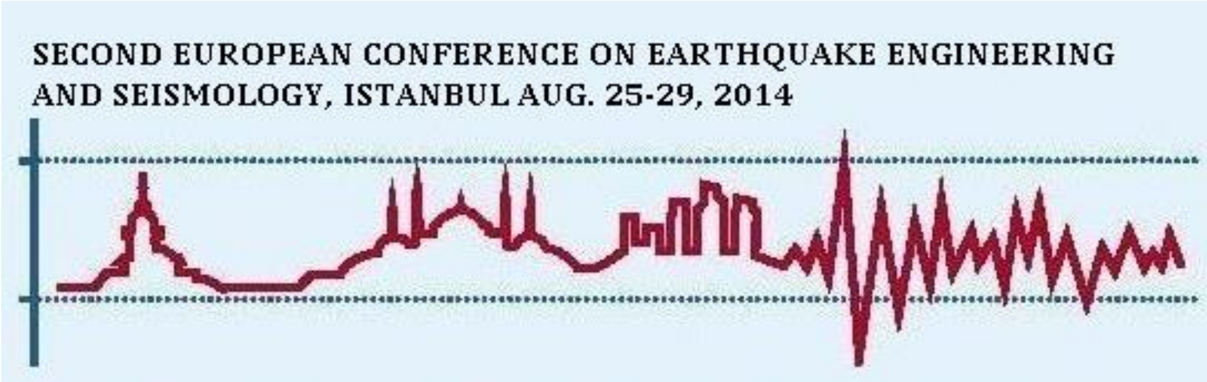

AMBIENT SEISMIC NOISE AND NEAR SURFACE RESONANCES: PHYSICAL MODELLING DATA

Yu.I. KOLESNIKOV[1], K.V. FEDIN[2] and A.F. EMANOV[3]

Methods based on the measurements of ambient seismic noise are widely used to estimate possible earthquake site response. However, the accuracy of such methods is usually not very high, especially when low-channel equipment is used. In particular, this is because of nonstationarity of a microseisms field. Comparison of data obtained in different observation points at different times with low-channel equipment can result in large errors.

One way to improve the accuracy of seismic microzonation with low-channel ambient noise measurements is realized in method developing by Emanov et al. (2008). This method is based on the conversion of nonsimultaneous data to “common” time using synchronous data from fixed reference receivers. Such technique allows extracting efficiently the coherent microseisms field components (standing waves in near-surface section). The paper presents the results of testing this method on the three-dimensional physical modelling data.

Scheme of experiments is shown in Figure 1*a*. The measurements were carried out in ultrasonic frequency range on the top surface of three-dimensional model. Geometry of the model is shown in Figure 1*b*. The model was made of three kinds of concrete in the form of parallelepiped with base size about 25*25 cm^2. Thickness and compressional velocity of the upper layer were equal to h = 2 cm and V_p = 1350 m/s, respectively. Underlying stratum with h = 23.5 cm consisted of two blocks with vertical boundary. Compressional velocities were equal to V_p = 2760 m/s for one block and V_p = 4450 m/s for another one. To speed up the experiment, the additional noise was generated on the top surface of model using simple device similar to car windscreen wiper with brush.

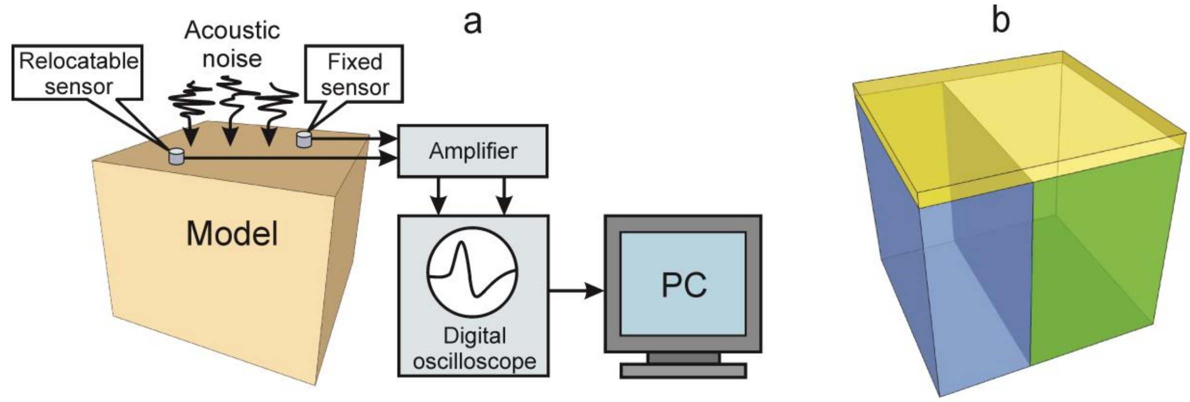

Figure 1. Scheme of experiment (a) and geometry of model (b)

Noise measurements were carried out using two receivers (wide-band piezoceramic piston-like sensors 2 mm in diameter). The maximum sensitivity axes of sensors were oriented normal to the top

[1] Dr. Sci., Trofimuk Institute of Petroleum Geology and Geophisics, Novosibirsk, kolesnikovyi@ipgg.sbras.ru
[2] Researcher, Trofimuk Institute of Petroleum Geology and Geophisics, Novosibirsk, fedinkv@ipgg.sbras.ru
[3] Dr. Sci., Geophysical Survey SB RAS, Novosibirsk, emanov@gs.nsc.ru

surface of the model, so mainly vertical oscillations of this surface were measured. One sensor was used as reference receiver and was fixed during the whole experiment. The second receiver during experiment was placed sequentially in the nodes of square grid 23*23 on the top surface of the model. Grid spacing was 1 cm. After installing the relocatable receiver at each node of grid, synchronous noise signals from both sensors were recorded using two-channel digital oscilloscope B-423, and these records were stored on the hard disk of personal computer (PC) for further processing. Recording time for each position of the relocatable receiver was equal to about 2 s, and sampling rate was equal to 1 MHz.

Synchronous records from the fixed reference receiver are employed for simulation of simultaneous observations using nonsimultaneous data recorded with low-channel (in our case two-channel) equipment in a large number of observing points. Algorithm for data conversion to "common" time and extraction of coherent oscillations from incoherent noise is described in (Emanov et al., 2002).

At averaged amplitude spectrum of experimental noise records (Figure 2*a*) one can see sharp resonance peaks at frequencies approximately proportional to 17 kHz. The same resonances for this model gives the finite element simulation using software system MSC Nastran (Figure 2*b*). These peaks correspond to vertical compression standing waves in the upper layer of our model.

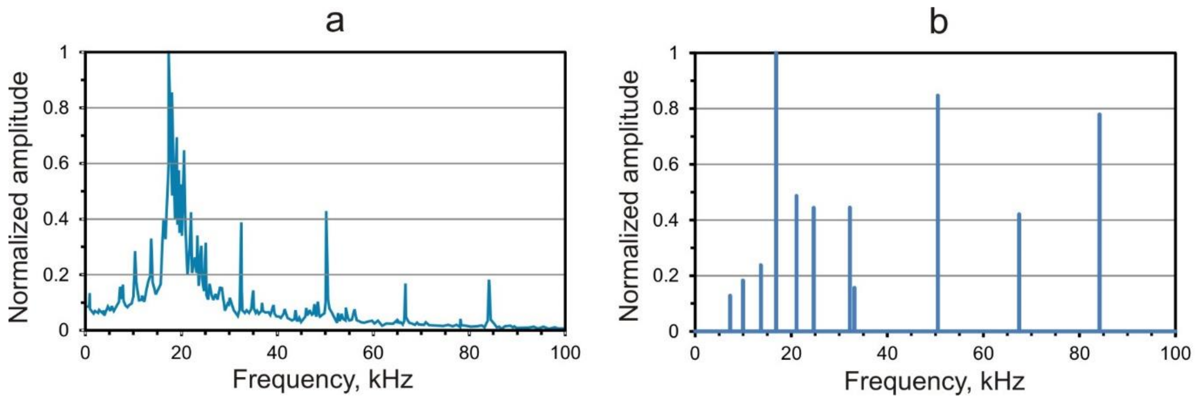

Figure 2. Experimental averaged amplitude spectrum (a) and resonances calculated by finite element method (b)

Obtained experimental data allow us to show how the conversion of nonsimultaneous records to "common" time decreases the influence of noise nonstationarity on the extraction of its coherent components (standing waves). Figure 3 shows amplitude distribution for lowest mode of compressional standing waves (with frequency about 17 kHz) on the top surface of the model before and after conversion of experimental noise records to "common" time. As one can see, after conversion to "common" time the scatter of amplitudes considerably decreases. Similar results were obtained for the higher modes of standing waves.

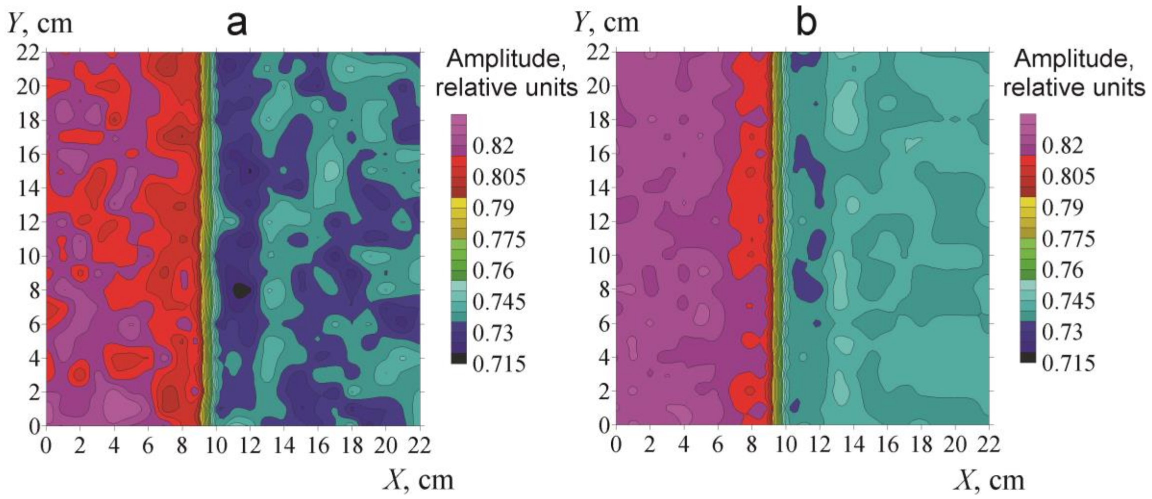

Figure 3. Amplitude distribution for lowest mode of compressional standing waves on the top surface of the model before (a) and after (b) conversion of nonsimultaneous data to "common" time. The vertical boundary in the underlying stratum corresponds to X = 9.5 cm; zones of increased amplitudes (left) are situated above more rigid block

Figure 3 also illustrates how the properties of underlying stratum influence on the resonance amplitudes of upper layer. As one can see in the figure, the amplitudes of lowest mode of compressional standing waves are about 10% greater above more rigid block (left parts of the Figures 3*a* and 3*b*) than above another one. Similar behavior is observed for the higher modes. These results are in good agreement with the data of finite element simulation carried for this model (Figure 4), suggesting a high efficiency of tested method for determining the resonance properties of a near surface section using low-channel microseisms measurements.

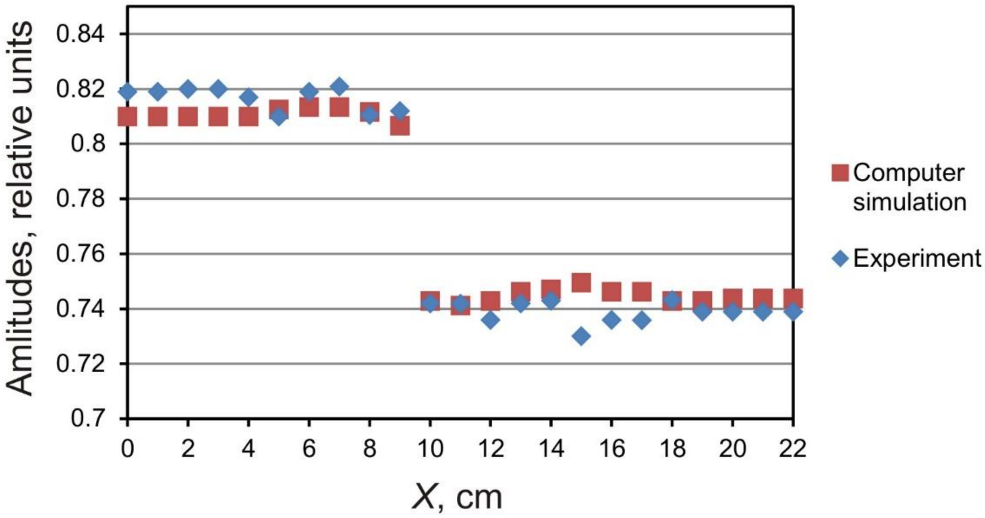

Figure 4. Amplitudes of lowest mode of compressional standing waves on the top surface of model obtained experimentally and calculated numerically for the line $Y = 11$ cm

Thus, the experimental results showed that for low-channel measurements with relocatable receivers, the conversion of nonsimultaneous data to “common” time decreases the influence of noise nonstationarity on the extraction of its coherent components. Such processing technique may improve the quality of seismic microzonation.

REFERENCES

Emanov AF, Krasnikov AA, Bakh AA, Chernikh EN, Emanov AA, Semin AYu and Cherepanov AV (2008) “Resonance properties of the upper part of geological section”, *Physical Mesomechanics*, 11(1): 26-36 (In Russian)

Emanov AF, Seleznev VS, Bakh AA, Gritsenko SA, Danilov IA, Kuz'menko AP, Saburov VS and Tat'kov GI (2002) “Recalculation of standing waves in detailed seismological engineering studies”, *Russian Geology and Geophysics*, 43(2), 192-207