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Measurement of surface vibration accelerations propagated in the environment

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Abstract

The paper presents the analysis of the influence of the method of accelerometers attachment to the ground on the recorded level of vibration acceleration. Measurements of vibrations were conducted using two types of accelerometers with various weights and measuring accuracy. Accelerometers were mounted to the ground in four different methods using various mounting bases anchored in the ground with one, three and four rods. The vibrations were generated using Light Falling Weight Deflectometer (LFWD) and recorded in longitudinal, transversal and vertical directions at the distance of 5 and 10 m from the source of vibrations. Measurements of vibration accelerations were carried out using 32-channel and 24-bit mobile data acquisition system - SIEMENS LMS SCADAS Recorder, as well as a set of 18 low-frequency, seismic piezoelectric accelerometers type 8340, manufactured by Brüel&Kjær, and two triaxial, high sensitivity accelerometers type TLD356B18 manufactured by PCB Piezotronics. The comparative analysis of Peak Particle Accelerations (PPA) has demonstrated that the method of attaching of accelerometers to the ground is crucial for the credibility of measurements. The best way of attaching transducers to the ground was shown in the paper. The resulting values of vibration acceleration may constitute a basis for a reliable analysis of vibration in the subsoil, which is particularly important in terms of the credibility of assessment of the impact of physical pollution in a form of vibrations propagated in the environment on the newly designed buildings and their future users.

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Keywords: surface vibrations, subsoil, propagation of vibration, accelerometers;

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1. Introduction

Modern technology of vibration measurement is based on the use of advanced measurement systems to enable data acquisition. The resulting data usually come from measurements made using accelerometers [1] or geophones [2]. In the civil engineering, in the case of propagation of vibrations in the ground and the need to assess their impact on existing buildings (e.g. [3,4,5,6]), the comfort of use [4,5,7,8], or the impact of vibrations on the machines and equipment fitted in buildings [8,9], the issue of implementation of reliable measurement does not pose major problems. Sensors, depending on the type of assessment, should be installed in the locations indicated by the relevant regulations, in such a way as to enable reliable recording of vibrations of the structural component to which they are attached (e.g. the foundation walls of buildings from the vibration source side and at the level of the surrounding terrain, the place where vibrations are received by people - usually in the middle of the span of ceilings, etc.).

The situation becomes more complex when assessing the impact of existing sources of vibration to the building which has yet to be built in that location and the users. The evaluation of this type, apart from the dynamic interaction of soil - building, requires the implementation of a reliable measurement of the propagation of vibrations in the ground at the site of the planned investment. In this case, it is usually necessary to carry out the measurements by means of sensors installed on the ground. Correct implementation of the measurements is also essential if the research is purely scientific. The aim of such studies may be alone the issue of the propagation of vibrations (for example, determining the curves of attenuation [10]). Another example might be the testing of the subsoil by the methods of the group of surface seismic tests (e.g. SASW, CSWS), especially when accurate values of acceleration or velocity of vibrations are indispensable for the evaluation process, and not only the propagation time or phase shift [11].

Unfortunately, provisions generally do not specify how such measurements should be conducted. A common practice is to measure the vibration using the sensors attached directly on the ground or on a specially constructed mounting bases (anchored or not anchored in the ground) to which the sensors are fixed. Variety existing in this area (e.g. [1,2,5,12]) is the cause of the fact that the recorded time waveforms of vibration can significantly differ from each other.

The aim of the study is to assess the impact of methods of measurements on the recorded level of acceleration of surface vibrations propagated in the ground.

2. Measurement of acceleration of surface vibrations propagated in the ground

The study assumed that the tests will be conducted for four different ways of mounting of vibration transducers on the ground and two different anchoring depths (L_1 = 15 cm and L_2 = 30 cm):

- a steel anchor bolted to the ground (bolt diameter 10 mm) with a miniature triaxial accelerometer and magnetic base;
- a ring mounting base with transversal reinforcement and three rigid anchors hammered in the ground;
- cross mounting base hammered in the ground, with four rigid anchors and two-point fastened duralumin head;
- light, duralumin double-ring mounting base anchored in the ground with three rods; with the function of rectification and correction of measurement directions (horizontal and vertical).

Field studies were carried out in a disused gravel pit (in Poland, on the outskirts of Bialystok). In the location selected for measuring, homogeneous medium dense fine sands were found at a depth of at least 3 m.

Light Falling Weight Deflectometer (LFWD) type ZFG-01 (mass shooting m = 10 kg, drop height h = 0.83 m) was selected as a stable and repetitive source of vibration.

Measurements of vibration accelerations were carried out using a 32-channel measurement system - SIEMENS LMS SCADAS Recorder with VB8-II and V24 modules (24-bit analog to digital conversion, 130 dB dynamic range, signal to noise ratio - minimum 106 dB), as well as a set of 18 low-frequency, seismic piezoelectric accelerometers type 8340, manufactured by Brüel&Kjær (measuring ranges: ±0.5 g, 0.1-1000 Hz ±5%) and two triaxial, high sensitivity accelerometers type TLD356B18 manufactured by PCB Piezotronics (measuring ranges: ±5 g, 0.5-3000 Hz ±5%).

Mounting bases with attached sensors are shown in Fig. 1.