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Displacement and stress Green's functions for a constant slip-rate on a quandrantal fault

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In numerically calculating the elastodynamic field created by slip on a fault in a 3-D medium, the fault plane is often discretized into a set of small rectangular elements, on each of which the slip is assumed to follow certain types of spatio-temporal variation profiles. One of the simplest and most popularly used categories of such assumption is that of the so-called 'piecewise-constant slip-rate', which states that the slip-rate takes a constant value everywhere and at every moment within a given rectangular element and within a given discrete time window. The elastodynamic field in the medium can then be calculated by convolving the discretized spatio-temporal profile of the fault slip with the Green's functions corresponding to a constant slip-rate that takes place on each discrete fault element within each discrete time window.

In mathematical terms, a constant slip-rate profile on a discrete space-time element with a rectangular shape can be synthesized by a superposition, with appropriate offsets in space and time and with appropriate sign reversals, of eight identical profiles of slip-rate that takes a constant value everywhere on a quadrantal part of the fault and at every moment after the onset of slip (e.g. Fukuyama and Madariaga, 1998). In the present study I have derived rigorous expressions for the Green's functions which represent the displacement and stress response of an infinite, homogeneous and isotropic medium to a constant slip-rate on a quadrantal fault that continues perpetually after the slip onset.

The displacement Green's functions were derived by two independent methods; direct evaluation, in the time domain, of relevant integral equations given by Tada, Fukuyama and Madariaga (2000), and the Cagniard integral method proposed by Madariaga (1978). All components of the Green's functions are expressed by linear combinations of just four different sorts of functions with relatively simple form, plus Heaviside step function terms representing instantaneous response.

I also substantially simplified the expressions for the stress Green's functions that Aochi, Fukuyama and Matsu'ura (2000) had obtained earlier. I have found out that all components of the stress Green's functions can be expressed by linear combinations of just five different sorts of functions with relatively simple form, plus Heaviside step function terms representing instantaneous response. The same expressions were obtained by differentiating the displacement Green's functions with respect to space coordinates. The new and simplified expressions are expected to help reduce the computation time required in numerical simulations of fault dynamics.

Two quadrantal planes make a half-plane when welded together. Using this fact, I verified the consistency of the 3-D Green's functions with their 2-D counterparts obtained earlier by Tada and Madariaga (2001).