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A Study on Seismic Risk Analysis

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Abstract

Despite all the research and scientific advances that have been made, earthquakes and the financial damages and human casualties caused by them have been accepted as an inevitable event in human life. Scientific advances and available facilities in the present era have grabbed the attention of researchers and experts, finding appropriate solutions to reduce the resulting damages.

Today, considering population growth and the density of city buildings, the issue of earthquake risk and the resulting damages is of paramount significance. Apart from negative aspects of the phenomenon of risk, it can cause a broadening of the horizons, development, and prevention of negative events. Besides, a large part of the country of Iran is located in the earthquake zone with a high risk of occurrence. The causes of earthquake occurrence and measurement indices, the concept of risk, identification, analysis, and finally, risk management are presented in this report.

Keywords: Earthquake, Risk analysis, Risk management, Risk sharing.

Introduction

Despite all scientific research and progress, earthquakes and the resulting financial losses and human tragedies have been recognized as an unavoidable part of human life. On the one hand, the possibility of earthquake-caused destructions, and on the other, the absence of adequate facilities to forecast earthquakes have prompted researchers and professionals to seek appropriate and comprehensive ways to prevent earthquake-related injuries. In order to evaluate the effects of the earthquake and its aftermath on various construction projects prior to the event, methodologies have been developed. By recognizing the plan's flaws and fixing or strengthening them, financial and human resource loss can be avoided. A substantial portion of this vast nation is situated within the earthquake belt. Due to the frequent occurrence of earthquakes in this country, as well as the presence of dams and gas pipes in cities and other sensitive areas that will be extremely hazardous in the event of an earthquake, it is vital to adopt certain measures to protect against these natural catastrophes.

History of earthquake prediction

As seen from the history of earthquakes, humankind has been concerned with earthquake prediction and mitigating the severity of life and property losses caused by earthquakes for centuries. Some of these forecasts have been accurate, while others have been inaccurate. They are, however, deserving of appreciation. Ancient Chinese and Iranian civilizations were the pioneers of earthquake prediction. In ancient Iran, the first earthquake forecast of which there is information is referenced in Assyrian letters from the Sarkani Dynasty (possibly in the eighth century B.C.) (Waterman) and in Hatfan's prediction.

Reporters, whether professional, casual, or indirect, have acquired and recorded an enormous amount of data on the precursory phenomena of seismic events throughout the last 25 centuries. Such data have been organized throughout the last 120 years and have been the focus of systematic applied research in the last 30 years. However, the scientific community has been reluctant to value these historical trajectories as a method of better comprehending the process of accumulating and applying knowledge in the field of earthquake prediction research [1].

For instance, the astronomer Abu Taher Shirazi predicted the earthquake that occurred in Tabriz in 1042 A.D. He unsuccessfully attempted to urge the inhabitants to abandon the city. Due to the frequency of earthquakes in this region, it was probable that another would occur. Despite his great efforts to predict, the people treated him with indifference and compassion. According to the history of earthquakes in Iran, over forty thousand people were killed as a result of an earthquake [2].

The earthquake that occurred in Qohestan in 1549 A.D. was also predicted by the local judge, who unsuccessfully attempted to order people to spend that night outside. But they refused to listen, and only the judge and his family stayed outside. Those who found the weather at night to be extremely cold, however, returned to their homes and were killed along with 3000 other residents of the region. Astrologers were more successful in forecasting the earthquake that struck Lar city in the summer of 1593 and persuaded its people to evacuate the city.

Before a major earthquake, astrologers frequently relied on the strange behavior of animals. However, there are relatively few instances in which such behaviors have been notably unique or identified as earthquake precursors. In China, the successful forecast of the earthquake that struck the Chang region in 1975 brought hope for the realization of this great human ambition. Even seismologists were unaware of earthquake prediction in the 1960s, despite significant research and many objective observations of several earthquakes.

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In any case, seismologists eventually became aware of the occurrence of some earthquake-related events. In concept, Japanese experts were the first to address the subject of earthquake prediction by establishing the Earthquake Prediction Committee (1960 to 1963 AD). In this field, cooperation between this country and the United States was formed in 1961. The publication of the "Savaransky" paper in 1967 also drew attention to the topic of earthquake prediction in the former Soviet Union. Simultaneously, the Chinese government studied various projects in this field. There were signs of an earthquake near the city of Haichang on China's east coast in December 1974.

Experts issued a warning, and people fled the city and scattered. However, the projected earthquake never occurred. Two months later, in February 1975, the public was told about the earthquake once more. People misinterpreted these warnings because they did not wish to leave the city or their homes. In any case, with police intervention, the city and vulnerable areas were evacuated. This time, a magnitude 7.5 earthquake struck, and because the city was evacuated, no one was hurt, and hundreds of people were rescued from imminent death. Before the 1976 earthquake, there were warning indications, but because there was no clear mechanism like there was in 1975, the citizens of the city were not warned, resulting in the deaths of thousands.

The 1975 earthquake in China was caused by the activity of one of the region's major active faults. Detailed analyses of crustal deformation in the fault zone led to the discovery of maximal deformation in late 1974 (December), indicating that this was not a typical occurrence in the past. Japan has the most advanced earthquake prediction system now. About seventy locations in this country have been equipped with sensors that broadcast the amount of gravity, magnetic properties, the slope of the land, and deformation of the earth's crust to the computer center at the Japan Meteorological Agency's headquarters in Tokyo. This information, along with other variables such as sea water height, tides, and other factors, is compiled in a particular table by specialists.

The Tokyo Metropolitan Disaster Prevention Agency is currently computer-recording the behaviors of a number of catfish since it is suspected that they exhibited strange behavior before the earthquake. Despite Japan's high level of readiness for earthquakes, there are still many outstanding concerns regarding the forecast and intensity of earthquakes. Human has not yet been able to make significant progress in this area; in fact, the effort is only underway. Because, for example, after eighteen months of successful earthquake prediction in Haichang, China, in 1975 (with the assistance of approximately one thousand professional experts and one thousand non-specialists), an earthquake with a magnitude of 7.8 Richter occurred in Tangshan, China, killing seven hundred and fifty thousand people.

However, it is important to recall that just 18 of the 31 earthquake predictions made in China within the two years were accurate, with the remaining seven being doubtful and the remaining six being completely wrong. Nevertheless, the Japanese are concerned about major earthquakes. Thus the government, the nation, and the country's scientists have taken extensive precautions in this area.

Precursor

Nowadays, advancements have been made in the realm of earthquake prediction. Numerous efforts have been undertaken by scientists and academics to collect information for predicting earthquakes. A precursor is any parameter that varies prior to the occurrence of an earthquake in such a way that the earthquake can be predicted by carefully evaluating these changes. More than 30 precursors have been found to date.

Causes of Earthquakes

The lowering of the earth's gravity is the leading cause of earthquakes. For instance, the inability to predict the magnitude 7.5 earthquake that occurred in Japan in 1975 was since the reduction in earth's gravity at that location was not instantly compensated. In December 1974, in Japan, the expected fall in earth's gravity at a specific location was offset by natural processes, and the predicted earthquake did not occur.

Crust deformation

The earth is not a stationary and lifeless planet but is constantly changing. The earth has three layers: the outer layer (crust), the inner layer (mantle), and the middle layer (core), which stores a great deal of energy. When the earth's gravitational force reduces at a certain place, the sun's gravitational force draws that point toward itself. At that point, the earth begins to take shape concurrently (in the form of uplifting, falling, and tilting). An earthquake happens if the earth's gravitational field weakens at that location.

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Figure 1: Example of crustal deformation (Anticline folds in bedrock, near Saint-Godard-de-Lejon, Canada) [3]

Figure 1 depicts anticline folding caused by compressive force, in which rock layers dip toward the fold's center and are almost symmetrical.

Fault

In reality, a fault is a sort of deformation of the earth's crust that takes the form of a depression, which might be horizontal, vertical, etc. The fault is caused by a decrease in the earth's gravity. The earth's core draws that point toward itself by releasing a large amount of energy, resulting in the formation of a fault. When the gravitational force around a fault decreases at the same time the fault forms, an earthquake occurs, it is also possible for the fault to remain unchanged for years without causing an earthquake or for an earthquake to occur anytime the gravity of the fault falls around the fault. In this instance, experts incorrectly attribute the earthquake to the fault. A prime example is the massive San Andreas fault, which is formed over a thousand kilometers from western California in a vast shear zone [4]. This large rift was responsible for two of California's largest earthquakes in 1857 and 1906. Due to the magnitude and significance of this fault, it was thoroughly examined upon discovery. After the 1906 San Francisco earthquake, this fault gained worldwide recognition. This earthquake killed 700 people and caused billions of dollars in damage. The San Andreas fault is the tectonic boundary between the North American and North Pacific plates and separates the southwestern portion of California from the rest of North America. The Pacific Ocean and the portion of California west of the San Andreas Fault generally move in a northwesterly direction relative to the rest of North America. Various methods have been used to estimate the amount of relative motion between the North American and North Pacific tectonic plates. According to seismic methods, this value is between 4 and 6 cm per year. In California, measurements of the earth's surface indicate a rate of 5 to 75 cm per year.

As with other faults, the San Andreas fault is not a single fracture in the rocks but rather a large area comprised of multiple activity lines that are nearly parallel to one another.

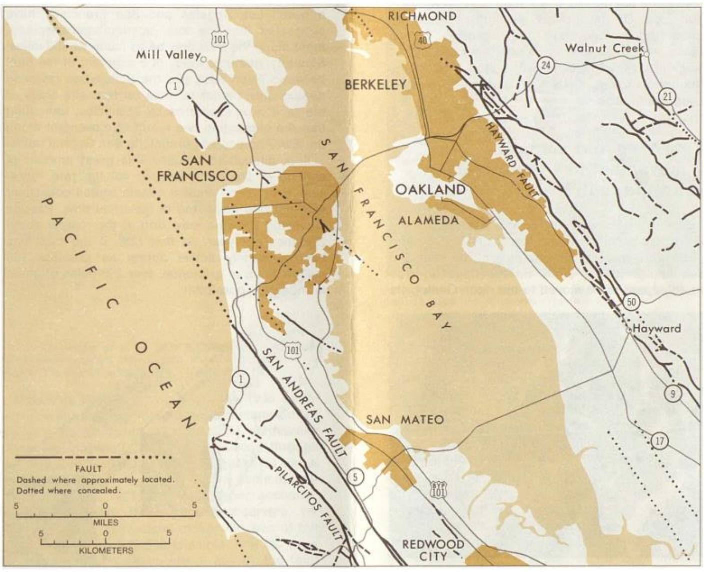

Figure 2: San Andreas Fault and other San Francisco Bay faults [4]

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Volcano

A volcano is characterized as a naturally occurring lava flow that is accompanied by an explosion and molten material eruption. The drop in earth's gravity is the cause of the volcano's occurrence. A volcano is characterized as a naturally occurring lava flow that is accompanied by an explosion and molten material eruption. The drop in earth's gravity is the cause of the volcano's occurrence. On the peaks of mountains, gravity is absent under normal circumstances. When the earth's gravity reduces near the peak of the mountains, the sun's gravity draws materials within the mountain towards itself, resulting in the eruption of the volcano. In this situation, an earthquake occurs, the magnitude of which relies on the drop in the earth's gravity.

For instance, when a person or any other living creature that inhabits the low, flat regions around the mountain is positioned on the mountain's peak, its weight reduces. For instance, when a person or any other living creature that inhabits the low, flat regions around the mountain is placed on the mountain's peak, its weight reduces. If this person or live creature is returned to the ground under the same conditions, their lack of mass will be compensated. The rationale is obvious. Elevations and mountain peaks have greater gravity than lowlands and plains.

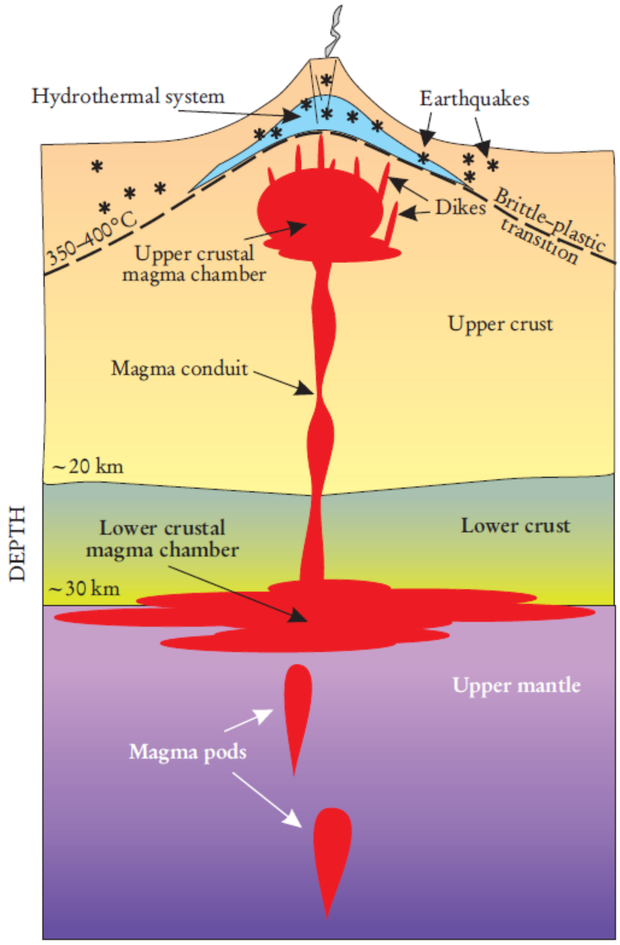

Figure 3: The volcano's formation process [5]

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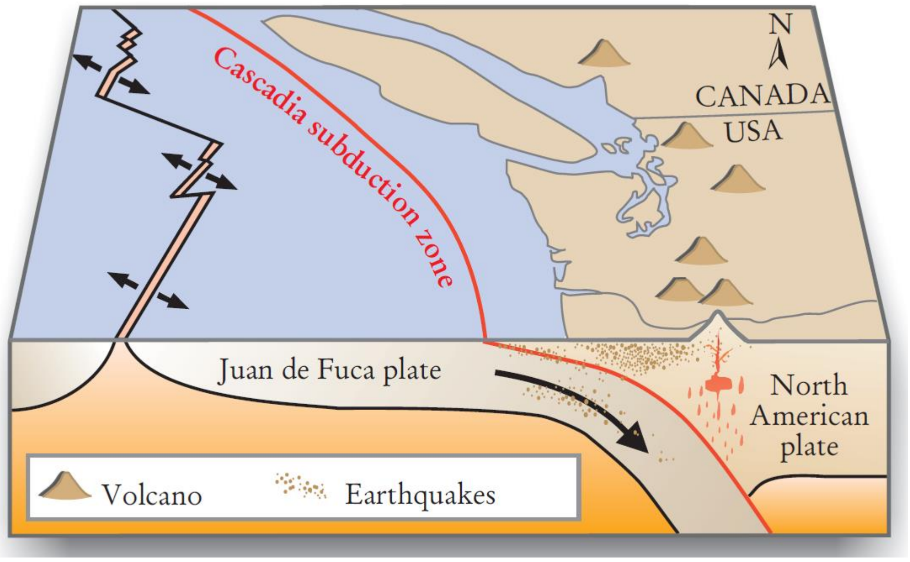

Figure 4: Changes in quasi-static stress, a mechanism that may link earthquakes to eruptions [5]

Earthquake waves

Earthquake waves are essentially the same energy that is released from the earth's core and radiates outward. Earthquake waves originate from the epicenter and radiate outward. At the epicenter of an earthquake, the earth's gravity begins to drop. The earth's core then draws that point towards itself by releasing a great deal of energy. In other words, earthquake waves depend on the rate of loss in the earth's gravity. P waves are formed if the gravity of the earth falls uniformly. If this force decreases in an inhomogeneous manner, S shear waves will be generated. Due to its uniformity, P waves lead rocks to get compressed. However, because S shear waves are not uniform, they force rocks to rise and fall [6].

The intensity of the earthquake

Definition: In reality, the magnitude of the earthquake is the decrease in the earth's gravity. Every earthquake has its maximum intensity near its epicenter, and its intensity lessens as it moves away from the epicenter. Typically, the epicenter of an earthquake is where the greatest economic and human losses occur.

The measurement scale of earthquake intensity

Rossi-Forel introduced the first scale for quantifying the intensity of earthquakes in the 1880s in Switzerland. Approximately twenty years ago, the ten-degree Rossi-Forel scale was utilized to investigate earthquakes and measure their global effects. Mercalli, an Italian seismologist, devised a new scale of 12 degrees in 1902, enabling a more precise estimation of serious damage. Two American seismologists named Wood and Neumann modified the Mercalli scale to include groundwater pipes in 1931, and the new scale is still in use today. The modified Mercalli scale is not an engineering scale used to measure the intensity of earthquakes. Rather, it is a theoretical scale for seismic consequences.

Earthquake intensity scale

Two types of scales are commonly used to express the magnitude of an earthquake. The intensity of the earthquake is a theoretical scale based on observations and impacts of the earthquake on structures and people, while the magnitude of the earthquake is a quantitative measure of the extent of the earthquake. Even if the earth's gravity lowers further, the earthquake will be severe. Because the main cause of earthquakes is a decrease in the earth's gravity, and the earthquake's magnitude is also affected by the drop in the earth's gravity.

Earthquake intensity scale

In general, the term "earthquake intensity" refers to the level of danger posed by an earthquake in a particular location, but it is actually a measurement of the impact caused by an earthquake. In other words, it represents the level of shaking at a particular location. Attempts have always been made to quantify the complex occurrence of earthquakes using a simple numerical scale, which cannot be devoid of logical and fundamental problems. Currently, the modified Mercalli scale, designated by the abbreviation MM, is the most popular. Obviously, this scale is not a precise engineering scale for assessing earthquake severity.
However, it is a theoretical scale of twelve degrees for the impacts of earthquakes. Another major intensity scale is the Japan Meteorological Agency's (JMA) intensity scale, which has seven degrees. Medvedev-Sponheuer-Karnik has revealed a new categorization called the MSK intensity scale, and in this classification, earthquake effects are evaluated based on the three key criteria listed below.

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A- Human perception and its impact on the environment
B- The impact on any kind of structure
C- Changes and impacts of underground water and water systems on earth.
The MSK scale also comprises twelve degrees, similar to the MM scale in this regard. In western countries, the modified Mercalli severity scale is most prevalent, while in eastern countries, the MSK scale is utilized [7].

Earthquake magnitude scale

In actuality, the intensity of an earthquake reflects the destructive force of an earthquake in a particular region, but it does not provide information on the size and magnitude of the earthquake. Examining the affected area and the nature and extent of the destruction helps to establish the magnitude of an earthquake. In general, the intensity of an earthquake decreases with increasing distance from its epicenter. However, the magnitude of an earthquake is a quantitative assessment of the extent and amount of energy released by the earthquake, and it is not necessary to examine a particular location to estimate it. They determined the magnitude of the earthquake in 1935 by statistically analyzing multiple shallow earthquakes. The magnitude of an earthquake M is equal to the logarithm in base ten of the maximum amplitude (in microns) of movement A measured by a standard seismometer one hundred kilometers from the epicenter [8].

$M = Log(10)\ A$

Due to the fact that, in practice, the distance between the earthquake's epicenter and the seismic measurement station is not 100 kilometers, additional corrections must be used to determine the magnitude of the earthquake. Since there is insufficient information about the nature of the ground between the measuring point and the epicenter, the typical error ranges from 10 to 40 kilometers.

Definition of risk

Risk literally translates as incurring hazards. According to the definition of risk, it contains the concepts of the future and uncertainty. It refers to an incident that is probable. A phenomenon about whose occurrence there is no doubt cannot be deemed a risk. According to this definition, everyone's risk perspective is negative, as it leads to injuries and losses. If the identification and recognition of the risk are accurate, the risk can be identified.
Consequently, risk can be calculated. It implies that risks can be detected, studied, decreased, decided upon, and then managed. Using the following logical relationship, the risk is calculated.

$$Risk = \frac{Loss \times Probability}{Preparation}$$

According to the above equation, after determining and identifying the probability of occurrence, the level of risk is defined as high or low based on the amount of potential damage and the degree of preparation (the amount of preparation or measures considered in the current situation).

Earthquake Risk

Knowing and analyzing the probability of an earthquake and its features, including its intensity, magnitude, and other factors, such as the number of potential damages and the level of preparedness for the current situation, determines the level of risk.

Risk analysis

Now, after identifying the risk, the preparedness to cope with it must be raised to mitigate the resulting damage. This enhancement of preparation necessitates an understanding of risk and its analysis. So as to estimate the risks, it is required to develop a rational model for risk measurement. These models must be based on known risks. Risk analysis has two objectives. First, they illustrate the relative significance of the detected risks, which demonstrates the possibility of prioritizing them. Second, it gives the knowledge necessary to choose the most effective strategy or combination of methods to mitigate the risk. The probability and consequence of a risk define its importance [9].

Qualitative analysis of risk

In qualitative risk analysis, the "effect" and "probability of occurrence" of identified risks are evaluated qualitatively. In practice, the risk assessment is evaluated using the product of the probability that the desired phenomenon will occur and the amount of potential positive or negative effects that phenomenon may have. The assessment of risks is divided into three categories: low-importance risks, medium-importance risks, and high-importance risks. You can use the brainstorming method, the Delphi method, an interview, or a questionnaire to qualitatively analyze risks and determine the likelihood of occurrence and the impact of each risk. These methods are explained below:

Brainstorming method

In this strategy, the project team frequently holds brainstorming sessions in the presence of experts from diverse domains who are not project team members. Under the direction of the secretary of the meeting, several concepts on the project's risks are generated. Risk classification types, such as the risk breakdown structure, can be utilized as a framework for classifying and defining identified risks according to their type.

Delphi method

This technique is a mechanism for achieving expert consensus on a single opinion. Experts in project risk participate anonymously in this technique. As a director, one individual distributes a questionnaire to collect the participants' perspectives on the project's

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most significant risks. The responses are then summarized and sent back to the experts for further clarification. After multiple rounds of this process, a consensus may be obtained. The Delphi method reduces data installation and eliminates the inappropriate effect of persons on the outputs.

Interview

Conversations with senior project agents, stakeholders, and subject matter experts can lead to the identification of risks. Interviews are one of the primary sources of information for identifying risks.

Quantitative risk analysis

It is a procedure for calculating the numerical value of the likelihood of occurrence and the magnitude of the consequences of risks. Some researchers equate quantitative risk analysis with risk measurement, defining risk measurement as a mathematical description of the frequency and probability of occurrence of risk variables. In general, quantitative risk analysis follows qualitative risk analysis. It is also necessary to identify the risks in order to achieve this. Here quantitative risk assessment methods are introduced and explained:

1. Analytical method

(below are the methods of risk analysis in earthquakes): For all significant faults located at a distance from a plan, the magnitude of earthquakes on the surface of the fault is calculated using the experimental formulae presented below. The magnitude of a potential earthquake is then calculated on each fault by averaging the acquired values using the following three equations.

❶m = 1.25 + 1.244 Log L
❷m = 4.671 + 1.248 Log L
❸ m = 3.24 + 0.7 Log L

In the following equations:
m: Potential earthquake magnitude on the Richter scale
L: The fault's half-length in kilometers.

Equation 4 is used to calculate the amount of earthquake intensity at the hypocenter of possible earthquakes.
❹m = 0.77 (I_0 – 0.07)
In the equation above, m represents the Richter magnitude of the earthquake, and I0 is the intensity of the earthquake at its hypocenter. Using relations (5) and (6), the earthquake's intensity at the desired location is then calculated.
❺ I_0- $I_{(R)}$ = - 3.44 + 0.002 R+ 3.1 Log R
❻ $I_{(R)}$ = I_0 + +.453 – 0.0012 R Log (R + 20)
The average intensity of the earthquake is calculated using equations 5 and 6. Then, using the velocity obtained from equations 7 and 8, the horizontal velocity resulting from potential earthquakes in each fault is calculated, and the average of the two is reported as the outcome of the analytical study of each fault.
❼Log a (h) = 0.251 + 0.25
❽ Log a (h) = 0.31 + 0.14

2. Statistical Method

In this method, earthquakes detected by seismographs are collected within a certain radius of the studied area (100 kilometers) over the course of multiple years. Because earthquakes with a magnitude of less than 4 Richter can be accompanied by large aftershocks, statistical studies disregard them. After classifying earthquakes greater than four on the Richter scale into 0.2 Richter categories, the cumulative frequency and logarithm of the cumulative frequency for each category are calculated (Nc, log Nc). This is followed by determining the relationship between Log Nc and the surface magnitude of earthquakes (MS). The resulting linear equation is shown below.
❾Log Nc = 6.76 – 0.99 MS
The return period of earthquakes is then determined using the following equation for the useful life of the structure and the percentage of different risks.
❿ $TR = \frac{1}{P} = \frac{1}{1-(1-q)^{1/n}}$
Where
Q: life expectancy of the structure
n: risk percentage
TR: Frequency of earthquakes per year
P: Possibility of a seismic event.
Using equation (11), the earthquake's magnitude is then calculated.

⓫ $$MS = \frac{\left[Log\left(\frac{TR}{T}\right)+6.76\right]}{0.99}$$

Where
TR: Frequency of earthquakes per year
MS: Earthquake surface-wave magnitude in Richter scale
Then, applying fowling equation:
Log a (h) = 0.251 + 0.258 (Log (h)) = 0.31 + 0.14
It is determined the horizontal velocity caused by earthquakes in the project area.
In this method, the epicenter distance closest to the site is chosen, and it is assumed that other earthquakes have occurred from the same distance.

3. Artificial neural network method

The application of artificial neural network (ANN) based on artificial Intelligence (AI) have been increasingly developed. In a short period of time, it was discovered to have broad relevance across different disciplines. As a result, there has been a surge in research into the art of applying such methodologies to real-world problems, revealing the inherent promise and limitations of such systems [10]. In the technique

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of ANN, the information is gathered from seismographs that can predict the time and magnitude of earthquakes in the study area. The earth's cumulative seismic energy up to the time of the earthquake is converted into the magnitude of earthquakes in this method and provided to the software as one of the input parameters. The information data used also includes other factors like focal depth, the distance between the earthquake's epicenter and the fault that caused it, and the time the earthquake occurred. All information is formalized and utilized as software input. Using these data, it is possible to prioritize the risks by specifying the hazards and risks in the area (in the case of earthquake risk) by selecting the appropriate model and then prioritizing the development of the corresponding management plans. Finally, the time of the subsequent earthquakes and the amount of energy that can be released from the earth at the desired time are determined, and the earthquake's magnitude is calculated. Risk analysis is one of the tools used for risk management. At the end of the paper, the risk management and its objectives are defined briefly.

Risk management

Due to urban sprawl and the increase in building density in cities, as well as the presence of high-risk infrastructure such as gas pipes, there is an urgent need to implement risk-reduction measures in urban residential areas. Risk management as a new and successful strategy in the phases of prevention and preparedness for catastrophic events has been implemented in many ways around the globe. Risk management is comprised of the processes required to recognize, analyze, and respond to a crisis. It follows that under normal circumstances, there is a balance between the needs of society on the one hand and the available capabilities and resources on the other and that a crisis is a mismatch between needs and resources. Natural and unnatural occurrences, such as earthquakes, floods, typhoons, and wars, among others, can cause critical conditions. No longer will there be a balance between a society's needs and its resources in times of crisis as a result of the special conditions imposed upon it. One of the distinguishing characteristics of risk management is making the necessary preparations before the occurrence of damages and unfavorable consequences. Among the risk management measures are responding to critical situations before an accident, reducing costs, and enhancing the effectiveness of crisis management programs. Crisis management is a collection of procedures conducted before and after a catastrophe to mitigate its consequences and complexities to the greatest extent possible. The application of the method of earthquake risk management to natural disasters in many nations has a lengthy history, and various organizations employ distinct frameworks. According to the cases cited, risk management and its methods give the opportunity for localization in accordance with the specific conditions of each region. General risk management stages include risk identification, qualitative risk analysis, quantitative risk analysis, risk response, risk reduction, risk decision, risk transfer, control, and monitoring of risk response outcomes [11], [12], & [13].

1- Risk identification: It is a crucial phase of risk management. It serves as the foundation for risk management planning by understanding the frequency of occurrence and the magnitude of the phenomenon's impact; at this stage, the risks are identified, and the direction of risk management is determined. One of the most effective methods for identifying and categorizing risks is to create a checklist of risks.

2- Qualitative and quantitative risk analysis: This article describes the procedure.

3- Risk response planning: It entails assigning responsibilities to individuals and groups to respond to identified risks, which is accomplished in six ways:
1-3- Risk acceptance: Risk acceptance can be either active or passive. Active acceptance involves the rational formulation of an executive plan and preparation for facing risk, whereas passive acceptance is the acceptance of losses caused by risk.
2-3- Risk mitigation: Minimizing the likelihood of occurrence or the severity of threatening risks to acceptable levels.

Risk sharing (participation in risk)

The major finding is that if the aggregate risk is very small, the agents with the most uncertain beliefs do not participate in risk sharing. The ambiguity of those agents' beliefs increases the likelihood of their nonparticipation. Agents with less ambiguous views have lower risk avoidance, which increases the likelihood of nonparticipation [14].
If it is difficult for one sector to reduce the risk, it is preferable to divide it across two or more sectors and manage it based on the proportion at which each department is best able to control it individually.
Risk transfer: Its ownership and risk are transferred to a third party. The third-party is responsible for the work or accident, and the stakeholders monitor it in a supervisory position.
Risk avoidance
By altering the plan or the desired range, risk can be avoided. This preserves the goals by removing the risk and its associated conditions or preventing the risk's occurrence.
Risk monitoring and control:
It is the process of monitoring recognized risks, controlling the residual risks, identifying new risks, obtaining guarantees from implementing risk strategies, and evaluating their efficacy in risk management.

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Conclusion and recommendations

In this paper, the significance of earthquake prediction, knowledge of earthquake causes, the concept of risk, and how to identify, analyze, and ultimately manage it is examined. Due to the rising population and construction densities in urban areas, the problem of minimizing earthquake risk and its possible risks is of special relevance. Risk is a window for the intelligent management and prevention of unfavorable occurrences. This is even though vast areas of Iran are situated in a region with a high risk of earthquakes. Consequently, by understanding the causes of earthquakes and the potential hazards involved, it is vital to take steps to mitigate the resulting damages and disasters.

This can be accomplished by retrofitting buildings, gas pipes, and facilities that are susceptible to exploding during an earthquake. In some circumstances, the consequent damages will be prevented entirely if people are made more aware of the importance of taking safety precautions during an earthquake and if earthquake-prone regions have a risk management plan.

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