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AN APPLICATION OF SEISMIC-ACOUSTICAL SET FOR GEOLOGY STRUCTURE INVESTIGATION AND SURVEY OF GROUND INHOMOGENEITIES UNTIL 100-M DEPTH

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The mobile seismic-acoustical set for the seismic wave survey and vision of underground engineering constructions is described in report. The set is created in IAP RAS and consists of electrical dynamic transducer of seismic-acoustical waves that operates at frequencies 200-800 Hz and receiver array and the control system based on PC (Note Book Pentium-150). The control network is entire electronic that permits to accumulate about of 10^3 radiated oscillation signals coherently. The signal is received by high sensitive geophones and amplified by low noise amplifiers and come to 16-range ADT and indicated by display finally. The success high resolution seismic waves survey of underground water drainage drift is accomplished by using of described set in the field experiments.

With the help of a specialized mobile high-frequency seismic complex created at IAP RAS in 1999 full-scale experiments on active sounding of ground on a site containing engineering facility - draining anti-landslide drive are conducted. The place of experiment is on a bank zone of the Volga-river slope, on which the ground surface goes down (angle with horizon is 30°), and the ground has tendency to landslide, in this connection drainage drives go into the ground on the lower horizon of the slope within the limits of urban building zone. The drive length makes some hundreds of meters, the drive cross section has a kind of a trapezoid slightly narrowed to the top, overall height is 1.8m, width of the lower basis is 1.2 m. The drive is covered with concrete tiles inside.

Problems of seismic monitoring conducting of landslide dangerous regions are very actual now as well as early and attempts to their solution were undertaken many times. Purpose of accomplished experiments is examination of seismic wave survey and vision possibility in application to artificial underground engineering facilities by the use of coherent seismic-sounding complex designated and created in IAP RAS.

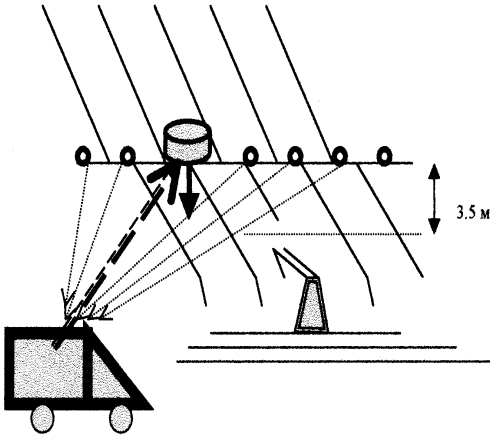

Fig.1.

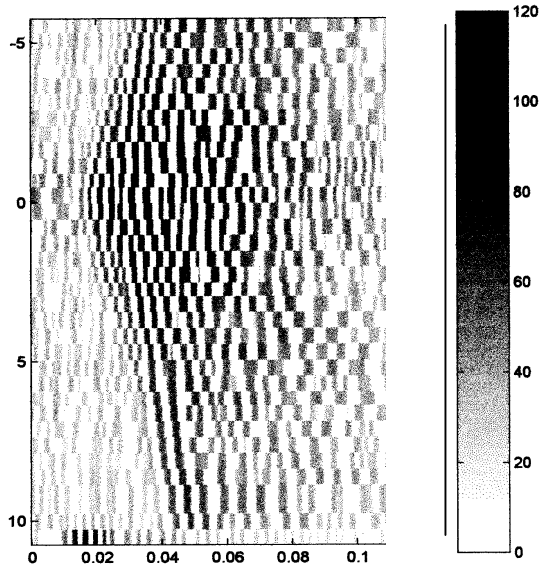

Fig.2.

The transmitting-receiving part of the complex was installed above the drive input (see scheme of experiment on Fig.1), depth along vertical from the nearest point of the receiving linear array to the

drive ceiling is 3.5 m. The array is eight-channel chain of geophones-accelerometers named SPAN, output of preamplifiers of each geophone is connected with the appropriate input of eight-channel ADC. The array is realized of 32 registration points with step of 0.5 m what is possible only due to high degree of coherence of the wave field radiated by the source. The restored on an inclined earth surface projection, of the drive line get on geometric center – the middle of the synthesized aperture consisting of 32 registration points. The source is a vibrator with vertical polarization of alternating force effect is installed on aligned horizontal site (0.3m õ 0.3m) removed by 1m from the receiving array line and shifted from the aperture center to the left by 2.5m. The source effects on ground providing modes of complex signals excitation within operational frequency band from 100 Hz to 1000 Hz with adjustable force which maximum value is 250 N.

Registering and controlling the source equipment which is connected to receivers and the source by electrical cables is installed in the cabin of the automobile located near the drive input. Dynamic registration band that is the difference of levels from a maximum signal registered in a linear mode down to electron noise level recalculated to the input of amplifiers is 100 dB. The registered signals are recorded in memory of PC-Notebook (Pentium 150).

Below we will consider the only results of sounding by tone-pulse signals, though the control equipment and electromechanical construction allow radiating signals of a different kind. Short trains consisting of 3 periods of carrier frequency 300 Hz were used in the described experiment for excitation, the quality of their reproduction by the mechanical construction was checked by means of a vibrosensor - accelerometer fixed vertically on the part of the source which is assumed to be immobile, i.e. in contact with ground. The signal from the indicated sensor was transmitted via a service channel and was also recorded in the computer memory.

Preliminary measurements aiming to evaluate attenuation of useful signal along the path of primary ray have preceded the experiments executed to determine necessary amplification of the input channel. These measurements have shown that the direct ray on frequencies of the order of 300 Hz on distance of 4 ì is attenuated by level of 50 dB; such significant level decrease called by high value of dissipative losses, testifies about the ground structure friability in landslide zone, that is further confirmed by low parameters of propagation speed of corresponding seismo-acoustical waves [2,5].

On Fig.2 the general picture of the wave field registered by the array is shown. The consideration of the general picture of the wave field indicates presence of in-phase axes poorly allocated on a general noise background, corresponding to an entrance of some regularly excited and surface-running waves on the chain of receivers. In the beginning these are the waves running by air (with speed 340 m/s) and registered by the nearest to the source 4 - 5 geophones, than it is possible to allocate two more in-phase axes which are "purely" seismic waves: Rayleigh wave (with speed of 200 m/s) and refracted by some more deep boundary wave (with speed 500 m/s), which are registered by sensors removed from the center of aperture. It’s called to notice the significant decrease of signal levels received by more remoted from the array middle, what is connected with dissipative processes during propagation of seismic waves. In summary the array aperture subjects to a natural apodization, the actual value of the aperture is within 16-meter section: 8m to the left and to the right of the array center. It is necessary to notice, that the irregularities of the surface microprofile and variability of elastic parameters, i.e. fluctuation of the acoustic characteristics of the ground medium from point to point near surface are rather significant. That’s why, it is difficult to select regular differences in the top and bottom halves of the wave field shown on Fig.2 having rather random view, though it is known beforehand, that there is an artificial inhomogeneity in the field of the left-hand wing of the array of receivers.

The focussing procedure on the medium area under the array on depth of the order of 20 m was made using speed value of 200 m/s. The obtained picture is shown on Fig.3 a, b, c, on which the medium section area along depth is shown near the drive vertical cross-section. On Fig.3a the picture of inhomogeneity distribution corresponds to focusing of tone-pulse signals with carrying frequency 300 Hz, on Fig.3b - with frequency of 400 Hz, and on Fig.3c result of multiplication of focusings obtained in two previous cases is shown. The last procedure allows sharpening the inhomogeneity form, though even after it is easy clearly to see additional spots except the main spot corresponding to the drive location within the limits of the focusing area. The additional spots result from the interference or going to and from (scattered on the obstacle) wave types.

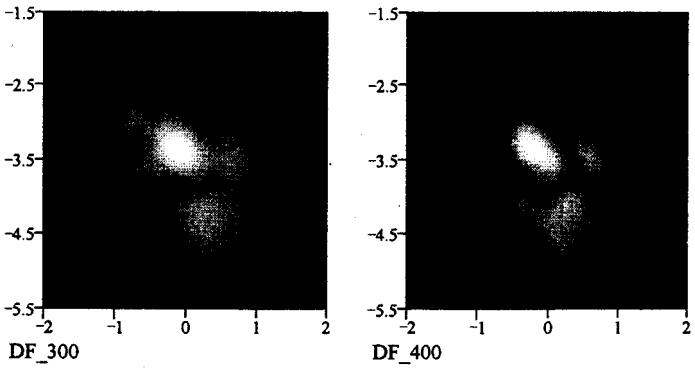

Fig.3. a,b

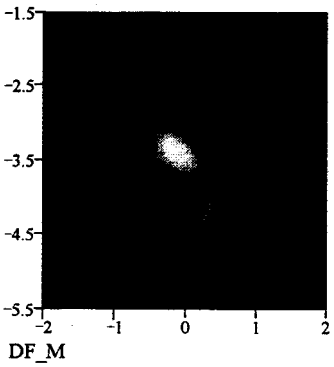

Fig.3. ñ

Thus, basing on conducted experiments on seismic sounding by means of mobile receiving-transmitting complex the conclusion can be made about practical realization ability of visualization of local inhomogeneities on high frequencies of seismic range. The constructed complex provides all stages of sounding, including program - algorithm procedures of processing of registered signal and representations of results as the brightness distribution picture corresponding to character of spatial distribution of physical parameters of the ground medium. Perspective plan of adaptation and modernization of the complex is developed, what will allow further increasing efficiency of its exploitation.

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