IDENTIFICATION OF NONSTATIONARY
CHANGES IN STRESS STATE OF GEOMATERIALS
BY INFRARED RADIOMETRY DATA

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The measurements of intensity of infrared radiation from the surface of rock sample under nonstationary change in stress state are described. The synchronized records of alterations in axial stress of sample under the uniaxial compression and the corresponding time variations in the intensity of infrared radiation from the sample surface are obtained. It is shown that identification of the parameters of elastic oscillations under the action of nonstationary load is reliable.

Geomaterials, stress, time dependences, infrared radiation, probabilistic analysis, nonstationary processes, damping

The up-to-date progress in technologies of high-precision measurements ensures improvement in methods of technical control over geomechanical processes corresponding to the best advantage to features of the object under investigation [1, 2]. Of interest is the development of acquisition and processing systems for data characterizing the state of geomaterials. The physical methods, unconventional for the applied seismology and geomechanics, should be the basis of the systems in question to reveal and predict natural and technogenic hazards in soil and rock masses [1].

In [3–6], the physical foundations are cited for using the alterations in intensity of infrared radiation from the surface of rocks to predict the change in their stress state and identify the mechanical processes proceeding in them. Also, the results of investigations to substantiate the method proposed are presented in these papers. Hence, the procedure for diagnostics of rapid quasi-adiabatic elastic pulsed and continuous periodical time-variations in stress state of geomaterials is concluded to be effective.

It is the infrared diagnostics of time-dependences of geomaterial stress state that holds the greatest practical interest in the study of natural processes. In applied problems, the real dependences of geomechanical parameters on time are simulated through the realization of random processes [7]. Such representation appears to be sufficiently general and efficient. However, the corresponding algorithms to process experimental data are constructed assuming periodicity of the processes under investigation [5, 6]. This is usually employed in seismic signal processing, but potentialities of the procedure to examine real phenomena of change in stresses of geomaterials both under laboratory and in situ conditions are limited.

In case of considerable nonstationary changes in stress state, the investigations should be continued. Below, the experiments are described for the rock sample under conditions of nonstationary wave action when the induced stress variations damped within a finite period of time. Such action was generated by pendulum loading device designed on the basis of soil-testing stand. The changes in the sample stresses were recorded by infrared radiometer and standard strain gage transducer for reference measurements.


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In the experiments under consideration, a sample represented by marble rod 16 cm in height and 17 cm² in rectangular section was subjected to uniaxial compression. The scheme of loading device and the arrangement of sensors are shown in Fig. 1. Sample 1 is between lower immovable 2 and upper movable 3 rigid plates of loading device. Plate 2 is backed by the surface of stand 4. The load is transferred from the upper joist of cross-bar 6 to plate 3 through centering ball support 5. The ends of rope 7 are fastened to the lower cross-bar joist and lever arm 8 at point 9. Thread 12 with load 13 is on the same lever arm at point 11. The distances from 9 to immovable lever axis 10 and from 10 to 11 are \( L_1 = 3 \) cm and \( L_2 = 41 \) cm, respectively. That is, the coefficient of the effort transfer by leverage is \( L_2 / L_1 = 13.7 \). In the experiments, the weight of load 13 ranged from 150 to 300 N. The vertical effort in the axis of pendulum at the end of lever 11 is changed by oscillations of physical pendulum represented by load 13 on thread 12 close to vertical equilibrium position. Through lever 8, rope 7, and cross-bar 6, the effort mentioned is transformed into compressive force applied to the sample. The oscillations are initiated by deviation of thread 12 from the vertical axis. The effort amplitude is governed by varying the load weight and initial deviation of the pendulum. Changing position of load 13 on thread 12, we can alter the period of pendulum oscillations and, consequently, the period of load time-variations. The length of the pendulum or the distance from point 11 to the center of gravity of the load is \( L_f = 0.55 \) m in most experiments, the oscillation period \( T_f = 2\pi (L_f / 9.8)^{0.5} \) [8]. Thereby, the procedure is tested in the range of values of the characteristic period \( T_f = 0.2 - 2 \) s to be noted as the most hazardous for constructions subjected to seismic and other dynamic actions [9].

Infrared radiation sensor 14 with input window 15 was mounted in the middle of the sample 1 – 1.5 cm apart from its surface (Fig. 1). For check measurement of stress variations in the sample, strain-gage element 16 was placed between plates 2 and 4.

The changes in the stress state of rock sample were independently recorded by sensors whose signals were transferred to PC after amplification. Another scheme is based on the use of strain gages glued on the sample surface [6]. Ibidem, the equivalence of these two methods of check measurements is substantiated.

Fig. 1. Scheme of test stand and sensor arrangement