Experimental investigation of the seismic effects during blasting works

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Abstract. The interested part of dynamic analysis is the blasting work effects propagation through soil. This type of the dynamic load can be significant when the soil structure dynamic interaction hasn´t favourable conditions. It can cause structural failures on buildings. The main aim of the paper is to investigate how we can estimate the magnitudes of the seismic waves during blasting works. The results are based on experimental studies.

1 Introduction

Nowadays is just technical seismicity part of the environmental issues. The increase in vibration induced by different sources have an unfavourable impact on buildings, structures and the people living there. Very often the sources of technical seismicity is the blasting work. These activities near residential areas have become a problems. Vibration induced by explosion is propagating through the geological subsoil into great distances [6]. The objects standing near the quarries are highly influenced by vibrations from technical seismicity. Results of this extremely load can be occurrence of various disorders on the structures [5]. Environmental effect of blasting is schematically shown on Fig. 1.

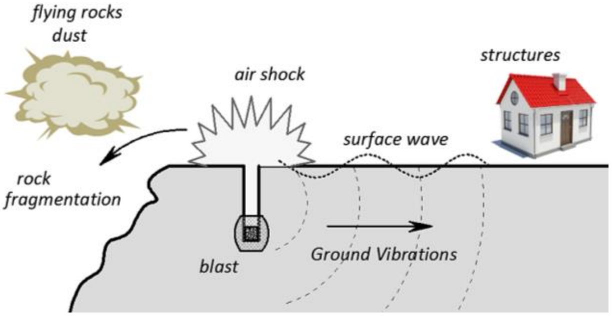

Fig. 1. Environmental effect of blasting.

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This paper deals with the investigation of the seismic waves magnitudes during blasting works in the stone quarry Dedová [1]. Analysed object is a family house located in the cadastral area of the village Hradište, Fig. 2.

Fig. 2. Overall situation – distance between object and the stone quarry - Hradište.

Investigated object is the permanently occupied house, which has a regular floor plan. It is partially basement and built on concrete foundations. Perimeter and interior load bearing walls are built from bricks, non-bearing interior walls are also brick, ceilings and wreaths are reinforced concrete. Building is covered with saddle-shaped roof and roof load bearing structure is created from standing stool. Distance between object and quarry is bee-line 250m.

2 Experimental investigation

2.1 Measurement progress

At first the accelerometers were placed on the monitored object [2]. The monitored variable was the vibration velocity (vibration velocity components *u, v, w* [mms^{-1}], the spatial vector addition of these components v_p [mms^{-1}] and the vibration frequency [Hz]). Vibration velocity was measured by two accelerometers sets with a frequency range of 1 ÷ 4000 Hz. Analysed object and the position of the measured points are schematically shown in Fig. 3.

Fig. 3. Analysed object and location of accelerometers.

The vibration level measurement was performed using a National Instruments A / D card. These card allows reading data with a sampling frequency of 1000 Hz. On the input of this card was applied the signals of vibrations velocity sensors (in three orthogonal directions) SM6 B04 with built-in amplifier INSENS 100. Recorded mechanical movement has been transformed by measuring line from an electrical signal (Fig. 4). This signal was amplified and integrated to the vibration acceleration - $a(t)$ and vibration velocity - $v(t)$.

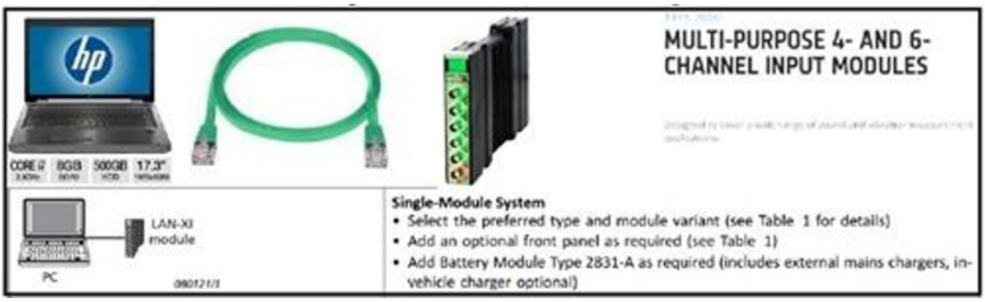

Fig. 4. Scheme of measurement.

Source of vibration was controlled blast in the quarry at one measuring point in the village of Hradište. During the measurement, the sensors and the data acquisition computer were secured against damage and distortion of the measured values. The measurement was performed in Roll mode = recording runs without a break. If vibrations are detected, the recording is interrupted and the part with the blast is stored separately. Graphic control and preliminary evaluation of the record were performed after saving and data backup. The settings of the whole measuring line is shown in Table 1.

Table 1. Settings of the measuring line – National Instruments

Measuring line - National Instruments			
Range	50 mm/s	**Connection mode**	differential
Sensitivity	100 mV/mms	**Measurement mode**	Roll mode
Sampling frequency	1000 Hz (samples/s)	**Recording time (max.)**	60 s (blasting)

2.2 Experimental measurement result

2.2.1 Measured values of vibration effects

The planned blast was realized at the beginning of the year. By accelerometers was measured vibration acceleration, vibration velocity, vibration displacement and vibration frequency. After evaluating the measured values, the maximum blasting effects were identified. Acceleration and velocity vibrations records are shown on Fig. 5. Maximum measured values in all orthogonal directions are summarized in Table 2.

Table 2. Maximal measured values.

Sensor position Registration channel number		Vibration acceleration $a(t)$	Vibration velocity $v(t)$	Vibration displacement $d(t)$	Vibration frequency
Hradište	[-]	[$mm \cdot s^{-2}$]	[$mm \cdot s^{-1}$]	[mm]	[Hz]
VIB1 v.č. 06048	*z*	145	**1.71**	0.325	5.6
VIB2 v.č. 06029	*y*	182	**2.80**	0.452	4.9
VIB3 v.č. 06030	*x*	191	**2.92**	0.364	5.1

During blasting in quarry were recorded the highest vibration velocity value (v = 2.92 mm/s) on accelerometer VIB3. It was a vibration in the x-axis direction.

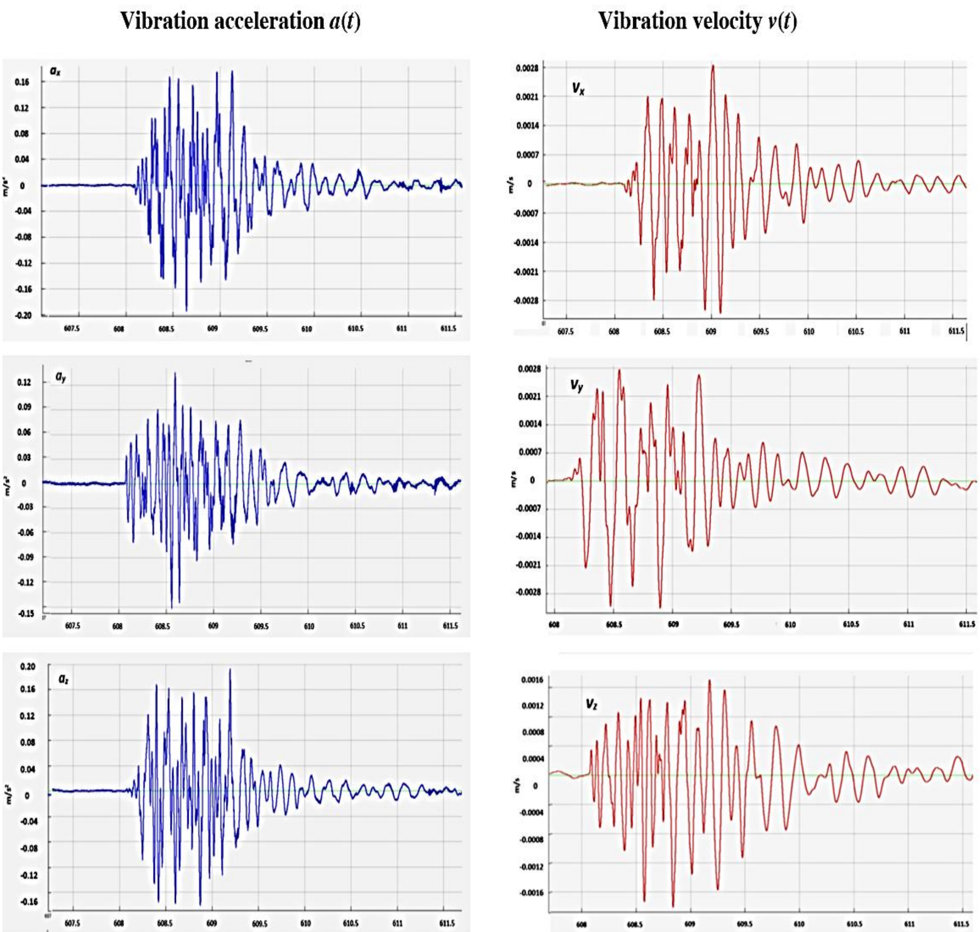

Fig. 5. Records of vibration acceleration and vibration velocity in all orthogonal directions.

2.2.2 Vibration level evaluation

Seismic measurements can be characterized as a three-component vibration velocity measurement. Obtained parameters are directly proportional to seismic load of buildings. They are related to the degree of their potential damage. The currently valid standard STN

EN 1998-1- Eurocode 8 uses the values achieved in each orthogonal direction (u, v, w) to evaluate the level of vibration velocity [3]. This standard concerns the design of structures for seismic resistance.

The object was classified into the class by standard. According to the resistance class of buildings it is an objects class **B**. This includes normal brick buildings, insulated or terraced houses with a floor area of up to 200 m^2, with a maximum of three floors. Then was assigned the investigated area to the appropriate category of geological conditions. According to the standard it was category **A.** The maximum vibration velocity value for the objects class B and geological conditions category A was not passed – Table 3.

Table 3. Dependence of degree of damage on maximum vibration velocity, type of object and ground (STN EN 1998-1 / NA / Z1).

Maximum vibration velocity for frequency domain [mm.s^{-1}]			**Degree of damage**	**Resistance class of building**	**Category of geological conditions**
f < 10 Hz	10 Hz < f < 50 Hz	f < 50 Hz			
$v < 3$	$3 < v < 6$	$6 < v < 15$	0	A	a
$3 < v < 6$	$6 < v < 12$	$12 < v < 20$	0	A	b, c
			0	**B**	**a**
$6 < v < 10$	$10 < v < 20$	$15 < v < 30$	0	B	b, c
			0	C	a
			1	A	a

Based on the results, it can be concluded that the effect of blasting in the quarry - Hradište has a negligible impact on the investigated object. The family house is located in the zone of possible damage [4]. It is appropriate to monitor the impact of technical seismicity in the long-time period.

3 Conclusions

The paper shows the possibilities of the vibrations monitoring caused by explosions in special locations. It is for example family house, which is built in zone with possible occurrence of blasting damage - in quarries. Besides building structures are affected people living in the buildings, too. This is the reason why is the detection of vibration levels very important. This is one of the options for determining the impact of technical seismicity on a house. Long-time vibration monitoring is also recommended for low vibration velocities and another values. The purpose is for the future to warn on the impending danger. In this way, it is possible to minimize the costs of repairing the damages. The impact of blasting works can be reduced by using less explosives.

References

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