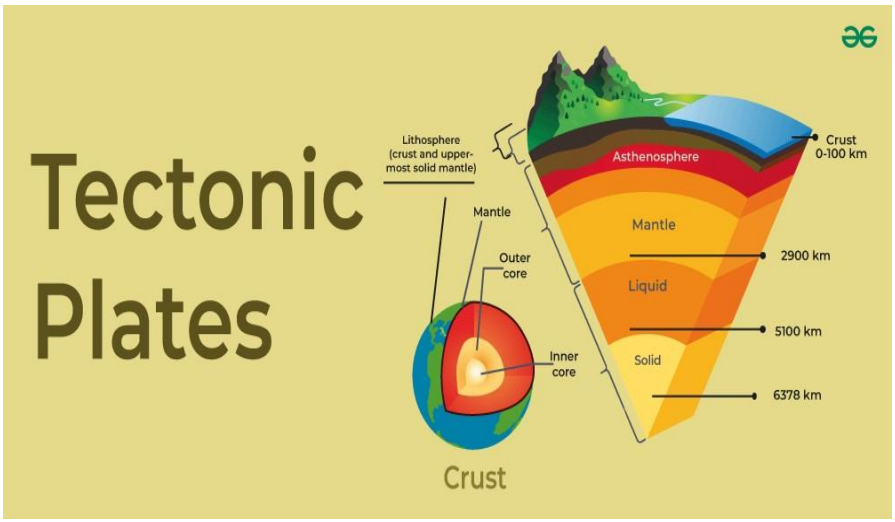


Fig 2.1: Tectonic Activity

2. Faulting: Earthquakes often occur along faults, which are fractures or zones of weakness in the Earth's crust. The movement of rocks along faults, caused by tectonic forces, results in the release of energy in the form of seismic waves.

Different types of faults, such as normal, reverse, and strike-slip faults, can produce earthquakes.

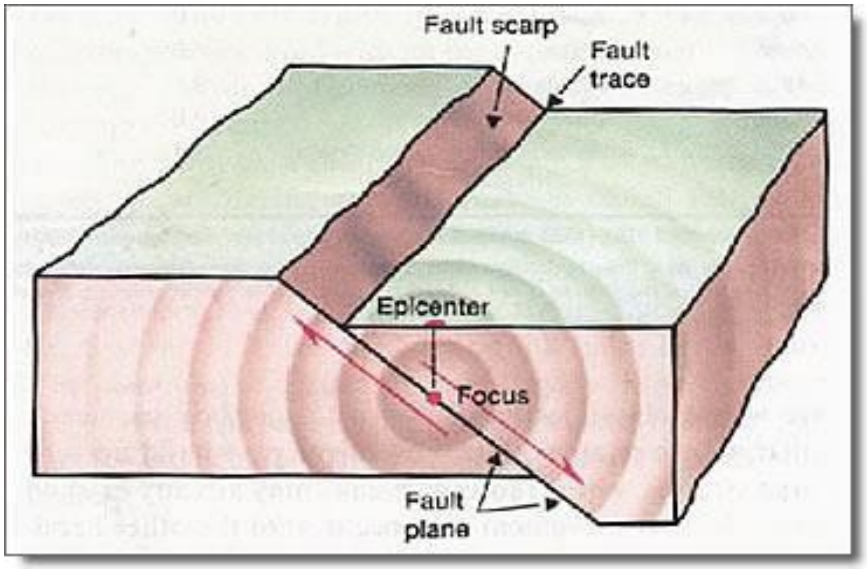


Fig 2.2: Fault line

3. Volcanic Activity: Earthquakes can be triggered by volcanic processes, particularly during the movement of magma beneath the Earth's surface. As magma rises and interacts with the surrounding rocks, it can cause fracturing and generate seismic activity. Additionally, volcanic eruptions can produce earthquakes due to the release of pressure within the volcano.

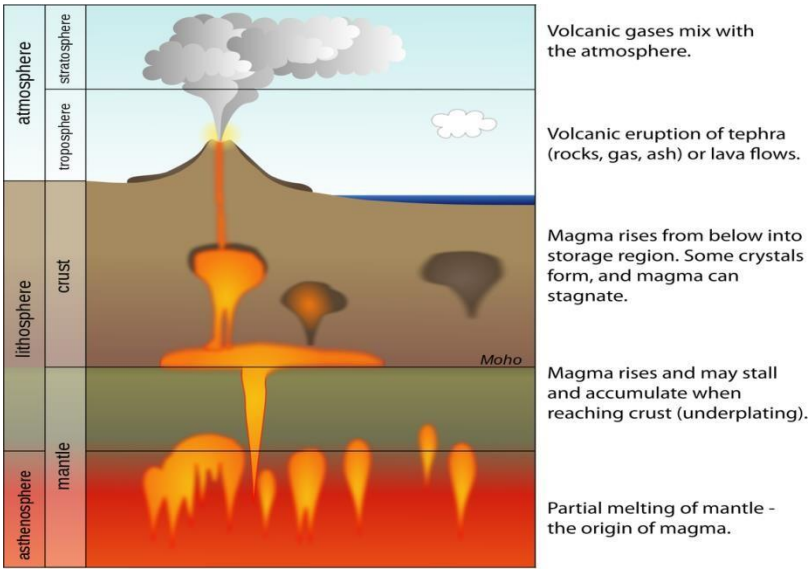


Fig 2.3: Volcanic Activity

4. Human-Induced Activity: Certain human activities, such as mining, reservoirinduced seismicity, and hydraulic fracturing, can induce earthquakes. These activities alter the stress distribution within the Earth's crust, leading to the activation of faults or the creation of new fractures. Overall, earthquakes are complex natural phenomena influenced by various factors, with tectonic activity being the primary cause. Understanding these causes is essential for assessing seismic hazards and implementing measures to mitigate the impact of earthquakes on society and the environment.

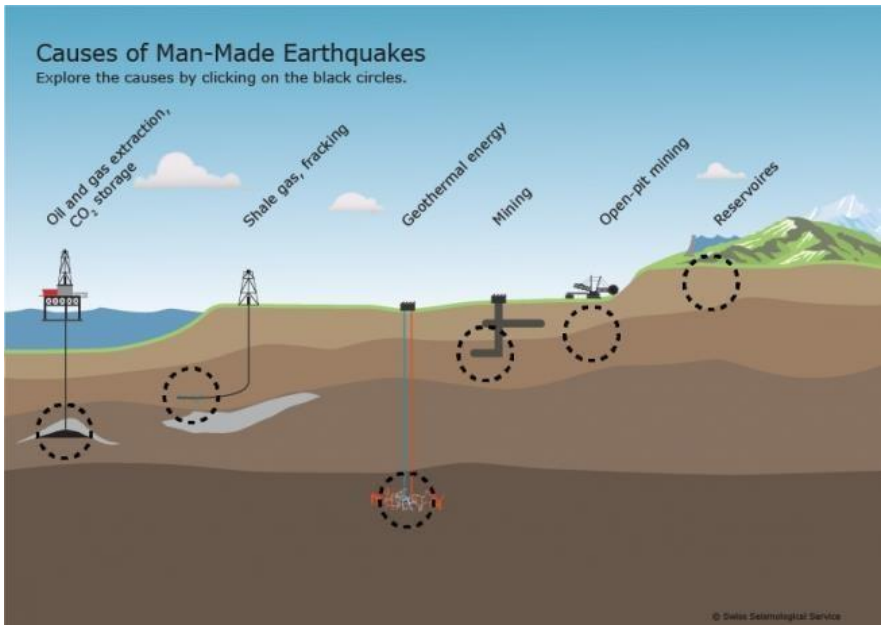


Fig 2.4: Human-Induced Activity

2.3 Effects of earthquakes on human lives and infrastructure

Earthquakes are natural disasters that can have devastating effects on human lives and infrastructure. The impacts of earthquakes vary depending on factors such as the magnitude of the quake, the depth of the epicenter, the proximity to populated areas, and the quality of construction. Here are some of the key effects:

1. Loss of Life and Injuries: Earthquakes can cause fatalities and injuries due to collapsing buildings, falling debris, and other hazards. The number of casualties can be significant, particularly in densely populated urban areas with inadequate building codes and infrastructure. Injuries can range from minor cuts and bruises to severe trauma requiring medical attention.
2. Structural Damage to Buildings: Buildings and other structures can suffer varying degrees of damage during earthquakes. Poorly constructed or older buildings are particularly vulnerable to collapse or significant structural damage. This can result in the loss of homes, workplaces, and community facilities, exacerbating the impact on affected populations.
3. Displacement and Homelessness: Earthquakes can force people to evacuate their homes due to safety concerns or the destruction of their dwellings. Displaced individuals may become homeless or seek temporary shelter in evacuation centers

or makeshift camps. The displacement of populations can strain resources and infrastructure, leading to challenges in providing essential services and support.

4. Disruption of Infrastructure: Earthquakes can disrupt critical infrastructure such as roads, bridges, airports, ports, water supply systems, and communication networks. Damage to infrastructure can hinder emergency response efforts, rescue operations, and the delivery of aid to affected areas. Restoration of infrastructure is essential for facilitating recovery and rebuilding efforts.
5. Economic Losses: The economic impact of earthquakes can be significant, with losses stemming from property damage, business interruptions, and decreased productivity. Reconstruction and recovery efforts require substantial financial resources and may take years to complete. The economic consequences can be particularly severe for developing countries with limited resources and resilience to withstand such shocks.
6. Psychological Trauma: Earthquakes can have lasting psychological effects on survivors, including trauma, anxiety, depression, and post-traumatic stress disorder (PTSD). Witnessing the destruction of homes, the loss of loved ones, and the uncertainty of the future can take a toll on mental well-being. Mental health support and counseling services are essential for addressing the emotional needs of affected individuals and communities.

2.4 Earthquakes Historical Documents

Throughout history, earthquakes have been documented in various historical documents, including chronicles, diaries, and official records. These accounts provide details about the timing, location, and intensity of seismic events, as well as their impact on buildings, infrastructure, and human lives.

1755 Lisbon Earthquake:

Striking on November 1, 1755, this earthquake had an estimated magnitude of 8.5 to 9.0 and caused widespread devastation in Lisbon, Portugal, and neighboring regions. The earthquake, followed by a tsunami and fires, resulted in tens of thousands of deaths and significant destruction. It sparked discussions on natural disasters, religion, and Enlightenment philosophy across Europe.

1811-1812 New Madrid Earthquakes:

A series of powerful earthquakes occurred near New Madrid, Missouri, United States, between December 1811 and February 1812. These earthquakes, estimated to have magnitudes ranging from 7.5 to 7.9, caused widespread damage across the central United States and were felt over a vast area, even causing the Mississippi River to flow backward temporarily.

1906 San Francisco Earthquake:

Striking on April 18, 1906, with an estimated magnitude of 7.8, this earthquake remains one of the most significant seismic events in U.S. history. The earthquake and subsequent fires destroyed much of San Francisco, causing extensive damage and loss of life. The disaster led to improvements in building codes, urban planning, and earthquake preparedness.

1960 Valdivia Earthquake:

Occurring on May 22, 1960, in Chile, the Valdivia Earthquake is the most powerful earthquake ever recorded, with a magnitude of 9.5. The earthquake triggered tsunamis that affected coastal areas across the Pacific Ocean, including Hawaii and Japan. The event highlighted the importance of understanding subduction zone earthquakes and their associated hazards.

2004 Indian Ocean Earthquake and Tsunami:

Striking on December 26, 2004, off the coast of Sumatra, Indonesia, this earthquake had a magnitude of 9.1 to 9.3 and generated devastating tsunamis that affected countries around the Indian Ocean. The disaster resulted in an estimated 230,000 to 280,000 deaths and highlighted the need for improved international coordination in early warning systems and disaster response.

2011 Tohoku Earthquake and Tsunami:

Occurring on March 11, 2011, off the coast of Japan, this earthquake had a magnitude of 9.0 and triggered a powerful tsunami that devastated coastal areas, including Fukushima Prefecture. The disaster led to nuclear meltdowns at the Fukushima Daiichi Nuclear Power Plant and highlighted the importance of preparedness, evacuation planning, and resilient infrastructure.

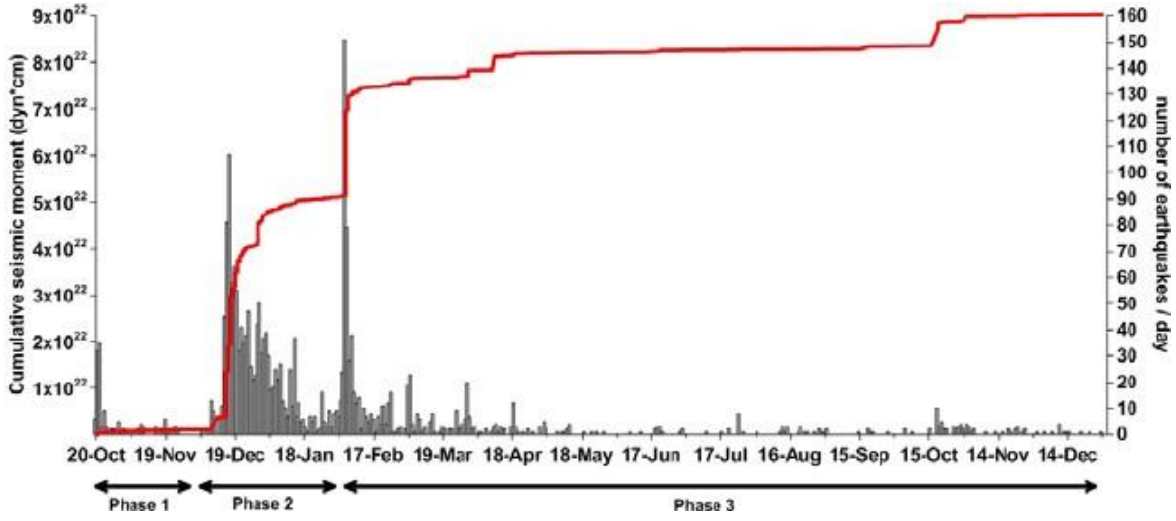


Fig 2.4: Cumulative Storage

2.5 Existing Detection Technologies

2.5.1 Overview of Current Earthquakes Detection Methods Seismometers and Seismic Networks:

Seismometers are the primary instruments used to detect and record seismic waves generated by earthquakes. These devices measure ground motion and vibrations caused by seismic activity. Seismometers are deployed individually or as part of a network of seismic stations strategically placed around the world. Seismic networks, such as the Global Seismographic Network (GSN) and regional networks operated by government

agencies or research institutions, continuously monitor seismic activity and provide realtime data on earthquakes.

- Advantages:
    - Highly sensitive to ground motion, capable of detecting a wide range of earthquake magnitudes.
    - Provide real-time data on seismic events, allowing for rapid earthquake detection and monitoring.
    - Can detect earthquakes even in remote or offshore regions.
- Limitations:
    - Expensive to deploy and maintain a network of seismometers, especially in sparsely populated or geographically challenging areas.
    - Susceptible to false alarms from non-seismic sources such as human activity or equipment malfunctions. ○Limited ability to provide detailed information about the location and depth of earthquakes, particularly for events occurring far from seismic stations.

Global Navigation Satellite Systems (GNSS):

GNSS, including the Global Positioning System (GPS), can detect ground movements associated with earthquakes. GNSS receivers track changes in the positions of satellites relative to fixed ground stations. By measuring displacements of GNSS stations before, during, and after an earthquake, scientists can estimate the deformation of the Earth's crust and infer information about fault movements.

- Advantages:
    - Provide precise measurements of ground displacements associated with earthquakes. ○Cover large geographic areas and can detect crustal deformations over time.
    - Complement seismic data by providing information on the long-term effects of tectonic activity.
- Limitations:
    - Limited spatial resolution compared to ground-based seismic sensors, especially in densely urbanized areas with tall buildings or dense vegetation.
    - Vulnerable to signal interference from atmospheric conditions, satellite orbits, and other factors.

Require a network of ground stations and careful data processing to accurately measure crustal movements.

InSAR (Interferometric Synthetic Aperture Radar):

InSAR is a remote sensing technique that uses satellite-based radar to measure ground deformation caused by earthquakes. By comparing radar images acquired before and after an earthquake, InSAR can detect surface displacements with high precision and map the extent of fault rupture.

- Advantages:
    - Provide high-resolution measurements of ground deformations with millimeter-level accuracy.
    - Can detect surface displacements over large areas, making them useful for mapping fault ruptures and assessing earthquake impacts.
    - Operate independently of weather conditions and can monitor ground movements day and night.

- Limitations:
    - Limited spatial coverage compared to GNSS, as satellite orbits and repeat intervals constrain the frequency of observations.
    - Relatively high cost and technical complexity associated with satellite missions and data processing.

Require stable ground surfaces and consistent radar returns for accurate measurements, limiting their effectiveness in vegetated or urban areas.

Accelerometers and Strong Motion Sensors:

Accelerometers are sensors that measure acceleration, including ground motion during earthquakes. These devices are commonly used in structural health monitoring systems to assess the dynamic response of buildings, bridges, and other infrastructure to seismic forces. Strong motion sensors are specialized accelerometers designed to measure strong ground motions during large earthquakes and are often deployed in earthquake-prone areas.

- Advantages:
    - Provide direct measurements of strong ground motions during earthquakes, critical for assessing structural performance and earthquake engineering. ○Can be deployed in dense arrays to capture spatial variations in ground shaking and characterize local seismic hazards.
    - Offer rapid response capabilities and real-time data transmission for emergency response and post-earthquake assessment.
- Limitations:
    - Limited to recording strong ground motions near the sensor locations, with coverage typically constrained to urban or infrastructure-rich areas.
    - Require careful calibration and maintenance to ensure accurate measurements, particularly for critical applications such as building code compliance.

Susceptible to damage or saturation during large earthquakes, limiting their effectiveness in extreme events.

Early Warning Systems (EWS):

Early warning systems use data from seismic sensors to detect the initial P-waves (primary waves) generated by earthquakes and issue alerts before the arrival of more damaging S-waves (secondary waves) and surface waves. These systems provide valuable seconds to minutes of advance warning, allowing people to take protective actions and mitigate the impact of earthquakes.

- Advantages:
    - Provide advance warning of earthquake shaking, allowing time for people to take protective actions and automated systems to initiate safety protocols.
    - Can be integrated with various communication channels, including mobile phones, sirens, and public alert systems, to reach a wide audience.
    - Help reduce casualties, minimize damage to infrastructure, and improve community resilience to earthquakes.
- Limitations:
    - Limited to regions with sufficient seismic sensor coverage and infrastructure to support timely warning dissemination.

- May produce false alarms or miss some earthquakes, especially for events near the detection threshold or occurring very close to populated areas.
- Require robust network infrastructure, reliable sensor data, and sophisticated algorithms for accurate and timely warning issuance.

Citizen Science Initiatives:

Citizen science projects engage the public in earthquake detection and monitoring efforts. Smartphone applications and online platforms allow users to contribute seismic data collected by their devices' accelerometers, expanding the coverage of seismic networks and enhancing earthquake research.

- Advantages:
  - Expand the coverage of earthquake monitoring networks by utilizing the ubiquity of smartphones and internet connectivity.
  - Engage the public in earthquake awareness, education, and preparedness efforts, fostering a sense of community resilience.
  - Provide valuable data for earthquake research, validation of existing detection methods, and development of new algorithms.
- Limitations:
  - Lack of standardized data collection protocols and quality control measures may introduce inconsistencies or errors in citizen-generated data.
  - Dependence on volunteer participation and user engagement, which can vary over time and across different regions.

Challenges in ensuring data privacy, security, and ethical considerations related to user consent and data ownership.

2.5.2 Case Studies of Successful Earthquake Detection and Alert Systems Around The World

1. Japan - Japan Meteorological Agency (JMA) Earthquake Early Warning (EEW) System:

The Japan Meteorological Agency operates one of the most advanced earthquake early warning systems in the world. It detects initial P-waves generated by earthquakes and issues warnings to areas likely to experience strong tremors from subsequent S-waves and surface waves.

The effectiveness of Japan's EEW system has been demonstrated in several earthquakes, including the 2011 Tohoku earthquake. Studies have shown that the early warning provided by the system has significantly reduced casualties and damage.

2. United States - ShakeAlert Earthquake Early Warning System:

ShakeAlert is a collaborative effort between the United States Geological Survey (USGS), universities, and state agencies to develop an earthquake early warning system for the West Coast of the United States.

The system has been operational in pilot phases in California since 2012. Studies have shown that ShakeAlert can provide seconds to minutes of advance warning, allowing people to take protective actions.

3. Mexico - Sistema de AlertaSísmicaMexicano (SASMEX):

SASMEX is Mexico's earthquake early warning system, operated by the Centro de Instrumentación y RegistroSísmico (CIRES) and the National Seismological Service (SSN).

SASMEX has successfully provided timely warnings to Mexico City during significant earthquakes, such as the 2017 Puebla earthquake. Research has shown that the system can effectively reduce casualties and damage by providing advance warning.

4. Turkey - Istanbul Earthquake Early Warning and Rapid Response System (IERWS):

Turkey's Istanbul Earthquake Early Warning and Rapid Response System (IERWS) is designed to improve earthquake preparedness and response in Istanbul, a megacity vulnerable to seismic hazards.

The system integrates real-time data from seismic and geodetic sensors to detect earthquakes and issue alerts to emergency responders and the public. Studies have shown that early warning systems like IERWS can contribute to saving lives and reducing the impact of earthquakes.

2.6 Conclusion

In conclusion, earthquakes represent complex natural phenomena that pose significant hazards to human populations, infrastructure, and the environment. Understanding the mechanisms and characteristics of earthquakes is crucial for assessing seismic risks, implementing effective mitigation measures, and improving community resilience. Through the integration of various detection technologies, including seismometers, GNSS, InSAR, accelerometers, early warning systems, and citizen science initiatives, scientists and authorities can monitor seismic activity, detect earthquakes in real-time, and provide timely warnings to minimize the impact of seismic events. While existing detection systems have made significant advancements in earthquake monitoring and early warning capabilities, ongoing research, technological innovation, and international collaboration are essential for further enhancing earthquake detection, preparedness, and response efforts. By leveraging the collective expertise and resources of the global scientific community, we can continue to advance our understanding of earthquakes and develop more effective strategies to mitigate their effects on society.

CHAPTER 3

POJECT BACKGROUND

3.1 Introduction

Earthquakes pose a significant threat to communities worldwide, emphasizing the need for effective detection and alert systems. This project aims to develop a modern earthquake detection and alert system utilizing sensor technology, data analytics, and communication networks. By providing rapid alerts, the system aims to minimize the impact of earthquakes on life and infrastructure, contributing to enhanced disaster preparedness and resilience in at-risk areas.

3.2 Internet of Things-Concept and Definition

Internet of Things(IoT) [4], [5]consists of two words-Internet and Things, The term "Things" in loT refers to various loT devices having unique identities and having capabilities to perform remote sensing, actuating, and live to monitor certain sorts of data.

IoT devices are also enabled to have a live exchange of data with other connected devices and applications either directly or indirectly, or collect data from other devices and process the data and send the data to various servers, The other term "Internet" is defined as Global Communication network connecting millions of computers across the planet enabling sharing of information. As forecasted by various researchers, 50 billion devices based on loT would be connected all across the planet by the year 2020.

The Internet of Things (IoT) has been defined as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual “Things" have identities, physical attributes, and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information. network, often communicate data associated wíth users and their environments", An ideal IoT device consists of various interfaces for making connectivity to other devices which can either be wired or wireless.

Any loT based device consists of the following components; I/O interface for Sensors, Interface for connecting to the Internet, Interface for Memory and Storage, and Interface for Audio/Video, IoT devices can be of various forms like wearable sensors, smart watches, IoT smart home monitoring, IoT intelligent transport systems, IoT smart health devices etc.

3.3 loT Enabling Technologies

Internet of Things has a strong backbone of various enabling technologies- Wireless Sensor Networks, Cloud Computing, Big Data, Embedded Systems, Security Protocols and Architectures, Protocols enabling communication, web services, Internet and Search Engines[5], [9]. Wireless Sensor Network (WSN): It consists of various sensors/nodes which are integrated to monitor various sorts of data,

Cloud Computing: Cloud Computing, also known as on-demand computing, is a type of Internet-based computing that provides shared processing resources and data to computers and other devices on demand.

It is a sort of computer system which consists of both hardware and software to perform specific tasks. It includes a microprocessor/microcontroller, RAM/ROM, networking components, 1/O units, and storage devices.

3.4 Required Equipment

3.4.1 Arduino Uno

The Arduino Uno is a versatile microcontroller board that serves as an excellent introduction to the world of electronics and programming. It features the Atmega328P microcontroller at its core, providing a wide range of digital and analog input/output pins for interfacing with sensors, actuators, and other electronic components. One of its key features is its simplicity and ease of use, making it ideal for beginners and hobbyists. The Uno can be programmed using the Arduino Integrated Development Environment (IDE), which offers a user-friendly interface for writing, compiling, and uploading code to the board. Additionally, the Uno includes built-in USB connectivity, allowing it to be easily connected to a computer for programming and power supply. This eliminates the need for external power sources and specialized programming hardware, simplifying the development process. The Arduino Uno is highly versatile and can be used in a wide range of projects, including home automation, robotics, interactive art installations, and more. Its affordability, accessibility, and extensive community support make it one of the most popular choices for electronics enthusiasts of all skill levels.

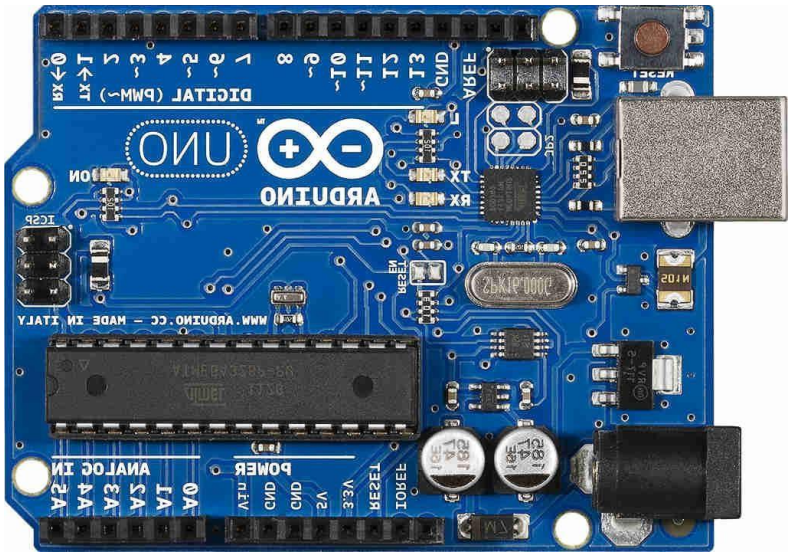


Fig 3.1 Arduino Uno

3.4.2. Vibration Sensor Module

The vibration sensor module is a versatile is a compact electronic device designed to detect and measure vibrations in its surrounding environment. It typically consists of a sensitive vibration sensor, such as a piezoelectric element or accelerometer, along with supporting circuitry for signal conditioning and amplification. These modules are commonly used in various applications, including structural health monitoring, machine condition monitoring, and security systems. When subjected to vibrations, the sensor generates electrical signals proportional to the intensity and frequency of the vibrations. These signals are then processed by the module's circuitry to provide useful output, such as digital or analog signals, that can be interfaced with microcontrollers, data loggers, or other electronic devices. One of the key advantages of vibration sensor modules is their

ability to detect subtle vibrations that may indicate changes in the condition of machinery, structures, or equipment. By monitoring these vibrations over time, users can identify potential issues such as excessive wear, misalignment, or mechanical faults, allowing for timely maintenance or intervention to prevent costly damage or downtime. Vibration sensor modules come in various form factors and sensitivity ranges to suit different applications and environments. They are often integrated into larger systems or networks for real-time monitoring and analysis, contributing to improved safety, reliability, and efficiency across a wide range of industries and applications.

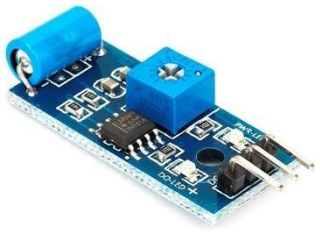


Fig 3.2 Vibration Sensor Module

3.4.3. SIM800L GSM Module

The SIM800L GSM Module is a compact and versatile communication device tailored for integrating GSM/GPRS capabilities into a wide array of electronic projects. With its small form factor and minimal power requirements, it proves to be an optimal solution for applications necessitating cellular connectivity in scenarios such as remote monitoring, tracking, and IoT implementations. Key attributes of the SIM800L module encompass its support for GSM quad-band frequencies, facilitating seamless communication across global cellular networks. Equipped with a SIM card slot, it effortlessly interfaces with standard GSM SIM cards to enable network access for data transmission and reception. Communication with the module is typically established through a UART interface, ensuring compatibility with a plethora of microcontrollers and development platforms like Arduino and Raspberry Pi. Moreover, its integrated TCP/IP stack empowers data transmission over the Internet via GPRS, while GPIO pins facilitate interaction with external sensors and peripherals. By leveraging an AT command interface for control and configuration, the module offers straightforward integration and customization of communication parameters. In summary, the SIM800L GSM Module stands as a dependable and cost-efficient solution for imbuing projects with cellular connectivity, catering to the needs of hobbyists, developers, and engineers seeking seamless wireless communication capabilities.



Fig 3.3 SIM800L GSM Module

3.4.4 Battery Charging Circuit

A battery charging circuit serves as the backbone for efficiently managing the replenishment of energy in rechargeable batteries or power storage systems within electronic devices. This essential component orchestrates the intricate dance of electrical currents and voltages, ensuring the safe and optimal charging of batteries. Comprising key elements like a power input port for connecting external power sources and a charging controller responsible for regulating the flow of current and voltage to the battery, it oversees the entire charging process. Voltage and current regulation circuitry within the system maintains safe charging parameters, preventing overvoltage, overcurrent, and overheating issues that could compromise battery health and safety. Additionally, charging circuits often incorporate indicators, such as LEDs or displays, to provide users with real-time feedback on the charging status. These indicators inform users about the progress of the charging cycle, alerting them when the battery is fully charged or if any issues arise during the process. Equipped with safety features like shortcircuit protection and thermal safeguards, a well-designed charging circuit ensures not only the longevity and performance of rechargeable batteries but also the overall safety and reliability of electronic devices.

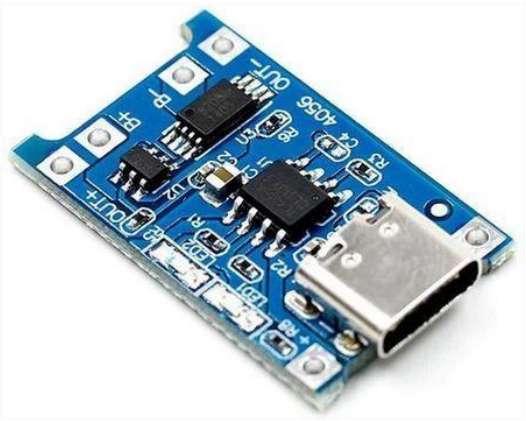


Fig 3.4 Battery Charging Circuit

3.4.5 16x2 LCD Display

The 16x2 LCD display is a versatile alphanumeric display module widely used in electronic projects for its simplicity and effectiveness in presenting information. With its characteristic layout of 16 columns and 2 rows, it offers a total of 32 characters for displaying text, numbers, symbols, and other alphanumeric characters. Equipped with an integrated LED backlight, it ensures easy readability in various lighting conditions, while its parallel interface facilitates straightforward communication with microcontrollers like Arduino or Raspberry Pi. A built-in potentiometer allows for easy adjustment of contrast, optimizing readability based on environmental factors. Renowned for its low power consumption, the 16x2 LCD display is ideal for battery-powered devices and finds application in diverse projects such as digital clocks, thermometers, and user interfaces. Its affordability, ease of integration, and compatibility make it a popular choice among hobbyists and professionals seeking a reliable means of displaying information in their electronic creations.



Fig 3.5 16x2 LCD display

3.4.6 LM2596 DC-DC Buck Converter Step Down Module

The LM2596 DC-DC Buck Converter Step Down Module stands as a pivotal component in countless electronic setups, offering efficient voltage regulation capabilities. Employing the LM2596 integrated circuit, this module adeptly steps down higher input voltages to lower output voltages with remarkable precision. Its versatility shines through with a wide input voltage range, typically spanning from 4.5V to 40V, accommodating diverse power sources like batteries, DC supplies, and solar panels. Users can effortlessly tailor the output voltage to their specific requirements using the onboard potentiometer, ensuring precise regulation for the connected load. Efficiency is a hallmark feature, as the LM2596 circuit minimizes power loss, ideal for energy-sensitive applications such as battery-powered devices. Furthermore, with output currents ranging from modest to substantial, the module finds utility across a spectrum of electronic devices and circuits. Equipped with built-in safeguards like overcurrent protection and thermal shutdown, it enhances operational reliability and safety. Compact in design, the module seamlessly integrates into space-constrained projects, offering a reliable and cost-effective solution for voltage regulation needs. In essence, the LM2596 DC-DC Buck Converter Step Down Module embodies efficiency, versatility, and reliability, earning its place as a cornerstone component in electronic systems and power supply designs.



Fig 3.6 LM2596 DC-DC Buck Converter Step Down Module.

3.4.7 Mini Buzzer

A mini buzzer is a compact electromechanical device designed to produce audible sound signals when an electric current passes through it. It consists of a piezoelectric element, typically made from materials like ceramic or crystal, encased in a plastic housing. When an electrical voltage is applied to the buzzer, the piezoelectric element undergoes rapid mechanical deformation, causing it to vibrate at a specific frequency. These vibrations generate sound waves in the surrounding air, producing the characteristic buzzing or beeping sound associated with buzzers. Mini buzzers are commonly used in electronic circuits and devices for various purposes, including alerting users to events or conditions, indicating errors or warnings, and providing feedback in interactive systems. They are often employed in small-scale electronic projects, prototyping, and hobbyist applications due to their compact size, simplicity, and ease of integration. Despite their small size, mini buzzers can produce sound output with sufficient volume to be heard in noisy environments, making them suitable for a wide range of applications, such as alarm systems, timers, doorbells, and electronic games. Mini buzzers are available in different configurations, including passive and active types. Passive buzzers require an external oscillating signal to produce sound, while active buzzers feature an integrated oscillator circuit and can generate sound with a simple DC voltage input. Overall, mini buzzers are versatile, cost-effective components that play a vital role in providing auditory feedback and alerts in electronic systems and devices.



Fig 3.7 Mini Buzzer

3.4.8 Jumper Wire

Jumper wires are fundamental components in electronics projects, acting as flexible connectors to establish electrical connections between different points on a breadboard or circuit board. Typically consisting of a thin wire encased in insulation, jumper wires come in various lengths and colors, allowing for customization and organization within a circuit. Their primary function is to bridge gaps between components, such as integrated circuits, resistors, and sensors, without the need for soldering. This versatility makes them invaluable for rapid prototyping, experimentation, and troubleshooting in electronics projects, as they facilitate quick changes and adjustments to circuit configurations. Jumper wires are essential tools for both beginners and experienced electronics enthusiasts, enabling the construction of circuits with ease and flexibility. They play a crucial role in learning electronics principles, testing circuit designs, and bringing ideas to life in a practical and tangible way. Overall, jumper wires are indispensable components in any electronics toolkit, offering simplicity, versatility, and efficiency in circuit construction and experimentation.



Fig 3.8 Jumper Wire

3.4.9 3.7V Battery

3.7-volt battery is a compact, rectangular-shaped power source commonly used in a variety of electronic devices and applications. It typically consists of six cylindrical or rectangular cells connected in series within a single housing. These batteries are widely recognized for their nominal voltage of 3.7 volts, which makes them suitable for powering devices requiring higher voltage levels than standard AA or AAA batteries. The cells within the battery are typically composed of zinc-carbon, alkaline, or lithium chemistry, each offering different performance characteristics in terms of capacity, discharge rate, and shelf life. 3.7-volt batteries feature a standard snap-style connector or terminals that allow for easy installation and replacement in compatible devices. They are commonly used in smoke detectors, portable radios, electronic toys, guitar effects pedals, and various other consumer electronics. One notable feature of 3.7-volt batteries is their relatively compact size compared to the voltage they provide, making them convenient for use in compact and portable devices. However, due to their higher voltage and lower capacity compared to other battery types, they may not be as suitable for high-current applications or devices requiring extended runtime. Overall, 3.7-volt batteries are

versatile and widely available power sources, offering a convenient solution for powering a wide range of electronic devices and equipment.



Fig 3.9 3.7V Battery

3.4.10 Battery Case Holder

A battery case holder is a practical accessory designed to securely store and organize batteries for various devices. Constructed from durable materials like plastic or metal, these cases offer sturdy protection against impacts and environmental factors. They come in different sizes and configurations to accommodate various battery types, from standard AA, AAA, C, and D cells to rechargeable lithium-ion batteries like 18650 cells. With features like individual compartments, snap-on lids, and carrying handles, battery case holders ensure batteries stay organized, protected, and readily accessible when needed. Whether at home, on the go, or during travel, a battery case holder provides a convenient solution for keeping your power sources organized and ready for use.



Fig 3.10 Battery Case Holder

3.4.11 Vero Board

A vero board, also known as a stripboard or perfboard, serves as a fundamental tool in electronics prototyping, providing a platform for constructing and testing circuits without the need for custom PCB fabrication. These boards feature a grid of holes arranged in rows and columns, complemented by copper strips running horizontally along one side of each row. These strips facilitate electrical connections, enabling components to be soldered onto the board and interconnected using wire bridges. Vero boards offer versatility, accommodating a wide array of electronic components, from resistors to integrated circuits, making them suitable for prototyping various circuit designs. Their customizability allows users to tailor the board to their specific circuit layouts by cutting traces and adding wire bridges as needed, fostering rapid iteration and experimentation. With durability ensured by materials like fiberglass or phenolic resin, vero boards withstand heat and moisture, ensuring reliable performance even in challenging conditions. Cost-effective and accessible, these boards are widely available and require only basic soldering skills to assemble circuits, making them invaluable to hobbyists, students, and professionals alike for bringing electronic projects to fruition.

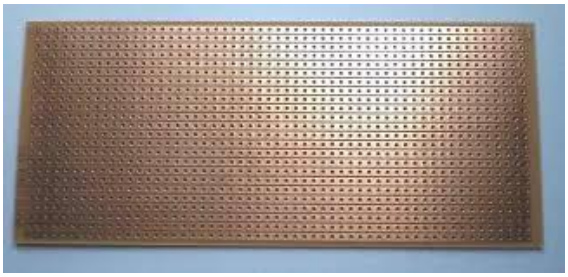


Fig 3.11 Vero Board

3.5 Conclusion

This chapter describes the different types of equipment used in this project with their proper figure. Also discussed the literature survey of this project . Finally, we can say that from this chapter, the using equipment of this project is reliable, cheap, easily available in any place. If we want, we can add more equipment to get extra benefit.

CHAPTER 4

HARDWARE IMPLEMENTATION OF THE PROPOSED PROJECT

4.1 Introduction

In response to the urgent need for effective earthquake detection and early warning systems, this project presents a hardware implementation aimed at providing timely alerts to at-risk communities. Leveraging advanced sensor networks and signal processing techniques, our system aims to accurately detect seismic activity and disseminate alerts swiftly. By combining engineering expertise with principles from geophysics and computer science, we strive to develop a robust framework for enhancing community resilience to earthquakes. This report outlines the key objectives, design considerations, and potential impact of our hardware implementation.

4.2 Working Process

The Arduino Uno is connected to a vibration sensor, a 16x2 LCD display, a sim module with a sim card, a mini buzzer and the whole thing is powered by 2 3.7v batteries which is held by a battery holder case.

When the earthquake happens the vibration sensor detects that and the mini buzzer alerts everyone with an alarm, the LCD display gives the message “Evacuate the building” to tell everyone to leave the building, the sim module sends a message “Emergency Alert: Earthquake detected at [location]. Please dispatch fire services.” to the nearest fire service which is provided before and the fire service rushes to the spot.

4.3 Block Diagram of The Proposed Project

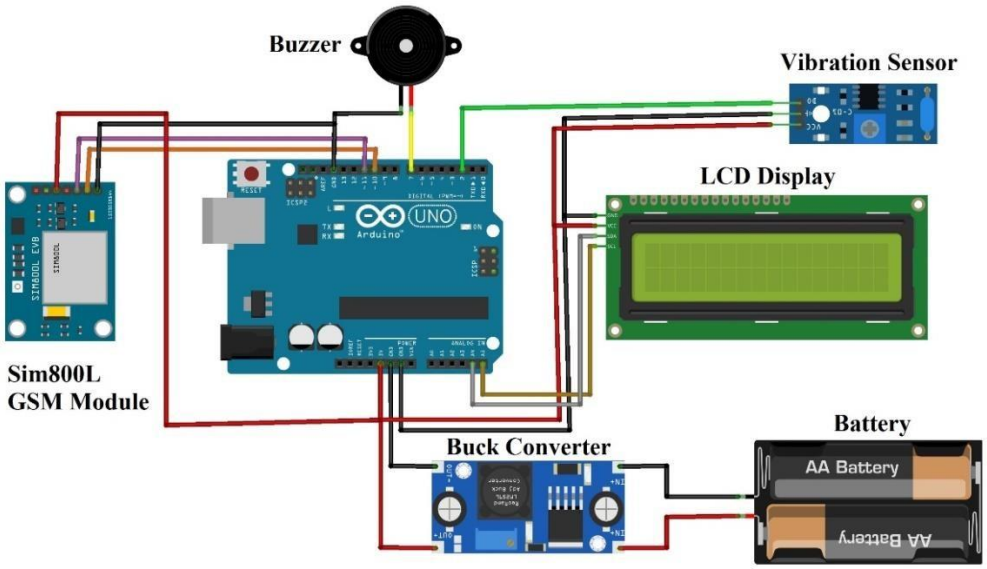


Fig 4.1 Block diagram of the proposed project.

4.4 Flow Chart of The Proposed Project

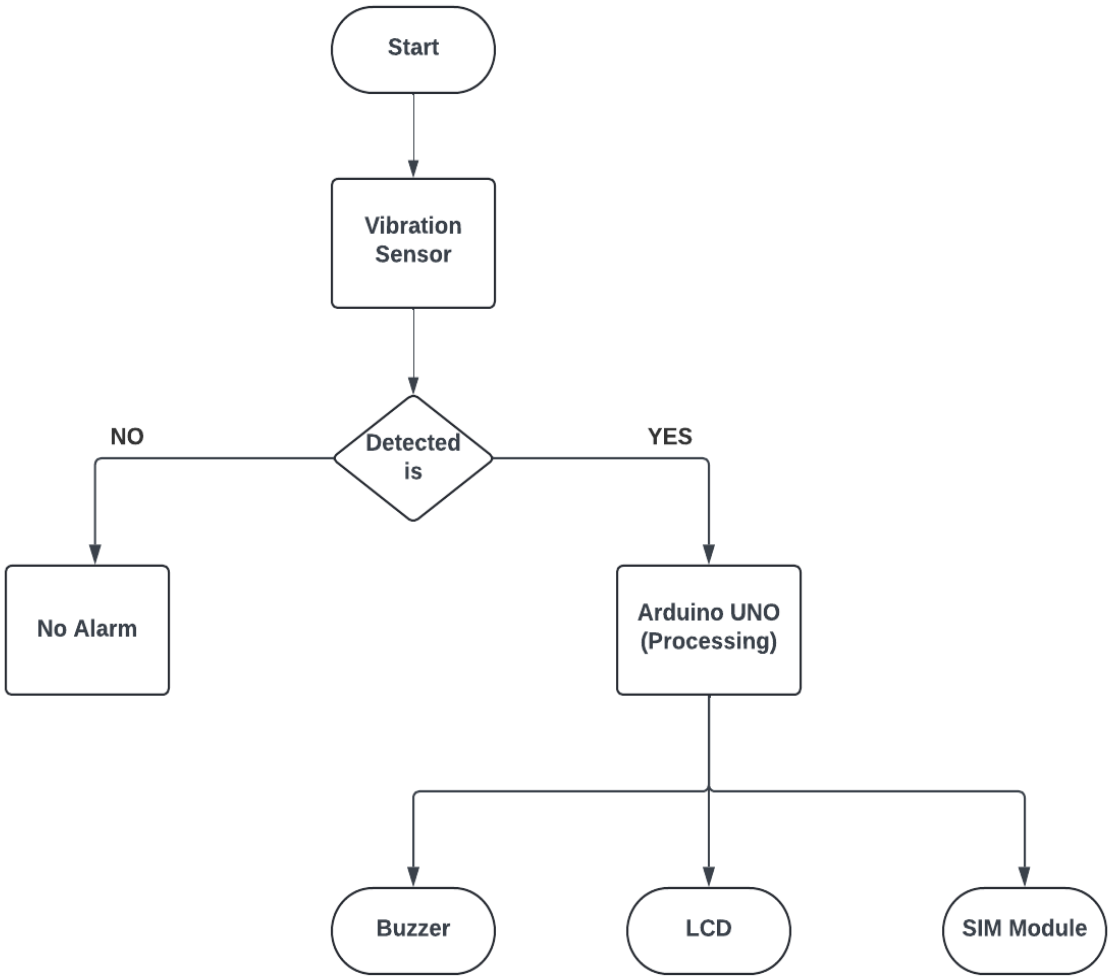


Fig 4.2 Working Flowchart of Earthquake Detection and Alert System

4.5 Final View of The Project

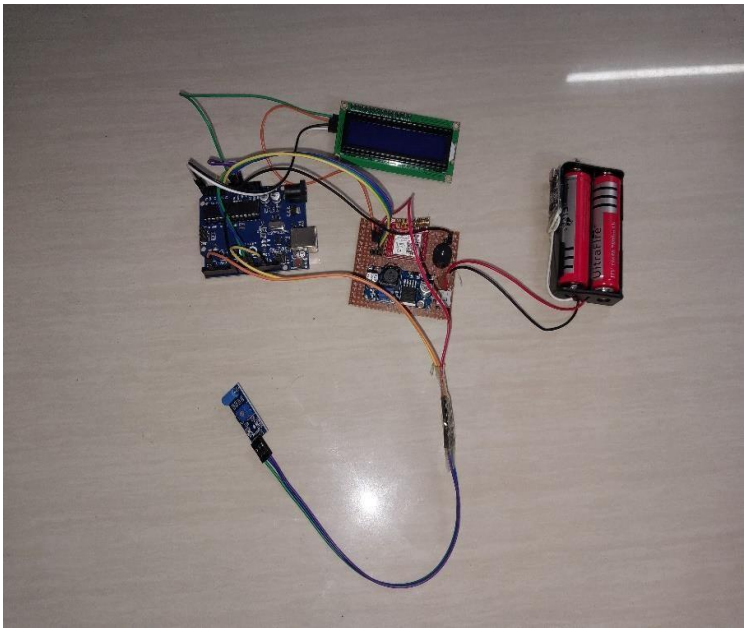


Fig 4.3 Final project view top

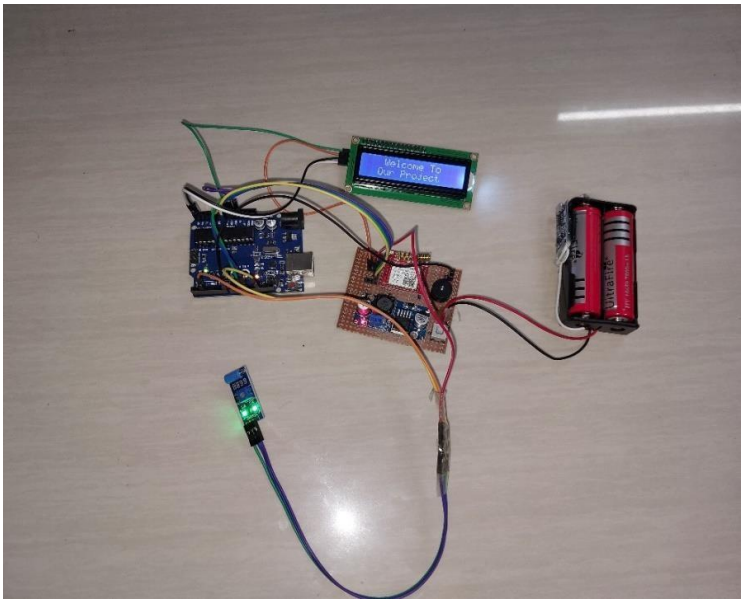


Fig 4.4 Final view of the project turned on

4.6 Mobile Message View

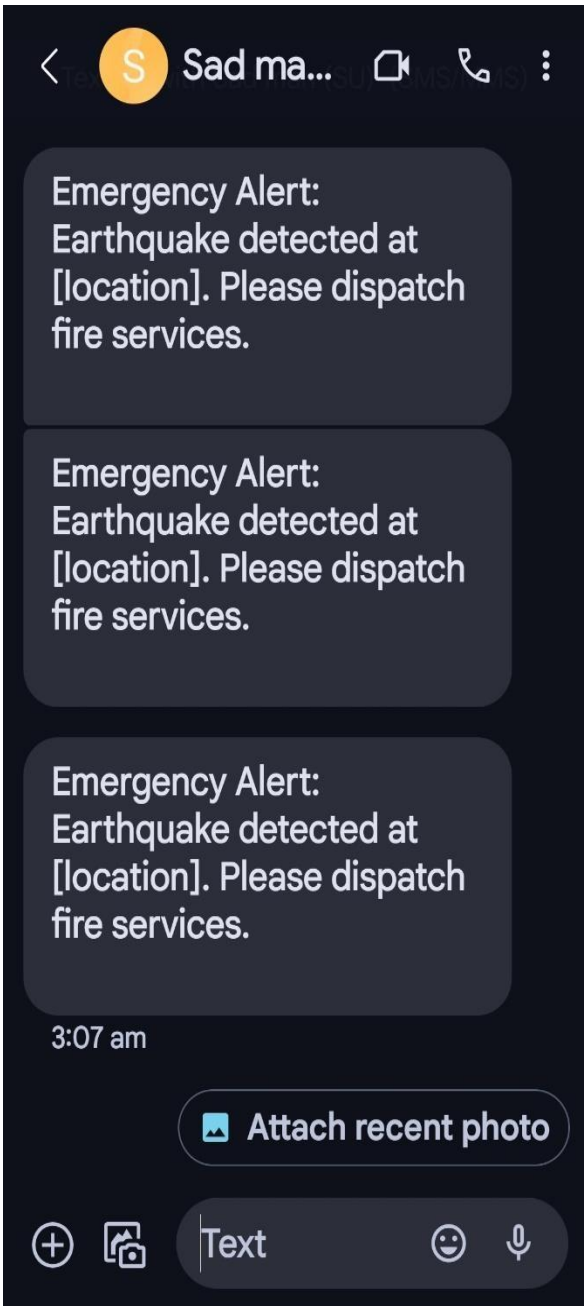


Fig 4.5 Mobile Message View

CHAPTER 5
TEST AND RESULT

5.1 Project Testing

When an earthquake happens the vibration sensor of our system detects that and gives a signal. With that signal the mini buzzer sounds an alarm and the LCD screen shows a message to guide residents to safety. Also the sim module sends a message to the service number which is provided before and the whole system is powered by 2 3.7V batteries. The batteries are held by a battery case holder. Which has a charging module. With that we can charge the battery. The DC-DC buck converter maintains the voltage.

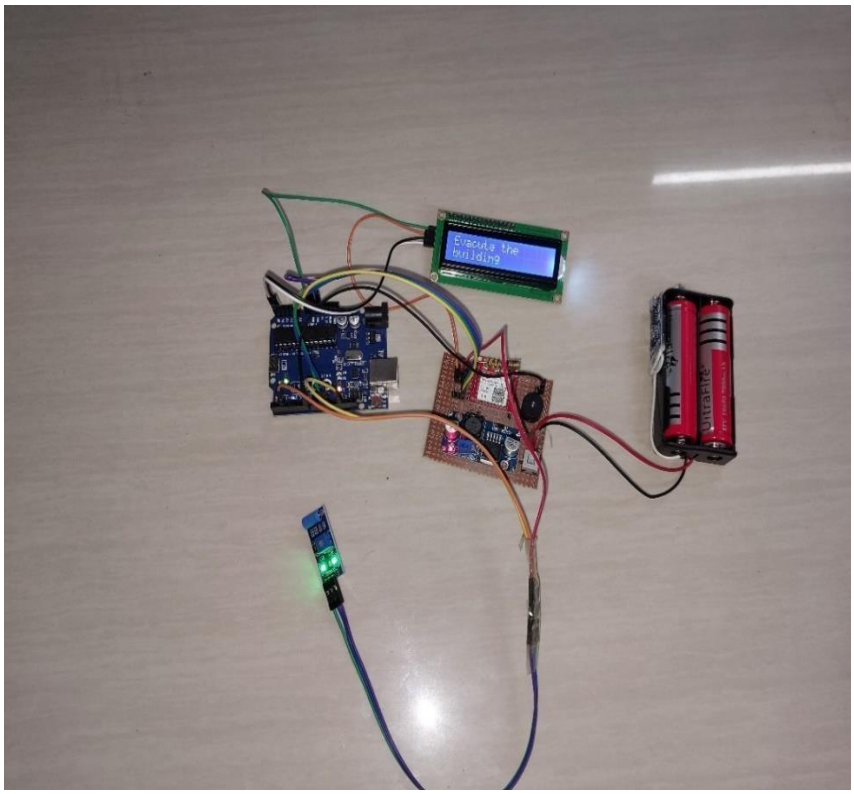


Fig 5.1 Earthquake Detected

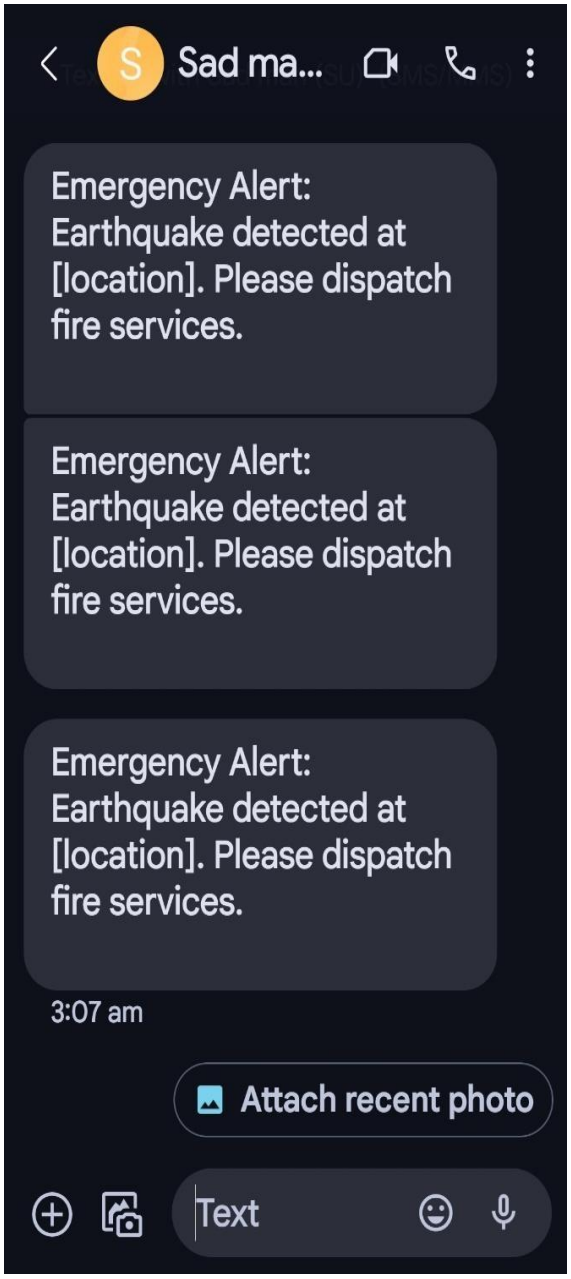


Fig 5.2 Alert Message Received

CHAPTER 6
CONCLUSION AND FUTURE WORKS

6.1 Conclusion

In conclusion, the development of an earthquake detection and alert system holds significant promise in mitigating the devastating impact of seismic events. Through innovative sensor technology, real-time data processing, and advanced algorithms, such a system can provide timely warnings to individuals and communities, allowing for prompt evacuation and preparation, thereby saving lives and minimizing damage. However, it's crucial to acknowledge the ongoing challenges in achieving widespread implementation, including infrastructure limitations and cost considerations. Nonetheless, continued research, collaboration, and investment in earthquake detection technology offer a pathway towards creating safer and more resilient societies in earthquake-prone regions.

6.2 Future Works

Issues to be addressed in future earthquake detecting include more systematic efforts to increase range, as well as improved quality of the hardware to detect the earthquake in a short time and take necessary steps.

- Improved Sensor Technology.
- Enhanced Data Analysis Algorithms.
- Integration with Advanced Technologies.
- Real-Time Monitoring and Response.
- Network Expansion and Optimization.
- Community Engagement and Education.
- Cross-Border Collaboration.
- Resilience Planning Integration.
- Validation and Testing.
- Predictive Modelling.

6.3Limitations

- **False Positives and False Negatives:** One of the primary limitations of any earthquake detection system is the occurrence of false positives (incorrectly identifying an earthquake when none has occurred) and false negatives (failing to detect an actual earthquake). These errors can lead to unnecessary panic or missed warnings, respectively.
- **Detection Thresholds:** The sensitivity of the detection system may vary based on factors such as sensor placement, environmental conditions, and the magnitude of the seismic event. Setting the detection thresholds too low may result in an increased likelihood of false alarms, while setting them too high may lead to missed detections.
- **Limited Coverage:** The effectiveness of the system relies heavily on the distribution and density of seismic sensors. In areas with sparse sensor coverage, detection capabilities may be limited, potentially delaying or preventing timely alerts.

- **Communication Latency:** The speed at which alerts are transmitted to end-users depends on the efficiency of communication networks. Delays in data transmission or processing can hinder the system's ability to provide timely warnings, reducing its overall effectiveness.
- **Dependency on Infrastructure:** Earthquake detection and alert systems rely on various infrastructure components, including power sources, communication networks, and data processing centers. Disruptions to any of these components due to natural disasters, technical failures, or malicious attacks could compromise the system's reliability.
- **Cost and Maintenance:** Building and maintaining a robust earthquake detection and alert system can be costly. Expenses associated with sensor deployment, data processing, and infrastructure maintenance may pose challenges, particularly in resource-constrained regions.
- **Limited Warning Time:** While early warning systems can provide valuable seconds to minutes of advance notice before the arrival of seismic waves, the warning time may be insufficient for individuals to take meaningful actions, especially in the case of rapidly developing earthquakes.
- **Effectiveness of Alert Dissemination:** The effectiveness of alert dissemination relies on the availability of reliable communication channels and the public's awareness of and response to earthquake alerts. Inadequate dissemination mechanisms or public complacency could undermine the system's ability to mitigate the impact of seismic events.
- **Geographical and Geological Variability:** Earthquake characteristics can vary significantly based on geographical and geological factors, including fault types, soil conditions, and tectonic settings. Designing a one-size-fits-all detection and alert system that accommodates these variations can be challenging.
- **Regulatory and Ethical Considerations:** Compliance with regulatory standards and ethical guidelines, particularly concerning privacy anddatasecurity, may impose constraints on the design and implementation of the earthquake detection and alert system.

REFERENCES

[1] Turcotte, D.L. and Schubert, G., 2002. Geodynamics (2nd ed.). Cambridge University Press.

[2] Bolt, B.A., 1993. Earthquakes and Geological Discovery. Scientific American Library.

[3] Tilling, R.I., 2018. Volcanoes. US Geological Survey.

[4] Ellsworth, W.L., 2013. Injection-induced earthquakes. Science, 341(6142), pp.1225942.

[5] Ashford, S. A. (2004). Water Supply Systems in Seismic Regions: The Effects of Earthquakes on Water Supply Systems. Natural Hazards Review, 5(4), 169178.

[6] Okuyama, Y., & Santos, J. R. (2014). Macro-Economic Impact of Earthquakes on the Economy. Natural Hazards Review, 15(1), 04013002.

[7] Norris, F. H., Friedman, M. J., & Watson, P. J. (2002). 60,000 disaster victims speak: Part II. Summary and implications of the disaster mental health research. Psychiatry: Interpersonal and Biological Processes, 65(3), 240-260.

[8] Sozen, M. A., &Scawthorn, C. (2004). Earthquake Engineering: From Engineering Seismology to Performance-Based Engineering. CRC Press.

[9] Spence, R., So, E., Scawthorn, C., &Zobeck, T. M. (2007). Human casualties in earthquakes: the development of a time- and space-dependent model. Natural Hazards, 41(2), 707-725.

[10] (Kusky, T. M. (2014). Encyclopedia of Earthquakes and Volcanoes. Infobase Publishing.)

[11] (Oliver-Smith, A. (Ed.). (2013). The Social Impacts of Earthquakes: A Case Study from Turkey's Eastern Provinces. Routledge.)

[12] (National Research Council. (2012). Disaster Resilience: A National Imperative. National Academies Press.)

[13] (United Nations Development Programme. (2016). Nepal Earthquake 2015: Post-Disaster Needs Assessment. UNDP Nepal.)

[14] (Allen, R. M., &Kanamori, H. (2003). The potential for earthquake early warning in southern California. Science, 300(5620), 786-789.)