S047-P006 Time: May 26 17:15-18:45

Simulations of SH waves scattered by 2-D cracks using the finite difference method

Yuji Suzuki[1], Jun Kawahara[2], Taro Okamoto[3]

[1] Grad. School of Science and Engineering, Ibaraki Univ., [2] Dept. Environmental Sciences, Ibaraki Univ., [3] Dep. Earth Planet. Sci.,

Tokyo Institute of Technology

When one synthesizes waves scattered by cracks, the boundary integral equation method (BIEM) may be popularly used (e.g., Murai et al. [1995]). Here we try instead to apply the finite difference method (FDM) to the same problem. Concerning the simulations of crack scattering, FDM is often considered to be less reliable than BIEM in terms of accuracy, though it has some advantages; e.g., it is easy to implement in computer codes, and it can handle cracked media with additional inhomogeneities. In this study, we synthesized SH waves scattered by 2-D parallel cracks using FDM and compared them with those by BIEM, thereby examining its accuracy and practicability. We also show some applied examples.

We adopted a standard velocity-stress finite-difference scheme with the accuracy of 4th (or 2nd) order in space and 2nd order in time (Viriuex[1984], Levander[1988]). All the cracks were assumed to be parallel and to have the same length, 2a. A stress-free condition was imposed on the crack surfaces, that was realized by just keeping the stress on the grid points corresponding to the crack locations being zero. The FDM results were compared with those by BIEM developed by Murai et al.[1995], of which accuracy we took special care.

We performed three tests. First, we calculated the displacement discontinuity along a single crack caused by incident quasi-monochromatic waves using 4th-order FDM. The obtained results appear to approach to values somewhat smaller than those by BIEM as the grid interval decreases. This discrepancy was removed when we used 2nd-order FDM instead. This is explained by the difference in the nonlocality of the finite-difference operators. Second, we made plain Ricker wavelets (with the dominant wavelength a/0.6) be incident on clustering several cracks and synthesized scattered waves at somewhat distant (greater than 4.5a) points by 4th-order FDM (with the grid interval a/40). Here the intervals between the cracks in the normal direction were 2 to 10 grid intervals. It was shown that the numerical errors (the residuals between the FDM and BIEM results) seem to increase gradually as the crack number increases maybe because of enhanced multiple scattering, though they remain sufficiently small for all the cases considered. Third, we carried out the same experiments as Murai et al.[1995] did using both FDM and BIEM. They measured the averages of the scattering Q and the phase velocity, V, of direct SH waves propagating through cracked media, and showed that the results agree with the predictions of the single scattering theory (Kawahara & Yamashita [1992]). Here we reconfirmed the agreement among the estimates by FDM, BIEM and the theory. In summary, FDM was shown to be a practical method to calculate the scattered waves by cracks.

We finally applied FDM to the measurement of the mean Q and V again, though this time we adopted the method proposed by Kawahara et al. (2002), who treated the scattering by 2-D circular cavities. The method has been shown to be stabler and more accurate than that of Murai et al.[1995]. The results thus obtained highly agree with the predictions of single scattering theory (Figure), suggesting the validity of the theory again.

Acknowledgment. The BIEM code is provided by Dr. Yoshio Murai (Hokkaido Univ.).

References

Kawahara, Ohno and Yomogida, 2002, JEPS 2002 Joint Meeting, Program, S044-005.
Kawahara and Yamashita, 1992, Pure Appl. Geophys., 139, 121-144.
Levander, 1988, Geophysics, 53, 1425-1436.
Murai, Kawahara and Yamashita, 1995, Geophys. J. Int., 122, 925-937.
Viriuex, 1984, Geophysics, 49, 1933-1957.

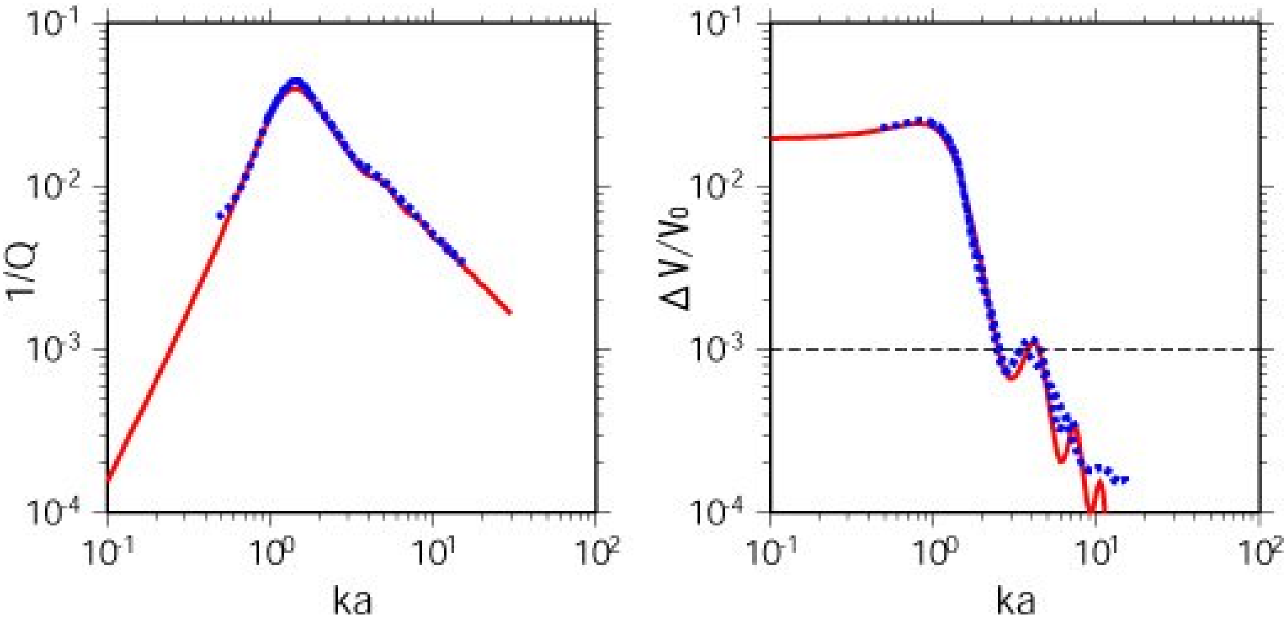

Figure. $1/Q$ (left) and relative decrease of the phase velocity (right) of SH waves due to crack scattering. Here k is the wavenumber and a is the crack half length. The crack density is 0.0125. The red solid and blue dotted curves indicate the theoretical and experimental estmates, respectively. The black broken line denotes the "measuring resolution", corresponding to phasedelay of one time step in the simulations.