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Influence of Seismic Noises Background Intensity on Waves Propagation Speed

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ABSTRACT

A research of the previous years has shown that on processes taking place in ground has a sufficient influence a background level of own ground microvibrations – microseism. This fact changes a view about ground model, explaining a difference in ground behavior at its studying in laboratorial and field conditions.

In connection with that there was offered a new mechanical ground model that detects not only and influence of mechanical behavior of ground skeleton but also wave processes occurring in it.

Conducted calculations of models shoved that offered ground model allows to describe processes observed in practice and not fitting in frames of the previous models.

To these processes should be first referred such processes as:

- Existence of "unlimited vibrations" of ground points at limited impacts;
- Existence of advantage direction of oscillations propagation for isotopic ground (determined by us as "dynamic anisotropy") and etc.

INTRODUCTION

Studying of the Earth weak high-frequency noises – microseism - led to a new understanding of physics and dynamics of the process occurring in the medium and showed that a classical approach to a description of these events is not always correct. This new understanding is related to the fact that at the level of weak energies you cannot observe the medium as a static object. On the contrary, it has its own field an intensity of which varies depending on changes of its stressed state and model of structure. From the side of our suggested approach to the medium studying the medium stress state and its wave field – are two sides of the same physical event. Existence of background level of the medium stress state is the main factor, which influences on propagation of weak wave fields in it and its energetic transformation. From the side of the classical approach these factors have non-liner character and cannot be described by generally accepted conceptions.

And exactly due to this fact explorers reveal considerable difference in data at studying of the medium behaviour or its separate areas in laboratories and natural conditions. This censers practically any stratum researches in laboratories conditions – speeds of seismic waves propagation as well as ground electrical parameters or its changes at high pressures and temperatures and etc. In order to get the same results in laboratories conditions it is necessary preliminary to place ground samples on vibroplatform so that to imitate, as well as possible, that uninterrupted field of waves which the medium experiences in the natural conditions.

Presence of own wave fields in ground considerably changes our views about real model of ground and processes occurring in it. One of those parameters is speed of seismic waves propagation in already stressed medium.

DETERMINING OF THE PROBLEMS

In order to elucidate background noises influence let's study wave propagation in unlimited medium. The medium will be modelled by elastic, isotropic, homogeneous object. Existence of background noises we will model by presence of variable in time initial stress. Let's suppose that initial stress is described by tensor with components σ_0^{ij} and they don't depend on co-ordinate i.e. the initial stress is homogeneous. Let's look at the problem of wave propagation. Suppose that a displacement the medium points is insufficient and value of additional stress, occurring in this case, is comparable to a value of initial stress. In this case equations of the medium points displacement in a Cartesian coordinates have a form (Washizu K., 1982):

$$\sigma^{kj}_{,j} + \sigma^{ij}_{0} u^{k}_{,ij} = \rho \frac{\partial^2 u^k}{\partial t^2} \qquad (1)$$

where σ^{kj} - components of additional stress, comma - differentiation on co-ordinate, u^k – components of displacement counted out off "natural" state, ρ - density of not deform medium. Initial stress tensor components we will take as in following form.

$$\sigma^{ij}_0 = \overline{\sigma}_i \quad (i = j)\ ; \quad \sigma^{ij}_0 = 0 \quad (i \neq j)\ ;$$

$$\overline{\sigma}_i = \sigma_{0i} + \sigma_{1i} \sin \omega t$$

where σ_{oi} – the main value, σ_{1i} - amplitude, ω – frequency of initial stress oscillation. Accepted view indicates that initial stress is orthotropic. Taking into account Hooke's law, which describes a medium, in system (1), we have:

$$(\lambda+\mu)\frac{\partial^2 u_i}{\partial x_k \partial x_i} + \mu\frac{\partial^2 u_k}{\partial x_j^2} + (\sigma_{0i} + \sigma_{1i}\sin\omega t)\frac{\partial^2 u_k}{\partial x_i^2} = \rho\frac{\partial^2 u_k}{\partial t^2} \qquad (2)$$

where λ and μ - Lame parameters. Received system of equations is a system of three differential equations in partial derivatives in relation to u_k. Boundary conditions for solution of this system are not taken because the medium is unlimited. However, it is supposed that solution at infinity has to be limited. Initial conditions are not taken also, because a periodical solution is being looked for.

SOLUTION TO THE PROBLEM

The solution to the received system we will look for in a form of a plane wave. Due to altemation of system (2) equation coefficients the solution will be:

$$u_k = e^{iqn_\alpha x_\alpha}\left(A_{ok} \sin qct + A_{1k} \cos qct\right) \qquad (3)$$

where q – quantity, inverse to wave length, n_α - components of vector normal to a wave plane, c - wave propagation speed, A_{ik} - amplitudes. We will note that if c - real number, then the displacements are limited and amplitude – constant (harmonic vibration), if c – complex number, then displacement amplitude changes in time. We will take into account (3) in system (2). After orthogonalization of equations, in respect to A_{ik} we receive a system of liner, algebraic, homogeneous equations. For existence of nontrivial solution it is necessary that determinant of that system is equalled to 0. This condition allows determining *c* value. There are two, not equalled to each other, values of that kind i.e. there are two types of waves. Their speed is determined by following equations:

$$c^2 = c_1^2 + c_0^2\ ; \quad c^2 = c_2^2 + c_0^2 \qquad (4)$$

where $\quad c_1^2 = \frac{\mu}{\rho}\ ; \quad c_2^2 = \frac{\lambda + 2\mu}{\rho}\ ;$

$$c_0^2 = \frac{\sigma_{0i} n_i^2}{\rho} - \frac{1}{2\rho}\sigma_{1i} n_i^2\left[-\left(J_\beta + J_\eta\right) + \sqrt{\left(J_\beta - J_\eta\right)^2 + 4J_\gamma^2}\right]$$

where J_η, J_β, J_γ – integrals depending on ω and q. c_i – speeds of plane wave propagation in unlimited medium at an absence of the initial stress. From (4) it is seen that at $\sigma_{0i} = \sigma_{1i} = 0$, two found values of speed concurs with classical (Clough R., Penzien J., 1975).

ANALYSIS OF SOLUTION

Value of c_o – depends on initial stress parameters and they can be selected so that $c^2 > 0$. In that case the plane wave is a harmonic and its amplitude is limited. Analysis of (4) shows that there are such values of initial state at which $c^2 < 0$. In that case the plane wave amplitude changes in time, moreover it increases unlimitedly. In case where initial state does not depend on time ($\sigma_{1i} = 0$) $c_0^2 = \frac{1}{\rho} \cdot \sigma_{0i} n_i^2$.

As is shown in (S. Kerimov), account of alternation of initial strain in this case leads only to quantitative changes. It is necessary to mention that in contrast to a classical case a wave speed depends on n_i, i.e. on propagation direction, which points to an existence of a preferable direction of propagation: this direction is determined by a minimum of spent energy. At comparing of solution, made by S. Kerimov and brought in this work, it follows that variability of initial state can lead not only to a quantitative but to a qualitative changes: existence of waves with increasing amplitude in time. Apart from that, at making analysis of (4) there was shown an existence of such kind of initial state parameters σ_{0i}, σ_{1i}, ω (at a fixed n_i value) at which a wave can be propagated with different speeds depending on initial stress. We will mention that for that case it is necessary to account of alternation of initial stain.

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