MICROCONTROLLER-BASED EARTHQUAKE ALARM SYSTEM IN SAMUEL CHRISTIAN COLLEGE

Written By ***Nicole Belardo*, John Cedric Felas**, Vleir Ivan Jeverson Macawili***, John Russel Villon****, Chriz John Regie Sansait***** & Engr. Jacy Abug*********

** Graduate of STEM Strand, Samuel Christian College, General Trias City, Cavite*

*** Graduate of STEM Strand, Samuel Christian College, General Trias City, Cavite*

**** Graduate of STEM Strand, Samuel Christian College, General Trias City, Cavite*

***** Graduate of STEM Strand, Samuel Christian College, General Trias City, Cavite*

****** Associate Professor 1/Assistant Department Head, Samuel Christian College, General Trias City, Cavite*

*******Instructor 2, Samuel Christian College*

ABSTRACT

Earthquake is one of the most devastating natural calamities which causes sudden shaking of the earth surface. Earthquake Alarm System was inspired to ensure the safety of the student within the school premises. The study was conducted from January 2020 to February 2020. It claimed to develop a microcontroller-based earthquake alarm system using Arduino UNO and ADXL 335 Accelerometer sensor. Specifically, the study aimed to develop an earthquake alarm system in Samuel Christian College, test and evaluate the device in terms of sensitivity and its accuracy and its strategic location for the implementation of the device.

The data gathered from DOST – PHIVOLCS Earthquake Simulator was programmed to Arduino UNO to determine the magnitude of the shaking of earthquake's surface and can detect magnitude four to magnitude seven.

The prototype is designed to alert the students and employees using GSM and a Siren system. This aimed to create a response system in times of earthquake disturbances through siren.

Based on the data gathered through various of testing and trials, the device gave consistent response rate. Using One-Way Analysis of Variance (ANOVA), it was proven that there is no significant difference between the response and response rate of the device.

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

INTRODUCTION

An earthquake consists of vibrations to the Earth's surface that follow a release of energy in the Earth's crust. The vibration is called seismic waves it travel outward from the source of the earthquake along the surface and through the earth at different velocities depending on the materials that they move through (Pakiser & Shedlock, 2016).

There are several, different kinds of seismic waves, and these move in different ways. The two main types of waves are body waves and surface waves. Body waves can travel through the earth's inner layers, but surface waves can only move along the surface of the planet like ripples on water. Earthquakes radiate seismic energy as both body and surface waves.

Earthquakes strike suddenly without a warning. Nevertheless, if your local schools are in a region at risk for earthquakes, there are things that can be done to reduce the chances of injury, damaged of school properties and risk of the students and its employees. (Fema, 2018)

Earthquake causes a lot of destruction, killing many casualties and destroying properties especially when intensity is high.

Earthquakes come without a warning. This, learning institutions should be prepared and ready. Creation of an emergency hazard plan and implementation of earthquake drills is one of best precautionary measures and it would create awareness among students, staff and teachers regarding appropriate actions during the actual occurrence of earthquake.

OBJECTIVES OF THE STUDY

Generally, the study aims to develop an automatic earthquake alarm system for Samuel Christian College.

Specifically, this study aims to achieve the following:

1. Develop a microcontroller-based earthquake alarm system for Samuel Christian College
2. Test and evaluate the device in terms of:
   a. Sensitivity and Accuracy of the device.
3. Identify a strategic location for the implementation of the device.

HYPOTHESES OF THE STUDY

H_0 There is no significant difference between response of the device and its Response rate.

H_1 There is significant difference between response of the device and its Response rate.

SIGNIFICANCE OF THE STUDY

According to PHIVOLCS, the province of Cavite is one of the provinces that lies in West Valley Fault System. This fault system is responsible for the occurrence of earthquake. According to study, the last known activity along this fault line was the year 1658 and is estimated to be active every 300 years plus or minus 100 years. As the experts put it, the "big event" is long overdue. It is for this reason that the government has given effort for earthquake preparedness program through earthquake drills. This earthquake drill commences when the assign official sound the bell, which is also the standard operating procedure if such event happens. The alarming system depends upon the discretion and the availability of the official that will sound the alarm.

This study aims to reduce human effort by automating the alarm system. This will not only eliminate the possibility of negligence and judgement on the part of the assigned personnel but also provide an instantaneous response whenever an earthquake happens.

TIME AND PLACE OF THE STUDY

The study was conducted from October 2019 and ended February 2020 at Samuel Christian College.

SCOPE AND LIMITATION

The prototype will use a microcontroller-based sensing mechanism that will detect any movement of the platform on where the device will be installed. This device will sense even as low as intensity one. The intensity would trigger the device. Once triggered, a two – minute alarm will be activated to modify individuals within the premises. The device should be installed in a strategic location to avoid a false alarm.

CONCEPTUAL FRAMEWORK

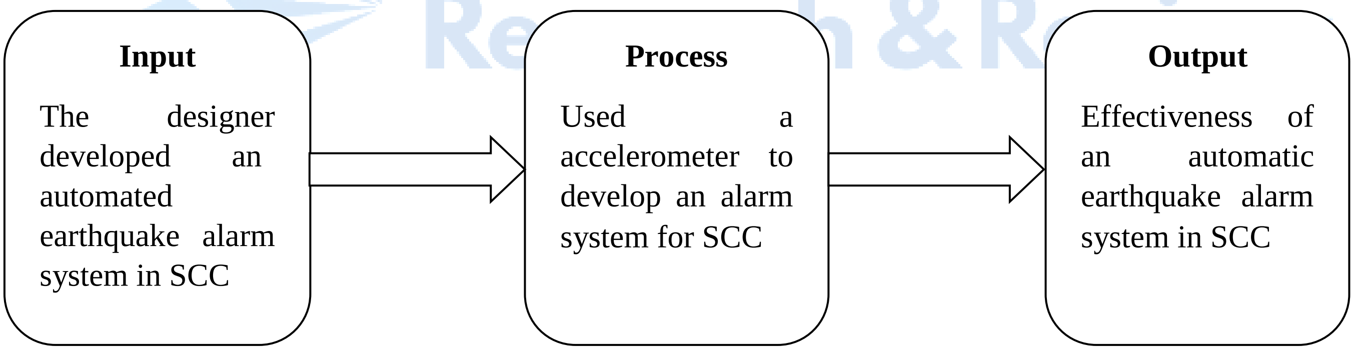


Figure 1. Conceptual framework

DEFINITION OF TERMS

In this part of this study provides few technical terminologies. Some of the meanings were cited from various books and dictionary.

Earthquake. is a sudden, violent movement of the earth's surface, often causing damage and sometimes deaths.

Preparedness.is the state of being prepared for a particular situation.

Signal. is an action, movement, or sound that gives information, a message, a warning, or an order.

Seismic waves. are the waves of energy caused by the sudden breaking of rock within the earth or an explosion. They are the energy that travels through the earth and is recorded on seismographs.

Body waves. arrive before the surface waves emitted by an earthquake. These waves are of a higher frequency than surface waves.

Surface waves. are of a lower frequency than body waves, and are easily distinguished on a seismograph as a result

REVIEW OF RELATED LIERATURE

The review of the related literature was conducted to construct and to provide additional information for the development of a microcontroller-based earthquake alarm system at Samuel Christian College. Also, literature helps with the identification of study.

Earthquake

Choudhury, Saha and Verma (2016) describes earthquake as one of the most devastating natural calamities which causes sudden shaking of the earth surface. It does not only cause damage to buildings and other structures but also affects the environment and lifestyle, significantly. Changes in the environment which are caused by the earthquake, can be classified as primary and secondary effects. Primary effects take place as a direct consequence of the earthquake. Primary effects depend on the size of the earthquake and the stress environment. The effects which occur in the natural environment as a result of the primary effects are known as secondary effects.

Seismic Waves

Seismic waves are generated by the release of energy during an earthquake. They travel through the earth like waves travel through water. The location within the Earth where the rock actually breaks is called the focus of the earthquake. Most foci are located within 65 km from the Earth's surface; however, some have been recorded at depths of 700 km. The location on the Earth's surface directly above the focus is called the epicenter ("Earthquakes and Seismic Waves," 2005, p. 10). 7

Kayal (2016) mentioned that there are two basic types of elastic waves or seismic waves generated by an earthquake. These are body waves and surface waves. These waves cause shaking that is felt and cause damage in various ways. These waves are similar in many important ways to the familiar waves in air generated by a hand-clap or in water generated by a stone thrown into water. The body waves propagate within a body of rock. The faster of these body waves is called Primary wave (P-wave), or longitudinal wave or compressional wave. It is the same as that of sound wave in air, alternately pushes (compresses) and pulls (dilates) the rock. The slower one is called Secondary wave (S-wave) or shear wave, it shears the rock sideways at right angle to the direction of propagation (p. 1).

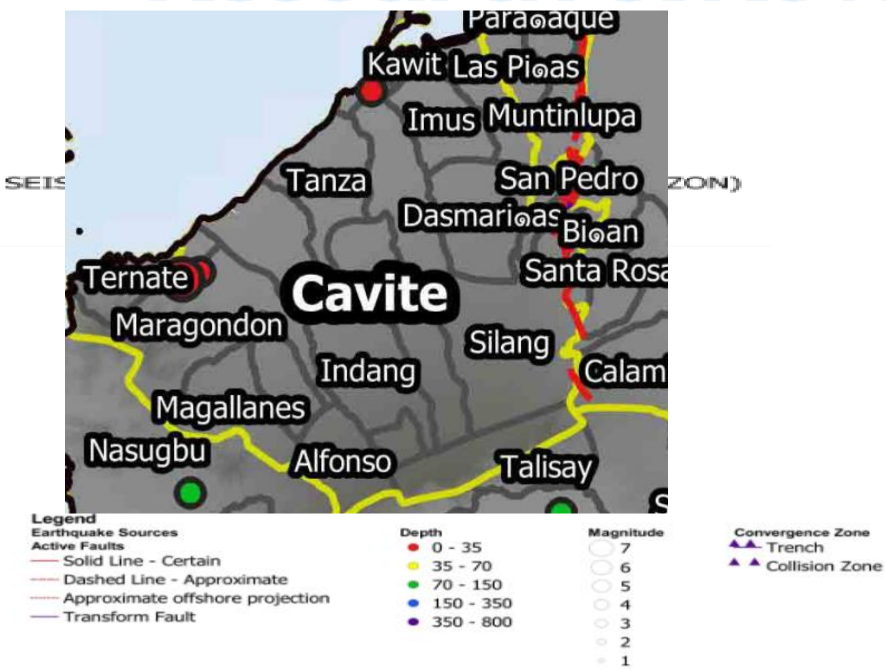


Figure 2. Seismicity Map of Region IV-A (CALABARZON)

Earthquake Risk

Although codes are refined each year, not all possible effects can be anticipated. Old buildings cannot cost-effectively be brought up to code, especially with yearly refinements to code. Even with construction to earthquake code, buildings fail for other reasons, like poor quality materials, poor workmanship, etc. that are not discovered until after an earthquake (para. 1).

Earthquake Hazards

According to British Geological Survey (n.d.), earthquakes are among the deadliest natural hazards. There are around 100 earthquakes each year of a size that could cause serious damage. They strike without warning and many of the Earth's earthquake zones coincide with areas of high population density (p.2).

Girty (2009) emphasized that any given earthquake produced by slip along a fault can produce a number of hazards including ground shaking, liquefaction, ground displacement, fires, and tsunamis. Ground shaking is simply the vibration of the land surface while liquefaction transforms what was a solid to a liquid-like state. In addition, ground displacement is a direct result of the slippage along the fault (p. 2).

Early Warning System

Sattele, Brundl and Straub (2015) defined that Early Warning Systems (EWS) are frequently applied as cost-effective risk mitigation measures against natural hazards, which provide timely information on future or ongoing events to reduce loss of life and damages (para. 1). The researchers noted that an EWS for natural hazards fulfils its designated function if it detects all hazard events in a timely manner, transfers the warning to the effected persons and leads to measures that avoid damage and loss of life (para.6).

Rouse (2016) explained that EWS for natural hazards include those designed for floods, earthquakes, avalanches, tsunamis, tornadoes, landslides and drought. Other systems exist for a variety of events including missile launches, road conditions and disease outbreaks (para. 1).

Earthquake Early Warning System

The goal of earthquake warning (EEW) is to provide advanced warning on expected ground motion which will exceed to damage – causing level. This will give individuals a chance to prevent potential damage (Minson et. Al., 2019, Para. 2).

United Nations Educational, Scientific and Cultural Organization (UNESCO) reported that Earthquake Early Warning System (EEWS) helps in disseminating timely information about potentially catastrophic earthquake hazards to the public, emergency managers and the private sector to provide enough time to implement automatized emergency measures (Disaster Risk Reduction, para. 2).

Earthquake Early Warning (EEW) can provide a few seconds to a few minutes of warning prior to ground shaking at a given location. EEW is used publicly. Prototypically in several countries around the world with the aim of damage reduction, lost reduction and casualties decrease. Actions taken in response to the alerts range from personal safety approaches such as “drop, cover, and hold” on to automated controls and situational awareness.

Lin li (2019) stated, “earthquake early warnings can come as false alarms, but it's better to be safer than sorry, researchers concluded in a new study.” (para. 1).

Accelerometer

Newton’s Second law of motion says that the acceleration (m/s) of a body is directly proportional to, and in the same direction as, the net force (Newton) acting on the body, and inversely proportional to its mass (gram).

Dadafshar (2014) noted that accelerometer measures force not acceleration:

> It is important to note that acceleration creates a force that is captured by the force-detection mechanism of the accelerometer. Thus, the accelerometer really measures force, not acceleration; it basically measures acceleration indirectly through a force applied to one of the accelerometer's axes. Accelerometers are fabricated in a multilayer wafer process, which measures acceleration forces by detecting the displacement of the mass relative to fixed electrodes. (p. 2).

A researcher stated that in choosing accelerometer it is important to consider some of its key.

Bandwidth (Hz) of a sensor indicates the range of vibration frequencies to which the accelerometer responds. Humans cannot create body motion much beyond the range of 10Hz to 12Hz. For this, a bandwidth of 40 Hz to 60Hz is adequate for sensing a tilt or human motion. (p. 7).

Sensitivity (mV/g or LSB/g) measures of the minimum detectable signal or the change in output electrical signal per change in input mechanical change. This is valid in one frequency only (Dadafshar, 2014, p. 7).

Frequency response (Hz): this is the frequency range specified with a tolerance band (±5%, etc) for which the sensor will detect motion and report a true output. The specified band tolerance lets the user calculate how much the device's sensitivity deviates from the reference sensitivity at any frequency within its specified frequency range (p.7).

Magnitude and Intensity

Philippine Institute of Volcanology and Seismology (2018) mentioned two ways by which earthquake can be measured earthquake: magnitude and intensity. **Magnitude** is proportional to the energy released by an earthquake at the focus. It is measured by an instrument called seismograph. It is represented by Arabic numbers (e.g. 4.8, 9.0). Intensity, on the other hand, is the strength of an earthquake as perceived and felt by people in a certain locality. It is a numerical rating based on the relative effects to people, objects, environment and structures in the surrounding. The **intensity** is generally higher near the epicenter. It is represented by Roman numerals (e.g. II, IV, and IX). In the Philippines, the intensity of an earthquake is determined through the PHIVOLCS Earthquake Intensity Scale (PEIS) (para. 3).

Table 1. PHIVOLCS Earthquake Intensity Scale (PEIS)

Intensity Scale	**Shaking**	**Description**
I	Scarcely Perceptible	Perceptible to people under favorable circumstances. Delicately balanced objects are disturbed slightly. Still Water in containers oscillates slowly.
II	Slightly Felt	Felt by few individuals at rest indoors. Hanging objects swing slightly. Still Water in containers oscillates noticeably.
III	Weak	Felt by many people indoors especially in upper floors of buildings. Vibration is felt like one passing of a light truck. Dizziness and nausea are experienced by some people. Hanging objects swing moderately. Still water in containers oscillates moderately.
IV	Moderately Strong	Felt generally by people indoors and by some people outdoors. Light sleepers are awakened. Vibration is felt like a passing of heavy truck. Hanging objectsswing considerably. Dinner, plates, glasses, windows and doors rattle. Floors and walls of wood framed buildings creak. Standing motor cars may rock slightly. Liquids in containers are slightly disturbed. Water in containers oscillate strongly. Rumbling sound may sometimes be heard.
V	Strong	Generally felt by most people indoors and outdoors. Many sleeping people are awakened. Some are frightened, some run outdoors. Strong shaking and rocking felt throughout building. Hanging objects swing violently. Dining utensils clatter and clink; some are broken. Small, light and unstable objects may fall or

		overturn. Liquids spill from filled open containers. Standing vehicles rock noticeably. Shaking of leaves and twigs of trees are noticeable.
VI	Very Strong	Many people are frightened; many run outdoors. Some people lose their balance. Motorists feel like driving in flat tires. Heavy objects or furniture move or may be shifted. Small church bells may ring. Wall plaster may crack. Very old or poorly built houses and man-made structures are slightly damaged though well-built structures are not affected. Limited rockfalls and rolling boulders occur in hilly to mountainous areas and escarpments. Trees are noticeably shaken.
VII	Destructive	Most people are frightened and run outdoors. People find it difficult to stand in upper floors. Heavy objects and furniture overturn or topple. Big church bells may ring. Old or poorly-built structures suffer considerably damage. Some well-built structures are slightly damaged. Some cracks may appear on dikes, fish ponds, road surface, or concrete hollow block walls. Limited liquefaction, lateral spreading and landslides are observed. Trees are shaken strongly. (Liquefaction is a process by which loose saturated sand lose strength during an earthquake and behave like liquid).
VIII	Very Destructive	People are panicky. People find it difficult to stand even outdoors. Many well-built buildings are considerably damaged. Concrete dikes and foundation of bridges are destroyed by ground settling or toppling. Railway tracks are bent or broken. Tombstones may be displaced, twisted or overturned. Utility posts, towers and monuments mat

		tilt or topple. Water and sewer pipes may be bent, twisted or broken. Liquefaction and lateral spreading cause man-made structure to sink, tilt or topple. Numerous landslides and rockfalls occur in mountainous and hilly areas. Boulders are thrown out from their positions particularly near the epicenter. Fissures and faults rapture may be observed. Trees are violently shaken. Water splash or stop over dikes or banks of rivers.
IX	Devastating	People are forcibly thrown to ground. Many cry and shake with fear. Most buildings are totally damaged. bridges and elevated concrete structures are toppled or destroyed. Numerous utility posts, towers and monument are tilted, toppled or broken. Water sewer pipes are bent, twisted or broken. Landslides and liquefaction with lateral spreadings and sandboils are widespread. the ground is distorted into undulations. Trees are shaken very violently with some toppled or broken. Boulders are commonly thrown out. River water splashes violently on slops over dikes and banks.

ISSN 2582 8088
Volume 2 Issue 1 – March 2021

X	Completely Devastating	Practically all man-made structures are destroyed. Massive landslides and liquefaction, large scale subsidence and uplifting of land forms and many ground fissures are observed. Changes in river courses and destructive seiches in large lakes occur. Many trees are toppled, broken and uprooted.

Table 2. Magnitude and Intensity

Magnitude	**Typical Maximum Modified Intensity**
1.0	**I**
3.0	**II - III**
4.0 - 4.9	**IV – V**
5.0 – 5.9	**VI - VII**
6.0 - 6.9	**VII - IX**
7.0 and Higher	**VIII or higher**

WEST VALLEY FAULT

The Philippine archipelago has 23 active volcanoes and numerous active faults and trenches. The threat of tsunami is very high for most of the Philippine coastline, as both sides of the archipelago are bounded by active subduction zones associated with large earthquakes (Punongbayan et al., 2014, p. 25). In 2017 Baylon emphasized that the specific geographic location of the Philippines makes it vulnerable to a lot of tectonic activities. The country is susceptible to seismic hazards and it is essential for the people to know the threat that it will cause. Due to its vulnerability, there is a need to institutionalize systems and programs that would improve the disaster resilience of local communities (as cited in Salaverria, 2015).

16

The researcher stated that economic, academic, residential and commercial activities in the Philippines are at risk due to the West Valley Fault earthquake threat according to Metropolitan Manila Earthquake Impact Reduction (MMEIRS). In response to this, a need for seismic assessment of the most essential lifeline structure would be a great hand to national government, community and people within the vicinity (para. 1).

The next West Valley Fault "Big One" might happen within this lifetime. In the last 1,400 years, the West Valley Fault only moved four times and has an interval of 400 years. The last major earthquake from the West Valley Fault happened in 1658 (Solidum Jr., 2015).

Table 3. Seismological Data

Fault name	West Valley Fault
Tectonics	Crustal
Style	Strike Slip
Magnitude	7.2
Fault Length(km)	67
Fault Width(km)	21
Dip angle	90 degrees
Depth (km)	2
Past Earthquake along the fault,	August 19, 1658
Magnitude	5.7

Source: Matsuoka & Ikenishi (2014)

According to the Philippine Institute of Volcanology and Seismology, the Valley Fault System indicated that the Big One will pass through the dense Metro Manila area and its neighboring provinces.

Guiterrez (2018) stated that The Vulnerability and Impact Reduction to Earthquake (Viper) project have included Cavite in the Harmonized National Contingency Plan (HNCP) for the "Big

One," a 7.2-magnitude movement of the 100-kilometer West Valley Fault with Intensity 8 ground shaking.

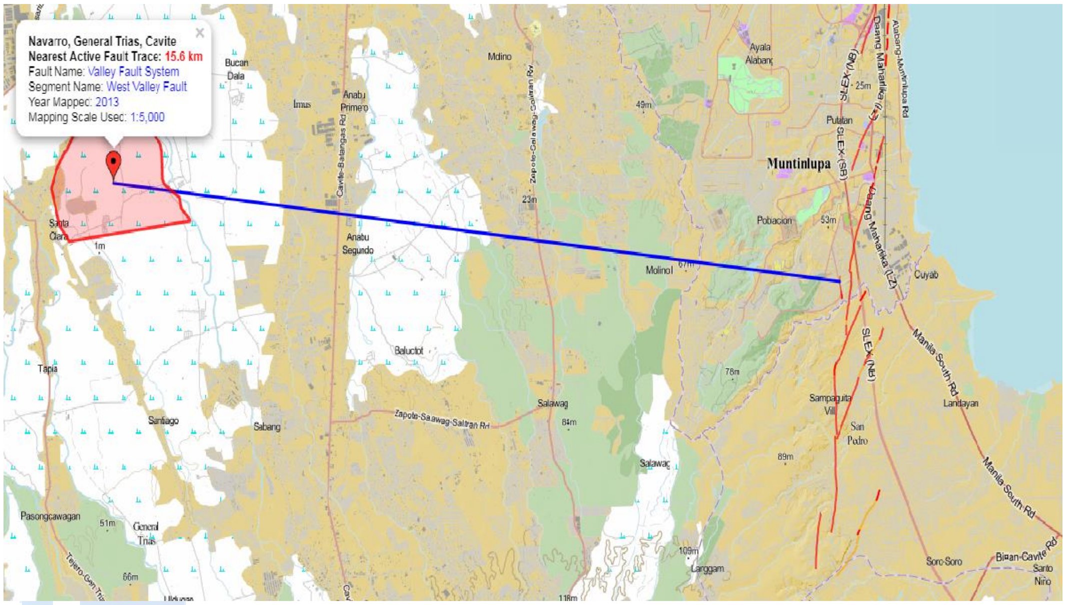


Figure 3. The distance of Brgy. Navarro from West Valley Fault

A study revealed that most of the respondents were not aware of the actions to be done before, during and after an earthquake. It is alarming that more than half of the respondents do not even know the initial response to an earthquake and to evacuate the vulnerable groups in their families. More than half of the respondents were not aware of the emergency contact numbers in their locality. They were also not aware of the evacuation area nearest their homes. Based on the results, it was recommended that the school should involve the families and the barangay [village] in their information and education advocacy campaign (San Pedro, 2017, para. 1).

STATISTICAL DATA OF EARTHQUAKES IN THE PHILIPPINES

According to the Eurasian-Philippines Sea plate collisions, the Philippines Islands and the adjacent areas are tectonicallycomplex. The relative plate motions range from 5–40 mm/year (Galgana et al., 2017).

A researcher stated that the Philippines is susceptible to various types of natural hazards due to its geographical location and physical environment being situated in the “Pacific Ring of Fire”, between two Tectonic plates (Eurasian and Pacific), an area encircling the Pacific Ocean where frequent earthquakes and volcanic activity result from the movements of said tectonic plates (Orallo, 2014, p. 3).

A researcher emphasized that over the past decades, the Philippines have been labelled as one of the most disaster-prone countries in the world mainly because of its geographic and geologic location and physical characteristics (para.2).

NATIONAL BUILDING CODE OF THE PHILIPPINES

The National Building Code of the Philippines Chapter XII section 1202, Excavation, Foundation and Retaining Walls stated that excavation or fills for buildings shall be so constructed or protected:

Excavation or fills for buildings or structures shall be so constructed or protected that they do not endanger life or property. Whenever the depth of excavation for any construction is such that the lateral and subjacent support of the adjoining property or existing structure thereon would be affected in a manner that the stability or safety of the same is endangered, the person undertaking or causing the excavation to be undertaken shall be responsible for the expense of underpinning or extending the foundation or footings of the aforementioned property or structure. Excavation and other similar disturbances made on public property shall, unless otherwise excluded by the Building Official, be restored immediately. (p.23)

EARTHQUAKE ALARM

A researcher stated that despite all the scientific advances in the field of earthquake prediction, the idea of accurate alarm and monitoring of incipient earthquakes using electronic monitoring tools for detection still remains a vision of the future (Dutta, 2017, p. 3582).

Dutta (2017) proposed a study that involves design and development for the earthquake alarm circuit:

he proposed study involves design and development for the earthquake alarm detection circuit based on electronic devices only which will be highly helpful for the determination of high frequency vibrations which will trigger an impulse when the S wave is detected by the earthquake sensor which in this case is a shaft with load that represents a steel or building structure that shakes vibrations when the corresponding surface wave reaches the ground.

Existing Earthquake Warning Systems (EWS) are often based on a deterministic approach which led to many false alarms after the strong faulting segments accumulate strain to become areas of instability (Dutta et al., 2012 a,b). Secondly, sudden occurrence of earthquakes and their incipient source showing precursory behavioral patterns (Dutta et al., 2013)

DETERMINING THE MAGNITUDE

A researcher obtain acceleration time histories from either earthquake records or from simulation for various magnitudes and distances (Murava,H.P. et. Al. p.1)

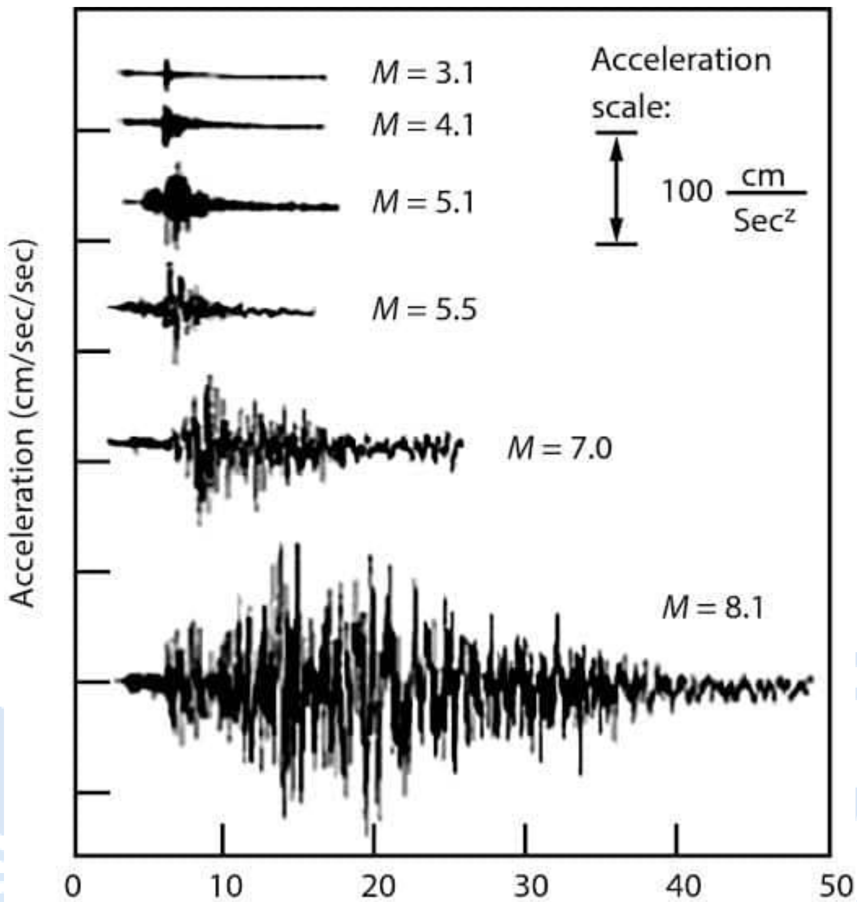


Figure 4. The actual data gathered from earthquake simulator

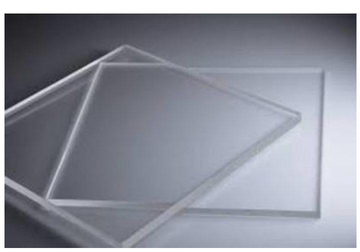
ISSN 2582 8088
Volume 2 Issue 1 – March 2021

METHODOLOGY

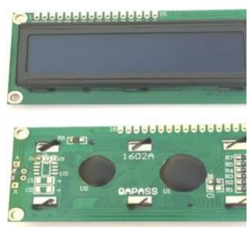
The researchers underwent planning phase then designed the prototype through assembling the selected materials. It was followed by the implementation and evaluation wherein the prototype's performance was assessed.

Table 4. Materials

Materials	**Image**	**Description Specifications**	**Amount**	**Price**
Arduino UNO		A powerjack and an in-circuit system programming header and a reset button	**1**	P350
Adxl335 triple axis accelerometer breakout		ADXL335 analog voltage output accelerometer sensor	1	P136

		from Analog Devices.		
Jumper Wires		Used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed.	10	P70 (20pcs.)
				22
Horn		It is the source of sound of the device.	1	P280
Acrylic Glass		**Acrylic** is a transparent plastic material with	6	P150

		outstanding strength, stiffness, and optical clarity		
LED Lights		A device that lights up and displays information when there is a earthquake.	3	P250
Arduino GSM shield SIM900A		It Allows to send SMS, MMS, GPRS and Audio via UART using AT commands	1	P365

4 Channel Relay Module		It is an electrically operated switch of mains voltage	1	P155
LCD Module		An LCD is an electronic display module which uses liquid crystal to produce a visible image.	1	169

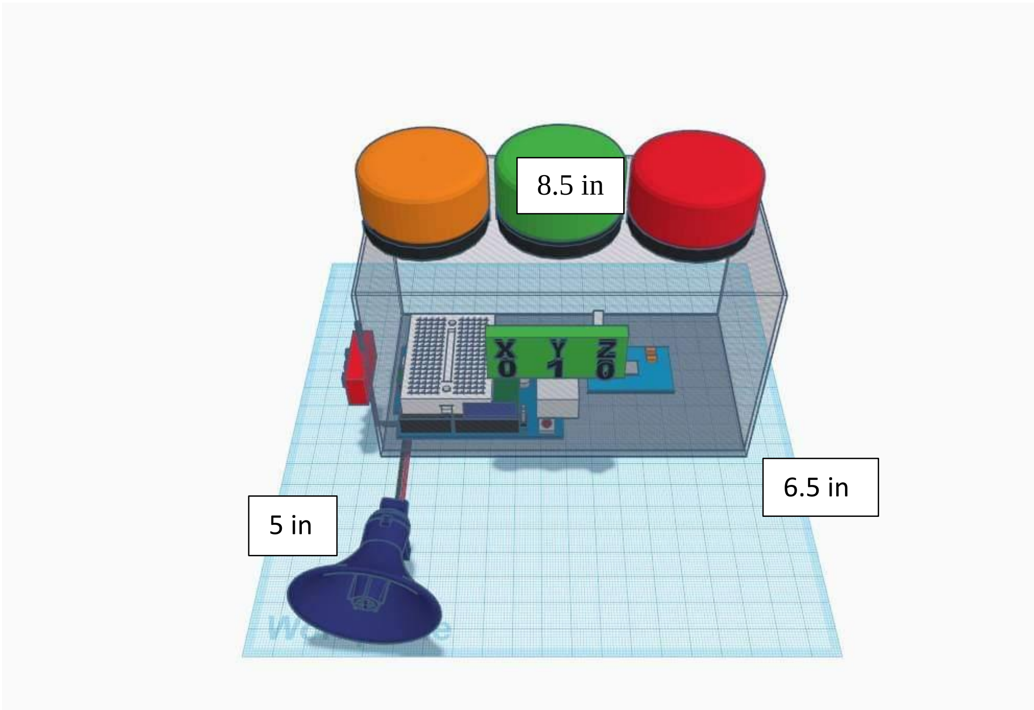
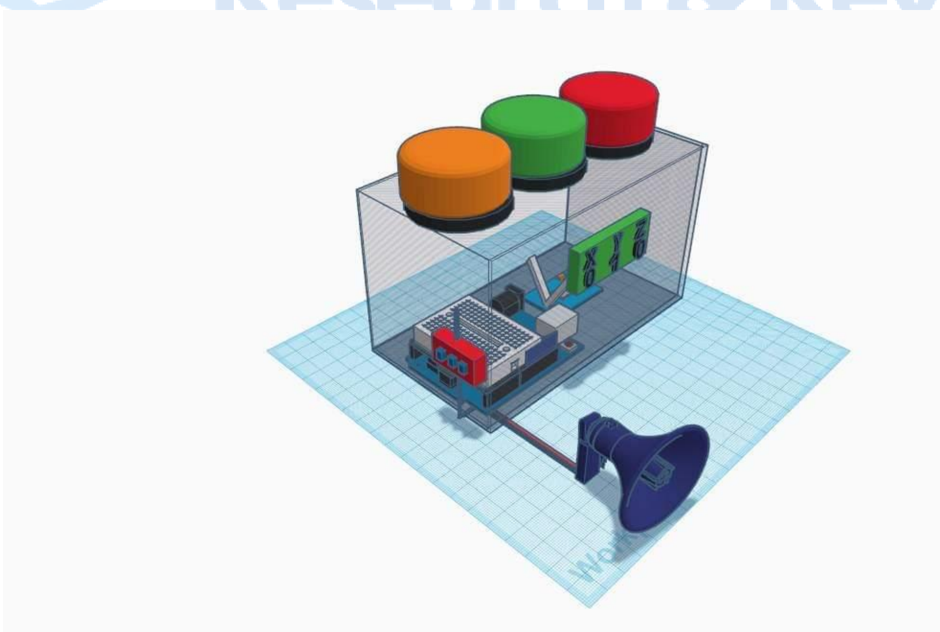


Figure 5. Top view of the 3D Model

Figure 6. Side view of the 3D Model



ISSN 2582 8088
Volume 2 Issue 1 – March 2021

Planning. During this phase the acceleration was programmed, as well as the database structure, application appearance and function.

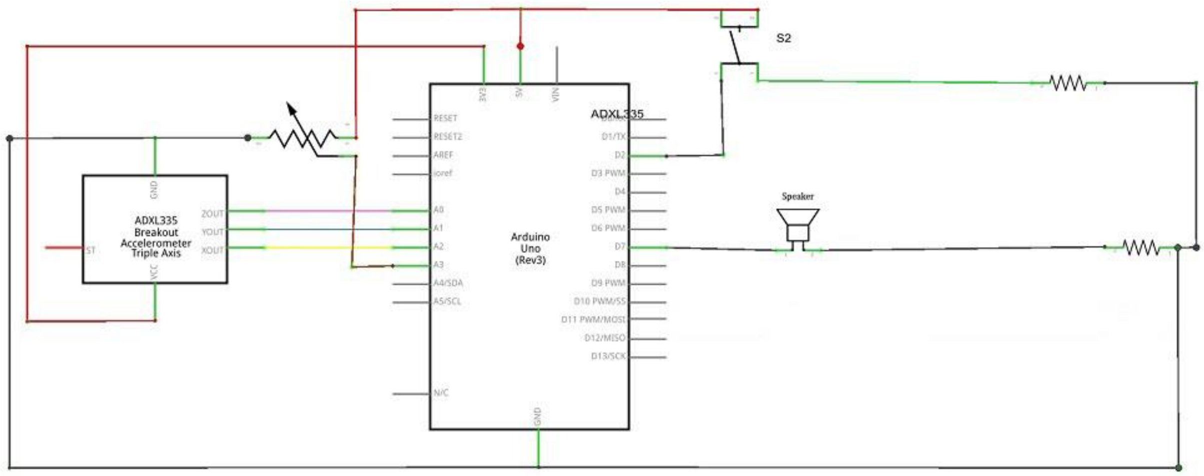
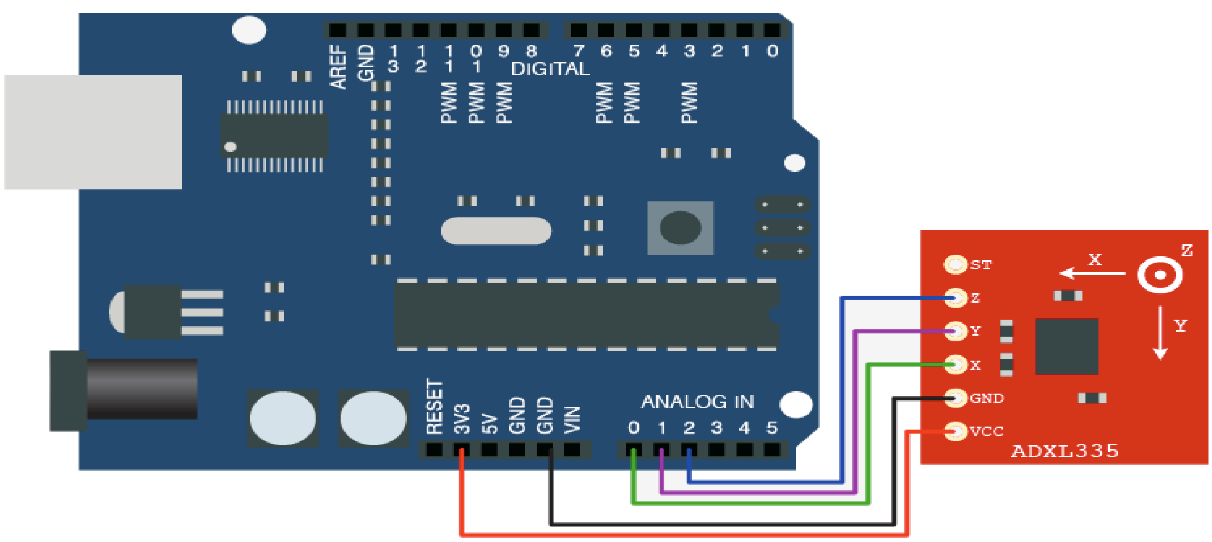


Figure 7. Schematic Diagram of the device.

Prototyping. In this phase, all the plans were materialized. The device was constructed, assembled, interconnected, integrated and the software and source codes will be embedded.

Figure 8. Wirings of the adxl 335 at Arduino uno

Testing. In this phase, the researcher conducted three sets of trials to test the receiving of



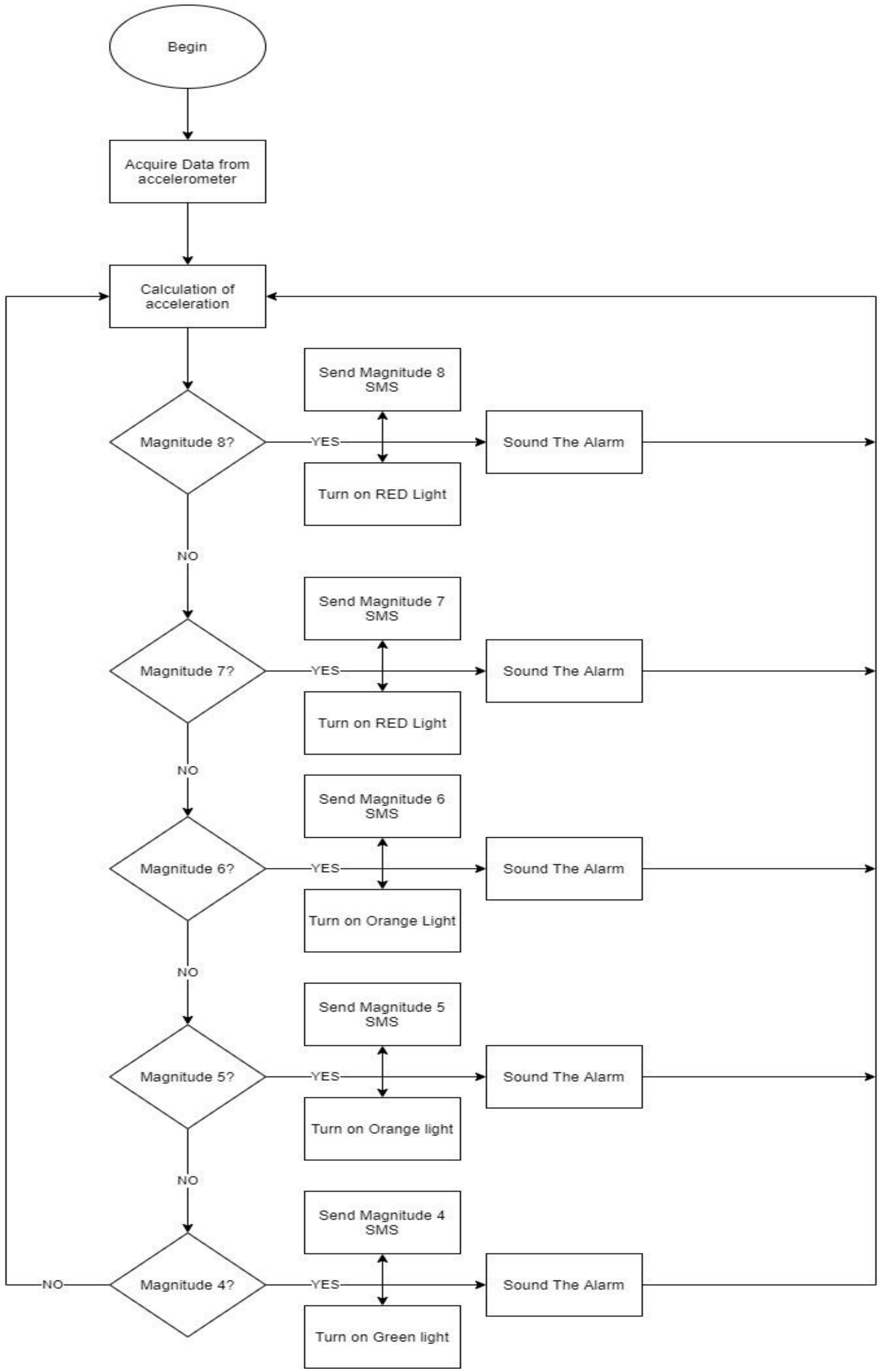
magnitude signal, the information dissemination delay and sounding alarm delay for the testing

ISSN 2582 8088
Volume 2 Issue 1 – March 2021

and evaluation of accuracy and sensitivity of the device. The researchers also conducted survey questionnaire to the student and employees to identify the strategic location of the earthquake alarm describing the three parameters: accessibility, source of electricity, and safe execution.

PRINCIPLES OF OPERATION

The design project operates by connecting the wires to a 220v AC that supplies power and to give source in the Adxl 335. The accelerometer is responsible to detect all the movement in the area and to give indication to the Color-coded LED lights and the sound of the siren. The GSM shield is responsible to send messages when there is an earthquake. Then the data gathered by accelerometer will be translated through Arduino uno. The sirens are responsible to give sound and alarm if the sensor detects earthquake movements and it is connected in each color-coded magnitude level indicator. The data could be viewed using a laptop/ computer.p



ISSN 2582 8088
Volume 2 Issue 1 – March 2021

Figure 9. System flowchart of the system

TECHNICAL EVALUATION

The researchers evaluated the sensor rate and loudness of sound in microcontroller - based earthquake alarm level indicator and also assessed the color-coded LED if this is visible from far part or not. The duration of sending SMS is also evaluated on how long it will take before the students and employees will received the notifications.

DATA GATHERING PROCEDURE

The researcher conducted three sets of trials to the sensor rate and sound alarm delay of the device and the duration of sending SMS on how long it will take before the students and employees will received the warning texts. The researcher also conducted survey to twenty students and employees to identify the strategic location for the implementation of the device.

STATISTICAL ANALYSIS

Data gathered from the technical evaluation was tabulated and analyzed using descriptive statistics which involved the one-way-analysis of variance (ANOVA) to determine whether there are any statistically significance between the response rate of the microcontroller-based earthquake.

RESULTS AND DISCUSSION

This chapter provides the discussion of the result obtained from the technical evaluation, the statistical analysis and interpretation of the data collected.

Actual Testing of the Device in Phivolcs - DOST Earthquake Alarm Simulator

The following are the interpretation of the data gathered during the actual testing in Phivolcs – DOST Earthquake alarm simulator.

At magnitude 4, the graph shows that there were constant force ranges from three to negative four and has seven spikes

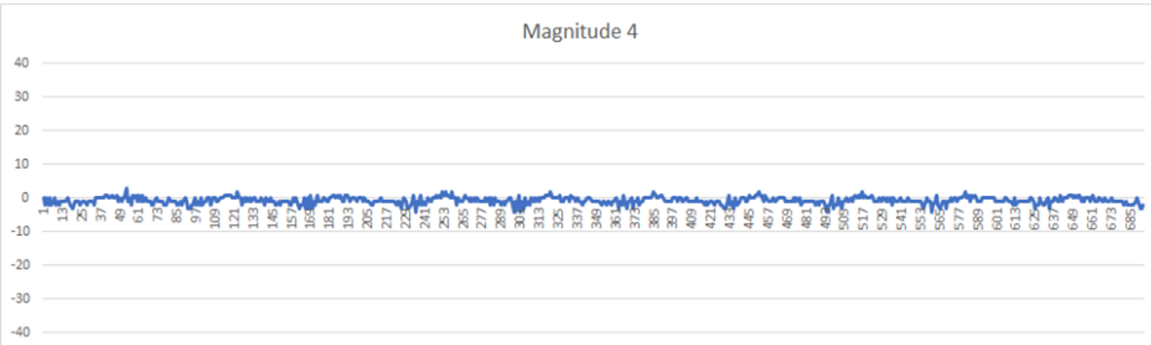


Figure 10. Waveform graph of Magnitude 4.

At magnitude 5, the graph shows that there were constant force ranges from three to negative four and has seven spikes

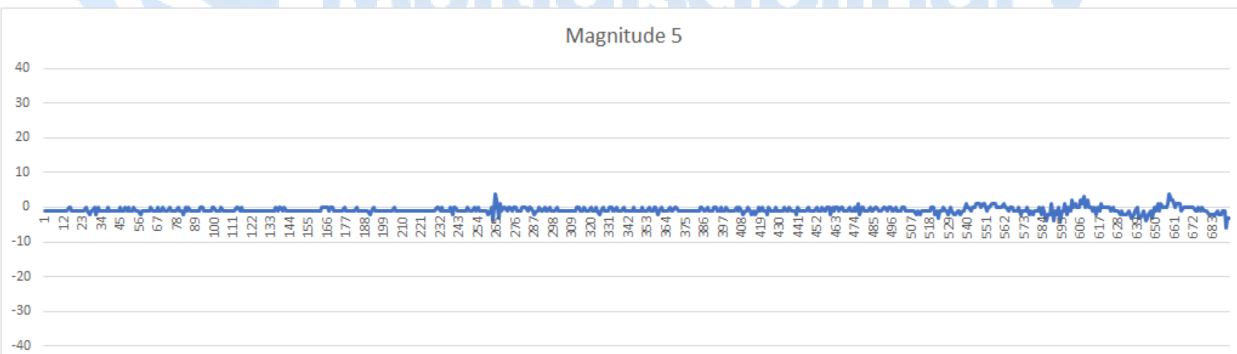
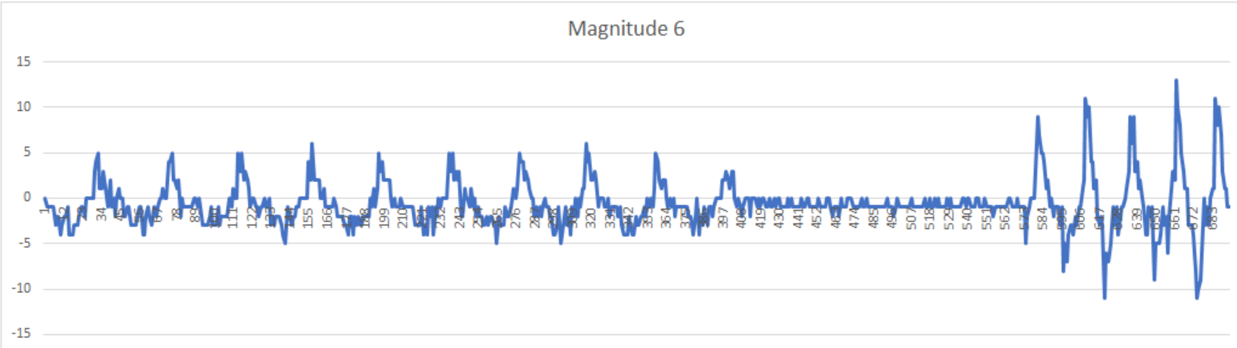


Figure 11. Waveform graph of Magnitude 5.

ISSN 2582 8088
Volume 2 Issue 1 – March 2021

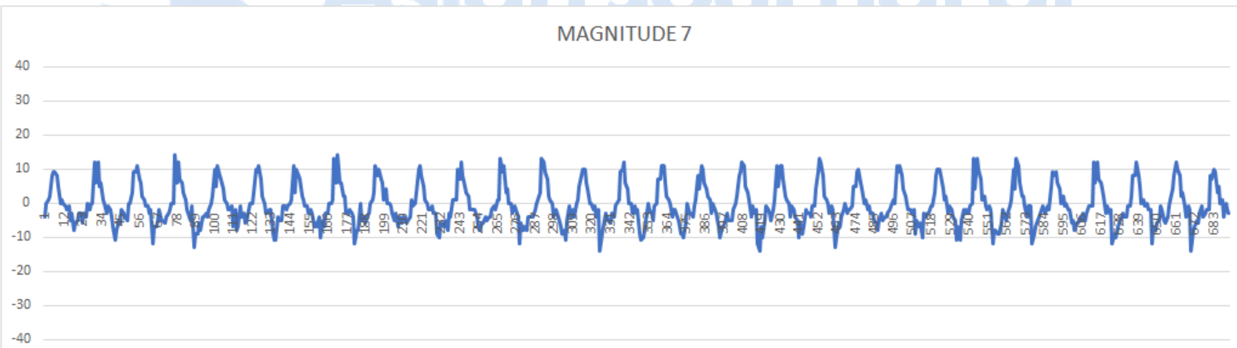
At magnitude 6, the graph shows that there were constant force ranging from thirteen to negative eleven and has three spikes

Figure 12. Waveform graph of Magnitude 6.



At magnitude 7, there were constant force ranging from fourteen to negative fourteen

Figure 13. Waveform graph of Magnitude 7.



At magnitude 8, the graph shows that there were constant forces ranging from thirty-six to negative forty-two and has four spikes

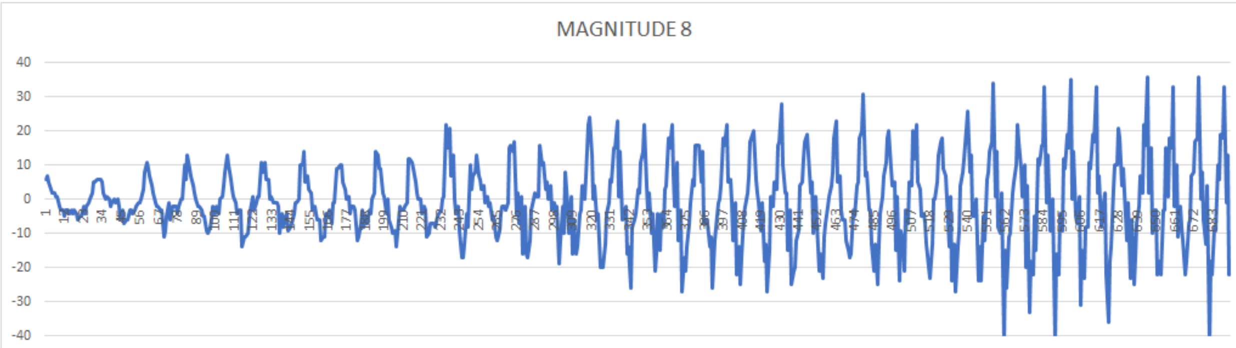


Figure 14. Waveform graph of Magnitude 8.

MEASUREMENT ACCURACY

The measurement of sensitivity by the Microcontroller-based Earthquake Alarm System was observed and tabulated. It is shown in Table 1.

Table 5. Receiving of Magnitude Signal

INTERPRETATION:

The failure to reject null hypothesis means that the three trials between each magnitude of 4 to 8 were not affected on receiving magnitude signal in seconds.

Table 5. ANOVA result in Receiving of Magnitude Signal

	SS	d_f	MS	$F_{computed}$	F_{value}	Decision
Between	-18.4134	4	-4.60	2.20	5.96	Failed to Reject H_0
Within	-20.9058	10	-2.09			
Total	**2.4923**	**14**				

Reject H_0 if $F_{computed} \geq F_{tabular}$

INTERPRETATION:

Since $F_{computed}$ value of 2.20 is less than the $F_{tabular}$ value which is 5.96, then the null hypothesis has been failed to be rejected. Thus, there is no significant difference among trials of the five magnitude 4, 5, 6, 7, and 8 in terms of receiving delay of magnitude signal in seconds.

INTERPRETATION:

Since $F_{computed}$ value of 1.33 was less than the $F_{tabular}$ value which was 5.96, then the null hypothesis has been failed to be rejected. Thus, there was no significant difference among trials of the five magnitude 4, 5, 6, 7, and 8 in terms of information delay.

Table 6. Information dissemination delay

ANOVA Result Information Dissemination Delay						
	SS	df	MS	F computed	F Value	Decision
Between	10. 27516		2.56879	1.332208	5.96	Failed to Ho
Within	19.2822		1.92822			

Table 7 shows the testing of sounding alarm delay with three trials. The trials showed that when the earthquake alarm detects a movement from the ground (magnitude four to eight) the sound alarm will activate within less than two seconds.

Table 7 Sounding Alarm Delay

Magnitude	T1	T2	T3	Mean
4	1.72 secs	2.39 secs	1.57 secs	1.89
5	2.33 secs	2.20 secs	1.22 secs	1.91
6	2.38 secs	1.66 secs	1.38 secs	1.80
7	1.77 secs	1.54 secs	1.96 secs	1.75
8	1.89 secs	1.10 secs	1.35 secs	1.45

34

Table 8 shows the assessment of strategic location in three different proposed locations in Samuel Christian College. The cafeteria and hallways are not eligible for the location of earthquake alarm considering the criteria for strategic location, while the guard house attained all the three parameters.

ISSN 2582 8088
Volume 2 Issue 1 – March 2021

Table 8. Assessment of Strategic Location

Parameters	Mean	Descriptive Rating
Accessibility	2.55	Excellent
Source of Electricity	2.55	Excellent
Safety Execution	2.68	Excellent
Ground Mean	2.59	Excellent

OPERATIONAL CONSISTENCY

Table 9 shows the consistency in the operation of the Microcontroller-Based Earthquake System Alarm in its function. The data were collected through the repeated operation of the system with three trials each. From the trials, each function was given 1 (success) or 0 (fail) with respect to its operation. The magnitude level indicator alarm operational consistency was 100% in all of its functions.

Table 9. Operational Consistency

FUNCTION	OPERATIONAL CONSISTENCY (%)
Starting of the device	100
Starting alarm	100
Starting signal light	100
Alarm 1 SMS Notification (Student & Employees)	100
Alarm 2 SMS Notification (Student & Employees)	
Alarm 3 SMS Notification (Student & Employees)	100
Alarm 1 Signal Light (System box)	
Alarm 2 Signal Light (System box)	100

Alarm 3 Signal Light (System box) Sounding Alarm 1 (Compatibility box) Sounding Alarm 2 (Compatibility box) Sounding Alarm 3 (Compatibility box)	100 100 100 100 100 100

COST ANALYSIS

The table 10 shows the cost analysis conducted after developing the system. The cost analysis consists of the summation of costs for the materials, components, and fabrication of the system unit (Microcontroller-Based Earthquake Alarm System) with the grand total cost amounting to 2,761.0

Table 10. Cost analysis of the system

QUANTITY	UNIT	ITEM	TOTAL PRICE
1	Pc	Horn	280.00
1	Pc	Arduino GSM Sim900A shield	365.00
1	Pc	Adxl 335 Accelerometer	136.00
1	Pc	Channel Relay	120.00
3	Pc	LED Signal Lights	750.00
1	M	USB Cable	50.00

1	CM	Arduino UNO	350.00
1	CM	LCD Module	210.00
2	CM	Power Supply	350.00
1	Pc	Acrylic Glass	150.00
TOTAL			2,761.00

SUMMARY, CONCLUSION AND RECOMMENDATION

SUMMARY

The study was conducted from January 2020 to February 2020. It developed an earthquake warning device that uses adxl sensors to monitor the movement of the ground, alert the students and employees using GSM and a Siren system, and create a response system in times of earthquake disturbances through siren. Specifically, this study aimed to; design and develop a microcontroller-based earthquake alarm system in Samuel Christian College, test and evaluate the device in terms of accuracy and sensitivity and Identify strategic location for the implementation of the device.

CONCLUSION

The researchers were able to develop a device using an adxl sensor to monitor the movement of the ground in times of earthquake and to give warnings for them to evacuate if necessary. The sirens will make a long-prolonged sound as a warning that indicated in each level as the magnitude rise up, and a SMS to give information to the students and employees of Samuel Christian College.

RECOMMENDATION

As the result of the study, the following recommendations are:

1. The researcher recommends the location of the device be put on the guardhouse.

2. To the future researchers they may use high quality materials for the durability of the device and to maintain its quality
3. The researchers want to propose this study to other schools or to the DepEd for the safety purpose of their institutions.

REFERENCES

Baylon, M. B. (2017). Seismic assessment of LRT Line 1 Monumento to 5th Avenue carriageway pier using fragility curve. International journal of real estates studies, 49-59.

British Geological Survey (n.d.). Earthquakes. Retrieved from November 12, www.earthquakes.bgs.ac.uk

Choudry, M., Saha, P., & Verma, S. (2016). Effects of Earthquake on the Surrounding Environment: An Overview. 1-3. Retrieved from https://www.researchgate.net/

Dutta, P.K (2017) Earthquake Alarm Detector Microcontroller based Circuits for issuing Warning for vibration in Steel Foundations.

Galgana, G., Hamburger, M., McCaffrey, R., Corpuz, E., and Chen,O., 2017, Analysis of crustal deformation in Luzon, Philippinesusing geodetic observations and earthquake focal mechanisms.Tectonophysics, 432, 63–87

Girty, G.H. (2009). Earthquake Hazards. 2-4.

Guiterrez,P.J. (2018, September 16). Cavite Now Included in HNCP for “Big One” through Viper. BusinessMirror. Retrieved from https://businessmirror.com.ph/2018/09/21/cavite-now-included-in-hncp-for-big- one-through-viper/

Introduction to earthquake – Earthquake. (2018). Retrieved September 11, 2019, from https://www.phivolcs.dost.gov.ph/index.php/earthquake/introduction-to- earthquake

Lin-li, R. (2019). Earthquake early-warning system will mean false alarms but it's still worth it, researchers say. Retrieved August 18, 2019, from https://phys.org/news/2019-02-earthquake-early-warning-false-alarms-worth.html

Matsuoka, K., & Ikenishi, N. (2014). Study for Earthquake Impact Reduction for Metropolitan Manila in the Republic of the Philippines (MMEIRS). Manila: Japan International Cooperation Agency.

Minson, S., Baltay, A., Cochran, E., Hanks, T., Page, M., McBride, S., Milner, K., . . . Meier, M. (2019). The Limits of Earthquake Early Warning Accuracy and Best Alerting Strategy. 2478, 3-6. https://www.nature.com/articles/s41598-019-39384- y

Muruva H. R., Kiran A.R., Bandyopadhyay, S.G. & Reddy, G.R (2019) Design Basis Ground Motion. Retrieved from https://link.springer.com/chapter/10.1007/978- 981-13-3176-3_2

Nelson, S. (2016). Earthquake Hazards and Risks. Retrieved August 18, 2019, from http://www.tulane.edu/~sanelson/Natural_Disasters/eqhazards&risks.htm

Orallo, A.L. D (2014) Study on Earthquake Risk and Vulnerability Management and Lessons Learned. Office of Civil Defense.

Pailoplee, Santi & Boonchaluay, Natchana. (2016). Earthquake activities in the Philippines Islands and the adjacent areas. Geosciences Journal. 10.1007/s12303-016-0017-x.

Prielipp, L. (2019). What is a vibration sensor? Retrieved August 18, 2019, from https://realpars.com/vibration-sensor/ 42

Punongbayan, B. J. T., Kumagai, H., Pulido, N., Bonita, J. D., Nakano, M., Yamashina, T., ... & Alcones, P. C. M. (2015). Development and operation of a regional moment tensor analysis system in the Philippines: contributions to the understanding of recent damaging earthquakes. J Disaster Res, 10, 25-34.

Rousse, M. (2016). Early Warning System. Retrieved August 18, 2019, from https://whatis.techtarget.com/definition/early-warning-system

San Pedro, M.G.J (2017) Assessment of Family Earthquake Preparedness in Malolos City. Agris, Philippines.

Sattele, M., Brundl, M., & Straub, D. (2015). Reliability and effectiveness of early warning systems for natural hazards: Concept and application to debris flow warning. Munich, Germany.

Shedlock, K., & Pakiser, L. (2016). Earthquakes. Retrieved August 18, 2019, from https://pubs.usgs.gov/gip/earthq1/earthqkgip.html

Solidum Jr., R. (2015). Earthquake Hazards and Risk Scenario for Metro Manila and Vicinity: the Need for Whole of Society Preparedness.

U.S Department of Homeland Security. (2018). Earthquake Safety at School. Retrieved from https://www.fema.gov/earthquake-safety-school

APPENDIX FIGURE

Figure 15. Actual data gathering in PHIVOLCS – DOST

ISSN 2582 8088
Volume 2 Issue 1 – March 2021

Figure 16. Programming of the device

ISSN 2582 8088
Volume 2 Issue 1 – March 2021

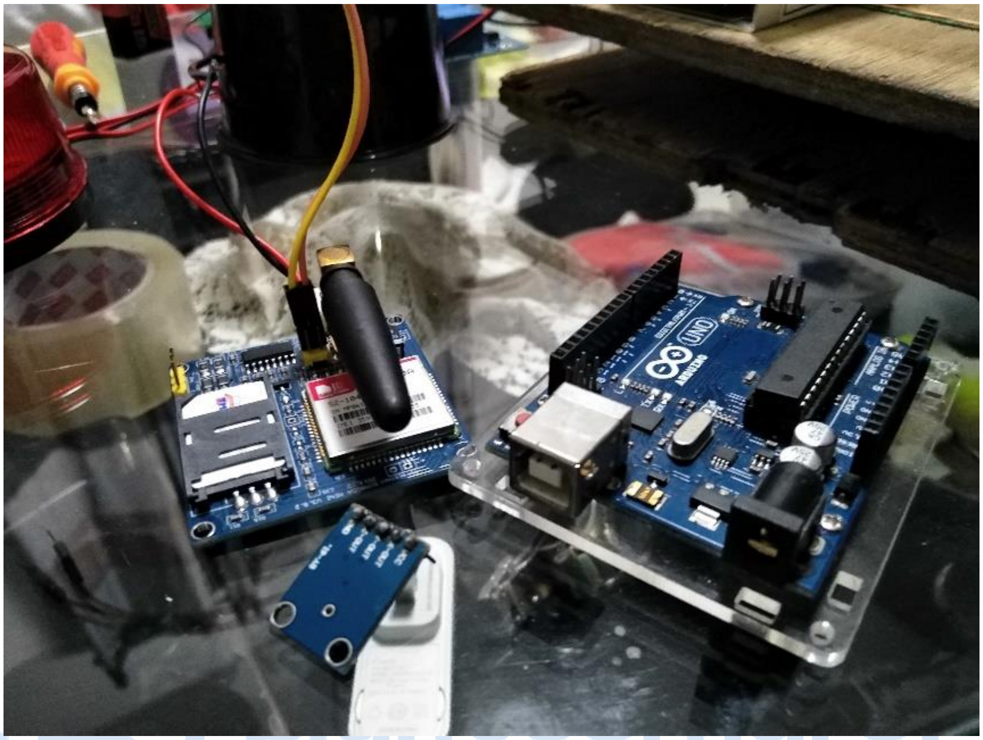


Figure 17. ADXL 335 & Arduino UNO

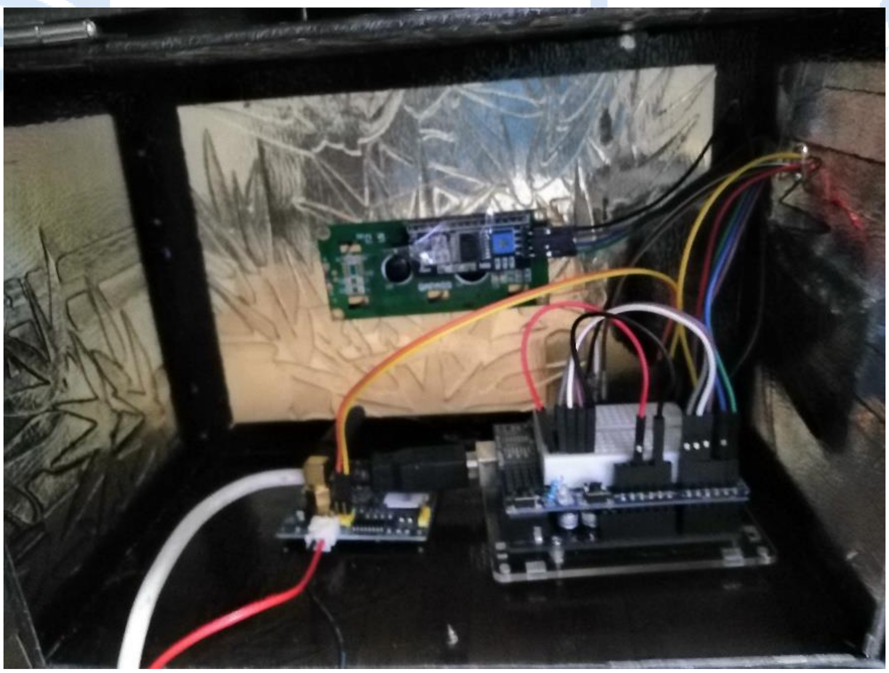


Figure 18. Actual assembling of the device

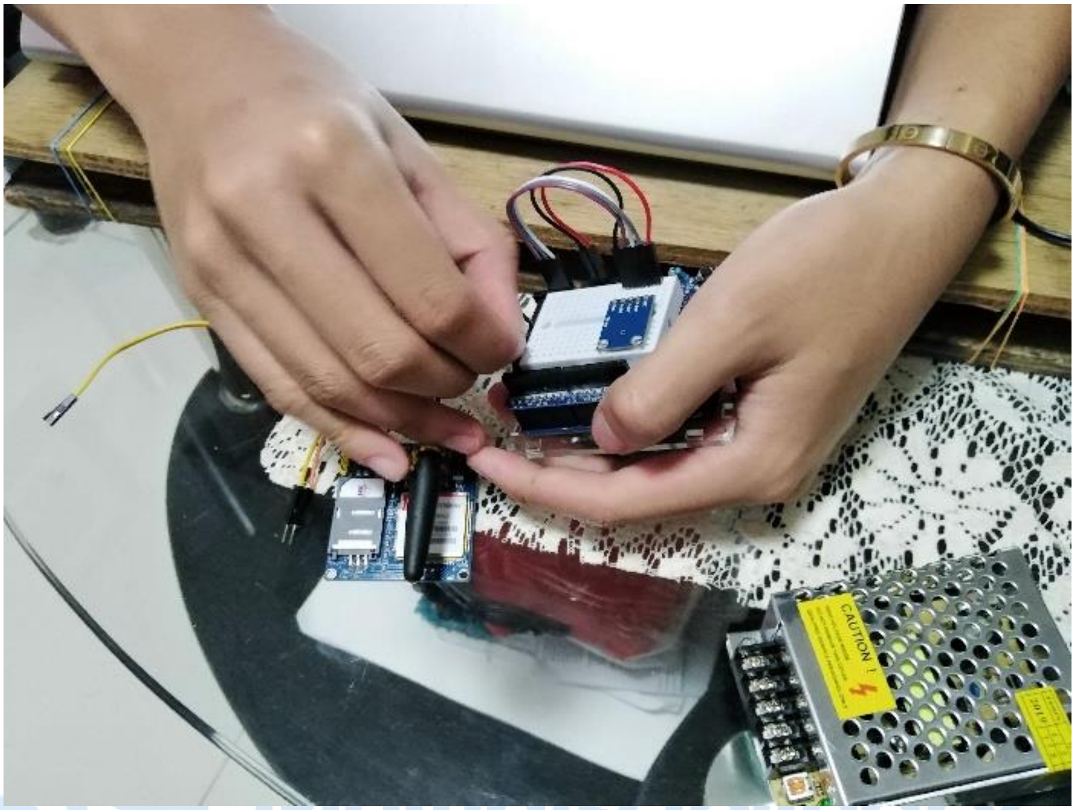


Figure 19. Inside of the earthquake alarm

Figure 20. Out view of earthquake alarm

ISSN 2582 8088
Volume 2 Issue 1 – March 2021

Figure 21. Actual data gathering in SCC

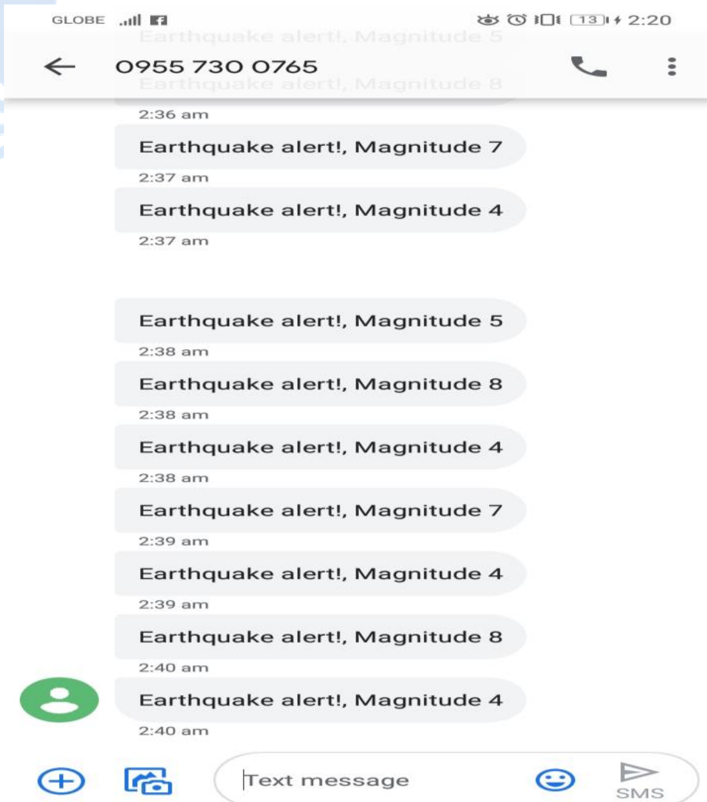


Figure 22. Alert level SMS

ISSN 2582 8088
Volume 2 Issue 1 – March 2021