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Change of Acoustic Properties of Soils During Physical Modeling of Unstable Slopes

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Investigations of the acoustic properties of moist soils during its shear deformation were carried out. Experiments were performed on the samples of sand, clay and loamy soil. The experimental technique has allowed to model a slope processes with continuous acoustic measurements in the investigated soils.
For slope process simulation the shear box with the soil was placed slantwise on the fixed base and its top part was influenced by the vertical load. As a result the shear stress appeared in the median part of the sample, whereas the normal component of the load didn't impress directly to sample, but it blocked possible dilatant expansion of soil owing to shear deformation. Ultrasonic source was located on the box bottom and ultrasonic receiver was placed on its cover. Such design allowed to measure soil acoustic properties along the perpendicular to shear plane direction.
For all the samples we observed accelerating displacement of the top part of shear box relative to its bottom part during quasi-linear increasing of load with time up to shear failure of the soil. At the same time acoustic properties of clay and loamy soil on the one hand and sand on the other hand have changed with the growth of shear stresses in different ways. In plastic clay and loamy soil P-wave amplitude and velocity decreased with shear stresses increasing. In contrast to more plastic materials velocity and amplitude of P-waves in the sand increased with the growth of shear stresses. In all cases, the most dramatic changes took place directly before failure.
Anomalous changes of sand acoustic properties can be associated with its dilatant hardening during shear deformation – in cramped shear deforming conditions the sand tends to increase its volume, but the normal component of the load blocks this process. In addition, thin water films are squeezed from sand particles surfaces making its contacts harder. An argument in support of such mechanism is that when the sand is deforming in not cramped conditions, its behavior is similar to plastic soils, since the change of volume isn't meet with opposition of the external medium. Spectral characteristics of propagating through different soils P-waves also have features. With the growth of shear loads in clay and loamy soil P-wave pulses become more low-frequency, but in the sand they become more high-frequency.
Dilatant nature of anomalous changes of sand acoustic properties is confirmed by experiment with separate changes of shear and normal (confining) loads, impressed to horizontally installed shear box. When normal confining load is constant, quasi-linear increase of shear load leads to growth of P-waves velocity and amplitude. Following reduction of normal load leads to decline of these parameters and subsequent shear failure of the sample.
Experiments have shown that acoustic parameters have high sensitivity to changes in the different soil during shear failure deformation. This fact allows us to hope on the possibility of using elastic waves kinematic and dynamic parameters for slopes stability estimation and short-term forecasting landslide phenomena activation.