Finite deformation and the influence of external stress on elasticity of solids

Toru Ouchi[1]

[1] Research Center for Urban Safety and Security, Kobe University

The influence of external stress on elasticity of solids that appear as initial stress and strain is quite important subject and needs the theory of higher order elasticity (e.g., Poincare, 1892; Brillouin, 1925). In the case of hydrostatic compression, this influence on the shear wave velocities is represented as d∗Vs2=G-P+e∗(negative effects of third order elasticity), where Vs2, d and G are square of the shear wave velocity, density and rigidity. Similar situation holds for longitudinal waves. P (positive) and e (negative) show initial hydrostatic pressure and strain. These are also regarded as external and internal effects and they are different in the frame work of higher order elasticity. In general, P reduces elastic wave velocities whereas e increases them. P comprises of the terms of thermal, hydrostatic and external stress, respectively. Most conventional arguments deal with first two effects. The last one is due to inelasticity of solids as plastic properties and intrinsic configuration of solids and has been missed in many relevant studies. Indeed, once this influence is introduced entire elastic nature of solids is changed. If the initial strain or internal pressure dominates, the wave velocity increases as we usually observe in laboratory experiments. However, for some reason, when the initial or external pressure becomes large, the velocity decreases, that might occur under large plastic deformation or some peculiar structure of solids. Importance of plastic deformation under high pressure conditions was stressed by Bridgman (1952) but has been little considered in high pressure studies on elasticity of solids. We cannot investigate the elastic properties of solids without evaluating inelastic nature of solids appropriately.