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Response Characteristics of Strain Seismograph at Matsushiro Seismological Observatory

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At Matsushiro Seismological Observatory, JMA, continuous observation of crustal movement has been performed by 100-meter-long 2-components quartz-tube extensometers. These extensometers have been able to be used as a wide dynamic range and very broadband seismograph by renewal of telemeter system in 2001 (Wakui et al., 2002). It is important to confirm the accuracy of the amplitude of the records from this strain seismograph before analysts use them for seismological applications. In the present study, we investigate the response characteristics of the strain seismograph to long period surface waves in a period range of 150-500sec.

First, we examined an amplitude ratio of EW to NS component strain for a Love wave. Theoretically, two seismograms from 2-component extensometers perpendicular to each other have the same amplitude for a Love wave traveling in any direction (Benioff and Gutenberg, 1952). We verified this fact for theoretical strain seismograms, which were synthesized based upon the normal mode theory (Gilbert and Dziewonski, 1975), by superpositon of eigenfunctions with periods longer than 45 sec. The Earth model PREM (Dziewonski and Anderson, 1981) and Harvard CMT solutions were adopted in the synthesis. In the calculation of the amplitude ratio, we first obtained spectrograms by applying the multiple filter technique (Dziewonski et al., 1969) to both EW and NS component strain seismograms and then took their ratio. Although we performed the same analysis for the observed seismograms, the ratios of EW to NS component strain for Love waves from Peru Earthquake of Jun. 23, 2001 and from Macquarie Islands Earthquake of Dec. 23, 2004 were 0.7 in the period range of 150-500sec.

Next, we examined an amplitude ratio of a strain to a velocity seismogram recorded with STS-1 seismometer also installed at Matsushiro. A ratio of a partial derivative of a displacement field with respect to time to that with respect to wave propagation direction equals a phase velocity of the wave theoretically (Mikumo and Aki, 1964, Sacks et al., 1976). We verified this fact for theoretical seismograms again. The way of obtaining the amplitude ratio is same as above analysis. Utilizing the fact, we estimated phase velocities of surface waves using observed velocity and strain seismograms after NS component strain had been multiplied by 0.7, and compared them with theoretical phase velocities. The result was 20% smaller for Love wave from Macquarie Islands Earthquake of Dec. 23, 2004 and 55% larger for Rayleigh wave from Sumatra Earthquake of Mar. 28, 2005 than the theoretical phase velocity.

Finally, we examined amplitude of a velocity seismogram recorded by STS-1 seismometer, by comparison with other velocity seismograms recorded by STS-1 seismometers at F-net observation stations near Matsushiro and by STS-2 seismometer at Matsushiro, and found that the every deviation from the record by STS-1 at Matsushiro was less than 10%, in the period range of 150-500sec.

From the results described above, we conclude as follows:
1. EW and NS component strain records are 20-30% and 70-80% larger than regional strain for Love wave, respectively.
2. EW component strain record is 30-40% smaller than regional strain for Rayleigh wave.
3. The response characteristics are not remarkably dependent on frequency, in the period range of 150-500sec.

These facts, which may be because of local geology and/or topography effects, must be taken into account when analysts use the strain seismogram for seismological applications such as CMT inversion.

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