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ИЗВЕСТИЯ

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OF THE REPUBLIC OF KAZAKHSTAN

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PROBABILISTIC GENERAL SEISMIC ZONING OF THE TERRITORY OF KAZAKHSTAN IN PEAK GROUND ACCELERATIONS

Abstract. In Kazakhstan seismic hazard assessment is realized on a new methodical basis, combining domestic developments and advantages of the Western approach fixed in the Eurocode 8. The General Seismic Zoning Maps of the territory of the whole country are created. Seismic hazard was analyzed from a probabilistic point of view, and the results are presented not only in macroseismic intensities but also in quantitative parameters – peak ground accelerations. In the article we consider the main differences and advantages of the new probabilistic approach for the case of acceleration estimates, performed by the authors. The General Seismic Zoning Maps in terms of PGA are prepared for inclusion in normative documents for further use in socio-economic land-use planning and earthquake engineering.

Keywords: probabilistic seismic hazard assessment, peak ground acceleration, return periods of 475 and 2475 years.

Introduction. The general seismic zoning (GSZ) of the territory of the Republic of Kazakhstan was implemented for the first time on a new methodological basis, corresponding to the provisions of the European standards Eurocode 8 (EN 1998-1: 2004) " Design of structures for earthquake resistance" [1]. A set of probabilistic GSZ was prepared and developed in order to be included in regularity documents. They show seismic hazard, both in macroseismic indices, and in quantitative parameters of ground shocks and peak accelerations. The work was carried out by the Institute of Seismology of the Ministry of Education and Science of the Republic of Kazakhstan with the participation of Kazakh Scientific and research institute of building and architecture and KDNTS IGI in 2013-2016 within the framework of the Scientific Research Program of the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan "Develop a map of general seismic zoning of the territory of the Republic of Kazakhstan" (heads of research T. Abakanov and A. N. Lee).

The main feature of the new methodology is probabilistic analysis of seismic hazard and its mapping in engineering parameters. In addition to the modern approach, an updated database was used, which included all the information currently available - updated seismic catalogs, maps of zones of possible seismic focus, models of attenuation of ground vibrations. The modern software, which allows to take into account more accurately different information about seismicity, was used while executing the calculation part.

The developed set of GSZ maps includes 5 maps at a scale of 1: 2500000: a map of seismic-generating zones on the territory of Kazakhstan (seismotectonic model); two maps characterizing the seismic hazard of the territory in the average numbers of average geometric peak accelerations (in g fractions) of the rock and rock-like soils at two levels of probability of occurrence and possible exceeding of the seismic effect of 10% and 2% during 50-year time intervals respectively 475 and 2475); and two maps characterizing the seismic hazard of the territory with MSK-64 (K) scores of macroseismic intensity, also at two probability levels. The analysis of seismic hazard in accelerations and scores is carried out independently. The maps are made for socio-economic planning of land use and earthquake-proof construction.

The created maps are the result of the work of several scientific teams and various aspects of their development will be reflected in the reports and publications. In this article, the authors stressed on the results of probabilistic analysis and seismic hazard mapping in peak ground acceleration (PGA).

Seismic intensity of the territory of Kazakhstan. Kazakhstan belongs to states where a significant part of the territory is seismically dangerous. 8-9-point zones are located in the south, southeast and east of the country. On the last normative map of the General seismic zoning of the Republic of Kazakhstan in 2003 [2] the areas with a seismic intensity of more than 5 points MSK-64 (K), where anti-seismic measures are mandatory, cover more than 30% of the territory. These are the most industrialized regions, with more than 400 residential areas, including the largest industrial and cultural center of the country - the city of Almaty with a population of more than 1.7 million people. At the end of the XIX - the beginning of the XX centuries the city was already exposed to the strongest North Tien Shan earthquakes (Verniyin 1887 with magnitude 7.2, Chilik in 1889 with magnitude 8.3, Keminskin 1911 with magnitude 8.2 (according to modern estimates 7.8 [3]), also repeatedly suffered from less strong earthquakes. The repetition of the strongest earthquakes near Almaty can lead to catastrophic destruction and large human casualties, which are caused not only by the strength of a possible earthquake, but also by the underestimation of the seismic hazard, selection of sites for construction and other factors.

On large areas lying within the platform areas (Kazakh shield, Turan plate, the Caspian basin, South Ural) 6-magnitude earthquakes are known, and in the Mangyshlak-Ustyurt region upheavalof 7 points can take place. Less strong earthquakes in the oil-producing western regions are associated with technogenicseismotectonic activation. The development of networks of seismological observations on most parts of the country led to a more reasonable approach to assessing the hazard in the previously considered aseismic regions of Kazakhstan.

The practice of seismic hazard assessment in Kazakhstan. The assessment of the level of seismic hazard in Kazakhstan was given, at first, by regulatory maps of general seismic zoning of the former Soviet Union (1937, 1957, 1968, and 1978) and then, by the map of the general seismic zoning of the Republic of Kazakhstan, developed in 2003 and included in the Building codes and regulations of the Republic of Kazakhstan in2006 [2]. While drawing up the maps of 2003 extensive materials on the seismically active regions of Kazakhstan and adjacent territories were compiled, in some areas a significant revaluation of seismic intensity was carried out, geological and geophysical and seismotectonic-criterias for seismic hazards were developed and applied [4]. Macroseismicindicators of earthquake consequences - points on a scale of seismic intensity – were parameters on the maps. The map was calculated as deterministic, but was conditionally assigned to a period of recurrence of 1000 years.

The approach to hazard assessment and development of seismic zoning maps in different countries is not universal. The historically established practice is of great importance. In the USSR, seismic zoning, including hazard assessment, was originally developed by geologists, later by seismologists and geophysicists [5]. As a result, the main output parameter describing seismic impacts in many post-Soviet countries is macroseismic intensity. It cannot be directly used to calculate the behavior of buildings and structures during earthquakes. The conversion of scores into the quantitative parameters of ground shocks (acceleration and spectral curves) is made in building codes and regulations [2].

The USA and other Western countries, where seismic zoning was carried out from the very beginning under the aegis of construction engineers, are based on a more "engineering" approach, close to the needs of earthquake-proof construction and addressing the problems of reducing seismic risk. For many years, hazard mapping has been carried out there in the parameters of ground motions - mainly PGA and spectral acceleration. Other countries have their own peculiarities in methodology, charted parameters and the form of presentation of final results.

In the building codes of Kazakhstan, the intensity of seismic impacts in points until recently is the final parameter of the general, detailed and micro-zoning. At the same time, Kazakhstan seismologists already use ([6-8] and others) the procedure of probabilistic estimation of seismic hazard (RESH), which meets the modern requirements and scientific and methodological foundations of the European construction standard Eurocode 8. The developed methodology includes both domestic developments in the allocation and parametrization zones of possible centers of earthquakes, and the advantages of the Western engineering approach.

On the basis of this methodology, a probabilistic seismic hazard analysis for the entire territory of Kazakhstan in PGA has been performed and maps of the General Seismic Zoning of Kazakhstan (GSZ), in peak accelerations for return periods of 475 and 2475 years, have been compiled.

Probabilistic analysis of seismic hazard in peak ground accelerations. Seismic danger is the threat of occurrence of seismic impacts on the territory under consideration, i.e. the potential danger of earthquake-related phenomena - earthquakes, soil dilution, rupture on the surface. It depends on many parameters and requires research in the field of seismic zoning, which "is based on a detailed and comprehensive study of the deep structure of the earth's crust and lithosphere, modern geodynamics, regional seismic intensity, seismotectonics and engineering seismology. They include the identification of seismic active structures, the determination of the parameters of their seismic regime and the damping of the seismic effect generated by them with distance, and as a result - probabilistic calculation and mapping of seismic hazard "[9].

Hazard maps show the distribution of ground shock levels with a given probability of their occurrence (excess) in the territory under consideration. Maps created for the entire country are needed to create and update building regulatory documents that are used by national and local authorities to establish the building requirements necessary to preserve public safety in future earthquakes.

Approaches to the assessment of seismic hazard are divided into two groups: deterministic and probabilistic. In the deterministic analysis, the worst possible case is calculated. A maximum seismic effect is simulated at a point under a scenario controlling earthquake, which is specified by a specific size (magnitude) and the distance from the point. Simply, the following tasks are solved step by step: the closest and dangerous active fault is revealed; its seismic potential is determined (the strongest possible earthquake on it); the epicenter of this earthquake is set at the shortest distance from the fault to the point; the value of the extreme possible shock in the point is calculated. In the case of strategic facilities, this approach gives direct estimates of earthquakes in the worst-case scenario. However, it remains unclear what is the probability of exceeding the estimates received, or what is the probability of implementing such a scenario for any specific period of time (for example, during the operation of the facility). These questions can be solved within the framework of probabilistic analysis of seismic hazard (PASH) [10].

In probabilistic approach, seismic hazard is calculated from all earthquakes of all possible magnitudes at all significant distances from the site under consideration, taking into account their frequency of occurrence. The analysis can combine alternative models of earthquake centers, periods of earthquake recurrence, the dependence of the damping of the seismic effect on the distance, as well as a number of uncertainties due to both unclear knowledge of various parameters and the random nature of occurrence of the seismic events themselves [9]. With the Probabilistic evaluation, the calculation of ground shocks at a point (or grid of such points) for a given finite period of time (for example, during the operation of the facility) is performed. The output of the PASH is a danger curve showing the probability of exceeding a given level of ground shocks in a point for a specified period of time. In the case of a grid of points, we obtain an area distribution of ground shocks, that is, a map.

The results of PASH are best suited for the design of buildings and structures for performance characteristics, since they give the probability of exceeding different levels of the ground motion parameter for a given period of time. They are needed for civil engineers who are designing construction sites in seismically hazardous areas, performing their modernization or seismic reinforcement. Hazard mapping also helps solve economic and social problems to prevent or reduce damage to an acceptable level.

The procedure for the implementation of the PASH includes 4 main stages [11]:

1) The areas of possible earthquakes centers near the site are identified and characterized, which can be specified as areas with an equal probability of occurrence of earthquakes at any point inside them, and also in the form of linear centers with an equal probability of events along the line. The set of marked zones is called a model of seismic sources.

2) With the help of the earthquake catalog it is possible to calculate the number of earthquakes per year in each potential seismic focus (zone) within the boundaries of the model of earthquake centers. The distribution of the number of earthquakes by magnitude is characterized.

3) Ground shakes caused by earthquakes from earthquake centers of all possible magnitudes are calculated.

4) The probabilities that the given ground shaking levels will be exceeded for a specific period of time are estimated.

The procedure for performing PASH in peak accelerations, which we used, is presented in the block diagram (Figure 1).

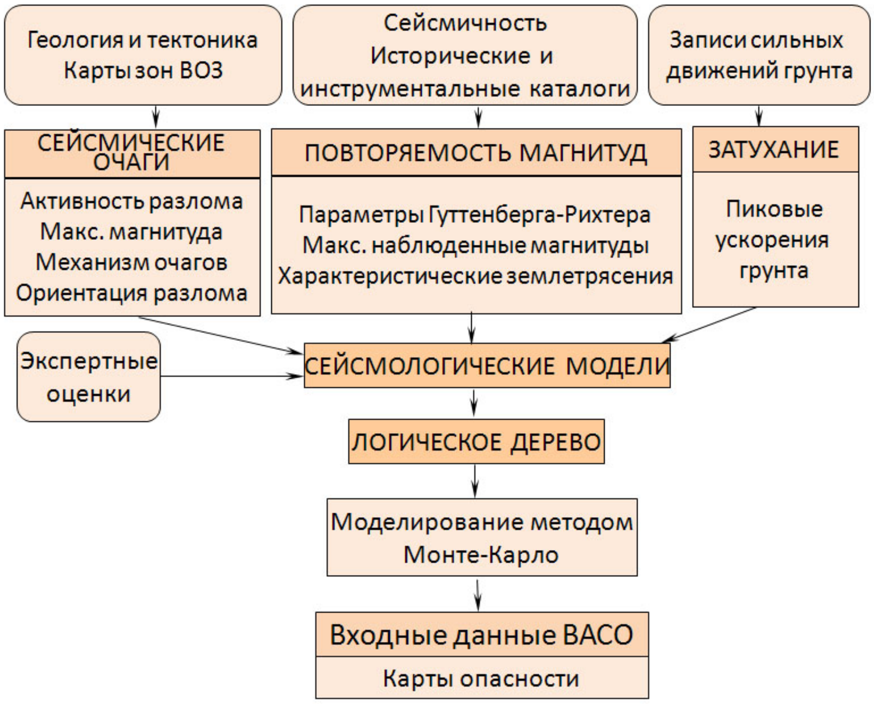

Figure 1 – Block diagram of probabilistic analysis of the seismic hazard of the territory of Kazakhstan in PGA

The model of seismogenerating zones of the territory of Kazakhstan was developed and modified with each new seismic zoning. It underwent a significant change in the direction of increasing seismic hazard when creating the 2003 OSR map of the Republic of Kazakhstan [2, 4], when large-scale studies on the generalization of materials in seismically active regions of Kazakhstan, seismogenerating structures were carried out on a complex of geophysical, geological and tectonic and seismological data and the establishment of their possible seismic potential. The development of networks with digital registration has given new data both in seismically active regions of Kazakhstan, and in those considered aseismic or weakly seismic. Seismic monitoring and methodological developments of the following years were reflected in the Map of Seismogenerating Zones of Kazakhstan and Adjacent Territories in 2012 [12].

In the course of the present seismic zoning, contours of the boundaries of the seismogenerating zones were also refined based on seismic monitoring data and interpretation of remote sensing data. Separate seismogenerating zones have been identified in some previously considered aseismic regions of Kazakhstan [13]. The detailed geometry of the zones reflects the geological features and the distribution pattern of the earthquake foci. The map of the seismogenerating zones of Kazakhstan used in the analysis is shown in the figure 2.

At PASH territory of Kazakhstan the model of seismic sources included 94 generalized seismic zones, completely or partially covered by a 250 km boundary around Kazakhstan. Each zone was specified by parameters such as: geometry, magnitude-frequency characteristics of seismicity, maximum magnitude, probable depth and expected orientation of the fracture. Since general seismic zoning was performed for a very large area, simplifications were made in the design of the model, in particular for each zone one maximum magnitude and one most probable depth were taken, and not their distribution. In cases of uncertain determination of the seismic potential, the zone was characterized by two magnitudes with their own weight coefficients. The spatial extent of the rupture for each earthquake within the seismic generation zone is estimated from the Wells and Coppersmith study [14].

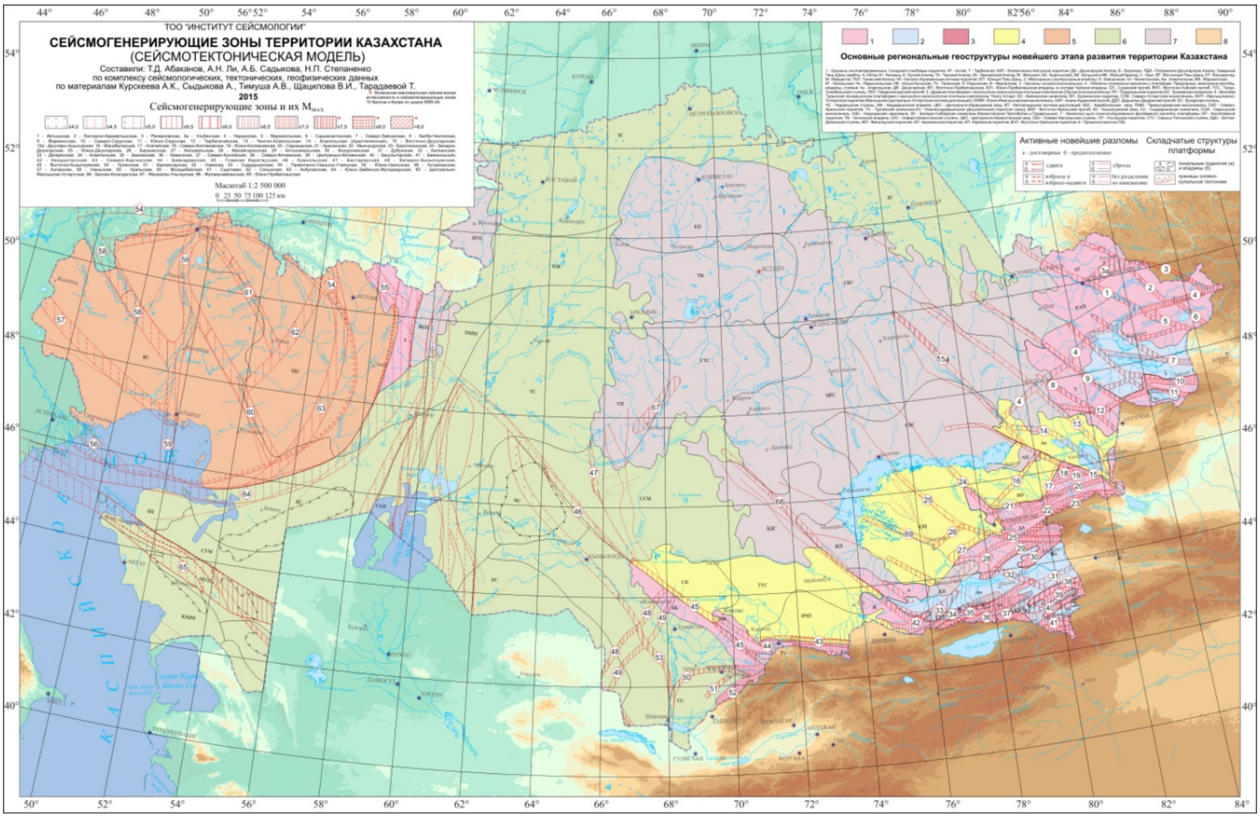

Figure 2 – Map of seismogenerating zones of the earth's crust of Kazakhstan [12]

To characterize the distribution of the number of earthquakes by magnitude, the parameters a and b were determined in the Gutenberg-Richter equation. The catalog of earthquakes for the territory encompassing the selected seismogenerating zones has been substantially supplemented and revised; First, it is reduced to the magnitude of the surface waves Ms, and then to the moment magnitude Mw; Declassification of the catalog was carried out. The recalculation of Ms in Mw was performed according to the Scordilis (2006) [15]. As the minimum magnitude, Mw4.0 is adopted, since smaller magnitudes do not represent an engineering interest and are beyond the scope of the recalculation dependence. For declarification, Gardner-Knopov's method [16], widely used in international practice, was chosen, for which the result of analysis of the Kazakhstan catalog declared by different methods was the best.

In determining the periods of representative catalog registration, the ZMAP software complex was used [17]. Estimates of the parameters a and b for the bands were performed using the maximum likelihood method (maximum curvature procedure). In addition, the program for calculating the parameters a and b used by the British Geological Survey was used, which is also based on the maximum likelihood method using the procedure proposed in [18]. The method allows to take into account the catalog of historical earthquakes as much as possible, believing that the data in different magnetic ranges will have different periods of representative registration.

In some zones, large earthquakes occur more often than would have been the case for logline extrapolation of the repetition schedules of weak and moderate earthquakes toward large magnitudes. Ulomov [19] explains the nature of this phenomenon by the processes of fault formation in a medium that increases its density, strength and dynamic characteristics with depth. Thus, the centers of large earthquakes (sometimes called characteristic ones), extending to great depths, give rise to other conditions, in comparison with smaller foci that occur closer to the earth's surface. For zones with characteristic earthquakes, parameters a and b were also calculated in a narrow band of magnitudes corresponding to these earthquakes. At the same time, the increase in the predicted seismic effect significantly increases for periods not less than the periods of recurrence of characteristic events. Examples of the obtained repeatability curves for zones with a normal seismic character and cases of characteristic magnitudes are shown in Figure 3.

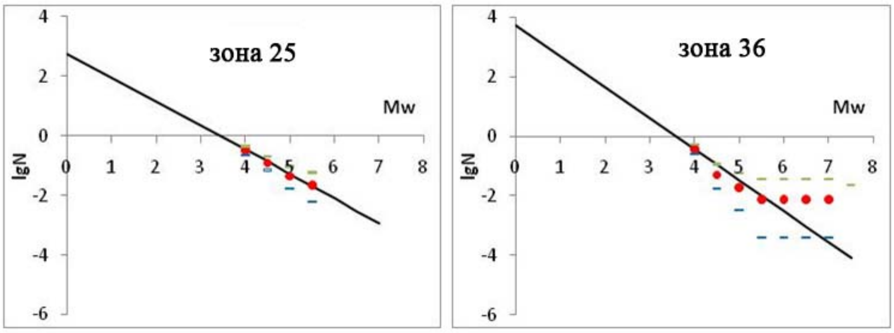

Figure 3 – Examples of repeatability graphs with good correspondence between the earthquake frequency of the approximating straight line (on the left) and the presence of characteristic earthquakes (right). Along the axis of abscissas values of magnitudes are plotted, along the ordinate axis – the decimal logarithms of the average annual number of the corresponding earthquakes

In the calculation of earthquakes, we used sets of attenuation models generated by us for the territories of Kazakhstan with different seismotectonicregimes on the basis of the criteria adopted in modern world practice. For independent modeling of soil motions in the whole range of magnitudes and distances of available regional data is not enough (even in high-seismic regions of Kazakhstan) due to the relatively short life of digital seismic networks and a small frequency of strong events [20].

As noted above, most of the earthquakes in Kazakhstan occur in zones with active bark (AR) in the seismic regions of the south, southeast and east of the republic. The central, northern and northwestern regions are characterized by a rather low level of natural crustal seismicity and can be attributed to a zone with a stable continental regime (SR). The events in the zone of the subduction boundary between the South Caspian microplate and the Eurasian plate - geographically in the transition zone from the South Caspian to the Middle Caspian and Ciscaucasia - can be attributed to earthquakes in subduction zones (NW) [21].

The main criteria for pre-selection are the reliability of the model, the ability to predict the entire range of magnitudes-distances-periods of interest, the use of parameters used in modern international practice. Further, in case of using world dependencies, models obtained from international, rather than from local data sets, are preferable. The functional form must have the desired characteristics, including saturation with magnitude, the distance dependence on magnitude and terms simulating the effects of inelastic damping. To adequately represent epistemic uncertainty, it is recommended to use models that show different trends if they are well supported by data. For different seismotectonic regimes, in turn, additional criteria are used to select the predictive models associated with the methods and characteristics of their production.

Selected forecast models for areas with shallow active bark were tested on the basis of the parameters of ground motions, namely regional data for peak accelerations and ground speed. The study made it possible to form a minimal set of models for use in assessing the seismic hazard of high seismic regions of Kazakhstan in peak soil accelerations. These are the models Akkar and Bommer (2010), Chiou and Youngs (2008), Boore and Atkinson (2008) / Atkinson and Boore (2011) and Campbell and Bozorgnia (2008). For stable continental areas, the selected models were tested on limited observational data. The set for use in the PASH includes models Pezeshket et al. (2011), Atkinson (2006) / Atkinson &Boore (2011), Silva et al. (2002) and Toro et al. (1997) / Toro (2002). Selected models for the prediction of earthquakes in the subduction zone earthquakes - Atkinson and Borre (2003) and Zhao et al. (2006) - were used without testing on regional data due to the absence of Kazakhstan seismic stations there.

The analysis was carried out for two levels of probability of occurrence and possible excess of seismic effect of 10% and 2% during 50-year time intervals, which corresponds to the periods of recurrence of 475 and 2475 years. The 50-year intervals correspond to the project lifetime of the objects of normal responsibility. Repeatability periods are adopted according to the recommendations of the ASCE7 Seismic Design Standard [22], as appropriate to the projected earthquake and the maximum estimated earthquake. These values are also associated with the limiting states in the seismic design, fixed in Eurocode 8 [1]: for objects of normal responsibility, the recurrence period of 475 years corresponds to the limiting state of the significant damage, and the period of 2475 years to the limiting state near destruction.

Thus, when assessing the seismic hazard in the peak acceleration of the soil, the following logical tree was adopted:

1) 1 seismotectonic model, including 94 seismic zones (focus)
2) 3 seismotectonic modes: AP, SR, NW
3) attenuation models:
   4 for AP - AkBo10, ChYo08, BoAt08 ', CaBo08
   4 for CP - PeEA2011, AtBo2006 ', SiEA02, ToEA97'
   2 for NW - AtBo03, ZhEA06.
4) two periods of recurrence of 475 and 2500 years

To carry out the calculation part, the M3C software [23] was used, which fully meets the modern requirements for performing the assessment in engineering parameters. The program allows you to calculate the probabilistic seismic hazard based on the Monte Carlo stochastic simulation method. The model of focal zones, fully describing the characteristics of seismicity in the territory under consideration, is used to generate artificial catalogs by the Monte Carlo method. Each such catalog gives an option of seismicity in the next 50 years, which is consistent with its character in the past. On the basis of a large number of simulations, the probabilities are calculated [23]. The advantage of the method is the possibility of introducing uncertainties into the input parameters as distribution functions with the observed average value and standard deviations, or a logical tree can be used. For each simulation, different values can be obtained from the distribution. The process of simulation of artificial catalogs can be controlled and used to verify the realism of the model. Disadvantage - the accuracy of estimates depends on the number of simulations, which significantly affects the calculation time. A great advantage of the program itself is the ability to take into account a number of additional parameters, including different types of distances and magnitudes, the extent and orientation of earthquake foci (rather than point ones) that were not envisaged by earlier software complexes.

Maps of general seismic zoning of the territory of Kazakhstan in peak soil acceleration. The developed NEO maps in mean values of root-mean-square peak ground accelerations correspond to the scientific and methodological foundations of Eurocode 8 and are harmonized with modern maps of the general seismic zoning of the countries belonging to the EurAsEC and the Customs Union. Maps in accelerations in the scale of 1: 2,500,000 are included in the main package of maps prepared for introduction to regulatory documents, and are accompanied by a list of settlements of the Republic of Kazakhstan located in seismic regions, indicating for them the predicted PGA values.

The hazard calculations are performed for the territory within 40-56° N lat. and 46-88° E. On the grid with an interval of 0.25° in both directions, which determines the spatial resolution of the cards. For each calculation point, the effect of seismic sources (zones) located within a radius of 250 km was taken into account, taking into account their seismotectonic regime. The isolines on the maps are drawn with an uneven step, chosen for the convenience of use by the builders, and correspond to the average calculated values of the rms peak accelerations in fractions, g: 0.02, 0.05, 0.075, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 and 0.9. These values are indicated on the isolines themselves, as well as in the legend, as the boundaries of the PGA intervals. Within the interval, the calculated values of the accelerations increase unevenly from the isoline with a lower value to an isoline with a larger one. Maps for the periods of recurrence of 475 years and 2475 years are presented in Figures 4 and 5 respectively.

The NEZ map of Kazakhstan in peak ground accelerations with a hazard level of 10% for 50 years (the period of recurrence of seismic shocks 475 years) predicts weak seismic impacts (PGA more than 0.02g) in almost half of the country. In the southern, southeastern and eastern regions, the values already range from 0.05 to 0.15g and higher. The maximum values of 0.5-0.6g here are expected to be obtained for the areas located to the southeast of Almaty, which corresponds to the location of the most seismically dangerous Kemin and North Kungei seismic generating zones. For Almaty, this period of recurrence is projected to average 0.4g (from 0.29g at the northern border to 0.48g on the southern border), in Taraz - 0.18g, Taldykorgan - 0.21g, Shymkent - 0.12g, Ust-Kamenogorsk - 0.11g. Areas of elevated values exceeding 0.05g appear in the eastern part of the Kazakh shield, due to the newly allocated Zhezkazgan-Ulytau seismic-generating zone with seismic potential 6.0, as well as in the Mangyshlak-Ustyurt elevation from the Central Mangyshlak-Ustyurt zone with Mmax 5.4–5.8.

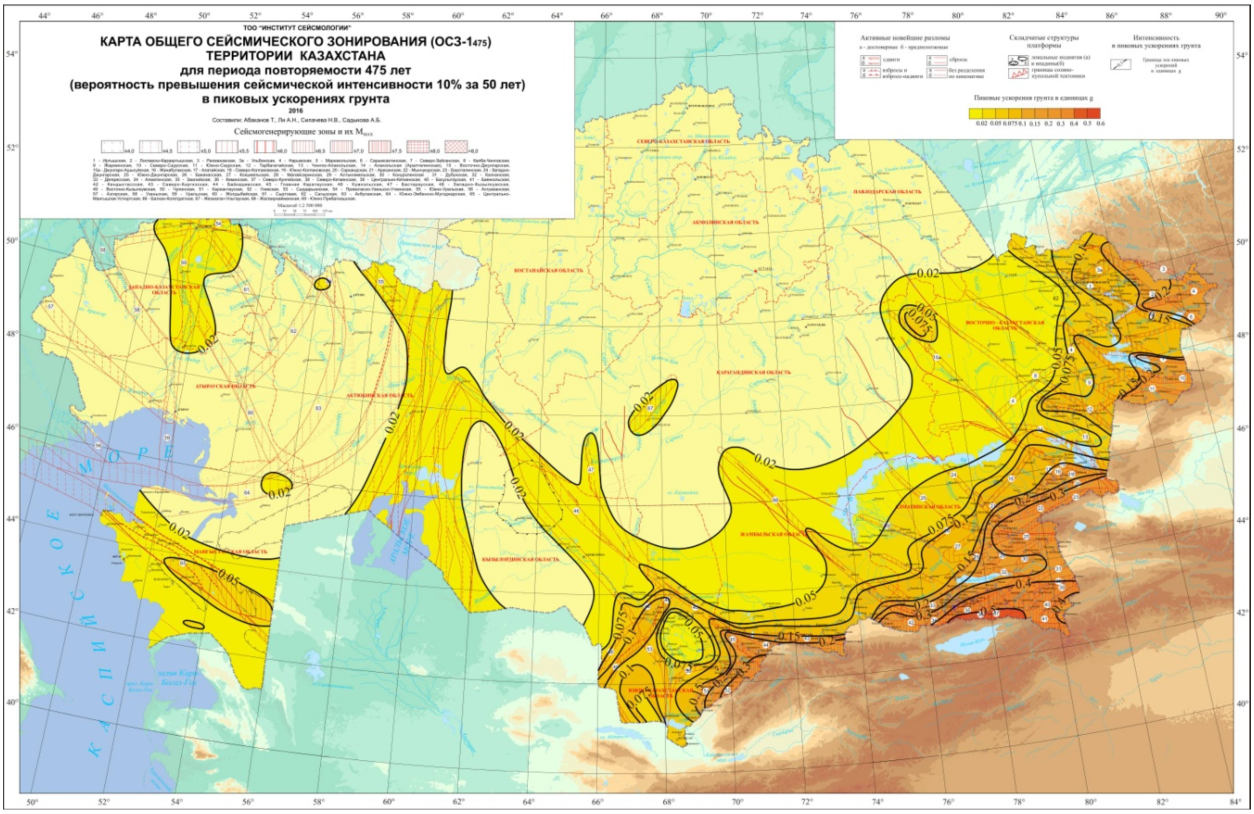

Figure 4 – Map of the general seismic zoning (NEO) of the territory of Kazakhstan for a period of recurrence of 475 years (probability of exceeding the seismic intensity of 10% for 50 years) in peak ground acceleration

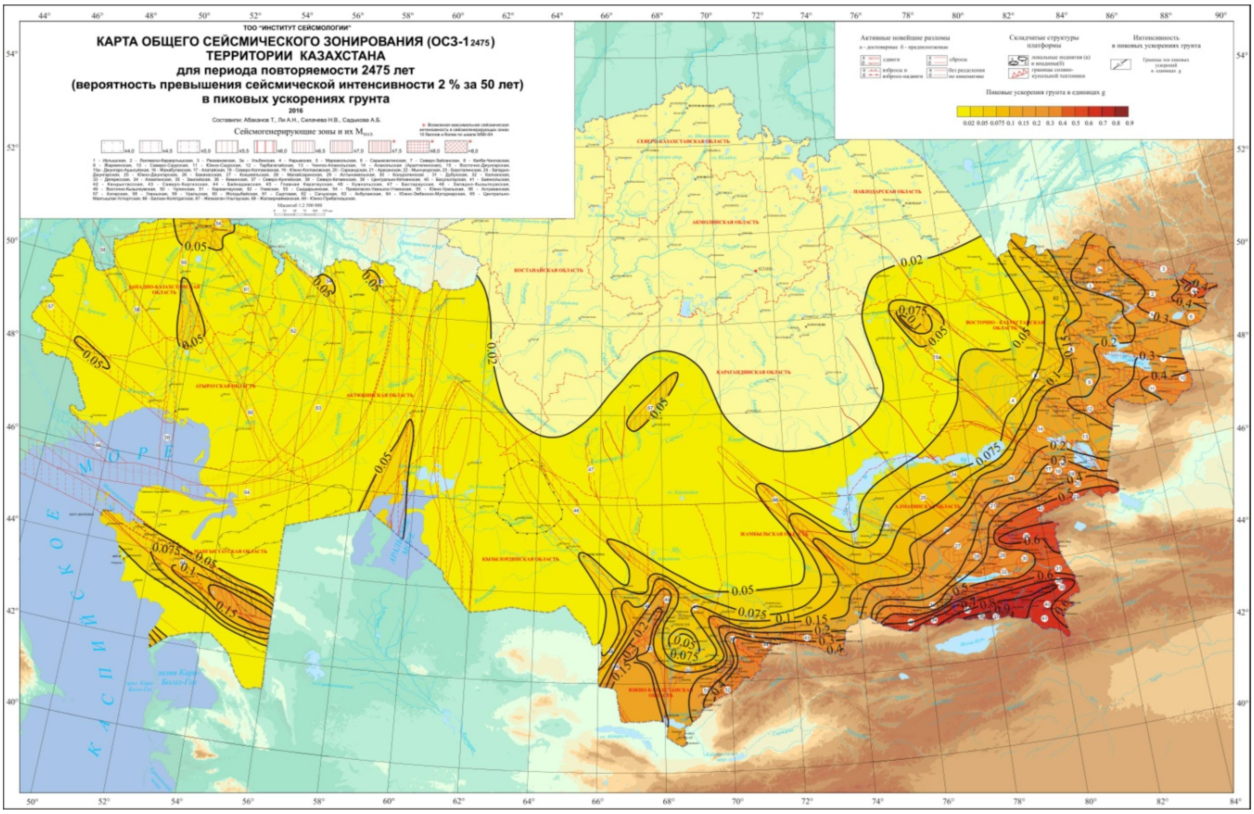

Figure 5 – Map of the general seismic zoning (NEO) of the territory of Kazakhstan for a period of recurrence of 2,475 years (probability of exceeding the seismic intensity of 2% over 50 years) in peak soil accelerations

On a map with a hazard level of 2% (a period of recurrence of 2475 years), the spatial distribution of the hazard becomes more pronounced. More than two-thirds of the territory lies within the 0.02g contour, the maximum magnitudes also correspond to the zones to the south of Almaty. Areas of elevated values exceeding 0.05g are additionally manifested in the Central Kazakhstan region due to the newly allocated Zhezkazgan-Ulytau seismic generating zones with Mmax = 6.0, in the area of the North Aral uplift in the zone with Mmax = 5.5 and in the Central Caspian basin, in the region zones with Mmax = 5.0.

In general, the predictions are consistent with earlier deterministic estimates, with some increase in the level of predicted seismicity in areas where the volume of data on seismicity has increased significantly due to the emergence of new seismic stations and the allocation of new seismogenerating zones in the last decade.

Conclusion. In Kazakhstan, the seismic hazard assessment has been implemented and will be fixed in a fundamentally new methodology based on the provisions of Eurocode 8. Seismic danger of the whole country is analyzed from a probabilistic point of view, and the results are presented not only in the macroseismic indicators traditional in the post-Soviet space, but also in quantitative parameters of earthquakes - peak accelerations. In addition to the new approach, the database, which includes seismic catalogs, maps of zones of possible earthquake foci, models of damping of ground vibrations, was updated on the basis of modern methods, equipment and requirements for parameter representation. Catalogs and maps of seismogenerating zones include earthquakes from previously considered aseismic regions. For the first time, a multifaceted work was carried out to analyze, select according to international criteria and test predictive earth shake models for different seismotectonic conditions in Kazakhstan. When executing the calculation part, software that is recognized in international practice and that meets modern performance of the assessment in engineering parameters is used.

A set of maps of probabilistic seismic zoning of the territory of the Republic of Kazakhstan, including maps in soil accelerations for two levels of probability of 10% and 2% of their excess for 50 years was created. Maps will form the basis for an adequate assessment of seismic hazard and risk, rational land use, earthquake-proof construction and long-term socio-economic planning.

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ҚАЗАҚСТАН АУМАҒЫН ТОПЫРАҚ ҮДЕУІНІҢ ЕҢ ЖОҒАРҒЫ ДЕҢГЕЙІНДЕ ЫҚТИМАЛДЫҚПЕН ЖАЛПЫ СЕЙСМИКАЛЫҚ АЙМАҚТАУ

Аннотация. Қазақстанда отандық атқарылған жұмыстармен бірге және Еврокод 8 арқылы бекітілген батыс тәсілдерінің артықшылықтарын үйлестіре отырып, сейсмикалық қауіпті жаңа әдістемелік негізде бағалау жүзеге асырылды. Еліміздің барлық аумағын Жалпы сейсмикалық аймақтау картасы жасалды. Сейсмикалық қауіп ықтималдық негізде талданды, және нәтижелері макросейсмикалық көрсеткіштерімен бірге, және топырақ тербелісі – үдеудің ең жоғарғы деңгейінде сандық параметрлермен көрсетілді. Мақалада орындаған авторлармен үдеудің ең жоғарғы деңгейін бағалаудағы жаңа ықтималдық әдістеменің негізгі ерекшеліктері және артықшылықтары қарастырылды. Жерді пайдаланудың әлеуметтік-экономикалык жоспарына және құрылыстың сейсмикалық берiктiлiгiне арналған Нормативті құжаттарға қосу үшін Қазақстан аумағын үдеумен Жалпы сейсмикалық аймақтау картасы дайындалып және жетілдіріліп ұсынылды.

Түйін создер: сейсмикалық қауіпті ықтималдықпен бағалау, топырақ үдеуінің ең жоғарғы деңгейі, қайталану кезеңдері 475 және 2475 жылдар.

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ВЕРОЯТНОСТНОЕ ОБЩЕЕ СЕЙСМИЧЕСКОЕ ЗОНИРОВАНИЕ ТЕРРИТОРИИ КАЗАХСТАНА В ПИКОВЫХ УСКОРЕНИЯХ ГРУНТА

Аннотация. В Казахстане осуществлен переход к оценке сейсмической опасности на новой методической основе, сочетающий отечественные наработки и преимущества западного подхода, закрепленного в Еврокоде 8. Созданы карты Общего сейсмического зонирования территории всей страны. Сейсмическая опасность проанализирована с вероятностной точки зрения, и результаты представлены как в макросейсмических показателях, так и в количественных параметрах колебаний грунта – пиковых ускорениях. Рассмотрены основные отличия и преимущества нового вероятностного подхода для случая оценок в пиковых ускорениях, выполнявшихся авторами. Представлены разработанные и подготовленные для внесения в нормативные документы карты Общего сейсмического зонирования территории Казахстана в ускорениях, предназначенные для социально-экономического планирования землепользования и сейсмостойкого строительства.

Ключевые слова: вероятностная оценка сейсмической опасности, пиковые ускорения грунта, периоды повторяе-мости 475 и 2475 лет.

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