Fling-steps displacements by the discrete wavenumber method

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The discrete wavenumber method introduced by Bouchon (1977, 1981, 2003), provides a way to accurately calculate the complete Green’s functions for many problems with a minimum amount of mathematics, and it is appropriate to represent the seismic waves by the summation of plane waves in the wavenumber domain for each frequency. However, there are still some problems to be solved by adoption of this approach in several specific cases. For example, the effects of imaginary part of complex frequency and the truncation of wavenumbers on near-fault fling-steps displacements.
For the first one, it advantages that a complex frequency with a small positive imaginary part is introduced in Bouchon (Bouchon, 1979) to solve the problem of integrand becomes zero when obtaining the near-fault ground motions. The determination and effects of the imaginary part of the complex frequency as defined by $\omega_c=\omega-\lambda i$, the values of λ in the range of $\lambda=[\pi/2T\omega,\ \pi/T\omega]$ recommended by Bouchon (2003) is still not clear. Therefore, in order to obtain more accuracy displacement waveforms, trail and errors have been conducted on near-fault fling-steps displacements under various point source models and it resulted that, $\lambda=2\pi/T\omega$ rather than $\lambda=\pi/T\omega$ can be recommended, (the displacement waveforms of dip-slip case under various could be obtained in Figure 1 below).
In terms of the second parameter, since for the near-fault displacements, in which seismic source and stations are located at a nearly same depth or at very low frequency range, the convergence of integration or summation over wavenumbers becomes very slow, the truncation of wavenumbers in such a case should be determined carefully. The use of $k_{max}=4k_\alpha$ was recommended (Bouchon and Aki, 1977), where $k_\alpha=\omega/\alpha$ and α stands for the P wave velocity. And the pioneering work of Honda and Yomogida (2003) addressed the issue of appropriately setting this parameter for the simulation of fling-step displacements by testing the accuracy of the fling-step displacements calculated through the DWN method by comparing the results with the analytical solutions for the static displacements (Okada, 1985) and proposed to use $k_{max}=4\ km^{-1}$ in the low frequency range. However, their study was focused on cases where a large amount of seismic moment is released at several kilometers under the surface. In this research, aimed at establishing a criteria for the k_{max} value applicable even for the shallow slip cases, based on the solutions in complete elastic wavefield, the truncation wavenumber was deduced related to the source depth dependent theoretically. And $k_{max}=5\pi/Z_s$ was recommended, where Zs is the depth of the source. The criteria for k_{max} was fully verified in the various point source model and the resultant displacements showed good agreements with analytical solutions (Okada (1985), which are illustrated in the following Figure 2).

Keywords: fling-steps displacements, discrete wavenumber method, complex frequency, point source depth dependent truncate number of the wavenumber integration, point source models

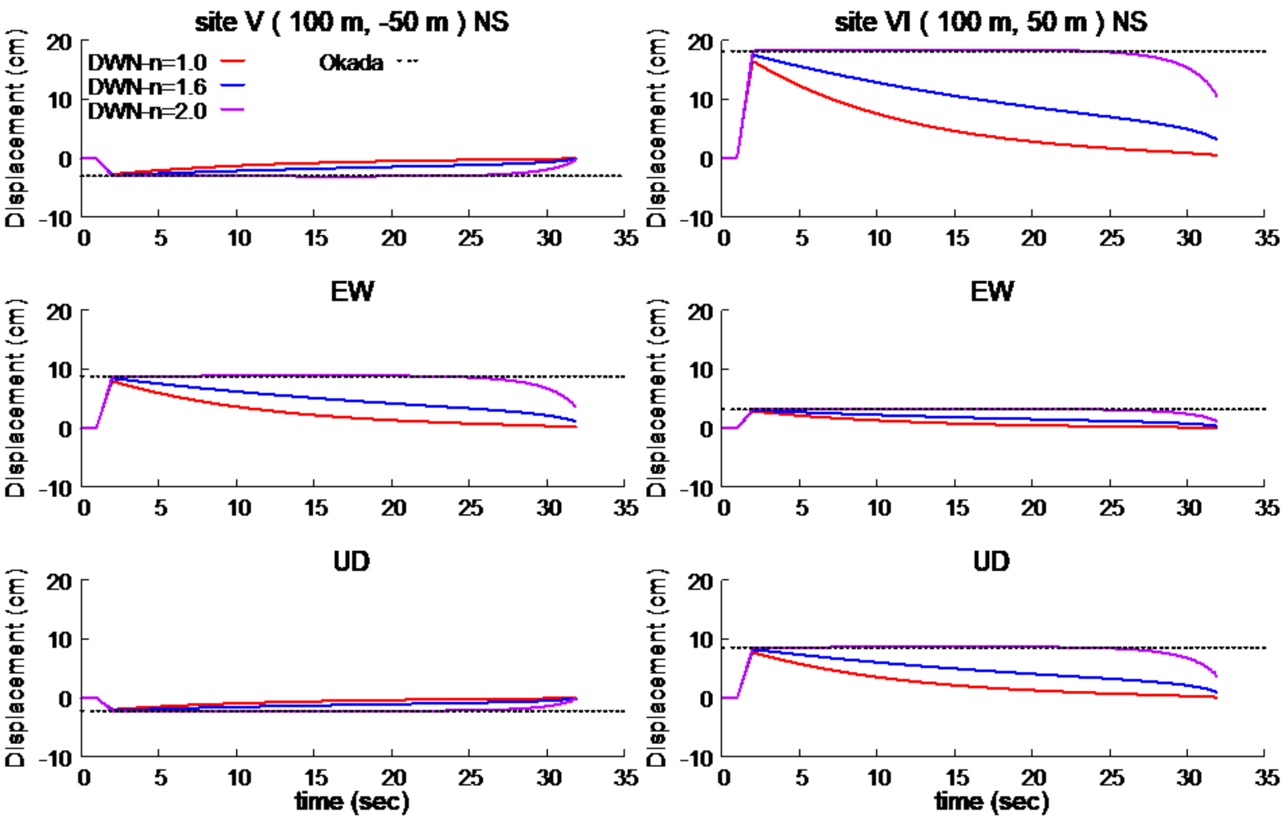

Figure 1 Dip-slip (dip45°): effects of complex frequency (i.e., n-value) on the near-fault fling-steps displacement

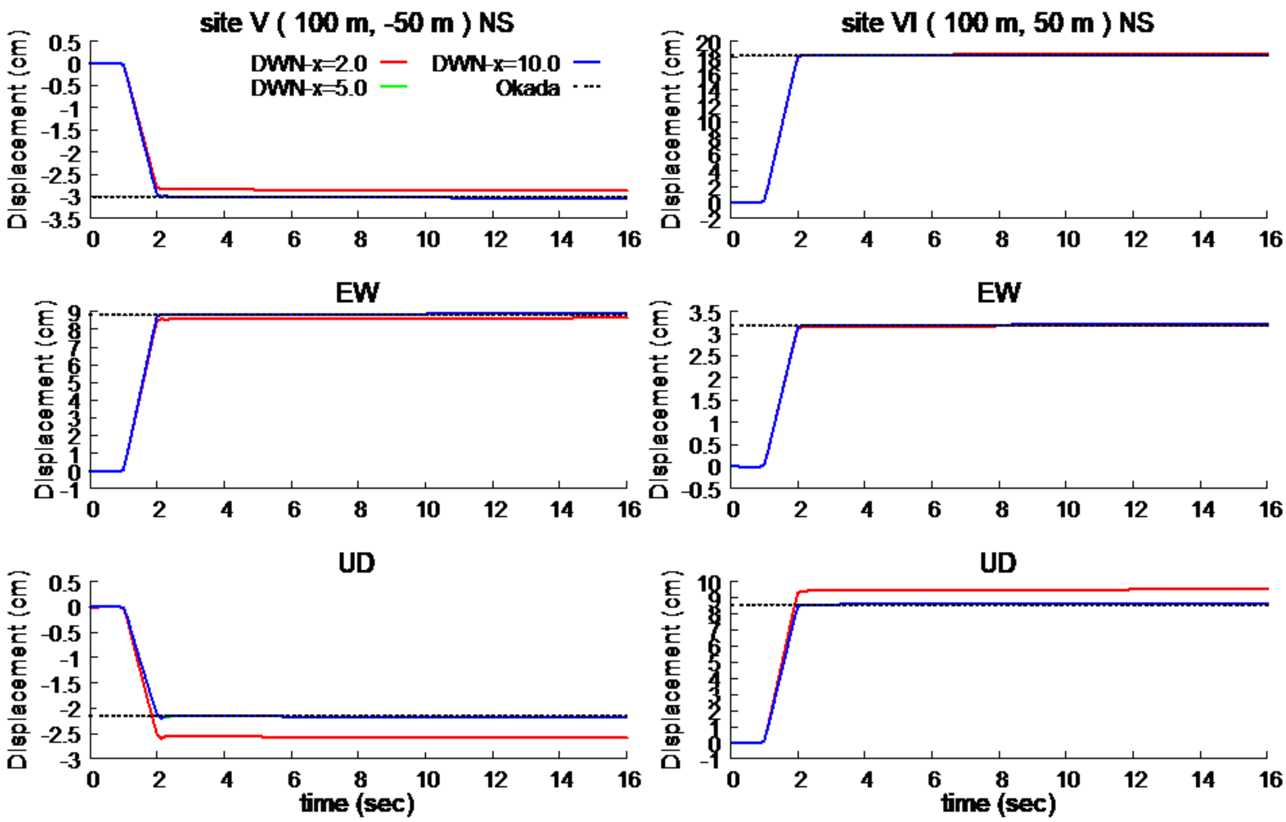

Figure 2 Dip-slip (dip45°): effects of point source depth dependent truncate wavenumber (i.e., x-value) on fling-steps displacements