Seismic microzoning of the industrial platform of the mining – concentration plant

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Abstract. The results of seismic micro zonation on the site of construction of the Elginsky ore mining and dressing plant are represented. Forecasting of increment of the seismic impact for the platform of construction has been carried out. According to the results of the direct instrumental observations and calculations a map of seismic microzoning has been developed.

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Introduction

Estimation of seismic danger is the result of carrying-out of seismic microzoning of three types, which differ in problems and objectives of their research.

General seismic regionalization (GSR) serves for purposes of planning of development of national economy all over the country and large regions.

Detailed seismic regionalization (DSR) is carried out with the purpose of detection and estimation of the characteristics of seismogenic zones, where seismic events are danger for concrete objects.

While carrying out GSR and DSR the sources of seismic danger are investigated - zones of occurrence of possible earthquake centres (PEC) and conditions of generation and spreading of earthquake vibrations.

Estimation of impact of local phreatic, hydrogeological and geomorphological peculiarities of the territory for distribution of seismic intensity is one of the tasks of seismic microzoning (SMZ) [1, 2, 3, 4].

Method

According to the map GSR-97-B [5, 6], the studied territory of Elginsky field belongs to the zone with magnitude8 of the possibleseismic vibrations.

Before conducting of seismic microzoning of the observed site, detailed seismic regionalization (DSR) was held. The purpose of the second procedure was detection of peculiarities of tectonics and drawing up of the scheme of active fractures, studying of the modern geodynamics of quarry stones and blocks, which interact on the south-east of Republic of Sakha (Yakutia), detection of the zones of possible occurrence of earthquake centres with their magnitude classification, refinement of the initial intensity for the objects of construction of the Elginsky mining and dressing plant. According to the results of the conducted researches [7], 8-scores isoseismal has moved southward of the industrial platforms and platforms for dwelling and changed by the 7-scores zone of intensity.

Using the methods of SMZ on the platform of construction of the Elginsky coal plant, sites with increased and decreased intensity are determined according to the middle level (calculated while carrying out DSR [7]).

A method of registration of microseisms was selected as the instrumental seismometricmethod of observations while carrying out seismic microzoning of the sites of construction of the industrial platforms of the Elginsky coal field.

The selection of the method is determined by the fact that in the region of working the regular industrial explosions are not produced and strong earthquakes are quite rare (in total 6 earthquakes were registered ≥ 6, in radius of 100 km for thewhole history of observations). The base for seismic microzoning is simultaneous registration of microseisms for the model and studied subsoil.

For instrumental observations seismological system of registration of seismic data with high dynamic span and resolution of 24-class – registrar “GSR-24” as a unit of three component accelerometer CMG-5T Compac.

On the basis of the results of handling of microseisms’ records necessary prevailing periods and amplitude level of micro vibrations were determined for estimation of resonance properties of subsoil. Reaction of subsoil at calculations of increment of seismic magnitude was estimated according to the amplitudes of vibrations.

Main part

For estimation of change of intensity of the strong earthquake according to the maximal amplitude of micro vibrations on the prevailing period the following formula is used:

$$\Delta J = 2\lg\frac{A\max_i}{A\max_э}$$

$A\max_i$ and $A\max_э$– are maximal amplitudes of micro vibrations respectively on the studied and model subsoil.

Plans of isolines (fig. 1) of increment of seismic magnitude on the platform of seismic microzoning are drawn according to the results of the calculations.

A method of seismic impedance in combination with instrumental method [8] was applied for quantitative estimation of relative changes (icrements) of seismic intensity on the sites with different engineering-geological conditions.

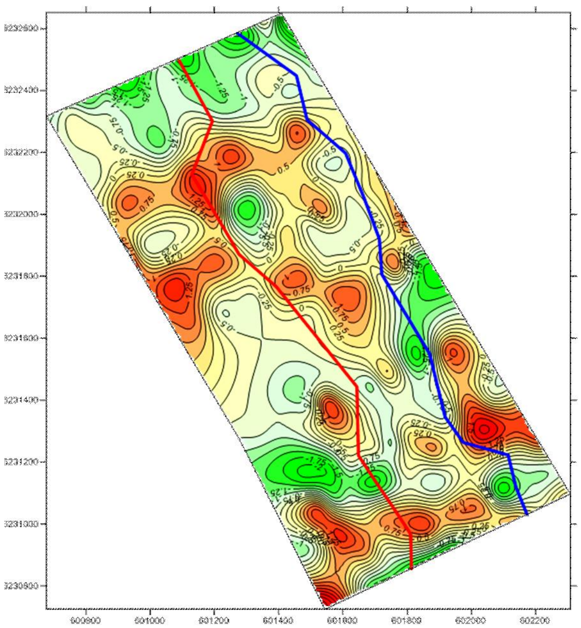


Fig.1. Plan of impedance of intensity of seismic impact calculated according to the data of registration of microseisms, normalization for readings of base station

Estimation of increment of seismic intensity according to the method of seismic impedances was conducted by means of comparison of values of seismic impedances of the studied and model subsoil taking into account influence of water cut of section and possible resonance phenomena by the formula:

$$\Delta J = \Delta Jc + \Delta Jв + \Delta Jres$$

ΔJ - total increment of seismic intensity (in scores) relatively to the initial (background) seismic magnitude, which is applied for the research region inaccordance with [7];

ΔJc - increment of seismic intensity for differences of seismic impedance of subsoil on the studied and model sites;

$\Delta Jв$ - increment of seismic intensity for worsening of seismic properties of subsoil on the studied site at water cut (water saturation);

$\Delta Jres$ -impedance of seismic intensity for possible occurrence of resonance phenomena at sharp difference of seismic impedance in the covered and underlying rock mass of the studied section.

Impedance of seismic intensity for difference of subsoil conditions ΔJc was determined according to the formula:

$$\Delta Jc = 1{,}67\lg\frac{\overline{V}(p,s)\cdot\overline{\rho э}}{\overline{V}(p,s)i\cdot\overline{\rho i}}$$

$\overline{V}(p,в)э$ and $\overline{V}(p,s)i$ - average weighted values of rates of spreading of prolonged or crosscut waves for calculated thickness of subsoil on the model and studied sites;

$\rho э$ and ρi - average weighted values of densities of subsoil for calculated thickness on the model and studied sites.

Width of the calculated thickness was taken in accordance with requirements [9].

The values of rates of spreading of prolonged and crosscut waves in subsoil are determined at interpretation of data of seismic prospecting performed by means of correlation method of refracted waves.

The values of density, included in the calculation of seismic impedance are received in accordance with laboratory data of studying of physic-mechanical properties of subsoil on the core material in the process of engineering-geological observations.

Increment of seismic intensity for worsening of seismic properties of subsoil at water cut $\Delta Jв$ was determined by the formula:

$$\Delta Jв = Ke^{-0{,}04h^2}$$

K – coefficient, depending on litho logical composition of the subsoil;

h – calculated position of the level of subsoil waters.

Thus coefficient *K*was taken equal to:

1 – for sand subsoil, plastic and viscous sandy loams, high-plastic, very soft loam and viscous mild clay and clay [8].

Increment of seismic intensity on account of resonance phenomena $\Delta Jres$ is calculated under condition of presence of isotropic layer of sand, clay, and coarse fragmentary subsoil with content of sand-clay filling more than 30%, underlying by hard rocks, which are characterized by far more values of seismic impedance comparatively to superincumbent sediment.

The values $\Delta Jres$ should be taken into account in total impendence in those cases when the period at which resonance T_{res}emerges, meets the periods of intensive vibrations of strong earthquakes, expected in the studied region, in particular at matching of the periods of normal vibrations of buildings and constructions with resonance periods of subsoil. If loose subsoil is in the rock mass, lying on the hard rocks in two or more layers with different seismic impedance then, the calculation of frequent characteristics of the subsoil and estimation $\Delta Jres$ are made by means of the analytical method in accordance with [8].

As model subsoil it is recommended to select middle subsoil, to which the value of an initial score belongs, determined by a map of seismic regionalization of the territory GSR-97 [5]. Most often such subsoil is more typical for the upper part of the section water free sandy and loamy subsoil, containing woody and rubbly or gravel and pebble material, or coarse and medium grained sand subsoil of the medium density, or subsoil having approximate composition and belonging to II category in seismic properties according to [10] having following parameters:

Vp= 500 - 700 m/s; Vs= 250 - 350 m/s; ρ = 1,7 - 1,8 g/ cm^3

If on the site of seismic micro zoning there are orifices of rocky ground, belonging to the I category according to seismic properties and having the following parameters:

Vp = 2000 - 2800 m/s; Vs = 1000 - 1400 m/s; ρ = 2,1 - 2,3 g/cm^3,

this subsoil should be taken as model, decreasing the value of initial seismicity for 1 point of seismic magnitude [10].

During the process calculating the increment of intensity of the earthquake effect, a maximally strict model was taken: rocks of the first category were taken as the model subsoil. The rocks contain the following characteristics – rate of spreading of the prolonged waves is 2400 m/s, of the crosscut waves is 1200 m/s, density of the rocks – 2,3 g/cm^3.

The method of seismic impedances allows estimate not only the increment of intensity of earthquake load on the day surface, but also to estimate the change of intensity when removing of the upper layer of loose sediments. Figure 2 shows plans of increment of intensity of earthquake load, calculated by means of the method of seismic impedances: a – on the day surface, b – removing 2m of the layer, c – removing 4m of the layer.

Revealingly, increments of intensity of earthquake load, calculated by the method of seismic impedances in all the three parameters align in the anomalies shape with the increments of intensity of seismic force, calculated by the method of registration of microseisms.

Linear anomaly of relative increase of intensity of the forces of the south – south – eastern bearing along the centre of the site and the platform anomaly of the considerable growth of intensity of the forces on the south-eastern wing of the site were distinguished in the first and second cases.

Some minor level of change of intensity of seismic forces according to the data of seismic impedances can be explained by relatively high rates of wave propagation generally on the studied section, while the calculated formula was applied for subsoil of the second category (for one point less than factual).

Conclusion

In analysis and comparison of the plan of the isolines of increment of the intensity of seismic load(ΔJ) and the plan of isolines of thickness of the dispersive rocks for the estimation of the degree of dependences of the indexes of increment of the seismic load on the thickness of the dispersive rocks.

According to the results of the comparison the eddy of the couples "thickness – seismic magnitude" for points along the network 5*5 meters. After that the indexes of thickness were averaged for fixed values of the indexes of seismic magnitude (with stage of magnitude 0,1).

For the received values the following equation of linear regression was formulated:

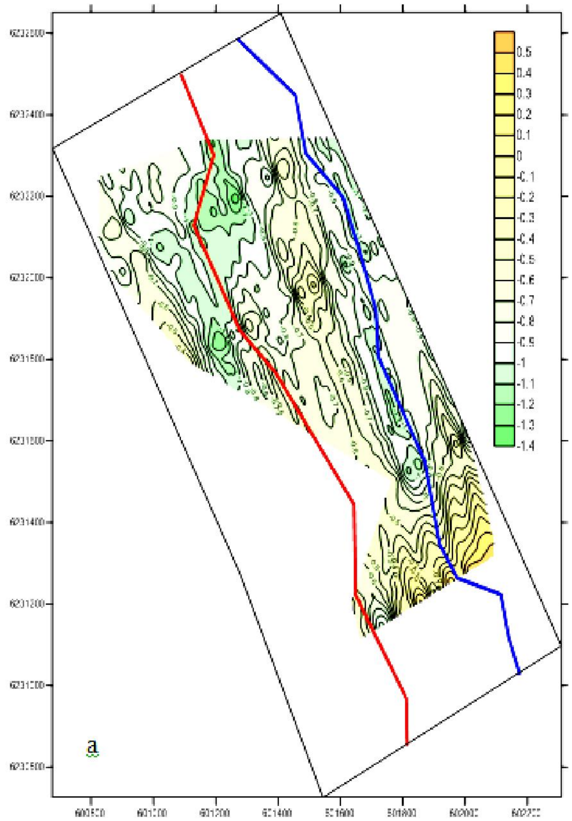
$$(\Delta J) = 6,5916 + 0,22072 * M_{avg}$$

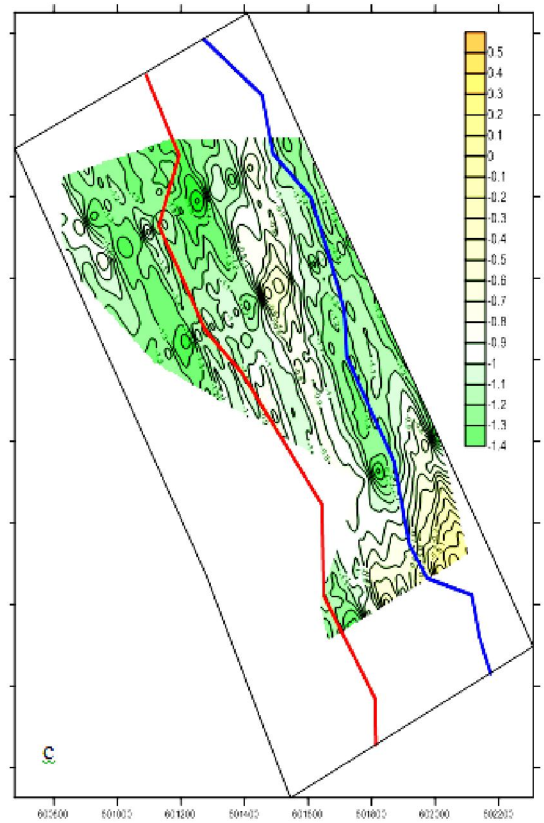
$M_{avg}$is the thickness of the dispersive rocks at the point.

Coefficient of correlation r = 0,092929that allows to suppose presence of close connection between the values of the thickness of the dispersive rocks and increment of intensity of the seismic load.

According to this presumption the equation of nonlinear regression was formulated:

$$J = 8.41989 - 6.1864/M_{avg} + 1.7358/(0.85158*M_{avg}) + 6.7583/(3.1176*M_{avg}^2)$$





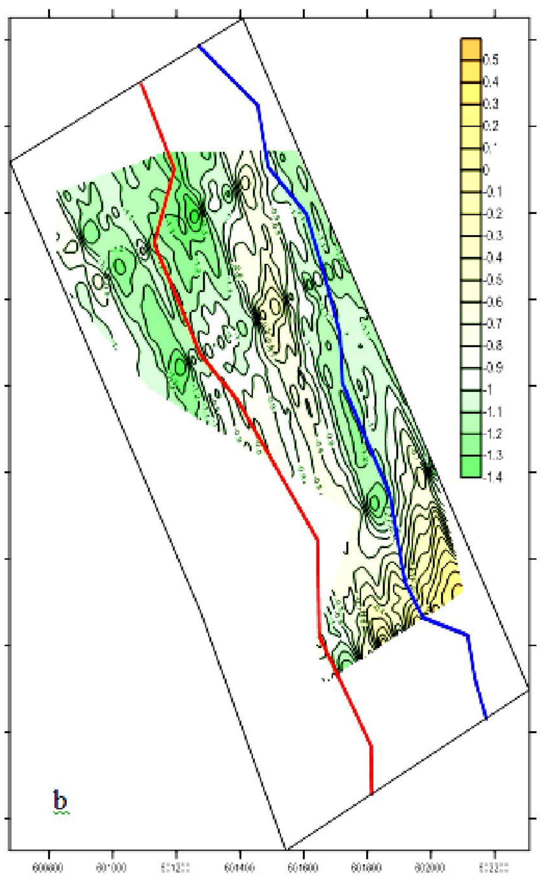


Fig.2. Plan of increment of intensity of earthquake load calculated by the method of seismic impedances. (Plan of increment of intensity of earthquake load, calculated by means of the method of seismic impedances: a – on the day surface, b – removing 2m of the layer, c – removing 4m of the layer.)

The indexes of increment of intensity of the seismic load for the wings of the site which are not covered by a network of geophysical profiles were calculated according to the specified regularity. The matched results of the calculations and prototype observations are represented on Figure 3.

Results

Prediction of the increment of the seismic load for the platform of construction has been carried out.

Plans of seismic microzoning were designed according to the results of direct instrumental observations and calculations and in accordance with the method of registration of microseisms and the method of seismic impendences.

At the proximate initial magnitude of the platform of 7 magnitude (according to the map GSR-97B for the second category of subsoil) the degree of seismic danger of the platform for the existing at the moment of conducting the researches of the phreatic conditions is estimated for **6,87** on the Richter scale (averaged index) at changing of the magnitude according to the taxonometric units from **5,6** to **7,9**.

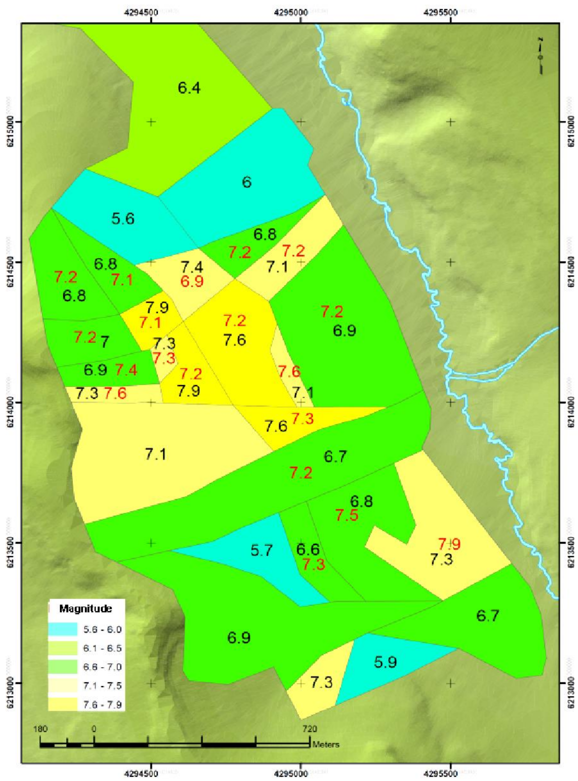


Fig.3 Map of seismic microzoning of the site of construction of the Elginsky mining-preparation plant (results according to the methods are matched).

7.9 – intensity of seismic load according to the method seismic impendences;

7.3 – intensity of seismic load according to the method of registration of the microseisms

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