ONLINE ISSN : 1881-4824
PRINT ISSN : 0912-7984

BUTSURI-TANSA(Geophysical Exploration)
Vol. 58 (2005) , No. 4 pp.319-329

Key properties underlying the characteristics of two longitudinal waves in Biot theory

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(Manuscript received February 21, 2005)
(Accepted June 28, 2005)

ABSTRACT In fluid-saturated porous media, contrastive characteristics of two longitudinal waves (I- and II-waves) are usually remarked, based on the Biot theory (Biot, 1956). These characteristics are connected by some relations, or controlled by common factors. A little attention has been paid to such properties, although they are keys to promote our understanding for various aspects of the wave phenomena. In such a point of view, we take up the following three properties, which were remarked in the previous papers by the author (Kitsunezaki, 2004, 2005a), but not fully discussed. The first is the reciprocal relation between displacement ratio and stress ratio of two longitudinal waves. The reciprocal relation in this case means that displacement ratio of fluid/solid in I-wave is equal to the opposite value of stress ratio of solid/fluid in II-wave. This relation was found in numerical calculations in the previous paper (Kitsunezaki, 2005a). We prove it analytically in this paper. This relation has wide applicability, and is used in discussion of the following items. The second is energy transmission ratio between solid and fluid in two longitudinal waves. A reciprocal relation is also confirmed in energy transmission ratio. It is held strictly in low- and high- frequency limits, but only approximately in the whole frequency range because of the phase differences between stress and particle velocities. The reciprocal relation in this case means that energy transmission ratio of fluid/solid in I-wave is equal to that of solid/fluid in II-wave. The third is the dynamic compatibility, which means that the relative motion between solid and fluid in I-wave disappears in the medium that satisfies a certain condition. The significance of this condition is discussed based on a relation between phase velocities and the relative motion of fluid and solid. Practical condition for dynamic compatibility is demonstrated in a graph, according to which the corresponding skeleton

stiffness is increased with the decrease in porosity.

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

doi:10.3124/segj.58.319
JOI JST.JSTAGE/segj/58.319