SECOND EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING
AND SEISMOLOGY, ISTANBUL AUG. 25-29, 2014

EVALUATION OF SEISMIC NOISE MEASUREMENTS IN UNDERMINED AREA-STONAVA LOCALITY, CZECH REPUBLIC

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Upper Silesian Coal Basin spreads out in Czech Republic and Poland. Black coal is exploited using underground mining for a long time in this area and intensive mining induced seismicity is also documented here (e.g. Rudajev 1993, Kaláb et al. 2009). The local geological pattern, especially subsurface sedimentary layers, belongs to one of the most important factors that influence the amplification of seismic effect on the surface. Information on the natural frequency of buildings together with information on the resonance frequency of the underlying soil layers is necessary for the study of seismic effects in urban areas with an expected seismic loading. So-called methods of spectral ratios may be used to determine these resonance frequencies. These methods are used not only in source areas of natural earthquakes, but they are also used for resonance frequency analysis in the surroundings of other sources of seismic loading. A number of authors have used these methods for the evaluation of resonance frequency of the underlying soil layers in undermined areas (e.g., Olszewska and Lasocki 2004, Frej and Zuberek 2008, Driad-Lebeau et al. 2009, Kaláb and Knejzlík 2006, Kaláb and Lyubushin 2008). In recent years, especially HVNR method (horizontal-to-vertical noise ratio) becomes widely used for site amplification studies (Bard 2008). The horizontal-to-vertical spectral ratio of the components of motion recorded at only one seismic station is computed using records of ambient noise (Nakamura 1989). The main benefits are significant reductions in field data acquisition time and costs. This paper summarizes the evaluation of resonance frequency of sedimentary layers in a selected locality in undermined area. Short-term measurement of seismic noise was performed near the permanent seismic station in Stonava village.

The monitoring of mining induced seismicity performed by the Institute of Geonics started in the year 1999. The solitary seismic stations were installed in selected objects on the surface in the localities of Stonava, Orlová, Doubrava and Karviná. Results from this monitoring and from experimental measurements in surface structures in the Karviná region document that more intensive seismic events exceed value of oscillation velocity 10 mm/s. Maximum measured value of velocity reached up to 25 mm/s, i.e. acceleration about 500 mm/s^2 (e.g. Doležalová et al., 2008).

The first studies by means of HVSR method (horizontal to vertical spectral ratio method) were carried out in the Karviná region mostly from the records of mining induced seismic events generated in the Karviná Coalfield. Analyses were performed for permanent seismic stations situated in localities with different thickness of sedimentary layers (Kaláb and Knejzlík, 2006). It was found out that the spectral ratio curves exhibit significant peaks in localities covered by sedimentary layers and two or more peaks were often detected which indicates a complexity of subsurface layers. This complexity of geological conditions at the locality may be connected also with changes of hydro-geological regime of the area and a deformation of the terrain, which are typical phenomena for undermined area.

In the year 2008 and 2009 experimental seismic measurements were performed at Stonava locality for evaluation of validity of data measured at a certain point for its surroundings (Kaláb and Knejzlík 2011). Differences of values of vibration velocity were studied for individual temporary

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seismic stations at the locality. It has been found out that an area of about 2 x 2 km needs at least two seismic stations, one in favourable foundation conditions and the other one in critical foundation conditions as the seismic effect may vary due to changes of geological conditions. Critical foundation conditions represent areas with active landslides, with current deformation of surface (sinking) and places covered by embankments, dumps and coal-ash settling basins (Kaláb and Lednická 2012).

Local geology in Stonava area (south-east part of Karviná region) is very complicated, thin layers of soft Quaternary sediments cover Tertiary sediments with different thickness (from 300 m up to 600 m) and different stiffness. In the area under study, several significant faults are found. This region is a populated area, where underground mining activities are still active. The current depth of exploitation ranges from 800 – 1000 m below the surface.

Measurement of seismic noise was performed in selected locality of Stonava village to evaluate changes of resonance frequency of sedimentary layers in the vicinity of permanent seismic station STO2. Profile of the length of 2 km was selected and short-term measurement of seismic noise was performed at about 18 places. Geological map of the surroundings of Stonava village with the places of measurement is presented on the Figure 1.

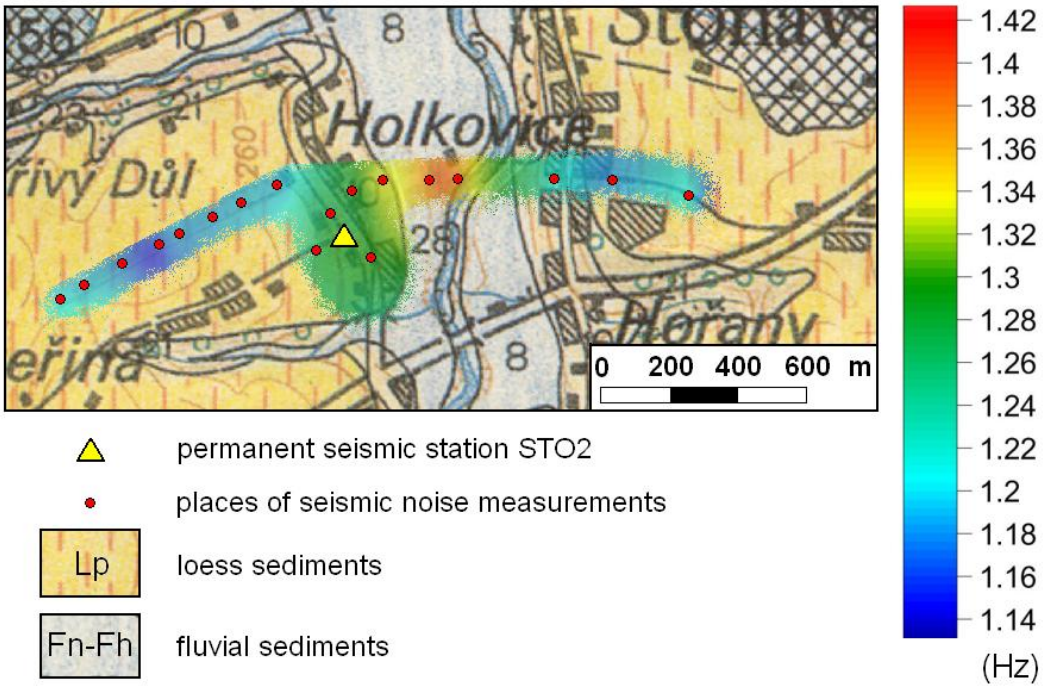

Figure 1. Geological map of Stonava village in the Karviná region with results of resonance frequency of sedimentary layers along the measured profile (tonality represents determined values)

Resonance frequency was determined using the HVNR method. Records of seismic noise with duration more than 30 minutes from individual measured points were analysed using Geopsy software package. Values of the resonant frequency on H/V spectral ratio curves were determined. Using this information, distribution of resonance frequency values along the measured profile was included into geological map of Stonava village (see Figure 1). The values of resonance frequency along the profile are in the range from 1.16 to 1.4 Hz.

According the results from presented profile measurement, we can state that changes of resonance frequency correspond to the change of geological conditions. Increasing values of frequency represent area with fluvial sediments around small stream with high level of water table (see Figure 2). But these fluvial sediments have small thickness compared to the values of determined frequency. As is mentioned above, geological pattern is very complex in Stonava locality and also loosening of upper sedimentary layers take place in different depth extent due to sinking of terrain above exploited areas. We suppose that not only quaternary sediments, but also upper loosened layers of tertiary sediments cause the site effect in this area.

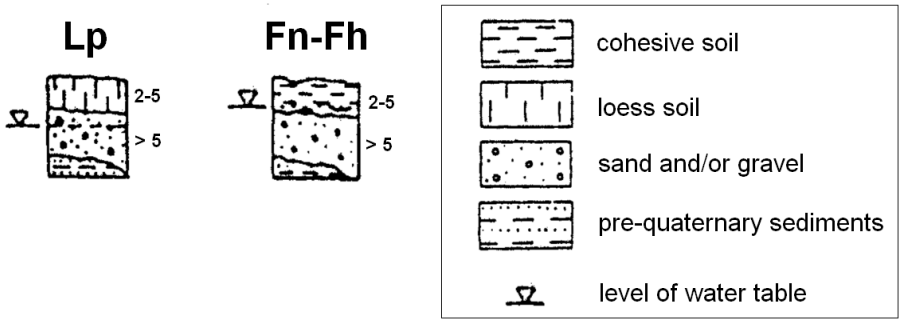

Figure 2. Example of the sections of sub-zones in Stonava locality with the thickness of Quaternary soils and with the average depth of groundwater table according the map of engineering geological zoning (Kašpárek 1998)

ACKNOWLEDGEMENT

This research is performed with the financial support of the Czech Science Foundation, No. 13-07027P "Investigation of the seismic characteristics of foundation soils using frequency analysis of vibration effects" and with the financial support of the Institute of Geonics, ASCR Ostrava, RVO:68145535.

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