Calculating Rotational Ground Motions by Finite Difference Method

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Main Point: A way to obtain the rotational components indirectly.

Background

- The ground motions caused by earthquakes include not only translational motions, but also rotations (Lee et al.,2009).
- At present, there are two methods to obtain the rotational ground motions. One is to calculate the rotational components with the translational components indirectly, the other is to record the rotational components directly with rotational sensors (e.g., Nigbor, 1994; Takeo, 1998; Huang et al.,2006).
- The methods used to calculate the rotations by translational components include the finite difference methods and the travelling-wave method mainly, among which the finite difference method is simpler and easier to be realized.

Simulated data

- We established a horizontal layered isotropic homogeneous model (Fig.1) and got the simulated data.
- We compared the waveforms between the finite difference method and the simulated data(Fig.2).

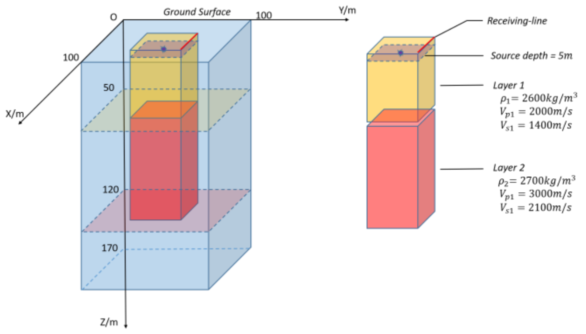

Fig.1 Horizontal Layered Isotropic Homogeneous Medium

Model Size：40m×40m× 120m
Source Type：expansion source
Wavelet Dominant Frequency：120Hz
Grid Spacing：1m
Sampling Interval：$dt = 0.0001s$
Recording Time：$t_{max} = 0.1s$
Boundary：Splitting Perfectly Matched Layer (SPML)

Table 1 Correlation coefficient of waveforms between the finite difference method and the simulated data

Rotational components	R_X	R_Y	R_Z
Correlation coefficient	0.987	0.989	0.271

We can draw some conclusions:

- The R_X and the R_Y calculated by the finite difference method are in good agreement with the simulated data in the first arrival time and the waveform.
- The R_Z calculated by the finite difference method doesn't fit the simulated data well in the first arrival time and the waveform.

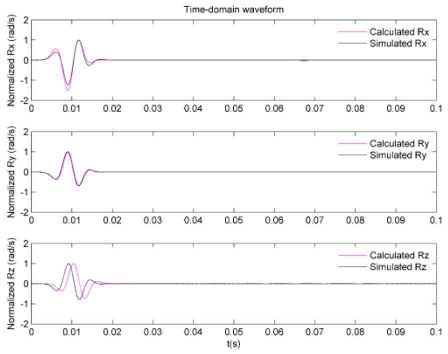

Fig.2 Waveform comparisons of the finite difference method and the simulated data

The improved finite difference method

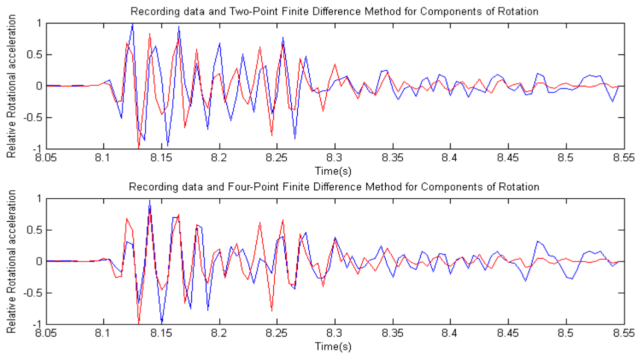

Fig.3 Waveform comparisons of the finite difference method and the improved finite difference method

- The recording six-component seismic data is used in this study(Lin et al.,2008).
- We compared the Rx calculated by the finite difference method with the one calculated by the improved finite difference method (Fig.3). By comparing the waveform of the finite difference method with that of the improved finite difference method, it can be found that the improved finite difference fits the recording rotational components better.
- For time-domain waveform, the correlation coefficient between the value calculated by the finite difference method and recording data is 0.5779, while that calculated by the improved finite difference method and recording data is 0.72.

- Further, the amplitude spectrum comparisons are considered(Fig.4).
- From the amplitude spectrum, it is found that the improved finite difference method is more consistent with the recording data on the whole, especially in the high frequency of 43Hz, which is the prominent frequency of the rotational sensors (Lin et al., 2009).
- the correlation coefficient between the value calculated by the finite difference method and recording data is 0.86, while that calculated by the improved finite difference method and recording data is 0.88.

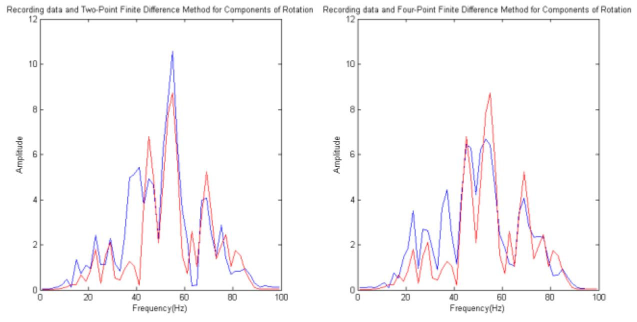

Fig.4 Amplitude spectra comparisons of the finite difference method and the improved finite difference method

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