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Analysis of a Proposed Basic and With Low Cost of Seismic Sensor in Tijuana, Baja California, Mexico

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Abstract – An analysis as a purpose, was made about the design, elaboration and being used as a pilot test, of new automatic sensor to detect movements in a place of educative institution located in the Tijuana city and generates an alert of the possibility of presence of seismic events in this important city of the Baja California State, which is in the northwest of the Mexican Republic. This evaluation is very relevant, because in the last five years, diverse seismic events have occurred in this industrial city, with low intensity. This concern to researchers of seismic analysis, topography people and building persons that have a lot responsibility to build with security buildings in this important city of the Baja California State and Mexico. The new seismic sensor was tested in a school, with positive results, detecting in some periods of the investigation that was made in 2025.

Keywords: Seismic events, seismic sensor, buildings, health symptoms.

1. INTRODUCTION

Baja California State is a zone where are occurred diverse seismic events from the last century, being increased in the last 25 years, which are presented some health symptoms in the population of this state that is located in the northwest of the Mexican Republic. In the Baja California state, are seven cities (Ensenada, Mexicali, Playas de Rosarito, San Felipe, San Quintín, Tecate, Tijuana), being the most important by the quantity of population the cities of Ensenada (almost 450,000 persons), Mexicali (alsmot1,000,000 persons) and Tijuana (almost 2,000,000 persons) (Informe Técnico, 2020). In these three cities are the major infrastructure for buildings taller than 5 steps of height. In the last 25 years (at begin of the XXI century), has been increased the quantity of events of seismic actions in these principal cities, generating concern in person who live in these cities, because the seismic actions can originate health symptoms in persons, especially in heart and breath systems, causing cardiac and respiratory symptoms in people of these cities (Gustavo López Badilla et al, 1999). The main city where was occurred more seismic events, from the 2000 to actual date, is Mexicali, where was presented the biggest seismic event in 2010, causing

some collapses in certain parts of buildings, one of these being the Universidad Autonoma de Baja California, located in the city of Mexicali. In this situation, was death two persons in the moment of the seismic event, and 10 more death by heart attack by the occurrence of this natural phenomenon. Other buildings were suffering damage in his structures (Bogris A. et al, 2022b).

1.1 Seismic events

One of the risks for any population in the world is the presence of natural disasters, with earthquakes being among the most impactful. These have occurred for many years, and their frequency has increased in recent years, becoming more common since the beginning of the 21st century (Villiger et al, 2020). Globally, this type of natural phenomenon has affected several countries, with varying degrees of intensity, including Mexico. The most remembered earthquake is the one that struck Mexico City, with its epicenter off the coast of Michoacán. It registered a magnitude of 8.1 on the Richter scale and caused severe damage to the central, southern, and western parts of the city (Kwiatek G. et al, 2016). Thousands of people died in that earthquake, along with thousands more injured, the destruction of hundreds of homes, significant damage, and widespread and chaos (Adinolfi G. et al, 2023), among the population of this important Mexican city. In addition to Mexico City, the presence of these types of natural phenomena has been felt in the city of Mexicali, which is very close to Tijuana. Tijuana is remembered for the 1987 earthquake, which measured 4.5 on the Richter scale, and the most impactful one occurred in 2010. Several earthquakes have been reported in Tijuana, the most recent being on April 30, 2025. According to seismology experts, this important city in northwestern Mexico is at high risk of earthquakes because it is located between two tectonic plates (the North American Plate and the Pacific Plate) (Becker J. et al, 2017b). Once the theoretical analysis was completed, they proceeded to evaluate the application of technology principles based on concepts of electricity and electronics, and in this way determine the use of essential components to design and manufacture a sensor capable of detecting seismic activity, thus helping to prevent major tragedies for the population, ecosystems, and infrastructure of the Tijuana city, in both urban and rural areas. Other form to call to the seismic events are earthquakes, which are movements caused by the fracturing of rocks underground, generating energy and manifesting particularly as waves that cause oscillatory (left to right and vice versa) and trepidatory (up and down and vice versa) movements. Both movements are also called vibration movements (Allam A. et al, 2019). This type of vibration can cause ground movements in certain areas of the world, which, depending on the intensity of the movement, could lead to serious human tragedies (injuries and deaths), damage to ecosystems and infrastructure in large cities, and economic losses due to the collapse of homes, schools, and commercial, government, and industrial buildings (Lo et al, 2024). Furthermore, this would cause social, health, and economic chaos by overwhelming shopping centers and markets where basic and other products are sold, leading to shortages of all kinds of commercial goods (Loi et al, 2024).

2. EARTHQUAKES OCCURRENCE IN THE MEXICAN REPUBLIC

Seismology experts in our country consider the analysis of earthquakes important because they have caused serious human and economic tragedies. This underscores the need to design and develop prototypes that operate automatically as part of the civil protection efforts of municipal, state, and national governments in our country. According to historical studies dedicated to the analysis of these types of phenomena, high-intensity earthquakes have occurred in the Mexican Republic since the last century, as shown in Table 1 cities (Gustavo López Badilla et al, 1999).

Table -1: Occurrence of earthquakes in the Mexican Republic

Occurrence de Seismic Events	Year	Intensity	City
1	March 26th of 1908	7.6	Mexico City and neighboring states
2	July 30th of 1909	7.5	Mexico City and neighboring states
3	June 03th of 1932	8.2	Mexico City and neighboring states
4	September 19th of 1985	8.1	Mexico City and neighboring states
5	September 20th of 1985	7.6	Mexico City and neighboring states
6	January 23th of 2003	7.6	Mexico City and neighboring states
7	April 04th of 2010	7.2	Mexicali
8	September 07th of 2017	8.2	Mexico City and neighboring states

Source. Analysis of the investigation

Table 1 shows the principal seismic events in the Mexican Republic from the begin of the last century (XX), and the main cities, where was observed that majorly of the seismic events occurred in the Mexico City and neighbors states of Mexico.

2.1 Earthquake aftershocks

These are smaller earthquakes that can occur after larger ones, potentially causing serious risks to the population, infrastructure, and buildings. This is because certain types of structures, such as houses, buildings, bridges, or other structures, may be damaged by the larger earthquake and pose a significant danger to communities, ecosystems, and buildings.

2.2 Use of technology for disaster prevention

Since the last century, technology has greatly supported the development of automated devices and systems for detecting, preventing, and reporting events that can cause major tragedies, such as earthquakes. Two of the most important areas of technology are electricity and electronics, which, together with other technologies, allow for the development of low-cost automated devices and systems, such as the one developed in this project called the "Antiseismic Sensor," which uses low-power, direct current components. The electronic components used in this project are an electromagnetic relay, a bipolar transistor, a 100-kiloohm resistor, wires, and a protection diode. In the event of a short circuit, the protection diode will block the earthquake detection system and the entire prototype, which is designed to detect seismic activity anywhere in the world. It was specifically developed for an area of Tijuana, where, in recent years, various types of low-intensity earthquakes have occurred. However, according to experts in this field, a high-intensity earthquake could occur at any time, potentially causing serious damage to the population, ecosystems, and building infrastructure of this important city in the state of Baja California and in northwestern Mexico. Figure 2 shows the anti-seismic sensor developed for this project, which could be installed in an area of Tijuana, if possible, at a cost of approximately 300 pesos.

2.3 Scientific study objective

To design and manufacture an earthquake sensor using low-cost electrical and electronic components that can detect even the slightest ground movement and assess specific areas of Tijuana, in order to determine risk prevention strategies for earthquakes and avoid damage to the population, ecosystems, and infrastructure of Tijuana.

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Fig -1: Seismic sensor developed with electrical and electronic devices

Source: Analysis of the investigation

2.4 Importance of the investigation

This type of electrical and electronic device, which can operate automatically, is of great importance in disaster prevention, specifically in earthquake prediction. Even with high-tech systems, it is difficult to predict the occurrence of these natural phenomena, even with predictive analysis of earthquakes from previous years and on specific dates. Based on this, the group of students, together with professors, decided to evaluate historical data on earthquake occurrences, analyze electrical and electronic components, and propose the development of an economical and functional seismic sensor with an estimated 80% efficiency.

2.5 Scientific study development

The project included a detailed analysis of earthquake occurrence in Mexico, primarily in northwestern regions, including the city of Mexicali, where earthquakes of magnitude greater than 7 have occurred, such as the one in 2010. Specifically, this project focused on the city of Tijuana. This is because, in recent years, seismic activity has been occurring, and few residents of Tijuana have considered preventative measures against these types of natural phenomena. A basic survey of 20 people in Tijuana indicated that 20% believe a high-intensity earthquake could occur and mentioned the need for an earthquake prevention plan, including the development of affordable technology, such as this proposed project. For the development of this project, most of the materials used were recycled, with only a few new materials (such as the low-cost electronic components), which are listed below:

2.6 Materials and equipment used in the investigation

This project evaluates basic materials at low cost, to design, elaborates and apply the new seismic sensor to detect movements as seismic events, and can prevent to population of the Tijuana city, and other cities of Mexico and in the world. The materials utilized in this investigation are expressed now:

1. Two pieces of recycled wood.

2. One recycled electrical socket.

3. One recycled 25-watt light bulb.

4. One meter of red of #12 of high-power wire (indicating positive polarity) and one meter of black of #12 wire (indicating negative polarity).

5. A 12-volt DC relay converted to 120-volt AC, for converting low-power DC to high-power AC.

6. A 2N2222 bipolar transistor, to control the on/off function of the seismic sensor system when it detects seismic activity. 7. A 100 KΩ resistor to limit the transistor's base current and prevent it from burning out.

8. A 1N4001 diode to protect the system in case of a short circuit in the seismic sensor and to prevent electrical hazards in this project.

9. One meter of 22-gauge low-power red wire (indicating positive polarity) and one meter of 22-gauge black wire (indicating negative polarity).

10. Green and brown glitter foam sheets.

11. Green and gray acrylic paint.

The anti-seismic system was installed connected to an indicator as is showed in figure 3, which was included #12 high-voltage cables (red and black), an electrical plug, and a light bulb with its corresponding socket (rosette)..

Fig -2: Electrical indication system of the seismic sensor
Source: Analysis of the investigation

3. CONCLUSIONS

This investigation was developed in any educative institution of Tijuana city, is very relevant because it can serve as a disaster prevention system for the civil protection department of the city of Tijuana. The thematic analysis helped to investigate earthquakes, their occurrence in Mexico, and specifically in the northwestern region of the country, particularly in the cities of Mexicali, where earthquakes have occurred since the 1980s, and Tijuana, where these types of natural phenomena are beginning to occur. The students, together with the advising professors, evaluated the electrical and electronic components, once they had acquired knowledge of the subject of technology related to the area of electricity and electronic topics, and designed

the anti-seismic sensor and carried out the necessary tests to obtain a high-efficiency anti-seismic sensor for detecting seismic movements and at low cost.

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