Internal deformation fields due to an arbitrary indigenous source in an elastic-viscoelastic layered half-space

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We obtained general expressions of internal deformation fields due to an arbitrary indigenous source in a two-layered elastic-viscoelastic half-space by using the source description in moment tensor, solving the elastic problem with a generalized propagator matrix method, and applying the correspondence principle in linear viscoelasticity to the elastic solution.

First, from the expressions of displacement fields caused by a single force in an infinite elastic medium in Cartesian coordinates, we derived the general expressions of displacement fields caused by an arbitrary indigenous source in cylindrical coordinates. Next, using these expressions and applying a generalized propagator matrix method, we obtained the general expressions of internal deformation fields caused by a moment tensor in two-layered elastic half-space. In general, an arbitrary indigenous source described by moment tensor can be decomposed into three independent source processes: explosions, crack opening and shear faulting. Among them, we have already obtained the solution of shear faulting. For the explosion source and the opening crack, this is the first success in obtaining the expressions of internal deformation fields. Applying the correspondence principle in linear viscoelasticity to the elastic solution, we finally obtained the general expressions of internal deformation fields caused by an arbitrary indigenous source in an elastic-viscoelastic layered half-space.

With the general expressions obtained in the present study, we numerically calculated the responses of an elastic half-space, a two-layered elastic half-space and an elastic-viscoelastic layered half-space to the three different types of indigenous sources: isotropic explosions, horizontal crack opening and vertical shear faulting. From the comparison of these numerical results, we obtained the following conclusions. (1) The displacement field of the two-layered elastic half-space shows a similar pattern to that of the elastic half-space, except for minor difference near the interface between the surface layer and the substratum. (2) The instantaneous response of the elastic-viscoelastic layered half-space is identical to the response of the two-layered elastic half-space. On the other hand, the response of the elastic-viscoelastic layered half-space after the completion of stress relaxation in the viscoelastic substratum is essentially different from that of the two-layered elastic half-space. It behaves like an elastic plate floating over fluid. Such a difference is remarkable especially in the case of the horizontal crack opening. (3) In the problems of viscoelastic deformation, the effect of gravity, which restores long-wavelength vertical deformation to an initial equilibrium state, is essentially important.