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# IMPROVEMENT OF THE SEISMIC SAFETY SYSTEM FOR THE POPULATION AND TERRITORY OF THE REPUBLIC OF UZBEKISTAN

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***Abstract:*** *Central Asian seismologists show high magnitudes of potential future earthquakes (8 and higher), which corresponds to a probable level of macroseismic intensity of 9 or more points. Considering that zones with a high level of seismic hazard coincide with densely populated areas, as well as taking into account the seismic vulnerability of existing buildings, it can be stated that in Each existing level of seismic risk is very high and the consequences of future earthquakes can be catastrophic.*

*In recent years, large-scale comprehensive measures have been implemented in the Republic of Uzbekistan to develop the fields of seismology, ensure earthquake resistance of structures and seismic safety, as well as radically improve the efficiency of facilities in economic sectors. In order to ensure seismology, seismic resistance of structures and seismic safety, Decree of the President of the Republic of Uzbekistan No. 144 "On measures to further improve the seismic safety system of the Republic of Uzbekistan" was issued on 30.05. 2022*

*Natural hazards include natural phenomena that pose an immediate threat to human life and health, such as earthquakes, volcanic eruptions, avalanches, mudslides, landslides, rockfalls, floods, storms, tsunamis, tropical cyclones, tornadoes, lightning, fogs, cosmic radiation, cosmic bodies and many other phenomena.*

*Various disasters arising from strong earthquakes and tectonic movement of Earth's plates, which have recently occurred in foreign countries, require acceleration of work to ensure seismic safety in the country, the introduction of modern approaches in this area.*

*This article discusses: the relationship between natural hazards, forecasting problems based on the seismic entropy method, the calculation of the lesion in earthquakes, as well as emergency protection measures.*

***Keywords:*** *earthquakes, deformation, seismic entropy forecast, geomagnetic field, monitoring, potential energy, geomagnetic field, magnitude, intensity, tectonics, safety.*

***Annotatsiya:*** *Markaziy Osiyo seysmolog olimlarining bashorati bo‘yicha, kelajakdagi zilzilalarning magnitudalari 8 va undan yuqori darajalarni ko‘rsatmoqda, bu 9 yoki undan ortiq ballning makroseysmik intensivligining ehtimoliy darajasiga to‘g‘ri keladi. Seysmik xavf darajasi yuqori bo‘lgan zonalar aholi zich joylashgan hududlarga to‘g‘ri kelishini va mavjud binolarning seysmik zaifligini hisobga olsak, har birida seysmik xavfning mavjud darajasi juda yuqori ekanligini hamda kelajakdagi zilzilalarning oqibatlari halokatli bo‘lishliligini ta'kidlash mumkin.*

*O‘zbekiston Respublikasida so‘nggi yillarda seysmologiya sohalarini rivojlantirish, inshootlarning seysmik mustahkamligini va seysmik xavfsizlikni ta'minlash, shuningdek, iqtisodiyot tarmoqlari obektlari faoliyati samaradorligini tubdan oshirish bo‘yicha keng ko‘lamli kompleks chora-tadbirlar amalga oshirildi. Seysmologiya inshootlarning seysmik mustahkamligini va seysmik xavfsizlikni ta'minlash tizimini yanada takomillashtirish chora-tadbirlari to‘g‘risida 30.05. 2022-yilda O‘zbekiston Respublikasi Prezidentining Farmoni chiqdi.*

*Tabiiy xavf - xatarlarga odamlarning hayoti va sog‘lig‘iga bevosita tahdid soladigan tabiiy hodisalar kiradi, ular zilzila, vulqon otilishi, qor ko‘chkisi, sel, ko‘chkilar, tosh qulashi, toshqinlar, bo‘ronlar, sunami, tropik siklonlar, tornadolar, chaqmoqlar, tumanlar, kosmik nurlanish, kosmik jismlar va boshqa ko‘plab hodisalardir.*

*Yaqinda xorijiy mamlakatlarda ro‘y berayotgan kuchli zilzilalar va yer plitalarining tektonik harakati natijasida yuzaga keladigan turli xil ofatlar mamlakatda seysmik xavfsizlikni ta'minlash bo‘yicha ishlarni jadallashtirishni, ushbu sohaga zamonaviy yondashuvlarni joriy etishni talab qilmoqda.*

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*Ushbu maqolada quyidagilar ko‘rib chiqilgan: tabiiy xavflar o‘rtasidagi munosabatlar, seysmik entropiya usuli asosida bashorat qilish muammolari, zilzilalarning shikastlanish nuqtasini hisoblash, shuningdek favqulodda himoya choralari ko‘rsatilgan.*

***Kalit so‘zlar:*** *zilzilalar, deformatsiya, seysmik entropiya, bashorat, geomagnit maydon, monitoring, potensial energiya, geomagnit maydon, magnit, intensivlik, tektonika, xavfsizlik.*

***Аннотация:*** *Прогнозные оценки ученых-сейсмологов ЦА показывают высокие значения магнитуд потенциально будущих землетрясений (8 и выше), что соответствует вероятному уровню макросейсмической интенсивности 9 и более баллов. Учитывая, что зоны с высоким уровнем сейсмической опасности совпадают с густонаселенными районами, а также принимая во внимание сейсмическую уязвимость существующих зданий, то можно констатировать, что каждый существующий уровень сейсмического риска является очень высоким и последствия будущих землетрясений могут быть катастрофическими.*

*В Республике Узбекистан за последние годы реализованы широкомасштабные комплексные меры по развитию сфер сейсмологии, обеспечения сейсмостойкости сооружений и сейсмической безопасности, а также по коренному повышению эффективной деятельности объектов отраслей экономики. В целях обеспечения в сферах сейсмологии, обеспечения сейсмостойкости сооружений и сейсмической безопасности 30.05. 2022 года вышел Указ Президента Республики Узбекистан за № 144 «О мерах по дальнейшему совершенствованию системы обеспечения сейсмической безопасности Республики Узбекистан»*

*К природным опасностям относятся явления природы, которые представляют непосредственную угрозу для жизни и здоровья людей, это - землетрясение, извержение вулканов, снежные лавины, сели, оползни, камнепады, наводнения, штормы, цунами, тропические циклоны, смерчи, молнии, туманы, космические излучения, космические тела и многие другие явления.*

*Разные бедствия, возникающие вследствие сильных землетрясений и тектонического движения земных плит, происходящих в последнее время в зарубежных странах, требуют ускорения работ по обеспечению сейсмической безопасности в стране, внедрения современных подходов в данную сферу.*

*В данной статье рассмотрены: взаимосвязь между природными опасностями, проблемы прогнозирования на основании метода сейсмической энтропии, дан расчет очага поражения при землетрясениях, а также приведены экстренные меры защиты.*

***Ключевые слова:*** *землетрясения, деформация, сейсмическая энтропия, прогноз, геомагнитное поле, мониторинг, потенциальная энергия, геомагнитное поле, магнитуда, интенсивность, тектоника, безопасность.*

## Introduction

Being a natural phenomenon of life and development of the natural environment, an earthquake is at the same time perceived by a person as abnormal.

Despite the deep differences in nature, an earthquake, like other natural hazards, obey certain general patterns:

• a certain spatial and temporal localization;

• the greater the intensity (power) of a dangerous phenomenon, the less often it occurs;

• Each earthquake is preceded by some specific signs (precursors);

• with all the surprise of an earthquake, its manifestation can be predicted with a certain degree of probability;

• In many cases, passive and active earthquake protection measures may be provided.

Speaking about natural hazards, it is necessary to emphasize the role of anthropogenic influence on their manifestation. Numerous facts of imbalance in the natural environment as a result of human activity are known, leading to increased dangerous effects. Thus, according to international statistics, 96% of earthquakes on Earth occur under compression conditions in the zones of interaction of lithospheric plates (90% occur on the Pacific Plate and 6% on the Mediterranean-Alpine-Himalayan belt, Fig. 1). In spreading zones (Eng. spreading zone is an area within which a certain a phenomenon or phenomenon that is the object of research.) in a stretching environment, less than 1% of the Earth's seismic energy is released [1,2].

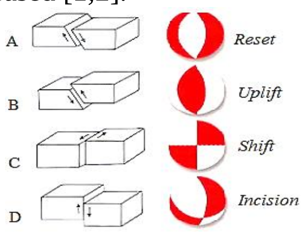


**Fig.1. The main types A, B, C, D of plate boundaries and characteristic focal mechanisms of earthquake foci**

The resulting fluctuations and sometimes catastrophic movements of the earth's surface are often associated with extensive stable deformations, which may include: warping of sections of the earth's crust; displacement along the discharge line;

compaction of loose or uncemented sediments; landslides and mudflows; soil liquefaction; snow avalanches and newly forming faults in rocks.

It is impossible to consider an earthquake as one independent natural phenomenon. There is a mutual connection between natural hazards. Having studied this connection, it is possible to prevent possible consequences from one or another phenomenon (Fig. 2).

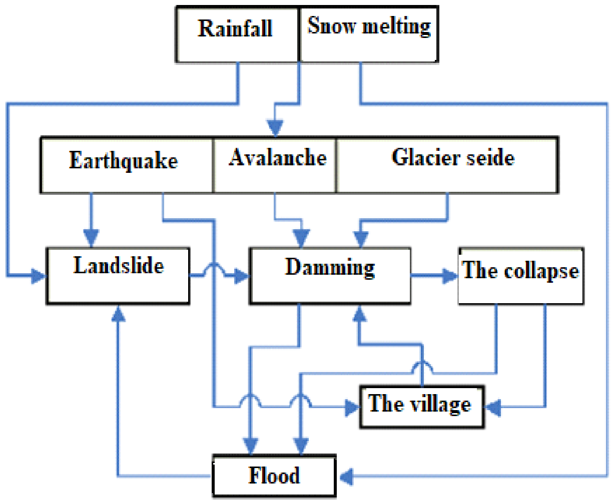


**Fig.2. The scheme of the "chain" interaction of natural phenomena**

**The solution to the problem**

The strength, location and time of the earthquake can be predicted with some errors. But to do this, it is necessary to create a scientifically based network of complex seismic prognostic observations, taking into account the geological, tectonic, seismotectonic features of the region.

A network of complex seismic, hydrogeoseismological and deformometric stations, including 10 stationary magnetometric stations, including the Yangibazar magnetic ionospheric observatory, is currently working to solve this problem at the geodynamic polygons of Uzbekistan. At these stations, continuous observations of a complex of geological, geophysical, hydrochemical and hydrodynamic parameters are carried out, which are analyzed at meetings of the Institute's Forecast Commission and, based on the identified abnormal changes in these fields, weekly forecast conclusions on the seismic situation in Uzbekistan are issued. In addition, magnetometric stations have been installed on the territories of man-made objects, the data of which, as needed, are also used to localize abnormal changes in the geomagnetic field [3].

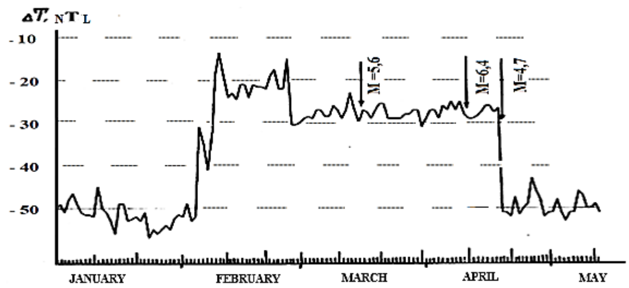


**Fig.3. Anomalous changes in the geomagnetic field from M=5.6; April 5 from M=6.4; April 14 from M=4.7**

An example is the study of anomalous changes in the geomagnetic field at the Shurchi station associated with the deep Afghan earthquakes of March 12, 2004 (Fig.3)

The Shurchi magnetometric station is the southernmost station, and it is the closest to the foci of deep Afghan earthquakes. In 2004, during the month of January, the variations of the geomagnetic field at the Shurchi station were calm, with an average level of about -53 NT (Fig.1). From February 4, the field began to grow intensively and by February 12 it began to vary at the level of -22 NT. By February 25, it decreased in the form of a step by 10 NT. After that, the field began to grow gradually until March 9, when the sign changed and the field began to decrease. On March 12, 2004, an earthquake with M = 5.6 occurred 280km southeast of the station. After the earthquake, the level of the geomagnetic field did not return to its original level. Sinusoidal variations were observed until April 4, when a sign change occurred and the field began to decrease. On April 5, a strong Afghan earthquake with M =6.4 occurred 260km southeast of the station. And even after this earthquake, the level of variations at the Shurchi station remained at an abnormal level until the sign of abnormal changes changed on April 13, when the field began to decrease. On this descent, 250 km south-east of the station, the last earthquake occurred with M = 4.7. As can be seen from Fig.3, the anomalous change in the magnetic field persisted until the stress state of the medium in the focal region was completely removed [3].

Seismologists of the Republic of Uzbekistan, using international experience, carry out monitoring based on the seismic entropy method. The seismic entropy method is based on the concept of a seismic system (SS), which are identified in earthquake-prone regions from the standpoint of plate tectonics. Currently, more than 130 SS and subsystems with sizes from 20 to 3000 km with threshold magnitudes from 5.0 to 8.5 have been identified. The development of the seismic entropy method from large systems to small ones and the reduction of threshold earthquake magnitudes to microscopic (nano - magnitudes from -3 to 0, sizes tens, hundreds of meters) will allow the use of the seismic entropy method to solve technological problems in the oil and gas and mining industries.

Comparison of microseismicity energy using the seismic entropy method with traditional parameters recorded by seismological observation networks makes it possible to identify a fluid, technogenic component in earthquake preparation.

The accuracy of forecasts is carried out using modern computer technologies. The forecast using the seismic entropy method is made within the framework of pre-agreed conditions:

- accuracy of earthquake prediction in time from 6 months to 1 week, depending on the specific situation;
- accuracy of the forecast by magnitude ± 0.1; large deviations in magnitude are negotiated separately;
- the accuracy of earthquake prediction by location on the Earth's surface and by the depth of the hearth is limited by the size of the SS and can reach the size of the hearth of the predicted earthquake;

• if a strong earthquake waiting area is indicated inside the SS, then a strong earthquake is automatically excluded in other places inside the SS, so the entire volume of the SS is controlled;

• depending on the development of the seismic situation, the forecast results may change and be updated over time;

• instability (predicted earthquake location) may migrate within the SS from one fault zone to another, the predicted waiting time for an earthquake may be moving away or approaching, and accordingly the magnitude of the expected earthquake may change (all this is inherent in the method);

• SS elements may be in an unstable state in a limited time interval (from 1 to 6 months), and if a strong earthquake does not occur during this time, the system will return to a stable state [4,5,6].

The method of releasing potential energy in an earthquake is not entirely clear. In accordance with new ideas about the global geological structure of the planet, Isacks, Oliver and Sykes (1972) conclude that the phenomenon of earthquakes can be explained as a result of interactions and other processes on the margins of huge mobile plates of the lithosphere radiating from oceanic ridges. Currently, it is believed that the shallowest earthquakes (at a depth of less than 14.5 km) can be caused by:

1. Sliding along large discharge sites that contain accumulated potential energy (Cook, Anderson, 1972; Nur, 1972; Scholz, Wyss, Smith, 1969; Wu, 1972);

2. The introduction of pore gases or a change in the pore pressure, which mechanically or chemically violates the conditions of unstable stress equilibrium (Byerlee, Wilson, Peselnick, 1972; Raleigh et al., 1970);

3. Concussion from the explosion of nuclear devices and as a result of volcanic activity (Endo, 1972).

Very little is known about the mechanisms of energy release during earthquakes at medium (60-300 km) and large (over 300 km) depths.

As possible mechanisms releasing the energy of deep-focus earthquakes, the following were considered:

1. Phase changes in molten magma (Griggs, Handin, 1963);

2. Unstable flows in plastically deforming magma (Orowan, 1963) and velocity discontinuity along mass deficit zones (Ver-hoogen et al., 1970) [7].

Earthquakes occur as a series of aftershocks, which include the main shock (foreshock) and secondary (aftershocks). The number of shocks and the time intervals between them can be very different. The main thrust is characterized by the greatest force. The duration of the main shock is usually several seconds, but subjectively people perceive it as very long. According to psychiatrists and psychologists who have studied earthquakes, aftershocks sometimes produce a more severe psychological impact than the main shock. People had a feeling of imminent disaster, and they, shackled by fear, did nothing instead of looking for a safe place and defending themselves.

## Research Methods and the Received Results

According to available estimates, the number of dangerous natural events on Earth does not increase or almost does not increase over time, but the number of human casualties and material damage is increasing. The annual probability of death of a resident of planet Earth from natural hazards is approximately $10^{-5}$.

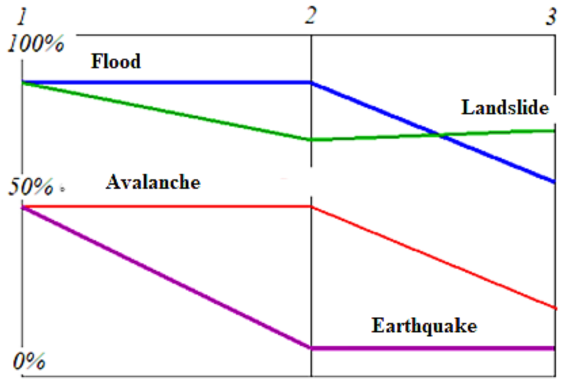


**Fig. 3. Approximate relationship between the study of hazards, their prediction and protection from them: vertically - 0% - levels of knowledge of the essence of the process; 100% - complete knowledge of the essence of the phenomenon; horizontally -1-occurrence and mechanism; 2 - forecast; 3 - protection.**

The prerequisite for successful protection against natural hazards is the study of their causes and mechanisms. Knowing the essence of the processes, you can predict them. And a timely and accurate forecast of dangerous phenomena is an essential prerequisite for effective protection. Figure 3 graphically shows the approximate relationship between the study of hazards, their prediction and protection against them.

Protection from natural hazards can be active (construction of engineering structures, intervention in the mechanism of the phenomenon, mobilization of natural resources, reconstruction of natural objects, etc.) and passive (use of shelters, etc.). In most cases, active and passive methods are combined [8].

The foci of earthquake damage by the nature of the destruction of buildings and structures can be compared with the foci of a nuclear explosion. The assessment of the possible extent of earthquake damage can be carried out in a similar way to the assessment of the destruction of a nuclear explosion, and the maximum earthquake intensity in points is taken as a criterion. Seismic waves can be longitudinal and transverse.

The earthquake center (earthquake hypocenter) is usually located at a depth of 8 to 65 km. If the depth of the earthquake source h is unknown, then it is assumed to be 20 km. Longitudinal seismic waves have a high velocity (6-8 km/s) and are felt on the earth's surface first of all. Transverse waves oscillate perpendicular to the longitudinal ones and have a velocity 2-3 times less. Longitudinal and transverse waves determine the destructive effect at short and medium distances from the epicenter of the earthquake. The destructive potential in the zone far from the epicenter is mainly associated with surface waves.

The main characteristics of an earthquake: magnitude *M* - is the logarithm of the amplitude of the maximum displacement of the soil in mm at a distance of 100 *km* from the $A=\pi r^2$ epicenter, measured on the 9 - point Richter scale; intensity *I* - is a qualitative indicator of the effects of an earthquake, estimated on the 12-point *MSK* scale; earthquake energy *E*, estimated in joules (*J*, depth hypocenter, h).

Four zones are formed in the lesion: full (overpressure $AP_f = 50kPa$ or more), strong ($AP_f$ = 30...50 kPa), medium ($AP_f$ = 20...30 kPa), weak damage ($AP_f$ = 10...20kPa).

The energy of an earthquake is equal to

$$E = 10^{(5{,}24+1{,}44)}$$

*M* is the magnitude of the earthquake, defined as the logarithm (*lg*) of the maximum amplitude of soil displacement in microns at a distance of 100 *km* from the epicenter, measured in points on the Charles Francis Richter (*0-9 points*) and is equal to

$$M = \frac{lgE - 5{,}24}{1{,}44}$$

We determine the intensity of the earthquake *I* (energy on the earth's surface), which depends on the depth of the earthquake source (*h*), R is the depth of the hypocenter and the distance to it in km, magnitude (*M*), soil composition and is measured on the scale of *MSC- 64* (*0 - 12* points)according to the formula:

$$I = 3 + 1{,}5M - 3{,}5\lg(R^2 + h^2)^2$$

Strong soil tremors are observed at great distances from the epicenter.

We determine the distance from the epicenter, at which fluctuations of a certain intensity may occur

$$R = h\sqrt{10^{(0{,}57\,(jo - jб)} - 1}\ , \qquad км$$

We calculate the first phase of the earthquake manifestation - the time of arrival of longitudinal waves (*c*), when tremors are felt, and buildings receive minor damage, according to the ratio:

$$t_{1TM} = \frac{(R^2 + h^2)^{0{,}5}}{V_{пр}}\ , c$$

where $V_{lon}$ is the velocity of longitudinal waves (for granite $V_{lon}$ = 6.9 km/s, sedimentary rocks $V_{lon}$ = *6.1 km/s*). Buildings receive minor damage.

We calculate the second phase of the earthquake manifestation - the arrival time of surface seismic waves, which determines the degree of destruction of the object and is calculated using the formula:

$$t_{2F} = \frac{h}{V_{lon}} + \frac{R}{V_{rep}}\ , c$$

where $V_{lon}$ is the average velocity of propagation of longitudinal waves, km/s. (for granite $V_{rep}$ = *5.6 km/s*; crushed stone, gravel, pebbles – *1.5 km/s*; sandy soil – *1.2 km/s*; clay soil – *1 km/s*; bulk soil – *0.35 km/s*). Buildings receive a certain degree of destruction. The time interval between phases 1 and 2 is 30-60 seconds, which allows you to take emergency protection measures:

- efficiency - the fastest possible response to the situation, timely and correct decision-making;
- the principle of consistency is the organization of actions on technical and managerial aspects in order to minimize damage and coordinate the efforts of different services;
- the principle of awareness is the competent informing of the population about what is happening, which reduces panic and promotes compliance with safety rules;
- the principle of professionalism is competent and effective crisis management, as well as the availability of the necessary knowledge and

skills of emergency and protection workers [9, 10, 11].

## Conclusion

In recent years, the Republic of Uzbekistan has implemented large-scale comprehensive measures to develop the fields of seismology, as well as to ensure earthquake resistance of structures and seismic safety. The republic is consistently continuing reforms in these areas, the introduction of new methods to ensure the seismic safety of the population. This is clearly reflected in the UP of the Republic of Uzbekistan "On measures to further improve the seismic safety system of the Republic of Uzbekistan" dated 30.05.2022, which gives the "Concept of improving the seismic safety system of the population and territory of the Republic of Uzbekistan until 2025"

The State policy in the field of seismology is aimed at improving the seismic safety system of the population and territory of the Republic of Uzbekistan, and There are also directions for reforming priority measures based on scientific and technical achievements, innovative ideas, developments and technologies [12].

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