CORRELATION BETWEEN SEISMIC VIBRATION PARAMETERS AND TYPE OF FAULTING

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Summary. The results of a comparison of the seismic motion parameters during earthquakes with different source mechanism are described. About seventy strong motion records of the earthquakes with known type of faulting were examined. The greatest difference between seismic vibration parameters is observed for contraction- and dip-slip faulting. The acceleration amplitudes in epicenter area for the contraction faulting are 2.5 times larger than ones for the dip-slip faulting. The other seismic motion parameters, such as frequencies, durations, polarization characteristics, also depend on the faulting type.

Recently to predict ground motion the expected earthquake magnitude, corresponding distance and local topographic and soil conditions are taken into account. Many theoretical papers show the dependence of seismic motion parameters on the earthquake mechanism, but theoretical estimations have very low accuracy because they depend on numerous medium and source parameters, many of wich are unknown. For this reason the combined examination of experimental data for strong ground motion and source mechanism is of special interest. The present work is one of the first attempts of this kind. During our investigation we took into account the general consideration on the influence of different factors on seismic motion:

The friction on the rupture surface may be significantly depend on the type of stress (compression or extension). This may influence all the seismic motion parameters.

It is known, that earthquake source size and deformation depend on source mechanism [Nur et al., 1973; Kasahara, 1975]. Many investigators have found that the rupture zones for thrust and normal faulting are larger, than for strike-slip faulting. This phenomenon may influence amplitude level in epicenter area and duration of seismic vibrations.

According to last publications the rupture speed is about 3.3 km/s for thrust and about 2.2 km/s for strike-slip and normal faulting. This difference may change the relation between the regular and diffuse components of the radiation and, consequently, may influence the shape of seismic vibrations [Kopnichev et al., 1979].

The gravity forces play a different part during uplift, strike-slip and dip-slip and this may appear in the seismic vibrations's characteristics.

The source forces orientation may appear in the polarization characteristics of seismic motion.

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According to these general considerations we have measured the following parameters on strong motion accelerograms:

1. A_o/A_e - the ratio of the maximum observed acceleration and expected value of acceleration for given earthquake magnitude and hypocentral distance;
2. T_o/T_e - the ratio of the observed period corresponding to maximum acceleration amplitude and expected value;
3. d_o/d_e - the ratio of the observed relative duration of seismic vibration and expected value; the relative duration is determined as the time interval during which the acceleration envelope is greater than or equal to 0.5 A_o [Aptikaev, 1977];
4. A_h/A_v - the ratio of the maximum amplitudes observed on the horizontal and vertical components;
5. T_h/T_v - the ratio of the periods corresponding to maximum amplitudes on the horizontal and vertical components;
6. d_h/d_v - the ratio of the relative durations on the horizontal and vertical components.

The expected values of maximum acceleration amplitude A_e, period T_e and relative duration d_e correspond to mean empirical estimations using many hundreds of strong motion accelerograms from different regions of the Globe. The earthquake magnitude and hypocentral distance were taken into account by computing of the expected values. Other parameters, such as local topographic and soil conditions, were neglected. The results were approximated with the following empirical formulas:

$$\log A_e(\mathrm{cm/s^2}) = \begin{cases} 0.28\ M - 0.8 \log R(\mathrm{km}) + 1.70, & A_e \geqslant 160\ \mathrm{cm/s^2}, \\ 0.80\ M - 2.3 \log R(\mathrm{km}) + 0.80, & A_e < 160\ \mathrm{cm/s^2}; \end{cases}$$

$$\log T_e(\mathrm{s}) = \begin{cases} 0.25\ M - 2.30, & R \leqslant R_1, \\ 0.15\ M + 0.25 \log R(\mathrm{km}) - 1.90, & R > R_1; \end{cases}$$

$$\log R_1(\mathrm{km}) = 0.45\ M - 1.80;$$

$$\log d_e(\mathrm{s}) = 0.20\ M + 0.50 \log R(\mathrm{km}) - 1.30\ .$$

As a rule, our estimations correspond to S-wave. By estimating of the hypocentral distance R, if possible, the macroseismic epicenter was used. In data processing every earthquake was taken with equal weight independent on records number. This study utilizes records of 59 earthquakes from Alaska, Montana, Washington, California, Nevada, Hawaii, Guatemala, Peru, Chile, Nicaragua, Argentina, Italy, Greece, Romania, Central Asia, India, Japan. The earthquakes were devided into five groups: contraction faulting (uplift and thrust), contraction faulting with strike-slip component, strike-slip, strike-slip with dip-slip component and dip-slip. The data on earthquake mechanism were taken from publications. All the computations we have provided in the logarithmic units because of the experimental data scattering corresponds to logarithmic-gaussian distribution. The table shows the mean values and 0.7 confidence intervals; the numbers of earthquakes utilized are given in parentheses. The estimations of the envelope increasing speed for the P-wave amplitudes obtained at teleseismic distances also are included into table:

$n = d \ln A / d \ln t$, where t - time from P-wave arrival.

The data given in the table are correlated: higher values of A_o/A_e, A_h/A_v and n as a rule correspond to lower values of other parameters. It is rather surprising that the parameter A_h/A_v separates the contraction faulting and dip-slip faulting much better, than the vertical and horizontal motions along the rupture surface.

The obtained results clearly show that it is possible to rise the accuracy of strong motion prediction taking into consideration the type of faulting usual for area studied. In the previous paper [Aptikaev and Kopnichev, 1979] it was shown, that using of experimental data on seismic motion allows to recognize even uplift and thrust.

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PARAMETERS OF SEISMIC VIBRATIONS FOR DIFFERENT TYPE OF FAULTING

Parameter	Type of faulting		
	contraction faulting	contraction fault. with st.-sl. comp.	strike-slip
log A_o/A_e	0.35 ± 0.13(16)	0.11 ± 0.17(5)	0.22 ± 0.08(17)
log T_o/T_e	-0.05 ± 0.13(16)	0.00 ± 0.16(5)	0.07 ± 0.09(16)
log d_o/d_e	0.19 ± 0.15(16)	0.12 ± 0.14(4)	0.30 ± 0.08(14)
log A_h/A_v	0.32 ± 0.13(12)	0.32 ± 0.08(5)	0.27 ± 0.07(12)
log T_h/T_v	0.13 ± 0.12(12)	0.19 ± 0.09(4)	0.16 ± 0.09(12)
log d_h/d_v	-0.22 ± 0.14(12)	-0.27 ± 0.10(3)	-0.14 ± 0.07(12)
n	0.04 ± 0.04(16)	0.21 ± 0.03(6)	-0.05 ± 0.03(10)

Parameter	Type of faulting	
	strike-slip with dip-slip comp.	dip-slip
log A_o/A_e	0.06 ± 0.13(6)	-0.06 ± 0.20(9)
log T_o/T_e	0.10 ± 0.16(6)	0.00 ± 0.13(8)
log d_o/d_e	0.23 ± 0.32(6)	0.35 ± 0.10(8)
log A_h/A_v	0.13 ± 0.10(5)	0.17 ± 0.11(5)
log T_h/T_v	0.21 ± 0.09(5)	0.29 ± 0.08(4)
log d_h/d_v	-0.03 ± 0.05(6)	0.01 ± 0.10(4)
n	-0.22 ± 0.03(5)	-0.22 ± 0.03(6)