Dear Ladies and gentlemen!

We offer you information that may be relevant primarily for construction, insurance and health care.

The goal of providing this information is search of potential partners in cooperation. Cooperation can occur in the form of advice, implementation of peer evaluations of seismic and seismotectonic hazard, earthquake risk and geodynamic conditions, assess of seismic effects on structures, as well as the preparation of proposals and projects on relevant topics, proposals for grants in the field of science research.

Why it might be important for Latvia?

In accordance with pre-existing notions, a seismotectonic danger is not urgent for Latvia, since it's territory is located far from the seismically active zone and is located in a platform, where the Earth's crust is relatively stable.

Indeed, from a geological point of view of Latvia is located on the northwest of the East European platform. There are a seismically active areas, such for example, as in China, Japan, Turkey, Greece, Italy, California, Indonesia, Peru, Mexico and also in some other countries. But is it really so serene in intraplatform conditions in which is located a territory of Latvia?

Industrial development started in the second half of XIX - early XX century and continuing today. Urbanization accompanied by increasing population density, by complexity of urban infrastructure with the different types of engineering buildings. A hydropower and a nuclear power is develops in industrial areas. Together with this there is growing impact of man-made factors on nature, on earth's crust and on man.

If by the end of the XIX century, i.e. before of origin the first electrical power stations was not aware of the so-called induced (induced) earthquake, but with the advent of hydroelectric power stations and by building of major dams and reservoirs - this problem was appeared. Induced earthquakes triggered by human activities, began to occur not only in the vicinity of dams and reservoirs located in a seismically active zones, but also on the territories of platforms. For example, in the vicinity of the dam and reservoir *Koina*, in India, in 1967 there was happened an artificial earthquake with a magnitude of 6.3 on the Richter scale. As a result of this earthquake was 177 people were killed and 2300 injured.

In Latvia, at the Daugava River is located a cascade of hydropower plants. The most unfavorable seismotectonic conditions are typical for the area Plavinu HPS. Southwestern edge of Piebalga tectonic fault is located here, in the immediate vicinity of the dam. Aizkraukles tectonic fault extends approximately at a distance of 3.5 km, parallel to him. A section of the earth crust located between the tectonic faults is dipped relatively of the surface of the crystalline basement at 50 - 100 m, i.e., a kind a tectonic failure. There are a sedimentary deposit which closes this tectonic structure from above.

No less man-induced impact on nature have nuclear power plants. And in terms potential environmental risk of nuclear power stations even more dangerous than hydropower. In the Baltic region and in States of Scandinavia adjacent to the Baltic Sea, are 9 nuclear power stations - *Leningradand* and *Smolensk* in Russia, *Loviisa*, *TVO* in Finland, *Oscarshamh*, *Ringhals*, *Forsmark*, *Agesta*, *Barsebaeck* in Sweden. The *Ignalina* NPP in Lithuania recently was closed. However, on the replacement of the outgoing NPP come new. Soon building will begin of the *Baltic* NPP (*Kaliningrad*) in the Kaliningrad region of Russia.

Of course there is a natural question: whether is needed to control the seismic conditions in the Baltic region and conduct seismic monitoring?

Judge for yourself.

Historical data indicate that in Latvia there were earthquakes, starting with the first known earthquake in 1616 in Bauska district. The intensity of tremors in its epicenter estimated to be VI - VII degrees to 12 point scale MSK-64.

Other perceptible earthquakes, which caused cracks in the ground and in walls of houses, took place in Koknese in 1821, in Riga in 1853, in the Irbe Strait in 1857, in Daugavpils in 1908. Historical data of Professor Bruno Doss also indicate on earthquakes in other regions of Latvia - Liepaja, Valmiera, Madona.

Earthquakes are known have a feature repeated. After "drop" tectonic stresses during the earthquake, may start a new cycle of concentration of tectonic stresses, until of the next "discharging". There are evidences of repeated earthquakes, and in Latvia. According to historical information B. Doss several earthquakes over the years have taken place in Riga (1807, 1853, 1870, 1907, 1908, 1909, 1910).

Seismic process may at some time to become quiet, but it does not mean that he can not resume again. Modern earthquakes showed in the Baltic region just this. After 1930, until the middle of the 70 years of the twentieth century, a "quiet" seismicity is dominated and earthquakes here weren't. However, in 1976, Estonia has happened VI degree earthquake, and in 2004 in the Kaliningrad region of Russia earthquake intensity VI - VII degrees by of 12 point scale MSK-64 or its contemporary European counterpart – EMS-98.

Magnitude of the main shock of the Kaliningrad earthquake (5.3 on the Richter scale) was highest of all known earthquakes in the Baltic region. It was a complete surprise not only for the population, but also for many professionals' seismologists.

What are the prerequisites for the occurrence

of earthquakes in the Baltic region?

All happens because of tectonic movements, which are caused by stresses arising at the boundaries of tectonic plates, where there are areas of tension (spreading zones) and zones of compression (subductional zone). Size of tectonic plates is huge and these immersed in a

viscous substance of the earth - the mantle. Tectonic plates can move, figuratively speaking "swim" in the mantle, due to the existence of convection flows in it. Flows may be characterized as vertical, circular, in convective cells. Cold and heavier material moves deep into from the surface. A hot material and more easy material rises to the surface from the depths. Such a cyclical mechanism leads to the emergence of new crust in spreading zones and its absorption into subduction zones. There is a kind recurrence of cycle of Earth material. Both zones (spreading and subductional zones) are the boundaries of tectonic plates.

The nearest known boundary of tectonic plates - the Eurasian and North American plates, is located in the Arctic Ocean, between Iceland and Spitsbergen, a distance of about 1850 km from Latvia. This boundary is zone of spreading. In the south, in the Mediterranean region, there is the boundary between the Eurasian and African tectonic plates (more than 1900 km). However, a more tangible tectonic pressure comes from the north.

Zones of expansion (spreading zones) generate tectonic crustal movements, which are transmitted over long distances, including up to the territory of Latvia. In particular, in Riga instrumentally recorded horizontal movements of mark of a global navigation system GPS (Global Positioning System) with a speed of 24 mm per year, while the vertical displacement is much smaller - only about 2.5 mm per year.

Tectonic plates, zones of spreading and subduction this is description for the global level. However, there is also the regional level. The average thickness of Earth crust of Latvia is 40 - 50 km and consists of separate blocks. Blocks are separated by deep tectonic fractures. All of this together is covered by of the sedimentary deposits with thickness of about 1 km. The topmost part of sedimentary cover is covered due the Quaternary deposits, which were formed in the most recent period of geological history of Earth, and therefore by of physical and mechanical characteristics they are of the least durable, and very often are not consolidated.

Blocks move along the tectonic faults. Deep tectonic faults are boundaries of crustal blocks. For tectonic fault isn't characteristic a flat and smooth surface, but a rough, nodular surface, with bulges and depressions. Due to the roughness of the tectonic fault, arises friction between earth crust blocks when they move. If there are large irregularities, hooks, then movement of blocks slows down and even stoped. However, the pressure from side of spreading zones is proceeds. Therefore, on inflections, hooks and edges of the faults are concentrated tectonic stress.

The strength of geologic rocks is not unlimited. When the concentrated stress exceeds strength, then will to happen slowly movements or so-called tectonic crip, or a fast shift is - an earthquake. Both types of motion is cause of deformation of the crust and the Earth's surface. In this case, there is a risk of damaging or even destroying buildings and structures. The zone of tectonic faults additionally poses a risk to human health and life due to infiltration from the bowels of the earth of radioactive gas - radon.

Features of geological conditions and their influence on seismic hazard in the Baltic region.

The tectonic stresses that have accumulated in the Baltic region, in September 2004 triggered a series of Kaliningrad earthquakes, the strongest of which was magnitude 5.3. This is still the most powerful earthquake from all known earthquakes in the Baltic region.

The consequences of the earthquake led to injuries of varying degrees at 20 people and the death of one person from a heart attack. Have been damaged or slightly destroyed about 2100 buildings, including schools and kindergartens. The total economic damage estimated at $ 5.3 million. Additional information about the Kaliningrad earthquake and other earthquakes of the Baltic region can be found on the Internet resource www.seismo.lv

However, not only earthquakes are linked with danger, but also the slow motions along active tectonic faults. Not every tectonic fault is active. Its activity depends on the age of geological deposits in which it is located, from the orientation of the fault plane to the direction of the prevailing regional pressure (compression or tension), and other factors.

There is the greater the likelihood of that activity of tectonic fault is active if it crosses of the younger sediments. Active faults are conduits for the transport of radon from the bowels of the earth. Radon - a colorless, inert gas. It is radioactive and can pose a risk to the health and lives.

Quaternary sediments, which are located at the surface earth in the Baltic region, are weakly consolidated, are loose and often are saturated moisture. These factors seriously affect the level of shaking during seismic loading. Under certain conditions, in the sedimentary rocks and soil can occur resonant phenomena, which contributes increase of intensity of shaking the earth's surface. Buildings and structures, which located on the soil and saturated moisture soils may experience more intense seismic vibrations than the same building, located on the solid, stable geological formations. For example, in Scandinavia, sedimentary rocks are practically absent or there is very small thickness. A crystalline basement presented granite and similar in strength of rocks, covered with a thin layer of sediments. At equal distances from the source, the intensity of tremors will be higher in the mellow soil than in the crystalline basement.

Thus, the local engineering geological conditions exert a significant influence on the intensity of seismic vibrations. For the Baltic region, and in particular for Latvia, such unfavorable conditions are widespread, and because the seismic vibrations may increase.

In what areas of human activity an assess of the seismic risk of seismotectonic and geodynamic conditions may be necessary?

1. Building.

First, seismic conditions should be taken into account for the construction. Since 2000, seismic conditions are defined in Latvian building codes LBN 005-99 (noteikumi par Latvijas būvnormatīvu LBN 005-99 "Inženierizpētes noteikumi būvniecībā") as a scheme of zones of seismic risk (Annex 12).

However, in accordance with the requirements of the EU since 31 December 2011 in Latvia to go into effect the recommendations of Eurocode 8, in particular - *Desigh of structures for earthquake resistance - Part 1: General rules - Seismic action and rules for buildings* and other regulatory documents (http://www.likumi.lv/doc.php?id=198634), as well as national application. In the national Annex are defined the seismic conditions for a strong, consolidated geological rocks, in Latvia the respective surfaces of Devonian deposits, which are overlayed by means young, unconsolidated Quaternary sediments. Seismic conditions characterized by such parameters of seismic risk as the contours of the seismogenic zone, PGA (Peak ground acceleration) - extreme acceleration of ground, the probability of exceeding the expected PGA, the spectral characteristics of the soil.

For a comprehensive and for more detailed assessment of the seismic parameters at the construction site must be evaluated and taken into account the reaction of the upper, at least, 30-meter sediments layer, Quaternary deposits on the seismic effects.

On a platform for further construction of the buildings (both theoretically and experimentally) must be measured the spectral response acceleration of the soil. Then they are used to calculate the seismic forces acting on the projected construction.

2. Insurance of buildings and structures.

The intensity of seismic effects defined by the following factors: 1) by of the distance from the object to the seismic source, 2) by means of the magnitudes of the seismic source, 3) by means of engineering-geological conditions at the construction site.

Seismic sources can to arise by natural sources of seismic energy - from sources of earthquakes, from karst holes, from landslides, as well as from artificial sources - from man-made explosions in industrial careers, from explosions in the area of the sea and lakes, from the sound wave produced at overcoming the sound barrier, and from other technological impact of shock or vibration type.

In 2004, the effects of earthquakes in the Baltic region revealed not only in the Kaliningrad region of Russia, but also in Latvia, the remote more than 150 km from the epicenter.

In the village of Kalni, Nigrandes parish, a remote for about 215 km from the epicenter of the Kaliningrad earthquakes were ascertained damages the small dam and a private home http://www.seismo.lv/viewpage.php?page_id=16. Appeal to specialists from the owner of mini hidro electrical station, allowed for a timely examination of the damaged facilities and preparation of an expert opinion. This has enabled the owner to get the financial compensation on insurance for damage resulting from the earthquake.

For insurance companies is expediently have the appropriate advance information about the seismic risk and the level of seismic effects in areas where assumed property insurance. Such information will useful for insurers to assess the economic risk. The premium should be proportional to the degree of seismotectonic and economic risk. In this case the insured event

can be qualified as a "Natural disaster. The damage and loss arising from seismic vibration or the slow tectonic deformation". In the event of such impacts, building, construction and property can be insured against partial damage or complete destruction (loss).

3. The health.

Tectonic faults can also affect the health and lives of people in addition to the immediate of seismotectonic hazard. This is due to the penetration of the radioactive gas radon (radon emanation) in the upper layers of sedimentary cover.

Radon - a colorless inert gas. He is a member of radioactive isotopes 238U, 235U and 232Th. The radon nuclei continually arise in nature in the radioactive decay of parent nuclei. Given the chemical inertness, radon is relatively easy to leave the crystal lattice of "parent" of the mineral and enters the underground water, natural gas and air. Therefore, the content radon in these environments is maximal.

Most long-lived of the four natural isotopes of radon is 222Rn. Half-life, ie reduce the number of particles in a 2-fold, equal to 3.8235 days. Radon is radioactive, can be dangerous to the health and lives.

Radon is the second leading cause of lung cancer in many countries. Nuclear decay of radon and its daughter isotopes in the lung tissue is caused due microburning and causes DNA damage, which is located in the nucleus, and consisting of chromosomes, because all the energy, which is emitted alpha particle is absorbed almost at the point of collapse.

Granites are active source of radon. In Latvia granites located on depth and from above overlayed by a thick layer of sedimentary cover, which acts as a protective screen, preventing the entry of radon to the surface. However, the presence of tectonic faults can "neutralize" the screening effect of deposits.

A tectonic fault is a zone within which there are grinding the fractured rocks (tectonic breccia) and hence these zones are much more permeable to radon than areas with a solid, unbroken geological environment. Radon can rise to the surface of the earth probably due tectonic fault.

At present, many countries carry out environmental monitoring of radon in buildings, because in areas of geological faults of its concentration in the premises of the buildings could be extremal high and to exceed the average for other regions. The maximum tolerable daily intake of radon inhalation is 146 MBq / year (146 x 106 Bq/year). Mean and outdoor level of radon is low and varies from 5 to 15 Bq/m3.

The Italian geologists and geophysicists have found that high values of radon concentrations correspond to epicentral zones of historical earthquakes in the northern Calabria. This probably indicates on modern and activated parts of the tectonic fault. It was noted for zones where the earthquake occurred in 1835, 1854 and 1870.

Territory of Riga is cut by several tectonic faults. These faults cross the crystalline basement (granite rocks) and penetrate above - in the sedimentary cover. Indirect indications show on the likely activity of some tectonic faults, which are crossing Riga. In accordance with the historical evidence, at Riga, there were several earthquakes. Thus, in regions of

Latvia, including Riga with a high population density, where there are tectonic faults, there is a possibility of existence of radon anomalies and consequently the negative, harmful effects on human health.

Research of Russian geophysicists at the East European Platform (ibid., where is located territory of Latvia) have shown the influence of tectonic structures on the location of zones of radon anomalies and the intensity of radon emanations. In addition, it was observed periodic variation in the intensity of radon emanations with periods 1, 4, 14 and 29 days. This cycle is related to the so-called tidal deformations of the Earth (the influence of gravity of the Sun and the Moon) and cyclonic processes in the atmosphere. There is connection between the activity of subsurface radon and atmospheric pressure.

Laboratory studies have shown the existence of a nonlinear relation between the radon emanations and frequency vibration. A maximum intensity of the emanations for the granites is connected with excitation (vibration) at frequencies of 16 and 32 Hz.

Experimental studies of microseismic background and activity of subsurface radon showed the close relationship between the activity of subsurface radon and microseismic noise with the dominant frequency of 16.5 Hz.

According to statistics http://www.csb.gov.lv/csp/content/?cat=2314 the number of patients with malignant diseases who were on sick-preventive supervision, risen in Latvia from 2004 to 2008 from 52128 up to 60,797 people, ie at 16.5%. According to the World Health Organization (WHO) http://www.who.int/whosis/whostat/EN_WHS09_Table2.pdf the number of deaths from malignant diseases in Latvia in 2004 was 156 people per 100,000 populations. According to this indicator in Latvia increased by 10 place in Europe. The range of variation of this index in the world is from 52 to 306.

The comparable figure for the cardio-vascular diseases for Latvia was 471 people per 100,000 populations. According to this indicator Latvia also took 10th place in Europe. The range of variation of this index in the world is from 114 to 673.

Thus, summarizing all the above information to the public health section, we can state that the identification of areas distribution of radon anomalies, which are characterize the risk for long-term presence there people, would reduce the risk of cancer and adverse effect on the human genetic code.

The solution to this problem is possible based on a comprehensive study of the relationship between the tectonic features of the Latvian territory, to identify possible radon anomaly at sectors discontinuity of the sedimentary cover and their relationship with microseismic noise.

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