ABSTRACTS
OF THE CONFERENCE PARTICIPANTS

MEDIUM-TERM ESTIMATION OF SEISMIC RISKS OF TERRITORIES BASED ON PROBABILISTIC MODEL OF POISSON DISTRIBUTION

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Medium-term estimation of seismic risks of various territories is of great importance for planning and taking the measures on reduction of damages and losses caused by earthquake disasters. Such estimations are demanded by government agencies and organizations managing the emergency situations.

In the course of presentation, participants will be familiarized with the achievements, approaches and methods used in Uzbekistan for estimation of seismic risks for long-term, medium-term and short-term periods and for earthquake early warning.

Probabilistic method based on model of Poisson distribution is the one of the ways used in Uzbekistan to estimate the earthquake risks of the territories for medium-term. Application of this method enables to obtain the map of the number of expected ground shakes for the given range of earthquake intensities and for the various length of future time intervals. The method also gives the map of confidence intervals for the number of expected ground shakes. Based on the statistical tests, the developed methodology evaluates the compliance of the accepted model with the structure of actual data.

During the report, the rationale and the theoretical fundamentals of probabilistic model based on Poisson distribution will be presented. As an example of the use of the model, the results of application of the method to several territories of Black Sea region will be shown.

THE THEORY OF THE STARTING EARTHQUAKE

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In the work is represented obviously for the first time the model of one type of earthquakes beginning from the preparation to the accomplishment of the event. The model based fully on the laws of physics and mechanics may reveal the new type of faulting earthquake called the starting one, as it precedes to strong crustal earthquakes, connected with the lithosphere plates' interaction. As lithospheric plates we take the Kirchhoff plates on elastic half-space moving to each

other till they approach. The earthquake is defined by drastic increase of stress concentration in a specified area in comparison with a normal condition. The mining allows evaluating with the aid of specific equipment the location, time and intensity of this type of earthquakes. The patterns of this earthquake are revealed. The theory of this earthquake is based on the mathematic methods of the high level such as the topology, external analysis, factorization, block element methods. This theory of this earthquake is presented in this report.

This work was supported by the Russian Foundation for Basic Research, projects nos. (14-08-00404), (15-01-01379), (15-08-01377), (16-41-230214), (16-41-230218), (16-48-230216), by the Program no 1-33P of the Presidium of the Russian Academy of Sciences, from (0256-2015-0088) till (0256-2015-0093) and State Order, project (0256-2014-0006).

PECULIARITIES OF AFTERSHOCK PROCESS OF THE EAST BLACK SEA $MW = 5.7$ EARTHQUAKE OF 2012

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Strong $Mw = 5.7$ earthquake occurred on 23.12.2012 at 13:31:42.46 in the Black Sea (Abkhazia) at the distance of 37 km from the coast, 38 km from Ochamchire, 51 km from Sukhumi, 46 km from Anaklia, Georgia, and 158 km from Sochi, Russia. To locate the event we used data of 37 seismic stations from Russia and Georgia. The final estimation of the hypocenter coordinates are $42.510\text{N} \pm 1.9$ km, $41.047\text{E} \pm 1.6$ km; the depth is 10 km. The epicenter is connected to a regional fault. The source is a strike slip fault.

The earthquake of 2012 has a great interest for the regional seismology as it is the strongest one in the history of seismic monitoring since 1900 in that part of the Black Sea and only two earthquakes had occurred in sea before 2012 had the magnitude greater than the last one. The earthquake of 2012 was followed by aftershocks which have been continuing till now. According to Russian Geophysical Survey there were 274 aftershocks with $ML > 2$ from 23.12.2012 till 31.12.2015. The aftershock epicenters agree with the regional fault system. An intensity of the aftershock process reached 44 events with $ML > 2$ per day in the first 24 hours after the mainshock.

In 57.2 hours after the mainshock an event with $Mw = 5.4$, which initiated a secondary aftershock sequence, occurred. We studied the two aftershock sequences as a whole by relaxation LPL model and trigger ETAS model. To compare the aftershock process produced by the earthquake of 2012 we fitted LPL and ETAS models for three aftershocks sequences occurred in the Northern Caucasus (1^{st} and 2^{nd} Racha–Dzhava earthquakes of 29.04.1991 and 15.06.1991 and Oni earthquake of 07.09.2009 as well). Bayes informational criterion (BIC) was used to choose the best fitted model.

The aftershock processes produced by the earthquake occurred before 2012 had a relaxation type (LPL model gives lower BIC values than the ETAS). Aftershock process by the earthquake of 2012 had trigger type (ETAS model gives more than 30 % lower BIC value than LPL one). Thus the aftershock process of the earthquake in the East Black Sea could not be described only by stress relaxation in the fault zone. To explore this non-relaxation behavior we fit the ETAS model in moving time window. We find a systematic variation in the external forcing strength which is incompatible by time with the large aftershocks driven by tectonic. We conclude that the non-relaxation behavior of aftershock process of the earthquake of 2012 was not controlled by tectonic deformation but fluid effect on the local stress field in the fault zone.

The research was supported by Russian Foundation for Basic Research (Project 16-05-00263).

THERMODYNAMIC ANALOGY IN THE PROBLEM OF PROPAGATION OF SEISMIC ENERGY

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Analysis of the vibration energy propagation in seismology is complicated by the fact that information about the mechanical properties of materials appearing in the dynamic equations, constitutive equations and boundary conditions are known only to a certain degree of confidence. Despite the fundamentally uncertain nature of these parameters we can offer an approach that takes into account the heterogeneity and the lack of statistical information on the properties of materials in the framework of the same approach. This unified approach utilises the apparatus of dynamics of systems with random mechanical parameters. Any attempt to describe pedantically all the complexity of real structures are doomed to failure for the following reasons. Firstly, the presence of many uncontrollable factors plays a fundamental role. They arise from elastic, mass and damping characteristics due to the heterogeneity of material properties and the unreliability of the interaction of individual substructures. Even if it would be possible to solve the boundary problem with account for all complexity of the structure, the interpretation of this result presents a challenging problem. The reason is that the vibration field in each substructure is a very complex function of time and space coordinates. Therefore it can be concluded that the attempts of the exact solution to this problem come to a deadlock due to the complexity of the calculations, the unreliability of the result and the infeasibility of reasonable interpretation. The presentation suggests an alternative approach to solving the problem based on the representation of the structure in the form of a great number of substructures with uncertain mechanical and geometric parameters.

It is shown that the vibrational energy flow in complex systems and its redistribution between the substructures obeys the equation which is a mechanical analogue of the discrete form of generalized Fourier law of heat conduction, namely

$$\sigma_n^{(\mathrm{input})}(\omega) = \eta_n \sigma_n(\omega) + \sum_{j \neq n} \eta_{nj} \left[\sigma_n(\omega) - \sigma_j(\omega)\right]$$

Here $\sigma_n(\omega)$ denotes the modal vibration energy of n-th substructure averaged over a narrow frequency band with the central frequency ω. Similarly, $\sigma_n^{(\mathrm{input})}(\omega)$ stands for the input of the averaged modal vibration energy of n-th substructure. The parameters η_n and η_{nj} are referred to as the coupling loss factor and the coupling exchange factor, respectively. The analogy with the Fourier law becomes evident if one understands $\sigma_n(\omega)$ as a vibrational temperature.

IMPACT LOADING AND STABILITY OF TRANSVERSE VIBRATION OF ROD

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It is investigated the problem of longitudinal impact loading of direct rod. Application of the Bubnov–Galerkin approach results in system of ordinary differential equations with periodic coefficients which are reduced to Mathiey equation. It is studied the instability regions for different set parameters. It is shown the specific situations.

ELECTROPROSPECTING TECHNOLOGIES OF STUDYING OF FLISHEVY THICKNESS BY TECTONIC DISLOCATIONS IN THE MOUNTAIN ZONE OF THE BLACK SEA COAST WHEN CARRYING OUT SEISMIC MICRODIVISION INTO DISTRICTS

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According to the standard requirements the seismic micro division into districts (SMD) includes works in the study territory the tectonic dislocation of rocks. This problem can be solved by the methods of spatial filtration of electric fields (MSEF) and electro-potential tomographic sounding (EPTS). The MPEF technology is based on measurement of components of the electric field of the inclined layers in each point of a profile in conditions of multidirectional excitation of this field with respect to the strike of the inclined layers (Fig. 1). It allows revealing the tectonically dislocated zones on the basis of mismatching of the forms of curves of potential differences of $\Delta U_{\parallel}$ and $\Delta U_{\perp}$.

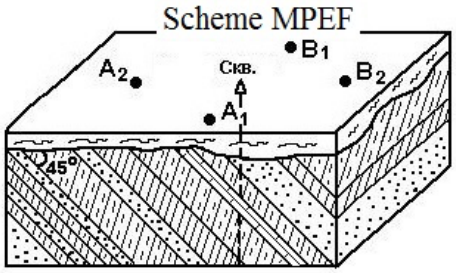

Figure 1.

EPTZ technology combines elements of sounding and profiling by sequential displacement of electric survey setup step fold the measuring line MN, which in turn moves along the profile with the arithmetic step. As a result at each shift of the feeding AB line in new sounding, the MN line passes through the same points, as on previous and, therefore, is one of electro prospecting tomographic systems (Fig. 2). The technology is selective as doesn't demand arrangement of special spits and is applicable in various spatial variations.

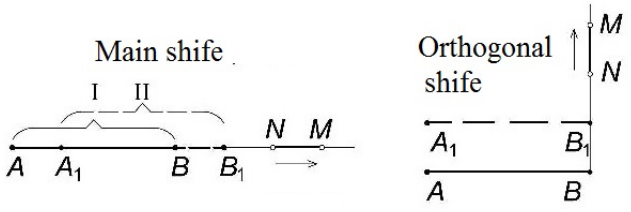

Figure 2.

Figure 3 shows a fragment of schematic section (Index IV) on the projected axis of the tunnel through the Markotkhsky Ridge for the laying of oil pipeline near Novorossiysk. The section has been studied in the course of carrying out the SMD with the use of drilling data and is constructed on the results of geophysical works by the EPTS methods in option of electric profiling (index I),

MPEF (index II) and the emanation surveying (ES). According to the graph of ES (index III), the dislocations, revealed in flysch sequence are estimated as low-active.

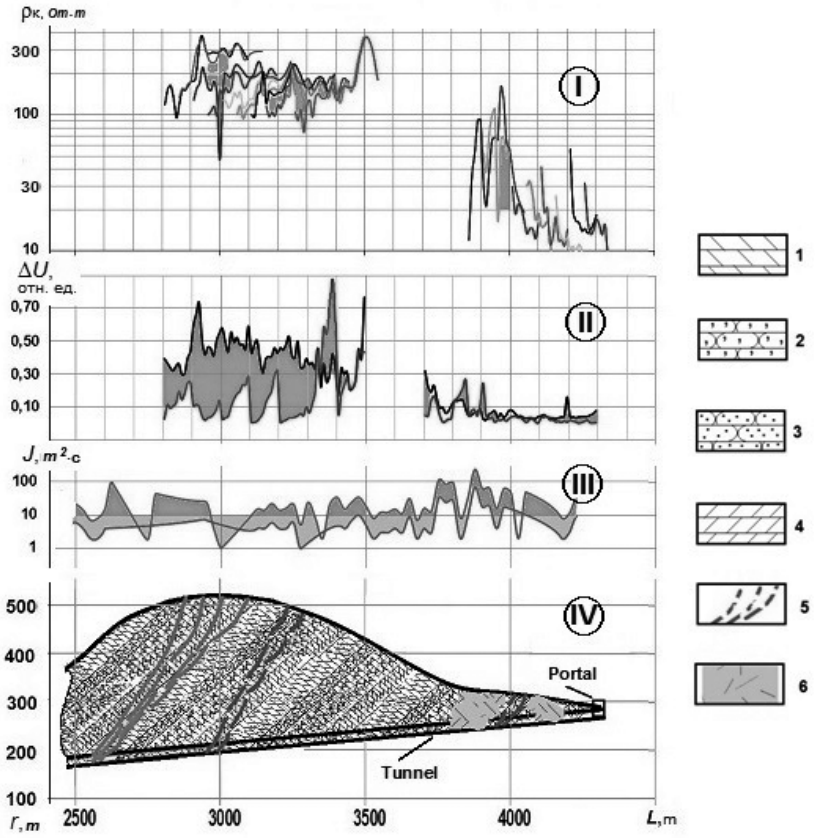

Figure 3.
I – graphs of electropotential tomographic sounding in the form of electric profiling;
II – graphs of a method of a spatial electric filtration (black color – ΔU curve $\parallel$ at an arrangement of the feeding AB line along the strike of rocks, red color – ΔU curve $\perp$ at situation with AB in a cross of striking of rocks);
III – graphs of emanation survey (top – radon flow density, lower – the maximum admissible error);
IV – schematic engineering-geological section up to the bottom of the tunnel depth.
1 – argillites; *2* – aleurolites; *3* – sandstones; *4* – marl; *5* – longitudinal upthrow – overthrow faults; *6* – cross-section of flooded faults.

SEISMIC RISK ASSESSMENT AT URBAN LEVEL: EXAMPLE FOR THE BIG SOCHI CITY

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Seismic safety of population and urban territories is one of the most complicated problems of seismology and earthquake engineering worldwide. It is especially vital for the earthquake prone regions with high level of seismicity and high density of population. According to recent seismic risk R_s assessment at regional level for more that 60 % of the Krasnodar area territory, the values of seismic risk computed taking into account the secondary technological accidents exceed the value of $1.0 \cdot 10^{-5}$ 1/year.

The paper addresses the methodological procedures of risk assessment, as well as analyzes the results of the recent study on seismic risk R_s assessment for the Big Sochi City, as the venue of Olympic Games in 2014, within the Russian Federal Program "Development of the Sochi City as a mountain resort in 2006–2014". The individual seismic risk R_s is determined as the probability of fatalities R_s caused by earthquakes within one year at a given territory and may be estimated through mathematical expectation of social losses $M(N_j)$ taking into account the number of inhabitants N in the considered settlement and probability of seismic event H.

Seismic risk R_s computations for the Big Sochi City were made in 2007, 2011 and 2013. As input data about seismic hazard the maps of seismic microzoning (scale 1:10,000) were used. The building inventory for the city was verified at different stages of study. Updated averaged city districts models (percent of buildings of different types according to MMSK-86 scale within the city districts and their average height) were developed based on building by building inspection undertaken in 1998 in order to collect information about each building. Together with land inspection, decoding of high resolution space images and web-mapping were applied for verification data on built environment inventory. Practical application of mentioned methods for verification data on built environment inventory and vulnerability showed high efficiency of joint use both Web panoramas and satellite images.

Analysis of the obtained risk values showed a remarkable decrease in the built-up areas of the city territory with high risk values (more than $30 \cdot 10^{-5}$) in comparison with 2007 estimates. Unacceptable level of risk was decreased by 30 % (Table 1). This is explained by an increase in the overall level of seismic resistance of buildings in the city due to the construction of Olympic Games' facilities and related infrastructure.

Table 1. Extent of built-up city areas with different levels of risk

Risk range R_s 10^{-5} 1/year	% of area, R_s2013, $T = 500$ years	% of area R_s2007, $T = 500$ years
$\geqslant 1$	18.7	20.6
1–5	56.3	25.8
5–10	16.2	14.7
10–20	5.6	9.9
20–30	2.9	14.3
$\leqslant 30$	0.3	14.7

Obtained in 2014 values of seismic risk R_{st} taking into account possible accidents at industrial facilities trigged by earthquakes for the Big Sochi City showed that contribution of technological accidents is about $0.5 \cdot 10^{-5}$.

It is worthwhile to continue seismic risk study for the Big Sochi City taking into account the growth of population and further development of infrastructure, as well as make use of the experience for other cities in the region.

TRAPPED MODES OF OSCILLATION AND BUCKLING OF A TECTONIC PLATE AS A POSSIBLE REASON OF AN EARTHQUAKE

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We suggest a mechanical model describing buckling of a tectonic plate due to non-stationary longitudinal wave of compression that propagates along the plate. For low frequencies the interaction of a tectonic plate with its environment can be approximately described by means of the Winkler elastic foundation. Introducing the inhomogeneous Winkler foundation with weakened zone can lead to the existence of trapped modes of transversal oscillation in this mechanical system, and makes possible the localized buckling of the plate. Such an instability can be considered as a possible reason of an earthquake. To describe this mechanism of an earthquake we need a coupled model that can describe both transversal and longitudinal motions of a tectonic plate.

We propose a one-dimensional model of a tectonic plate based on the nonlinear equations of the theory of elastic rods. In the framework of the model we deal with a straight extensible

rod, while the shear deformations and the rotational inertia are neglected. The coupled nonlinear equations for longitudinal and transversal motions of the rod are derived. For the case, when the rod is subjected to the slowly varying in time longitudinal load, we proceed with the asymptotic reduction of the nonlinear equations. Finally, we obtain a problem on the evolution of a trapped mode of transversal oscillation in a weakly nonstationary system. If the frequency of the localized oscillation approaches zero, the amplitude of the oscillation can be a growing quantity. This can explain the known experimental fact that ultra-low-frequency seismic pulses are registered before powerful earthquakes. The further increasing of the longitudinal load results in the localized buckling of the tectonic plate that causes an earthquake.

TERRITORIAL SEISMIC PROTECTION OF THE CRITICALLY IMPORTANT STRUCTURES

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A seismic protecting vertical barrier made of metamaterials with the desired acoustical properties and allowing to trap energy of the incident seismic Rayleigh or Rayleigh-–Lamb waves, is analyzed. The considered metamaterials resemble phononic or sonic crystals with a broad frequency band gap in respect of the deviatoric wave components.

Numerical experiments reveal that the considered seismic protecting vertical barriers allow much better seismic protection in terms of larger shadow zones and higher reduction ratios in respect of displacements and accelerations comparing with more traditional barriers made of homogeneous elastic materials.

The corresponding equations of state for the considered metamaterials are discussed. Hyper relastic models with the modified Arruda–Boyce and Mullins hyper relastic potentials, allowing to account hysteresis loops, are introduced.

Due to much better reduction ratios and larger shadow zones, the proposed seismic barriers can be used for seismic protection against Rayleigh and Rayleigh–Lamb waves of the critically important structures, along with constructions with large footprint and stretch constructions like runways and taxiways.

For the case of bulk S-waves the seismic pads made of similar metamaterials installed beneath foundation slabs, are considered. Similarly to seismic barriers, the seismic pad allow to trap energy of S-waves, thus, considerably reducing structural vibrations caused by arrival of seismic S-waves.

PARTIAL SLIP CONTACT PROBLEMS FOR ELASTIC BODIES

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The partial slip conditions in contact interaction of deformable bodies arise if the tangential force acting on the contacting bodies is less than the limiting load which causes the complete sliding. The analyses of the partial slip contact problems makes it possible to study the stress distributions in the contacting bodies and the conditions of transition to the complete sliding, and to predict the fracture of the bodies under the oscillating loads.

The 2-D contact problem for the elastic indenter with flat base and the rounded edges and the half-plane with the same elastic properties is considered. The indenter can be inclined at some angle to the boundary of the half-plane, so the contact region is non-symmetrical relating to the axis of symmetry of the indenter. The vertical load P, the shear force T and the moment M are applied to the indenter. The shear force T is acted on some distance d from the base of the indenter, so the moment $M' = T \cdot d$ exists even the active moment $M = 0$. The condition of the partial slip contact, i.e. $|T| \leqslant \mu P$ (μ is the coefficient of friction) is satisfied.

The analytical expressions obtained for the pressure within the contact region for various inclination angles (and so for different location of the contact zone in respect to the flat part of the indenter boundary) are analyzed and used to study the contact shear stress distributions. It was proved that only one stick zone exists in the contact under partial slip conditions.

The partial slip contact problem solution is used to study the wear process under the oscillating shear force satisfying the condition $|T| \leqslant \mu P$. The analytical model which is based on two-scale analysis of the wear contact problem, is developed and used to analyze the evolution of contact and internal stresses due to wear. The analytical study of the governing equations makes it possible to conclude that the size of the stick zone does not change from cycle to cycle under constant load conditions; the asymptotic solution exists as the number of cycles tends to infinity. Analytical expressions for the asymptotic contact stresses (normal and shear), the internal stress and the wear distribution within the slip zones were developed. It was shown that the asymptotic contact region coincides with the stick zone, and the asymptotic contact pressure and shear stress are singular at the ends of the stick zone. The asymptotic pressure, shear, and gap function distributions do not depend on the wear coefficient but depend on the applied normal and shear forces, and the initial gap function between the contacting bodies. The results are used for prediction of the crack initiation under the oscillating loads.

The research was carried out under the financial support of the Russian Scientific Foundation (RSF), grant (14-29-00198).

MONITORING OF GEODYNAMIC ACTIVITY OF THE AZOV – BLACK SEA COAST WITH USE OF A NETWORK OF GPS/GLONASS STATIONS

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The geodynamic activity monitoring system at the Azov – Black Sea coast of Russian Federation is presented on the basis of a network of permanent satellite geodynamic stations GPS/GLONASS. The network includes two segments, covering northwest and southeast parts of the Azov – Black Sea coast area of Krasnodar region. These segments describe areas with an individual style of Earth crust motion and are defined, accordingly, as Anapa – Novorossijsk and Tuapse – Sochi seismoactive zones.

The Northwest segment includes six GPS-stations and represent crustal deformation field of the Kerch and Taman zone. Four GPS-stations of a southeast segment, are located in limits of the main block boundaries.

Results of crust motion measurements and their characteristic features are presented. Dependence of geodynamic anomalies with level of seismic activity that gives possibility to carry out the further researches on working out of earthquakes precurses is shown. GPS/GLONASS network network developed in the Azov – Black Sea coast area can become the effective instrument as part of an early warning seismic hazard integrated system in the coastal zone of the Russian Federation and the countries of the Black Sea region.

THE MAIN ASPECTS OF HARDWARE AND SOFTWARE COMPLEX FOR FORECASTING EARTHQUAKES BASED ON THE ANOMALIES IN THE UNDERGROUND WATERS OF AZERBAIJAN

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Today in the world are not developed reliable methods of mathematical forecasting of the main parameters of earthquakes (coordinates of the hypocenter, its implementation, and the magnitude). However, work in the field of seismic forecast different methods do not stop. They are presented by the seismological, geophysical and seismic fluidodinamical (in abbreviated form – SFD) researches. To the fluids refer the waters of the Caspian sea, underground springs, artesian and sub-artesian wells and radioactive emanations of the local Earth's site. A priori, when solving problems in this field of science, and especially in real time ("on-line"), it is required the implementation of several critical issues: a) the long (no less than 5 years), all the year-round, stationary SFD monitoring; b) reliability of the primary SFD data monitoring; c) the speed interpretation of SFD data in real time ("on-line"); d) a high percentage of reliability of seismic forecast. Compliance with these conditions is an extremely challenging task. At the present time (2016), based on the published scientific literature data, only one country in the world meets the above requirements. It is Azerbaijan-one of the seismically dangerous regions of a planet. Here in the RSSC at ANAS, in the Department of "Seismic geochemistry" during 1979–2016 has complied with all necessary conditions for development of automated technologies operational seismic forecast based on year-round monitoring of SFD fields. After realization strong earthquakes (Lerik–1998; Caspian sea-Baku–2000), there was developed mathematical and software support to resolve basic issues in the field of short-term forecast of earthquakes only on the results of a year-round SFD. Over the period 1998–2015, by Keramova R. and her employees were designed, implemented and tested 2 different in content "Automatic technologies No. 1 and No. 2 for operative evaluation of seismic situation in the region on SFD fields". They solve the following important problems: a) interpretation of daily data year-round SFD monitoring (in 1 day: 305 values for 17 parameters at 26 sites observations); b) simultaneously for the different hypocenter of earthquakes, which differ by location, are calculated "range-spacing" coordinate of the focus, magnitude and the time remaining until realization of earthquakes. Region of the operational seismic forecast on anomalies in SFD fields: a) the Caspian sea and the Azerbaijan – $ml \geq 3.0$; b) neighboring countries (Russia-Dagestan, Georgia, Armenia, Turkey, Iran – $mb \geq 5.0$); c) countries of the deep focus ($h \geq 90$ km) of Hindu–Kush seismogenic zone; d) the hypocenters of the planetary catastrophic earthquakes ($h \geq 33$ km) – Indonesia, Japan, Chile. All these works are carried out automatically, but duplicated by 2 various technologies. The conclusions also stand out automatically, in the tabular and cartographical variants.

LOADS FROM WAVES OF TSUNAMI ON MARINE HYDRAULIC STRUCTURES

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Discusses the various types of loads on hydraulic structures. The example of calculation of all types of short-term loads on the structure, projected on Bering island. It was found that the maximum load is predicted from the tsunami waves. Further noted that for the calculation of loads from waves of tsunami in the Black and Azov seas there is no original data on heights of

tsunami waves. This is due to the underestimation of tsunami risk for these seas. The conclusion about the relevance of the zoning of the Black and Azov seas on tsunami risk for the purpose of determining initial data for calculations of hydraulic structures.

DEVELOPMENT OF NORTH CAUCASUS SEISMOLOGICAL OBSERVATIONAL SYSTEM

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The Caucasus region is one of the three most earthquake-hazardous regions of the Russian Federation, along with the Far East and South Siberia. Strong earthquakes with intensity 8 or 9 (according to MSK-64 scale) are possible in some zones of the North Caucasus. If take in to account the seismic risk, the western part of North Caucasian region will be the most hazardous region in Russian, because the high population density is combined with the large number of different important objects. Therefore seismological monitoring of the North Caucasus becomes essential to ensure the seismic safety of the region.

The XXII Winter Olympic Games holding in Sochi in 2014 gave the impact for the development of a network of stations in the western part of the North Caucasus. Only 3 seismic stations (Anapa, Gelendzhik and Sochi) have been on the Black Sea coast area in 2008. To the end of 2013 the regional network of 10 modern digital stations has been installed in the Greater Sochi area. The new seismic stations – Agoi, Tuapse, Fischt, Lazarevskoe, Guzeripl, Laura, Estosadok, Olympic Park and Aibga – were added. The installation of new seismological equipment upgraded the capability of the system of seismological observations. It has become possible to implement the monitoring of seismic events since the magnitude level $M \geq 1.0$.

The dense seismic network has allowed to implement an automated system for processing data in near real time. The operated system of automated data processing is based on the SeisComP3 software platform. The investigation of the real sensitivity of the created network for registration of regional earthquakes was carried out.

Earthquake catalog for western part of the North Caucasus including more than 100 earthquakes with magnitudes ML in the range from 1.5 to 5.0 was generated during 2 year period of automatic processing. The catalog has been used to evaluate the performance of the monitoring system.

TO THE METHODS OF STUDYING THE PHYSICAL AND MECHANICAL FIELDS IN THE GEOLOGICAL STRUCTURES TO DETERMINE THE DEGREE OF SEISMIC DANGER

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Development of theoretical foundations for the active seismic monitoring of a region includes the construction of mathematical models of the geological environment, exposed to the effects of different natures and the development of experimental methods for the detection of seismic event precursors, the identification of the seismic characteristics and study of the physical and mechanical processes in the crustal structures. From a practical point of view the monitoring of seismic activity in the region is aimed primarily at identifying signs of the tensions in lithospheric

structures and consists in the study of the latest, using various sources of physical fields, including vibroseismic.

Inhomogeneous layered-block structure of geological arrays often contains defects such as cracks and inclusions at the boundaries between the blocks defining their deformation properties and resistance to external influences, as well as places of possible destruction or sliding of array component. For the construction of adequate models of the environment it is necessary to establish the real parameters of block structure, ie, block sizes, the conditions of their conjugation and physico-mechanical properties. The latter can only be achieved using experimental methods for the analysis of geophysical data derived from monitoring using various instrumental means.

The proposed approach includes the construction of models of the earth's crust and the rock mass using the data from the study of block structure of the Earth's crust in the region and seismological data from instrumental observations (data GPS/GLONASS receivers and tiltmeters). The study of the complex of problems, modeling deformation and wave processes in medium (elastic homogeneous medium, layered medium, structure with continuity breaches), experiencing a dynamic harmonic effects of surface source and/or vibration of internal inhomogeneities, was conducted.

In solving the problems we use an integral approach and its generalization – differential factorization method, applicable in restricted and unrestricted areas, which allows to take into account the mutual influence of geometrical and physical parameters of the problem, to describe the behavior of solutions at infinity and to perform the selection of waves carrying energy at infinity.

The study has been carried out with support of the grants RFFR and Administration of Krasnodar Territory (16-41-230184).

ABOUT REGULATIONS EXECUTION ON SAFETY OF BUILDINGS AND CONSTRUCTIONS IN SEISMIC COUNTRIES

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In the report new problems in the design and building practice, connected with execution of technical regulations about safety of buildings and constructions in seismic countries in the light of requirements of the joint venture 14.13330.2014 are considered. Examples of application of seismoisolation of residential units in Sochi are resulted. It is shown that the carried out engineering decisions on decrease in seismic impact do not lead to building rise in price.

EXPERIMENTAL STUDY OF THE MODEL SECTIONS RESIDENTIAL BUILDING OF TYPICAL SERIES 1-335AC UNDER DYNAMIC EFFECTS

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One reason for the inconsistency of field and calculated data on the behavior of buildings under seismic impacts is an insufficient registration in terms of computational models of the

interaction of the base and surface structures. This calls for full-scale testing. However, they are expensive and do not allow one or even several experiments show the entire diversity effects and interactions.

The article presents the formulation and results of the experiment on small models typical residential house section 1-335AS series, made of the piezo material (Plexiglas), on the dynamic effects. Scale models are performed in compliance with the geometrical and physical similarity. Free oscillations model arose because of mechanical shock sensor device ONYX on the wall with sand trough, which was a model section of the building 1-335AS series, loaded, in addition to its own weight payload created a layer of sand on the floors. Measurements of displacement models, as well as soil, produced by the electrodes two-channel microphone amplifier, connected to the computer in the oscilloscope mode. Using piezoelectric effect allows you to read electrical signals arising from the free vibration model, and to register their computer. The results of measurements of displacement of the frame compared with the corresponding calculated values obtained with a 7-point seismic impact spectral method.

Comparison of experimental and calculated data field tests in Irkutsk and Angarsk showed, that the horizontal movement of small models made of plexiglass exceed the calculated values of displacement obtained by the spectral method, and are close to those of full-scale tests. The resonance characteristics of the model correspond to a calculated performance.

Thus, it was shown that small model of piezo materials and set out the method of testing can be used to assess the vulnerability of buildings under seismic impacts.

SET-UP AND IMPLEMENTATION OF KEY CORE COMPONENTS OF A REGIONAL EARLY-WARNING SYSTEM (EWS) FOR MARINE GEOHAZARDS OF RISK TO THE ROMANIAN – BULGARIAN BLACK SEA COSTAL AREA

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MARINEGEOHAZARD Project means "Set-up and implementation of key core components of a regional early-warning system (EWS) for marine geohazards of risk to the Romanian – Bulgarian Black Sea costal area". It is part of the cooperation program Romania – Bulgaria 2010–2013, co-financed by the EU through the European RD Fund. Bringing together the expertise of the two countries, the MARINEGEOHAZARD project aims for the establishment of a joint regional early-warning system and of a common decision tool for protection of the local communities, from consequences of natural marine geohazards (earthquakes, landslides, tsunamis, etc.). This is a first attempt in this area and brings all risks in such innovative approach. The Project was executed during 2011–2013 and implemented an integrated EWS accompanied by a common decision-support tool, for the adequate detection, assessment, forecasting and rapid notification of natural marine geohazards of risk to the ROM-BG Black Sea coastal area. The future intention includes integration with other countries of BSEC.

The main results are:

– Definition and implementation of a unified and integrated approach to assess the marine geohazards of risk for the Black Sea common area.

– Installation of a real-time, fully automatic detection system comprising of deep Black Sea complex measurement stations (gauges and bottom seismometers), and on-shore seismicity monitoring system and digitalized GPS stations.

– Implementation of a common decision-support tool (DST) by provision of unique forecast and assessment software package and development of a joint database of scenarios, to facilitate and support management and mitigation of marine geohazards.

– Creation the regional technical capability to perform marine seismic measurements together with other countries.

– Preparation of the joint, updatable databank by integrating the existing national data, the real-time data from deep-sea gauges and OBS, remote sensing and national seismographic networks and performance of the coordinated marine geohazard investigations to fill-in the gaps.

– Clustering and enhance the regional expertise by training the staff and establishment of data exchange platform between national institutions.

Since the creation of the EWS all data are transferred to two regional centers – Varna and Constanta and can issue the early warning messages. The real problem is related to the lack of legislation for the dissemination of the warning to the public in real time. In the frame of the Project a lot of research and investigations have been done, common maps of the local and regional seismicity created and gaps identified. Several marine geo hazards have been localised and their threats quantitatively assessed (according the previous executed EU projects -– TRANSFER and SCHEMA). Future cooperation with the BSEC countries is intended for transformation of the local EWS (BG-ROM) to the entire Black sea involving all threaten by marine hazards countries.

NEW CONCEPT OF DEEP STRUCTURE, TECTONICS AND GEODYNAMICS OF THE GREATER CAUCASUS. DETAILED SEISMIC HAZARD ASSESSMENT

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Using the microseismic sounding geophysical method, deep sections along three profiles intersecting the central part of the Greater Caucasus in Ossetia and its northwestern pericline part near the town of Tuapse and Taman' peninsular have been compiled. The revealed heterogeneities of the lithosphere display close relationships to orogenic tectonic deformations and young volcanic activity. Along the profile in the Ossetian sector of the Greater Caucasus, three deep seated bodies of the Earth's crust with characteristic properties and morphology have been identified beneath the mountain system. These are a near vertical low velocity body and two high velocity bodies framing the latter in the north and the south. The low velocity body is primarily situated beneath the axial zone of the Greater Caucasus Meganticlinorium, whereas the high velocity bodies occur beneath its southern and northern limbs. The persistent horizontal roof of the low velocity body is traced beneath the entire core of the fold edifice at a depth of approximately 10 km. In the Tuapse and Taman' sectors near the western pericline of the meganticlinorium, the contrast of the low velocity body is much less pronounced. The most contrasting narrow low velocity bodies are related to the boundary of the Caucasus (West Kuban) foredeep with the mountain edifice and the Adygean ledge. The Taman' peninsula profile demonstrated reality of several vertical deep faults separate blocks of the Earth's crust near by the Kerch Strait. On the all profiles large faults represented by narrow low-velocity the vertical or inclined "pockets", penetrating into the crust.

The results of a new aggregation of the seismic hazard assessment of the North Caucasus were received. Prepared fundamentally new layout seismotectonic basis for seismic hazard maps in the region. On the basis of the model calculations are carried out of seismic effects on a probability basis. On-drawn maps the Northern Caucasus looks a seismic area where levels of seismic effects reaches 8.5 points intensity on cards In several exceeds 9 points on the map C. At the same time, in comparison with the data of the Maps of General Seismic Zoning 1997 results seem more differentiated and, in general, significantly reduce the level of seismic hazard level in the region.

Work is important from the methodological point of view in the light of the prospects for the compilation of new maps of General Seismic Zoning of the territory of Russian Federation.

SEISMIC HAZARDS IN THE CRIMEA-CAUCASUS REGION

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New scientific results on the conditions of preparation and development of seismic processes in the Crimea-Caucasus region as well as the analysis of the seismicity in the vicinity of the city of Sochi are presented. On the basis of the long-term experimental observations there have been originally distinguished specific geomagnetic disturbances accompanying large seismic events on a regional scale. Comparative analysis with the results of similar observations of magnetic disturbances associated with preparation and development of the deep-focus earthquake in Kamchatka allowed formulating a new paradigm for a seismic source structure.

ABOUT ONE METHOD OF IDENTIFICATION OF FRACTURES AS SEISMOGENIC ELEMENTS UNDER THE CONDITIONS OF VIBRATIONAL AND STATIC EFFECTS

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The research is aimed at the development of the mathematical apparatus and efficient algorithms for the study of features of the interactions between lithospheric structures with faults and identification of the defect's nature in the contact area. In the study of the regional seismicity problems within the concept of deformable medium mathematical apparatus including differential and integral methods of factorization, is applied to the study of the dynamics of lithospheric plates through two-dimensional simulation of the plates on the three-dimensional deformable substrate sufficiently reliable considering the scales.

In the development of new approaches to the study of regional seismicity, must be considered that the increase in seismicity is slow due to the change in the stress-strain state of lithospheric structures, which is confirmed by the data of GPS-receivers. Displacements of plates for the week reach only a few millimetres, which suggests the need to also study and model static interactions in the contact area, to the study of which we will pay attention in the course of the project. We propose a modification of the method of eigenfunctions using the method of block element in relation to the construction of solutions of spatial problems of steady oscillations of different plate types contacting along a straight fracture on the surface of the elastic base, as well as for solutions of problems describing their static interaction. New types of functional equations for dynamic and static problems, solved by the factorization method, are based on the proposed method.

Experimental studies of the seismic signal transmission through the fault and features of the interaction of lithospheric structures at faults require significant material and time expenses. Obtained theoretical results will allow testing of the fracture types of the lithospheric structures using vibrational seismic sources, rationally defining the programs of experiments. Additionally, the proposed approaches will provide the opportunity to conduct a detailed study of the influence of the contact conditions between the elements of a composite coating on the state of the system coating/substrate and, if necessary, will make it possible to trace the stages of the fault's

destruction process (from initial whole plate to its complete subsequent separation into two half-planes).

The advantage of the methods proposed in the project is the possibility of their application for the study of stress-strain state of structures with faults, under the influence of vibrational loads, as well as for the study of slow or static interaction.

The study has been carried out with support of the grants RFFR (16-31-0067) and Administration of Krasnodar Territory (16-41-230184).

DURABILITY OF FENCING AND BEARING STRUCTURES MODULAR BUILDING SERIES 1–335AS UNDER SOCHI

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1–335 Series has been developed for mass housing construction in 1959 and to 90 has undergone a number of significant design changes. Walling – wall panels there is a flow of joints due to the fact they do not continuous and they become wet with damaged roof eaves or gutters tubes. In the 2000 s, in Sochi, in a complex of measures for energy saving thermal protection of buildings completed series 1–335 and 1–335 AC system "wet facade". To date, we have already accumulated information on the operation of thermal protection defects "wet facade" that are caused by building technology and appear in the first 5 years.

Here are some of them: installation of a heater with large gaps; low-quality insulation material; incorrect fastening of plugs of insulation to the wall, resulting in insulation sags, crawls and stretches plaster, in which there are cracks on them moisture gets into the insulation layer; protection of poor insulation plaster, which is manifested in the form of cracks on it.

We recommended when working on warming facades 1–335 series speakers homes, do not use multi-type system "wet facade" and the single-layer plaster on the basis of cellular glass insulation, manufactured in Russia. In the case of damage, plastering facades, you can always be repaired locally, rather than replacing the whole, as required for "wet facade".

ALGORITHM "MAP OF EXPECTED EARTHQUAKES" (MEE): RESULTS OF THREE DECADES OF TESTING AND LATEST FINDINGS

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The Map of Expected Earthquakes (MEE) algorithm was suggested in the mid-1980s by G. A. Sobolev, T. L. Chelidze, L. B. Slavina, and A. D. Zavyalov, Over the last 30 years, the algorithm has been tested in a variety of seismically active regions all over the world, including the Caucasus, Kamchatka, the Kopet Dag, the Kyrgyz Republic, Southern California, Northeast and Southwest China, Greece, West Turkey, the Kuril Islands, and New Zealand. The average predictive effectiveness for these regions was $J_{\mathrm{MEE}} = 2.56$ and 3.82, with conditional probability value $P(D1|K) = 70$ % and 90 %, respectively, selected as an alarm level. This being the case, 68 % and 41 % of predicted earthquakes occurred in the zones with these levels of conditional probability; the area of alarm zones was 30 % and 14 % of the total area of observations, respectively.

The most recent paper was the first to use the MEE medium-term earthquake prediction algorithm to develop maps of expected earthquakes in a classical area with a transient seismic regime, namely the Koyna–Warna reservoir site (India).

The local earthquake catalogue for this area, covering the period of time from 1996 to 2012 (approximately 17 years) and including 4,500 earthquakes with $ML = 0-6.5$ magnitudes that occurred in the depth range of $H = 0-20$ km, was used as the database for this work. Linear dimensions of the seismic area are 40×60 km. A standard set of seismic predictor parameters (dynamic characteristics) used for expected earthquake mapping of seismically active regions with pronounced tectonic activity was used for the Koyna–Warna area: b-value of the magnitude-frequency relationship, number of earthquakes in the form of relative seismic quiescences Nq and in the form of seismicity activations Na, released seismic energy in the form of energy quiescences Eq and in the form of energy activations Ea, and density of seismogenic ruptures Ksf. Time and space distributions of seismic parameters were calculated in half-overlapping rectangular grid cells $\Delta X \times \Delta Y$.

A series of 42 expected earthquake maps was developed for the Koyna–Warna area, from 1 July 2002 till 1 October 2012, with 3-month step and 2-year prediction periods for each map. The findings of using the MEE algorithm in a classical area with a transient seismic regime for the first time were very encouraging. They showed that its prediction reliability was quite high and equal to $J_{\text{MEE}} = 2.76$. Zones with conditional probability levels $P(D1|K) \geq 90$ % experienced 56.3 % of all earthquakes with $ML \geq 4.0$. The alarm area was 20.4 ± 8.4 % of the total area of observations. The MEE algorithm was particularly efficient in predicting the largest earthquakes in the Koyna–Warna area that occurred during the retrospective prediction period. At a later stage, more accurate adjustment of algorithm parameters may improve the overall prediction reliability.

Therefore, integral predictive reliability estimates obtained when the MEE algorithm was used for the Koyna–Warna reservoir site are close to the average values of these parameters for all previous seismically active regions. These findings, firstly, may be considered proof of the flexibility of the proposed algorithm. And, secondly, this example can be useful for medium-term earthquake prediction in other seismoactive areas around high dams.

ABOUT THE DEVELOPMENT OF THE MATHEMATICAL DEVICE OF INVESTIGATION BLOCK STRUCTURE OF DIFFERENT-TYPE BLOCK

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World and Russian experience shows, that one of the real causes of earthquakes is intensive human economic activities, which affect the geodynamic processes, create local hotpots of anomalously high tensions, which can provoke seismic event. The impulse for the occurrence of induced earthquakes may be resource development, hydrocarbon extraction, creation and filling of reservoirs, conducting underground nuclear explosions, construction of large underground engineering structures, pumping of waste water into deep aquifers, pumping of open water into oil reservoirs.

By forecasting the seismic situation in the developed and industrialized areas, information about the level of natural and seismic intensity of area are very important, this fact requires their special complex consideration.

To determine the level of natural and technogenic tension of the Earth crust seismic monitoring systems are widely used, allowing for a long time to reveal the presence of significant technogenic

changes in the upper part of the Earth's crust as a result of human activities. However, for interpretation of seismic monitoring data it is necessary to use a complex mathematical device for solving inverse problems, but it is not done in practice. As a rule, approximate methods of geology and geophysics are used, that reduces the accuracy and reliability of the results. The received data and regularities are true only for the territory of observation; they do not have the similarity and predictive value.

For overcome these drawbacks there is more useful approach, which consists in the development of the mathematical device for analysis of technogenic seismicity and forecasting of conclusions. For correct solution of this problem it is necessary to consider the geophysical environment, which is maximum close to the natural, and the model of linear and nonlinear elasticity theory, which properly describes the tension and deformation of materials, having different physical and mechanical parameters. For researching is offered to take the model of block structure of lithospheric plates' environment, which is formed in rocks by means of cracks and other heterogeneities. The solution of the problems for the block structure with different-types blocks is carried out by factorization method, which is based on the differential factorization method, specially adapted for represented class of tasks.

Work was supported by RFBR (grant 16-08-00191_ a), RFBR and the administration of the Krasnodar Krai (grant 16-41-230154).