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STRONG GROUND MOTION MONITORING NETWORK IN THE LEGNICA-GŁOGÓW COPPER MINING DISTRICT

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ABSTRACT
Some of mining areas are characterized by occurrence of mining tremors induced by exploitation. Ground motion caused by mining tremors may be dangerous for people and surface structures and should be monitored especially in the highly urbanized areas.
We can observe such a case in the Legnica-Głogów Copper District. The monitoring network in this area was initiated in 2001 by connecting to the SEJS-NET system two measuring stations. At present dozen of measuring station comprise the network to control vibration level of the ground and buildings localized in the mining areas and nearby its boundary.
The monitoring network makes use of Internet technologies for data collection and distribution. Authorized users access the system using web browsers, palmtops and cellular phones. Moreover, the stations can be configured logically in the so-called 'projects', being under control of independent groups of users, respectively.

KEYWORDS: strong ground motion, accelerometer monitoring

1. INTRODUCTION

The presented accelerometer network is located on the northern part of a mining area of Legnica-Głogów Copper District (Fig. 1). The network is especially designed to measure ground motion effected by mining tremors. Exploitation of copper ore in this region causes occurrence of mining tremors. These tremors are dangerous for highly urbanized areas.

The network is property of local communities and it is administered by AGH University of Science and Technology. All stations are SNRC type and they are part of the SEJS-NET System based on Internet technologies. The SEJS-NET system is designed for monitoring of strong ground motions and building vibrations.

2. HISTORY OF THE NETWORK AND RECEIVER LOCALIZATION

First two stations of the network have been installed in October 2001 in Rudna Community area (Mirek and Bowanko, 2002). One of these stations is localized in Rudna, the second one in Rynarcice. Both of them are free field type and use triaxial accelerometers. According to mining regulations receivers are localized in concreted shallow wells. These two stations are property of Rudna Commune.

One year later, in August 2002, next two stations have been connected to the system. These stations provide five measuring points equipped with triaxial accelerometers. One station is localized in Polkowice town in Skalników housing estate; the second one is installed in Tarnówek. The station in Polkowice collects data from three receivers. The first receiver is installed in the concrete shallow well near the building where the station is installed, the next two receivers are installed on ground floor and eleventh (last) floor of the building. Station located in Tarnówek is equipped with two triaxial accelerometers. One receiver is installed in the concrete shallow well and the second one on the ground floor of building. The Polkowice and Tarnówek stations are properties of Polkowice Commune.

In December 2003 the Świnino station has been connected to the system. This station is equipped with one triaxial accelerometer and provides free field-monitoring receiver, which is located in the concrete shallow well. Station in Świnino is property of Grębocice Commune.

In November 2004, there have been installed next five stations in Polkowice Dolne, Szklary Dolne, Kwielice, Gaiki and Jakubów. All these stations are equipped with triaxial accelerometer mounted in the concrete shallow well. These stations are equipped with new SNRC-TX type of recorders.

Free field sensors are oriented according to geographical directions: X-axis in N-S direction, Y-axis in W-E direction and Z is vertical. Sensors located on the buildings has X axis along a wall, Y-axis transverse and Z vertical. Location, type of receivers, and installation date of all stations incorporated in the network are put together in Table 1.

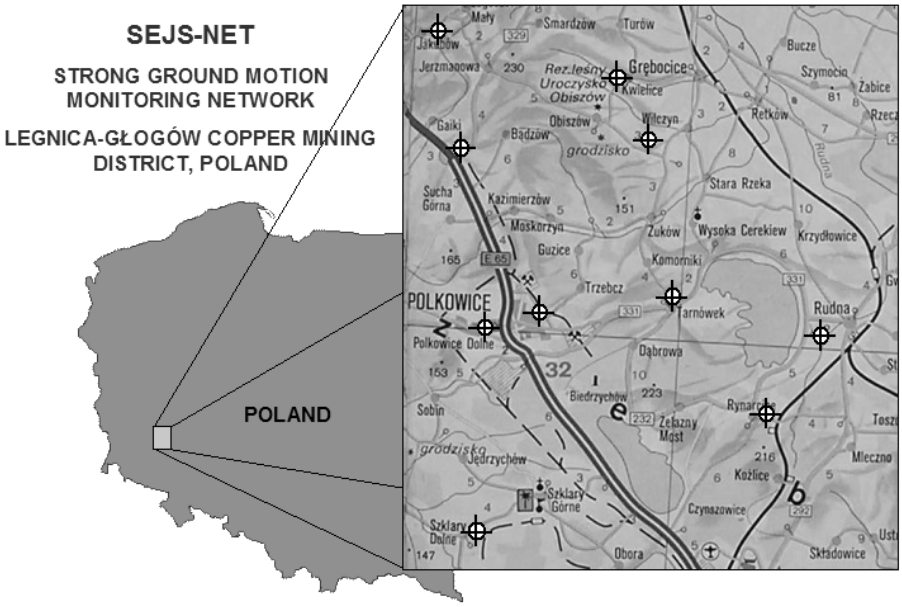

Fig. 1 Localization of the survey area and network stations.

Table 1 Location of the network stations and date of their installation.

Station name	Opening Date	Latitude (N)	Longitude (E)	Elevation (m)	Receiver location
Rudna	2001-10	51° 30’ 28.19”	16° 15’ 18.23”	130	1. free field
Rynarcice	2001-10	51° 28’ 19.71”	16° 12’ 52.16”	160	1. free field
Tarnówek	2002-08	51° 31’ 00.55”	16° 09’ 55.02”	125	1. free field 2. ground floor
Polkowice Skalników	2002-08	51° 30’ 32.72”	16° 04’ 25.07”	180	1. free field 2. ground floor 3. tenth floor
Świnino	2003-12	51° 34’ 09.21”	16° 08’ 48.72”	90	1. free field
Polkowice Dolne	2004-11	51° 30’ 11.36”	16° 03’ 27.58”	163	1. free field
Szklary Dolne	2004-11	51° 26’ 03.15”	16° 04’ 27.66”	142	1. free field
Kwielice	2004-11	51° 35’ 51.14”	16° 06’ 48.55”	118	1. free field
Gaiki	2004-11	51° 34’ 17.78”	16° 00’ 32.25”	152	1. free field
Jakubów	2004-11	51° 36’ 15.09”	16° 00’ 28.27”	208	1. free field

Table 2 Type of the stations comprising to the network, trigger level and type of communication.

Station name	Station type	Number of active channels	Trigger level [cm/s^2]	Communication type
Rudna	SNRC	3	0.5	Dial-up Internet
Rynarcice	SNRC	3	0.5	Dial-up Internet
Tarnówek	SNRC	6	0.5	Broadband Internet
Polkowice Skalników	SNRC	9	0.5	Broadband Internet
Świnino	SNRC	3	0.5	Dial-up Internet
Polkowice Dolne	SNRC-TX	3	0.5	Dial-up Internet
Szklary Dolne	SNRC-TX	3	0.5	Dial-up Internet
Kwielice	SNRC-TX	3	0.5	Dial-up Internet
Gaiki	SNRC-TX	3	0.5	Dial-up Internet
Jakubów	SNRC-TX	3	0.5	Dial-up Internet

Table 3 Sensor parameters

Type	accelerometer
Axis	Triaxial
Sensitivity	1000 mV/g
Broadband resolution	0.00005 g rms
Measurement range	±5g
Operating temperature	-29 ÷ +76 °C
Frequency range	0.3 ÷ 5000 Hz

3. RECORDING SYSTEM

Strong motion monitoring network in the Legnica-Głogów Copper District is a part of the SEJS-NET System designed for acquisition and interpretation of vibrations caused by mine seismicity. Based on Internet technology (Mirek, 2002), the SEJS-NET system was designed in 2000 (Mirek, 2000). One year later, it was ready-for-use with specialized database, transmission protocols and especially designed recording (Mirek, 2001; Lasocki and Mirek, 2001). The stations in Rudna and Rynarcice were one of the first stations connected to the system. At that time, however, the system was being tested in several projects connected other sources of vibrations like sawmill, stamping press, etc. The tests proved that the system, which was principally designed for measuring vibration caused by mining tremors is also suitable for monitoring seismic effects of many other sources. Such w is duet to SNRC recording stations used within the SEJS-NET system, whose parameters give possibility of fine-tuning in accordance to the kind of vibration of interest. The SNRC station can work in triggered mode with trigger level adjusted separately for every channel, with full-time save mode and with scheduled mode, where recording process is controlled by timer. The SNRC station can also use practically any kind of connection to the Internet (ppp dial-up, DSL, Frame Relay, GPRS, etc.). All SNRC stations use sixteen channels, 12 bit A/D converters and can collect signals from up to five triaxial sensors. At the end of 2004 a new recording station, SNRC-TX, has been worked-out. This station has the same functional parameters as SNRC station, but its dimensions are smaller and it has lower power consumption.

Table 2 presents types of the stations that presently comprise the network, trigger level and method of connecting the Internet. All stations are using triaxial accelerometers with parameters described in Table 3. Since free field sensors located in concrete shallow well and such mounting affects measured signals, at present a new sensor is under construction, which will be placed directly into the ground.

Records collected by SNRC stations are transmitted through Internet to the Central Measuring

Table 4 Numbers of collected records in PGA of the horizontal component ranges.

Receiver	PGA<0.05 [m/s^2]	0.05<PGA<0.1 [m/s^2]	0.1<PGA<0.2 [m/s^2]	0.2<PGA<0.3 [m/s^2]	0.3<PGA<0.4 [m/s^2]	0.4<PGA [m/s^2]
free field	366	77	31	4	6	1
on building	369	114	55	11	7	4

Database (CMD), the main administrative centre. There are two CMD-s: the first located in Krakow owned by AGH University of Science and Technology and the second located in Polkowice owned by Polkowice Commune. CMD uses relational database to collect field records and their parameters. It is also equipped with many procedures useful for data interpretation and presentation. Authorized users can access CMD through the Internet using web browsers. Usually users use typical web browsers installed in personal computers. In special situation there is possible to get connection with CMD using palmtops connected to the Internet or cellular phones using WAP browsers (Mirek, 2004). Altogether the structure of SEJS-NET system gives possibility to control the network all the time with minimum human involvement and also to explore the database from any place around the world.

4. COLLECTED EVENTS

The SEJS-NET monitoring system in the Legnica-Głogów Copper Mining District covers area of over 500 km^2. Till now it has collected in its database almost one thousand records. Table 4 presents numbers of records in the specified amplitude ranges. The amplitude is defined as the peak ground acceleration (PGA) of the horizontal component.

A lot of records comes from the station Polkowice Skalników, where is installed one free field receiver and two receivers are located in building. In Figure 2 we can see, that mining activity in Polkowice area is very high.

Figure 3 presents accelerograms of one of the strongest event registered in CMD since the year 2001. The event occurred in March 2003 at 11:10 CET. In Figure 3a we can see the accelerogram recoded by the free field receiver at Polkowice Skalników. The epicentre distance was about 1020m. Figure 3b shows the accelerogram from the receiver localized on the tenth floor with a visible effect of rock especially on X-axis. The next two accelerograms (Figure 3c, 3d) were recorded at the epicentre distance about 5960 m by free field receiver and on-building receiver in Tarnówek. The last accelerogram (Figure 3e) shows record from Rynarcice. In this case the epicentre distance was about 9750 m.

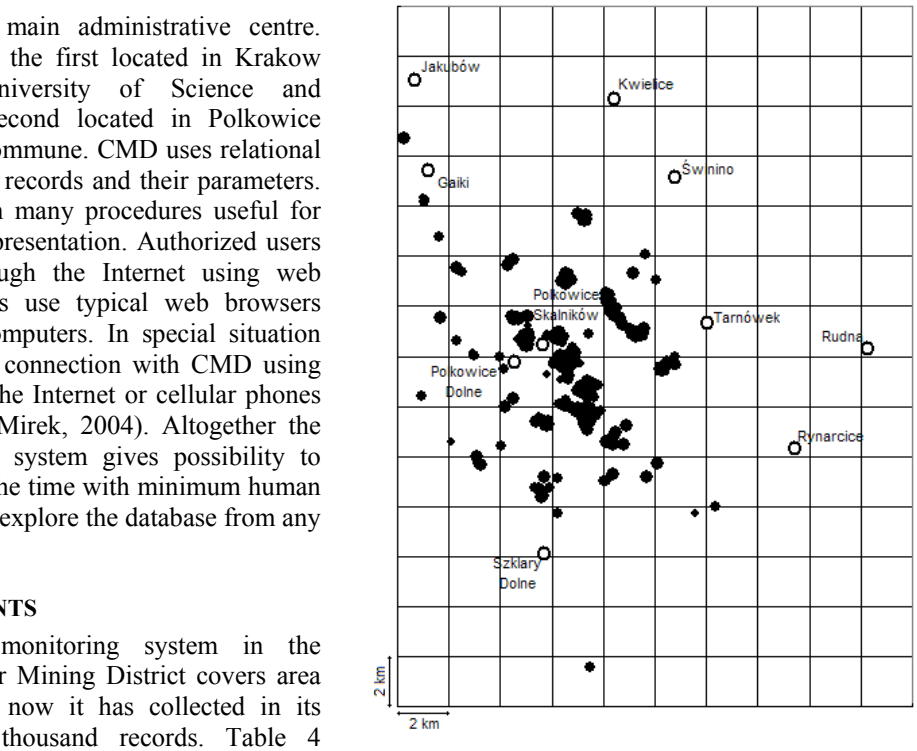

Fig. 2 Localization of the stations (white circles), and epicentres of measured events (black dots) in the survey area.

5. SUMMARY

The accelerometer network in the Legnica-Głogów Copper District supported by SEJS-NET system has worked since 2001. At present it consists of ten measuring stations with free field receivers and three stations with receivers located in buildings. The network covers area of more then 500 km^2. The Central Measuring Database has storred till now about one thousand records. Authorized users can access Database using Internet through standard web browsers and WAP browsers installed in cellular phones.

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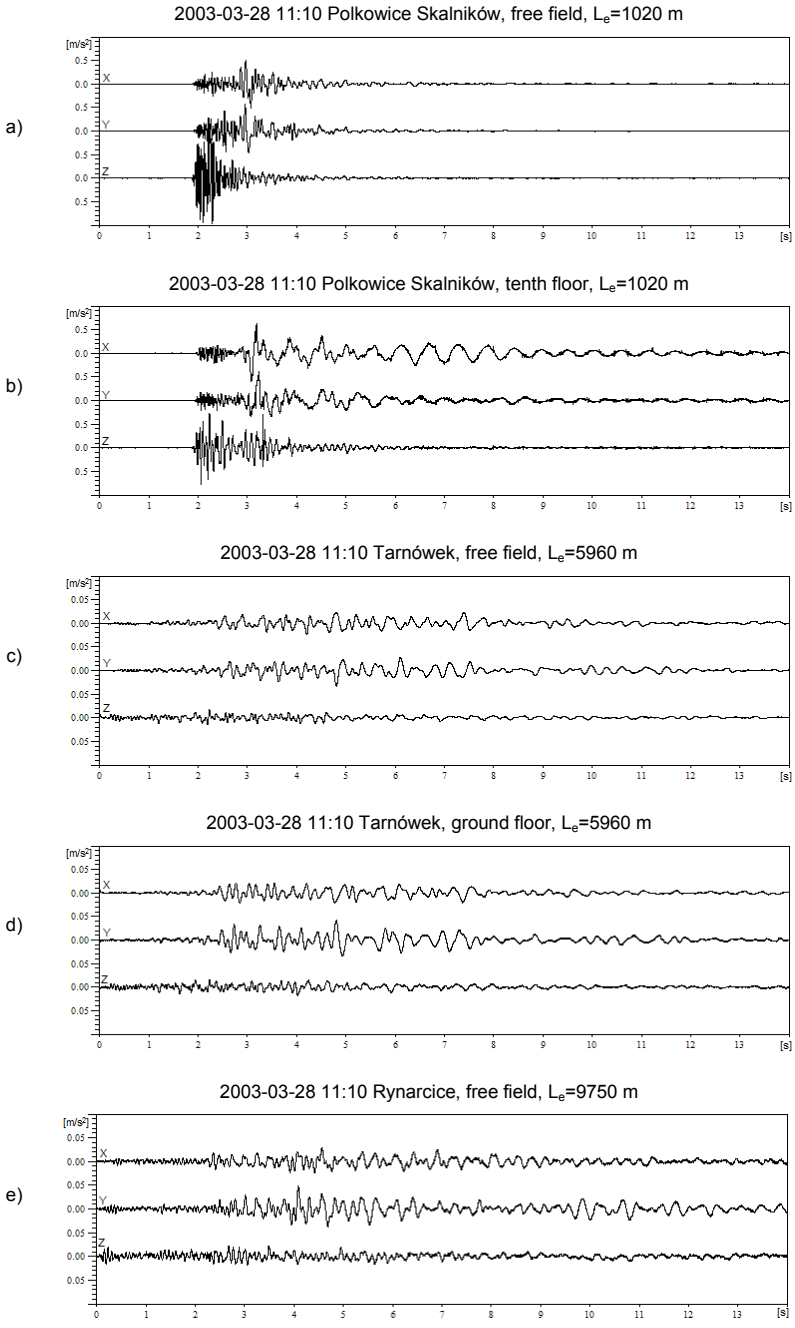

Fig. 3 Accelerograms from stations Polkowice Skalników (a, b), Tarnówek (c, d) and Rynarcice (e). Date 2003-03-28 11:10 CET, energy 1.7e8 [J].

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