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Variation of Biot wave properties in fluid-saturated porous media with decrease of skeleton-stiffness

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ABSTRACT In this paper, various characteristics of the Biot waves in fluid-saturated porous media are examined numerically and analytically based on the relations in the previous paper (Kitsunezaki, 2004a), whose notation is also kept here. The Biot waves mean elastic waves in the Biot theory (Biot, 1956), which consist of two longitudinal waves (I-and II-waves) and a transverse wave. The main aim of this study is to reveal general variation tendency of characteristics of the longitudinal waves in wide range of sediments, typically from consolidated stiff sandstone to unconsolidated loose sand, mainly in connection with variation of skeleton-stiffness, which is represented by the velocity ratio in P-wave of skeleton to sound wave in fluid, V_{Pb}/V_f. In the wave characteristics, special attention is paid to displacement ratios and stress ratios in fluid to solid, as well as velocities and attenuation (logarithmic decrements). The both ratios are key factors to understand propagation mechanism of the two longitudinal waves. Main points of this study are as follows. First, general feature of the above properties is viewed as functions of frequency and skeleton-stiffness. The frequency characteristics are examined for typical two models of media with hard and soft skeletons. The properties in the low and high frequency limits are remarked to examine the effects of skeleton-stiffness. Second, approximate expressions of the characteristics are derived for media with very low skeleton-stiffness ($V_{Pb}/V_f << 1$), which almost corresponds to loose alluvial sand, in order to clarify factors controlling wave properties. Third, dynamic process in the media with very low skeleton-stiffness is analyzed. Then the results are represented as schematic models of stress-strain relations which demonstrate clearly the contrastive properties of I-and II-waves. In all examinations

mentioned above, such a reciprocal relation between the two longitudinal waves is remarked as a useful general law, that the displacement ratio of I-wave in fluid/solid is equal to the opposite value of stress ratio of II-wave in solid/fluid, where I and II are mutually exchangeable.

Key words: Biot theory, porous media, longitudinal waves, reciprocal relation, dynamic compatibility

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