

**EARTHQUAKE - CAUSES, TYPES, CHARACTERISTICS, POPULATION
PROTECTION**

Ravshanova Inoyat Erkinovna

Lecturer of the Department of Special Pedagogics of KSU
inoyatxonravshanova@gmail.com

Abstract: This article is about the causes of earthquakes, the main mechanisms of their formation and classification by origin and characteristics. Particular attention was paid to the differences between tectonic, volcanic and artificial earthquakes, as well as the features of their manifestation, strength, duration and scale of destruction.

Keywords: geosystem, tectonic, volcanic, artificial earthquakes, Richter scale, Mercalli, lithosphere, seismic safety.

Introduction

Earthquakes are among the most destructive natural phenomena, significantly affecting geosystems, infrastructure and human settlements around the world. This phenomenon is a sudden shift in the earth's crust caused by the release of accumulated energy as a result of the movement of tectonic plates.

In modern seismology, the study of the causes of earthquakes, their types and characteristics is of particular importance, since the effectiveness of measures to protect the population and minimize the consequences of such disasters depends on this. The relevance of this topic is due to the need to increase the level of seismic resistance of buildings, develop early warning systems and form the readiness of the population to act in case of emergencies.

Historically, earthquakes accompanied the development of human society, often leading to large-scale destruction and human casualties. Modern research shows that the main causes of earthquakes are associated with the activity of tectonic plates moving relative to each other. The mechanisms of occurrence include collision, divergence and sliding of plates, as a result of which energy accumulates at the boundaries, which, when suddenly released, causes seismic waves. In addition to natural causes, earthquakes can be caused by volcanic activity and artificial influences such as explosions and mining. These factors complicate the picture of earthquake occurrence and require a comprehensive analysis.

Earthquakes are classified into several types, each with its own characteristics. The most common are tectonic earthquakes, which occur due to movements in the earth's crust. Volcanic earthquakes are associated with magma movement and volcanic activity, while artificial earthquakes are associated with human activity, including construction, explosions, and mining. Each type has its own parameters - strength, duration, depth of the source, and area of propagation of seismic waves. The destructive force is assessed using scales such as the Richter and Mercalli scales, which allows us to determine the extent of possible destruction and threats to life and infrastructure. Knowledge of earthquake characteristics plays a key role in the development and implementation of measures to protect the population. Important aspects include the creation of earthquake-resistant buildings, early warning systems, training the population in emergency response, and planning evacuation measures.

Modern technologies for monitoring, modeling and predicting earthquakes make it possible to increase the effectiveness of preventive measures, but there are still challenges associated with

insufficient forecast accuracy and the need for constant infrastructure upgrades. In the context of growing urbanization and increasing population density in seismically hazardous areas, the development of science and technology in the field of seismic safety is becoming especially relevant. Thus, studying the causes, types and characteristics of earthquakes, as well as developing modern methods of protecting the population are the most important tasks for reducing the negative consequences of natural disasters and increasing the resilience of societies to seismic threats. In this work, special attention is paid to the analysis of the mechanisms of earthquake occurrence, their classification and characteristics, as well as assessing the effectiveness of existing measures to minimize their impact. The study of this issue contributes to the formation of scientifically based approaches to risk management and the development of a seismic safety system, which is especially important in the conditions of the modern world.

I. Main Causes and Mechanisms of Earthquakes

The main causes and mechanisms of earthquakes are caused by the movement of lithospheric plates - large segments of the earth's crust that are constantly in motion. These movements occur as a result of tectonic processes, which are a consequence of the internal energy of the planet. The internal forces of the Earth cause collisions, divergences and sliding of plates relative to each other, which ultimately leads to the accumulation of energy in the area of plate boundaries. When this energy reaches a critical value, it is suddenly released in the form of seismic waves, causing an earthquake.

Tectonic processes are the most common cause of earthquakes. Basically, three types of lithospheric plate boundaries are distinguished: convergent, divergent and transform. At convergent boundaries, collisions and compression of plates occur, which leads to the subduction of one of them under the other and the formation of powerful earthquakes. In divergent zones, where plates move apart, new sections of the earth's crust are formed, accompanied by seismic phenomena. At transform boundaries, plates move side by side, which causes faults and earthquakes of varying strength.

In addition to tectonic causes, earthquakes can be caused by volcanic activity - when magma moves inside the earth's crust, energy accumulates, which, when released, causes local or large-scale seismic events. Artificial causes of earthquakes are associated with human activity: explosions, construction of large infrastructure facilities, mining, which can also lead to the occurrence of seismic waves, especially in areas with intensive industrial activity. The mechanism of earthquake occurrence can be explained through the processes of stress and ruptures in the earth's crust. When moving plates collide, stress accumulates in the fault area. When the stress exceeds the strength of the rocks, a rupture occurs, and the energy accumulated in the form of deformations is released in the form of seismic waves. These waves spread from the earthquake source - the rupture point in the earth's crust - in various directions, causing vibrations and destruction on the surface.

The key mechanism is shear activity on faults, which is the source of most earthquakes. The most dangerous and destructive earthquakes occur during shear along large faults, such as the San Andreas Fault in California or faults in the Himalayas. An important aspect is that earthquake mechanisms can be combined, and in some cases earthquakes are caused by the simultaneous action of several factors.

In general, earthquake mechanisms are closely related to the movement and interaction of lithospheric plates, as well as to internal processes within the Earth. Understanding these

mechanisms is important for developing methods for predicting and preventing destructive consequences. Modern geophysical research uses seismographs, satellite technology and computer modeling to track plate movements and assess the risk of earthquakes. Despite the active development of science, it is still impossible to fully predict an earthquake, but studying its causes and mechanisms can significantly increase the effectiveness of measures to protect the population and infrastructure.

II. Classification of earthquake types and their characteristics

Classification of earthquake types and their characteristics is an important part of the study of seismology, since it allows us to understand the nature of this natural phenomenon, its manifestations and possible consequences for humans and infrastructure. Depending on their origin, mechanism and characteristics, earthquakes are divided into several main types, each of which has its own characteristics and also requires specific methods of prevention and protection.

The first and most common type are tectonic earthquakes. They occur as a result of movements in the earth's crust associated with the activity of tectonic plates. The main mechanisms of their occurrence include the collision, divergence and sliding of plates relative to each other. Energy accumulates at the boundaries of these plates, which, when released, causes seismic waves. Tectonic earthquakes can have different strengths and durations, and their scale depends on the nature and speed of plate movement, as well as the depth of the source. This type of earthquake is considered the most dangerous and destructive, since it can cause significant destruction of buildings, infrastructure and lead to human casualties. Volcanic earthquakes are associated with the movement of magma within the earth's crust. They are caused by changes in the magmatic system, such as the rise of magma to the surface or its movement within volcanoes. In these cases, energy is released as a result of the pressure created by the magmatic masses and causes the earth's surface to tremble. Volcanic earthquakes are usually less powerful than tectonic earthquakes, but they often precede or accompany volcanic eruptions. They can serve as an important indicator of volcanic activity and require special attention when monitoring volcanic areas.

Artificial earthquakes are caused by human activity that causes sudden changes in the earth's crust. These include explosions associated with mining, construction of large infrastructure facilities, and nuclear weapons testing. These earthquakes are usually less powerful, but in some cases they can reach significant sizes and cause localized destruction. An important feature of artificial earthquakes is the ability to control and predict them, which allows for measures to minimize their negative consequences. Each type of earthquake has its own characteristics, which include strength (power), duration, depth of the source, and area of propagation of seismic waves. The strength of an earthquake is assessed using the Richter scale or the Mercalli scale, where the former characterizes the quantitative force, and the latter characterizes the degree of destruction and impact on the population. An important aspect is that earthquakes can have a local effect, limited to a certain territory, or they can spread to large regions, causing large-scale destruction and human losses.

Studying the types of earthquakes and their characteristics allows us to develop more effective measures to protect the population. This includes the construction of earthquake-resistant buildings and structures, the creation of early warning systems, conducting training programs for the population on actions in emergency situations, and the development of evacuation plans. Knowledge of the characteristic features of each type helps to correctly assess potential risks and promptly respond to possible threats. In general, the classification and understanding of the

characteristics of earthquakes are the foundation for increasing seismic safety and reducing damage from this natural phenomenon.

III. Methods of protecting the population and preventing consequences

Methods of protecting the population and preventing the consequences of earthquakes are an important component of seismological safety and require a systematic approach, including both technical and organizational measures. The main objective is to reduce the risk of human casualties and material losses associated with the destructive consequences of this natural phenomenon.

One of the key methods of protection is the construction of earthquake-resistant buildings and structures. Modern design standards provide for the use of special design solutions, materials and technologies capable of absorbing and distributing seismic energy. For example, the use of rubber shock absorbers, seismic belts, and seismic-resistant foundation systems can significantly increase the resistance of buildings to earthquakes. In countries with high seismic activity, such as Japan or Chile, seismic-resistant construction is a mandatory regulatory requirement, which significantly reduces the risk of collapses and injuries.

The establishment of early warning systems is another important element of prevention. These systems use networks of seismographs located throughout the region to quickly detect the initial tremors of the earth's crust. Once the first weak seismic waves are registered, signals are automatically transmitted to control centers, which can trigger public alerts and activate safety measures. As a result, residents receive timely information about the impending danger and can take the necessary actions, such as evacuation or shelter in safe places. In countries such as Japan and California, early warning systems are already successfully operating and demonstrating their effectiveness in minimizing losses.

Educating the population on how to act in emergency situations is an important aspect of prevention. Regular training, information campaigns, and distribution of leaflets help to increase the level of preparedness of citizens for earthquakes. People should know how to behave correctly during tremors, where to seek shelter, and how to organize a safe evacuation. For example, it is recommended to avoid being in buildings with poor seismic resistance, keep a set of necessary items on hand, and have an action plan in case of an emergency. The development and implementation of evacuation plans is a critical element of protective measures. These plans are developed at the level of municipal and regional authorities, taking into account the characteristics of specific territories and infrastructure facilities. They specify evacuation routes, temporary accommodation locations for victims, as well as measures to ensure safety and provide first aid. Regular testing and updating ensures that they are relevant and effective in the face of a real threat.

State regulation plays an important role in ensuring seismic safety. The development of regulatory documents, standards and rules, monitoring their implementation, as well as funding for measures to strengthen infrastructure and train specialists create a solid foundation for reducing the effects of earthquakes. An important aspect is also international cooperation, exchange of experience and technology, which allows for the use of advanced methods and increasing the level of population protection at the global level.

Modern research and the development of monitoring technologies make it possible to identify signs of possible earthquakes in time and model their development. The use of satellite data, sensors and artificial intelligence increases the accuracy of the forecast and allows for a prompt response to emerging threats. Despite this, it is impossible to fully predict an earthquake with high

accuracy, so prevention is based on the implementation of the most effective protective measures, population training and infrastructure development.

In general, a comprehensive system of methods for protecting the population and preventing the effects of earthquakes includes the construction of earthquake-resistant buildings, early warning systems, citizen training, development of evacuation plans and state regulation. These measures, implemented in combination, allow to significantly reduce the negative consequences of natural disasters and ensure the safety of the population, which is especially important in conditions of high seismic activity. Continuous improvement of technologies and increasing the level of awareness of citizens are key factors in strengthening the resilience of society in the face of natural threats.

Conclusions

Earthquakes are complex and multifaceted natural phenomena caused by the movement of tectonic plates, volcanic activity and human impacts. The study examined in detail the causes of earthquakes, the main mechanisms of their formation and classification by origin and characteristics. Particular attention was paid to the differences between tectonic, volcanic and artificial earthquakes, as well as the features of their manifestation, strength, duration and scale of destruction. This knowledge is an important basis for understanding the nature of this phenomenon and assessing its potential threats.

Of particular importance in the work is the analysis of population protection methods, including the construction of earthquake-resistant buildings, the introduction of early warning systems, public training and the development of evacuation plans. Modern monitoring and modeling technologies can improve the accuracy of forecasts and the effectiveness of preventive measures, which is extremely important for reducing human and material losses. Despite the progress, the tasks of improving prediction methods and increasing the resilience of infrastructure remain relevant, which requires further scientific research and international cooperation. This work emphasizes that a comprehensive approach to studying the causes and types of earthquakes, as well as the systematic implementation of measures to protect the population are key aspects of minimizing their negative consequences. The importance of further scientific developments and the introduction of innovative technologies is due to the need for society to adapt to constantly changing natural conditions and increase its level of safety. In the future, it is necessary to continue research in the field of earthquake prediction, improving early warning methods and strengthening infrastructure, which will significantly increase resilience to these natural disasters.

In general, understanding the causes, types and characteristics of earthquakes allows us to develop more effective measures of protection and prevention, which is an important contribution to ensuring the safety of the population. Ongoing scientific research and technological development in this area will play an important role in strengthening the resilience of societies in the face of natural hazards, helping to reduce their destructive consequences and preserve human life and health.

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