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# ECOLOGICAL SAFETY PERFORMANCE IN THE KREMENCHUK INDUSTRIAL REGION UNDER ACTION OF INDUCED EARTHQUAKES

**Purpose.** To decrease influence of occurrences of ecological hazards formed by induced earthquakes in an industrial region on the man and environment.

**Methodology.** Determination of the rate of displacement of soil or structural elements during induced earthquakes is based on multichannel recording of short-term processes occurring in geological environment followed by the analysis of amplitude-frequency parameters. For instrumental measurements, the vibrating graph I-00-2, the magnetographer NO-68, the seismic sensors SM-3, CB-20, ATP-1M were used. The calibration of the seismic channel was carried out dynamically on the vibration stand VUT-300/6. Consequences of manifestations of environmental hazards were determined by visual observation and determination of geometrical parameters of damage, as well as medical control and population surveys.

**Findings.** Based on the system analysis the structure of the monitoring system of distress during induced earthquakes was considered, which includes detection of sources, instrumental measurements of parameters of their influence on objects, detection of defects, public opinion poll. According to the results of instrumental measurements of the rate of displacement of soil and elements of constructions of buildings in the event of induced earthquakes of various origins, their impact on the state of ecological security in the Kremenchuk industrial region is determined. Mechanical damages to residential and industrial building structures and temporal health disorders of inhabitants were detected. Explosions at careers and transport highways as sources of induced earthquakes were studied. Exceeding of possible level of vibrations is fixed in residential and industrial building, located in the zones affected by these sources. A system of technical solutions as for decreasing influence of ecological hazards is offered. In particular, artificial change of parameters of environment is foreseen in direction of passing of mechanical waves to objects of the different purpose.

**Originality.** Scientific principles of improving the states of ecological safety at influence of induced earthquakes got their further development by working out the system of technical measures as a result of the ecological monitoring, in particular, change of parameters of environment between the source of danger and object which it influences on.

**Practical value.** The use of research results will help to ensure the constructive integrity of buildings of different purposes and comfortable living conditions of the population.

**Keywords:** *ecological hazard, influence of occurrences, industrial region, induced earthquakes, quarry, transport, vibration speed*

**Introduction.** Technogenic influence on the environment, insufficiency of environment impact assessment of placing of economic objects and other factors resulted in ecological hazards.

Basic ecological problems in the industrially loaded region are related to transformation of natural environment under the action of factors of anthropogenic origin. The necessary condition of effective management of ecological safety is an analysis of conformities to law and features of forming of ecological hazards [1]. The latter stipulates conducting of corresponding experimental and model research studies.

The feature of modern anthropogenic activity is an intensive use of equipment and technologies which generate mechanical vibrations that are distributed in the lithosphere, that is, sources of induced earthquakes. Such sources are concentrated, mainly, in densely populated industrial regions, that results in the increase in the level of ecological hazards. The last is of probabilistic nature, id est, it can potentially exist for a long time without influencing people and environment. And only, when the sources of danger are initiated, the last reveals itself.

Taking into account mentioned above, research on manifestation of ecological hazards formed by induced earthquakes, and their consequences, is relevant research and practical task.

**Analysis of the recent research and publications.** An essential element of providing ecological safety is engineer-geological prognostication of changes of geological environment as a result of action of seismic factors of natural or technogenic character. In spite of a considerable number of scientific publications from the different aspects of engineer-geological prognostication, conformity to law of changes of geological environment has not been studied enough. Special attention in engineer-geological prognoses is paid to the questions of estimation of firmness of geological environment [2].

Various aspects of hazard formation in case of natural earthquakes are sufficiently studied. Some scientists

investigate natural-anthropogenic earthquakes. In [3] it is determined that these earthquakes often occur in the areas of building of storage pools and hydrocarbon production. In [4] it is shown that in the Dnepropetrovsk region the cases of occurrence of earthquakes became more frequent in the places of localization of active extraction and processing of minerals. The authors [5] analyze the appearance of induced earthquakes in the territory of aseismic regions and their development in the regions of long and intensive development of minerals in connection with the increase in mining depth and scale mining and industrial works. In [6] the model of zones of origin of technogenic earthquakes, that describes character of spatio-temporal distribution of seismic events on territories with considerable anthropogenic influence on seismic activity, is offered.

Conceptual principles of management of ecological safety in the conditions of action of induced earthquakes are defined by Professor Shmandiy. Experimental research is of episodic nature and concerns certain types of sources of danger. In particular, [7] studied the impact of induced earthquakes in Poltava on residential buildings. In [8], earthquakes that occur while producing apatite are investigated. In [9] the methodology of ecological risk was used.

The results of analysis of literary sources allowed establishing the fact that a system approach to the study of the states of ecological safety in the industrially developed region with different types of sources of technogenic earthquakes has not been developed.

**Objectives of the article.** The aim of work is to decrease influence of ecological hazard occurrence formed by induced earthquakes in an industrial region on the man and environment.

**Description of methodology.** Determination of speed of displacement of soil or elements of constructions during induced earthquakes is based on multichannel registration of short-term processes occurring in the geological environment, with further analysis of amplitude-frequency parameters. For instrumental measurements, the vibrating graph I-00-2, the magnetographer NO-68, the seismic sensors SM-3, CB-20, ATP-1M were used. The graduation of seismic channel was carried out by a dynamic method on the vibrostand of VUT-300/6. The consequences of displays of ecological danger were determined by a visual supervision and establishment of geometrical parameters of damages, as well as medical control and public opinion poll.

**Presentation of the main research.** We consider that management of ecological safety will be scientifically reasonable and effective only in the case when it is based on data of monitoring of the states of ecological hazards. The feature of ecological hazards is that as compared to other types of danger they are of hidden imperceptible nature. Probably that is why ecological hazards are not perceived properly by a wide circle of different subject matter specialists. We determine substantive theoretical provisions in relation to features of ecological hazard formation that concern induced earthquakes. Analyzing the state of ecological hazards, it is expedient not only to take into account functional descriptions of objects, but also their position properties. The degree of a hazard is largely determined by the unfavorable placing of its sources in relation to objects and building of the different setting. It is expedient to take into account mutual location of zones of distribution of hazards and territories with a different degree of propensity to influence of its manifestation. Thus, when a powerful quarry with an explosive mode of operation is located quite close to a powerful hydrotechnical structure and the geological environment has a structure that promotes active spread of seismic waves, the level of ecological hazards will be extremely high. Thus, not only the spatial placing of sources of danger in relation to various objects but also descriptions of environment in which hazards spread is taken into account. Simultaneous influence (synergy) of different constituents of ecological danger is of importance as well. For example, motor transport creates ecological hazards related both to the action of chemical (emissions from exhaust gases of harmful substances) and physical (induced earthquakes, noise contamination) factors. Consideration of all factors results in the necessity of strengthening the requirements to safe exploitation of cars. Simultaneous presence of a few constituents of danger of different genesis can be unfavorable, neutral, and favorable; unfavorable synergistic influence can substantially strengthen the negative operating on the man and environment. In terms of ecological hazard formation substantial influence produces the difference of quality (influences on the man and environment that differ qualitatively) and intensity of its sources. Intensity of sources determines the degree of manifestation of danger. The structuring of hazards in a space-time continuum is determined by a set of ecologically dangerous objects of any genesis, which, as a result of interaction and mutual influence, form a dangerous biotite for life and threaten the functioning of technical structures, objects, and others.

Sources of induced earthquakes are situated in industrially-housing complexes quite often. The Kremenchuk industrial region (KIR) is one of these sources. There are concentrated quarries with mining by an explosive method (Fig. 1), which is situated in a close proximity from different residential and industrial buildings. Moreover, there are a number of induced earthquake sources of other types in the KIR [10].

Transformation of landscapes is characteristic for the objects of this region. Excavations that reach a depth of over 100 m intercross water-bearing horizons, interfering to their integrity. The water masses in huge quantities come in a career bowl, from where pumped out. When the pumping equipment stops work, flooding of the quarry and adjoining areas occurs.

A significant number of sources of induced earthquakes and their location in residential areas with a developed network of communications and facilities of different uses significantly increase the degree of ecological hazards.

We consider that monitoring of the states of ecological danger must be conducted being based on principles of the system analysis. In our opinion, such monitoring must include the following stages.

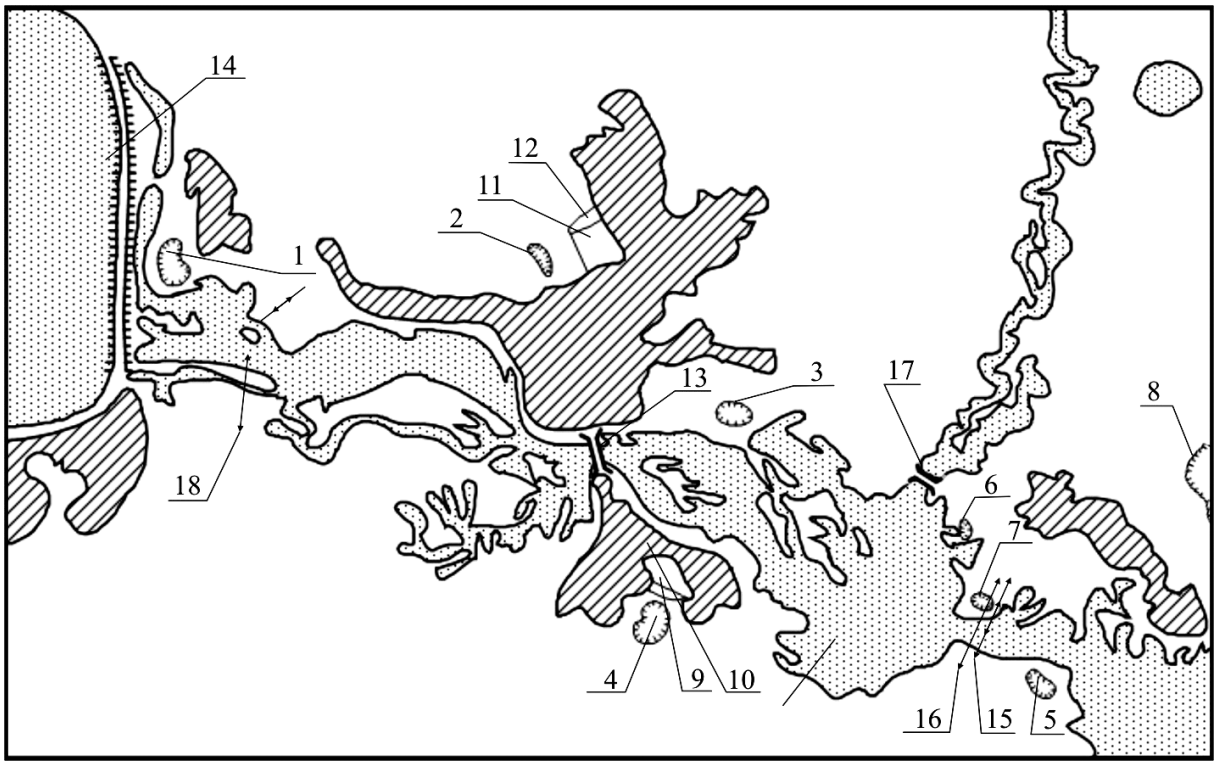


*Fig. 1. Sources of induced earthquakes (1–8) and objects which they influence (9–12 – industrial enterprises; 13, 17 – bridges; 14 – hydrotechnical structures; 15 – oil pipeline 16 – electrical transmission lines) in the KIR; ▨ – residential area; ▩ – waters of reservoirs*

The first stage is detection of sources of induced earthquakes of different power efficiency.

At the second stage of monitoring, we instrumentally identify occurrences of ecological hazards by measuring the speed of displacement of soil and elements of building structures by the standard approved methodologies. Virtually all the objects of the KIR influenced by the sources of induced earthquakes are located in distant or middle zones of induced earthquake action. In these zones longitudinal waves substantially go out and it is possible to assume that surface transversal waves (less in volume) were essentially measured. That is, the waves that lead to significant damage and are the most dangerous for various objects of the KIR.

At the third stage of monitoring, we record the temporary health disorders of the inhabitants of the zones of the impact of induced earthquakes, and conduct a visual observation of damage to the building structures.

On the basis of the obtained results we determine the degree of ecological hazard manifestation, determine correlation of the obtained data of the instrumental measuring with the results of opinion poll by people living in the affected zones and observation.

Among the sources of induced earthquakes in the KIR explosions in careers are the most powerful. A considerable number of sources of induced earthquakes in the investigated region are predefined by the geological conditions of the region, namely bedding of crystalline foundation in the shallow land. The marked feature also determines insignificant absorption of energy of seismic waves at their spatial distribution. The long-term operation of quarries contributed to transformation of geological environment and accumulation of mechanical stresses in the structural elements of buildings and constructions, which creates high probability of ecological hazard manifestation.

In particular, we studied occurrences created by two quarries for extraction of granite, located in dwelling-industrial zones. The border of one quarry field passes at a distance of 200 m only from multistory housing building, approximately at the same distance from the other quarry in the industrial zone where a steel-making plant is located. This situation makes them one of the most dangerous sources of ecological hazards in the KIR. We determined that the registered high speed of displacement exceeds possible norms at a distance of about 250 m from the sources. From anthropocentric positions, there is a hazard to a medical establishment that is located at a distance of about 1.2 km from the source of earthquakes (quarry). For such objects the possible norms of influence are reduced. We consider that to calculate parameters of blasting works in careers it is expedient to take into account the influence not only on a building that is located nearby, but also, on occasion, on specific remote objects.

As a result of visual observation of the state constructions and buildings affected by induced earthquakes, consequences of ecological hazard manifestation were determined, in particular, formation of cracks and falling of plaster in residential and industrial buildings. The mentioned defects were educed in the room of the Department of Ecological Safety of Kremenchuk National

University as a result of work of pile drivers on a building site located nearby. In places of cracks high humidity occurs, which results in negative sanitary-and-hygienic consequences. On results the public opinion poll, temporal health disorders of the habitants (headaches, changes in blood pressure, and others) were identified. A direct harmful physical effect on the habitants of the KIR is insignificant due to short duration of the process (4–7 s). In addition, the factor of danger is leveled by the fact that greater part of the population got used to the earthquakes after long time residence, while psychological discomfort emerges at the appearance of mechanical damages of buildings and constructions. Regular appearance of cracks in houses and publication in mass media on catastrophes that happened in other regions, are factors that constantly retain the population in the state of psychological tension.

Let us consider transport as a source of induced earthquakes. First of all, these are highways and railway lines with heavy traffic of vehicles. The residential area, as a rule, is located at an insignificant distance from transport highways. We defined that motor-vehicle and railway traffic causes oscillation of subzero and middle power. Exceeding of possible level of vibrations is fixed in the residential buildings located near transport highways. By the instrumental measuring the maximal value of speed of displacement is determined to be 0.6 mm/s (exceeding the norms by 1.8 times).

The influence of induced earthquakes that occur during the movement of vehicles on uniform sections of highways, as well as in the presence of rail joints on rail transport tracks not protected against vibrations and defects of road pavement for motor transport has been investigated. It is determined that the presence of heterogeneities (rail joints and defects of travelling coverage) contributes to strengthening ecological hazard occurrences. Experimentally fixed speed of displacement of soil near rail joints (averaged value makes 3.2 mm/s) is on the average 1.8 times higher in value (1.8 mm/s) that corresponds to the traffic on the uniform area of railway lines. Qualitatively, a similar situation is also observed for a motor transport. For example, on the certain area of motorway with the present defects of roadway covering (pits and hills) at a distance of 5 m, average speed of displacement of soil of 2.8 mm/s is experimentally fixed. After repair of the area of the road, there is observed a decrease in value (1.3 mm/s) of the indicated parameter, which is related to elimination of defects of roadway covering and, as a result, shock load on the last. A similar effect is observed in case of railway transport in the summer period as a result of reduction of expansion gaps between rails. Development of continuous welded rail can be an effective measure to decrease the level of ecological hazards formed by induced earthquakes that arise during the movement of rail transport.

Based on results of experimental research studies, it has been established that the movement rate and mass of transport vehicles influence the intensity of hazard manifestation. The increase in the movement rate of heavy trucks (KrAZ) from 40 to 60 km/h causes increase in the value of vibration speed by 1.5 times on the road with no defects and by 2 times on areas slipshod. We found that an appreciable ecological threat was formed by transport vehicles weighing over 6 tons.

It should be noted that rather high level of ecological threat in the KIR is caused by a bridge across the river Dnipro. The bridge is two-tiered and there is heavy vehicular and railway traffic circulation on it. The results of our observation showed that the terms of safe carrying capacity of the bridge and maximal possible weight of transport vehicles are violated; roadway covering is damaged. Thus, there is a high probability of destruction of the bridge that can entail considerable negative ecological consequences.

The Kremenchuk reservoir storage dam is another object of an increased ecological threat. Over the dam, as well as over the bridge, there is heavy vehicular and railway traffic circulation. To perform instrumental measuring there were set seismic sensors on the verge of the overhead plane of the dam and on the dam parapet wall between motor-car and railway ways. The average maximal value of speed of displacement makes 1.2 mm/s (at simultaneous movement of both vehicles and trains). On the bridge, the sensors were set on the concrete superstructure at 2 meters from the support and in the middle of the metal superstructure. The indicated sensors fixed parameters of vibrations of the bridge girder during movement of vehicles and trains. The average value of speed of displacement makes 7.9 mm/s.

The generalized results of the experimental studies on the territory of the KIR on two types of sources of induced earthquakes are shown in Fig. 2. Let us note that we chose such experimental points for which measuring testing facilities were uniform. Transport highways were investigated with dense traffic of heavy motor trucks (KrAZ and the like), the average rate of movement made 40 km/h. Fig. 2, *a* presents the data on induced earthquakes caused by industrial explosions, which relates to extraction of granite by the explosive method at "Quartz" quarry office, whose quarry is in the residential and industrial zone of the KIR. From a set of all the results of three-year research studies, we chose those which correspond to the same type of explosion conditions. For verification of uniformity and authenticity of the obtained experimental data we conducted statistical analysis of them. By the method of the rectified diagrams using software package of Microsoft Excel we confirmed hypothesis for normality of data distribution.

It is established that the dependence of the quantum on the value of the variant is of reciprocal exponential nature. On the logarithmic dependence, the calculation points are located along the line, with the reliability of $R^2 = 0.96$ described by the equation $y = 0.9x + 6.61$. Thus, the experimental data correspond to the lognormal distribution law. With the Student's $\tau$-criterion, data coherence was checked. The critical maximum value of $\tau$ for the five-percent significance level is 1.67. Since the maximum calculated value of the criterion is less than the critical one, the hypothesis for the affiliation of the analyzed variant to the sample is confirmed, and the sample data can be considered homogeneous with a confidence level of 0.95.

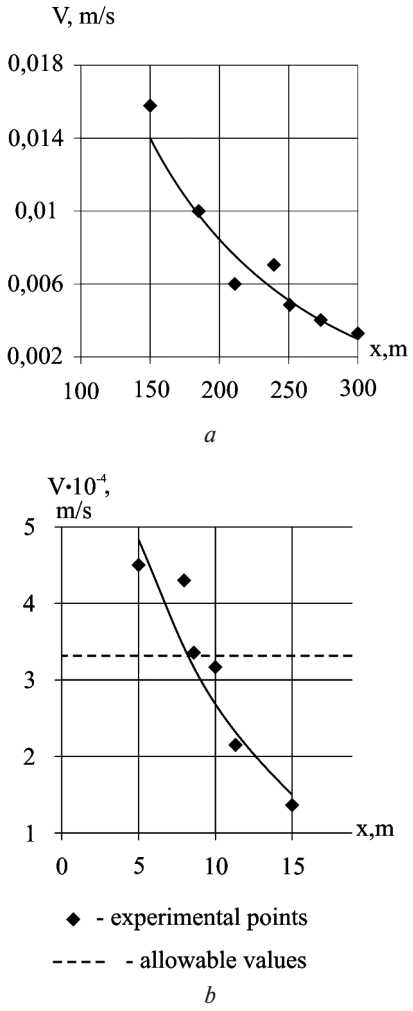


*Fig. 2. Averaged values of speed of displacement of V at different distances of x from the sources of induced earthquakes:*

*a – for industrial explosions; b – when driving a vehicle*

The analysis provided the data to size the appreciable effect of induced earthquake zones [10].

Let us generalize the results of our research studies on those sources of induced earthquakes, near which the most dangerous objects are located. In the KIR (in the zones affected by sources of induced earthquakes) the following types of objects whose damage can result in the ecological hazard occurrence of different degree of complexity, are educed:

- locally significant facilities – production facilities of industrial enterprises, electrical transmission lines, that cross the river Dnipro, residential buildings and assemblies. The damage of civil and industrial objects creates a threat to life and health of people, and can result in contamination of environment in a direct closeness;

- regionally significant facilities include an oil pipeline, the bridge over the river Dnipro. In particular, railway and motor-car accidents caused by destruction of the bridge can result in ecological threat that causes contamination of environment in the region;

- a nationally significant facility – is the Kremenchuk reservoir storage dam, that is located in the zone affected by earthquakes induced by granite quarry (minimum distance of sources of technogenic earthquakes from the dam makes only 450 m). Large-tonnage motor and railway transport that moves over the dam, and generator aggregates of the hydroelectric power station are also the sources of induced earthquakes. That is, there is an overlap of the negative influence of sources of ecological threat of different genesis, which increases the level of danger.

Occurrences of ecological hazards, related to the dam damage, can include flooding of considerable territories, which will be accompanied by destructions of objects of the categories mentioned above. Damage of other dams and protective dikes of other reservoirs is also possible. Different ecologically dangerous objects of the country, including Zaporizhzhya Nuclear Power Plant can get in a flood zone. All mentioned above can result even in contamination of aquatorium of the Black sea.

Let us consider the system of measures to decrease the influence of different types of induced earthquakes.

In relation to induced earthquakes that arise during the heavy truck traffic (displacement speed measurement was conducted on the different areas of highways which correspond to the experiment conditions), we offer:

- speed restriction and weight limit for vehicles; at speed restriction for a car from 60 to 40 km/h, as shown above, the degree of ecological threat decreases by 1.5–2 times;

- for railway transport – creation of continuous welded rails or use of construction of track with antivibration mounting that decreases the soil displacement speed by 3–4 times.

Regarding the bridge over the river Dnipro and The Kremenchuk reservoir storage dam, we consider implementation of the system of the concerted initiation of earthquake sources: when a train is moving, heavy truck traffic (travel speed and traffic density are regulated) is limited. It allows decreasing stress accumulation in the elements of constructions of the buildings considered and, thus, decreasing a probability of ecological hazards.

We consider that an effective measure to undercut the influence of induced earthquakes of different genesis is improvement of positional characteristics of its sources in relation to the objects it influences. It is possible to attain by changing parameters of the environment where mechanical waves spread from the source of induced earthquakes. It is known that in hard (for example, massive rock) rocks elastic waves spread with less losses and are passed at longer distances, than in loose rocks (sand, alluvium, and others), where they quickly lose the energy as a result of decay. In connection with the stated above, we consider it reasonable to implement artificial change in parameters of geological environment in direction of mechanical waves passing with the purpose of limitation of a zone of their distribution in relation to hazardous objects. We offer the following ways of solving the set task:

- to conduct a series of shallow explosions for crushing of massive rocks on the way of wave distribution. These must be superficial explosions of small power, because potentially dangerous objects, as a rule, are in the distant zones of earthquake action, where surface waves

mainly spread. Such a measure is expedient to apply during explosions in careers;

- to construct of the simple deepening building filled with porous materials (macadam, claydite) on the way of wave distribution. The construction screens the zone where the objects are located, from longitudinal waves that appear in the process of initiation of an induced earthquake source. The constructed elastic structure provides a frequent break and wave reflection, which results in energy absorption. The measure described is expedient to apply for different types of induced earthquake sources;

- to form a network of green planting (trees with a well-developed root system) on the way of mechanical wave distribution from the induced earthquake source. In fact, roots form an elastic "net" that takes in mechanical vibrations due to elastic forces. Such a measure is expedient to implement in case of transport sources of induced earthquakes.

Application of the measures described to decrease the influence of technogenic earthquakes allows increasing the degree of ecological safety and providing sufficient comfort of conditions for people in residential and industrial buildings that are in the affected zone. There is also decrease in psychological influence on people – prevention of such intensity of vibrations, at which there is no damage to buildings, but people experience the same feelings as during more powerful natural earthquakes. Structural and architectural integrity of buildings and structures, prevention of damage to different equipment are also provided.

**Conclusions and recommendations for further research.**

1. On results of the instrumental measuring of speed of displacement of soil and elements of constructions during induced earthquakes of different origin, their influence on the environmental safety in the Kremenchuk industrial region is determined. Mechanical damage to constructions of residential and industrial buildings and temporal health disorders of the habitants are educed.

2. On principles of system analysis, the structure of the monitoring system of the states of the environmental safety during induced earthquakes is considered, which includes detection of sources, instrumental measuring of parameters of their influence on objects, detection of defects, public opinion poll.

3. Explosions in careers and transport highways as sources of induced earthquakes are investigated. Exceeding of possible level of vibrations is fixed in residential and industrial buildings located in the zones affected by these sources.

4. A system of technical solutions to decrease the influence of ecological hazards. In particular, the artificial change in parameters of the environment in direction of mechanical waves passing to the objects of the different purposes is provided.

5. The prospects of further research studies are considered in detection and research and practice study of other factors of ecological threat formation, which along with induced earthquakes have negative influence on the vital functions of people and environment.

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## Стан екологічної безпеки у Кременчуцькому промисловому регіоні при дії техногенних землетрусів

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**Мета.** Зниження впливу на людину й довкілля проявів екологічної небезпеки, що формується техногенними землетрусами у промисловому регіоні.

**Методика.** Визначення швидкості зміщення ґрунту та елементів конструкцій при техногенних землетрусах ґрунтується на багатоканальній реєстрації короткочасових процесів, що протікають у геоло-

гічному середовищі, із подальшим аналізом амплітудо-частотних параметрів. Для інструментальних замірів використано віброграф И-00-2, магнітограф НО-68, сейсмодатчики СМ-3, СВ-20, АТП-1М. Градуювання сейсмічного каналу здійснювали динамічним методом на вібростенді ВУТ-300/6. Наслідки проявів екологічної небезпеки визначалися шляхом візуального спостереження та встановлення геометричних параметрів ушкоджень, а також медичного контролю та опитування населення.

**Результати.** На засадах системного аналізу розглянута структура системи моніторингу станів екологічної небезпеки при техногенних землетрусах, що включає виявлення джерел, інструментальні вимірювання параметрів їх впливу на об'єкти, виявлення дефектів, опитування населення. За результатами інструментального вимірювання швидкості зміщення ґрунту та елементів конструкцій споруд при техногенних землетрусах різного походження визначено вплив їх на стан екологічної безпеки у Кременчуцькому промисловому регіоні. Виявлені механічні пошкодження конструкцій житлових і виробничих будівель і тимчасові розлади здоров'я мешканців. Досліджені вибухи на кар'єрах і транспортні магістралі як джерела техногенних землетрусів. Зафіксовані перевищення допустимого рівня коливань у житлових і промислових приміщеннях, розташованих у зонах впливу цих джерел. Запропонована система технічних рішень щодо зниження впливу проявів екологічної небезпеки. Зокрема, передбачена штучна зміна параметрів середовища в напрямку проходження механічних хвиль до об'єктів різного призначення.

**Наукова новизна.** Набули подальшого розвитку наукові засади поліпшення станів екологічної безпеки при впливі техногенних землетрусів шляхом розробки за результатами екологічного моніторингу системи технічних заходів, зокрема, зміна параметрів середовища між джерелом небезпеки та об'єктом, на який вона впливає.

**Практична значимість.** Використання результатів дослідження сприятиме забезпеченню конструктивної цілісності споруд різного призначення й комфортних умов життєдіяльності населення.

**Ключові слова:** *екологічна небезпека, вплив проявів, промисловий регіон, техногенні землетруси, кар'єр, транспорт, віброшвидкість*

## Состояние экологической безопасности в Кременчугском промышленном регионе при действии техногенных землетрясений

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**Цель.** Снижение воздействия на человека и окружающую среду проявлений экологической опасности, формируемой техногенными землетрясениями в промышленном регионе.

**Методика.** Определение скорости смещения грунта или элементов конструкций при техногенных землетрясениях основывается на многоканальной регистрации кратковременных процессов, протекающих в геологической среде, с последующим анализом амплитудно-частотных параметров. Для инструментальных замеров использован виброграф И-00-2, магнитограф НО-68, сейсмодатчики СМ-3, СВ-20, АТП-1М. Градуировки сейсмического канала осуществляли динамическим методом на вибростенде ВУТ-300/6. Последствия проявлений экологической опасности определялись путем визуального наблюдения и определения геометрических параметров повреждений, а также медицинского контроля и опроса населения.

**Результаты.** На основе системного анализа рассмотрена структура системы мониторинга состояний опасности при техногенных землетрясениях, которая включает выявление источников, инструментальные измерения параметров их воздействия на объекты, выявления дефектов, опросы населения. По результатам инструментального измерения скорости смещения грунта и элементов конструкций сооружений при техногенных землетрясениях разного происхождения определено влияние их на состояние экологической безопасности в Кременчугском промышленном регионе. Выявлены механические повреждения конструкций жилых и производственных зданий, временные расстройства здоровья жителей. Исследованы взрывы на карьерах и транспортные магистрали как источники техногенных землетрясений. Зафиксировано превышение допустимого уровня колебаний в жилых и промышленных помещениях, расположенных в зонах влияния этих источников. Предложена система технических решений по снижению влияния проявлений экологической опасности. В частности, предусмотрено искусственное изменение параметров среды в направлении прохождения механических волн до объектов различного назначения.

**Научная новизна.** Получили дальнейшее развитие научные основы улучшения состояний экологической безопасности при воздействии техногенных землетрясений путем разработки по результатам экологического мониторинга системы технических мероприятий, в частности, изменение параметров среды между источником опасности и объектом, на который она влияет.

**Практическая значимость.** Использование результатов исследования будет способствовать обеспечению конструктивной целостности сооружений различного назначения и комфортных условий жизнедеятельности населения.

**Ключевые слова:** *экологическая опасность, влияние проявлений, промышленный регион, техногенные землетрясения, карьер, транспорт, виброскорость*

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