SIMPLIFIED FREQUENCY CONTENT ESTIMATES OF EARTHQUAKE GROUND MOTIONS

By Ellen M. Rathje, Norman A. Abrahamson, and Jonathan D. Bray (1998)

Parameters

(a) Mean square period (T_{ms}) is defined as

$$T_{ms} = \frac{\sum_i C_i^2 \cdot \left(\frac{1}{f_i} \right)}{\sum_i C_i^2} \qquad \text{for } 0.25 \text{ Hz} \le f_i \le 20 \text{ Hz}$$

where C_i are the Fourier amplitudes of the accelerogram and f_i are the discrete Fourier transform frequencies between 0.25 to 20 Hz.

(b) The predominant period (T_p) is defined as the period at which the maximum spectral acceleration occurs in an acceleration response spectrum calculated for 5% viscous damping.

(c) Average period (T_o) is defined as

$$T_o = \frac{\sum_{i=1}^{nPer} T_i \cdot \ln\left[S_a(T_i)\right] \cdot H\left[S_a(T_i) - 1.2 \cdot MHA\right]}{\sum_{i=1}^{nPer} \ln\left[S_a(T_i)\right] \cdot H\left[S_a(T_i) - 1.2 \cdot MHA\right]}$$

where *nPer* is the number of periods in the response spectrum, T_i are the discrete periods in the response spectrum (equally spaced on a log period axis), and $S_a(T_i)$ is the spectral acceleration at period T_i. H[x] is the Heaviside function and is equal to 1 when $x > 0$ and equal to 0 for $x < 0$.

Empirical Equations (Active Plate-Margin Regions)

The form of the predictive equations for T_{ms}, T_p, and T_o are

$\ln(T_{ms}) = \ln(C_1 + C_2 \cdot (M_w - 6) + C_3 \cdot R) + \varepsilon$ for $M_w \le 7.25$

$\ln(T_{ms}) = \ln(C_1 + 1.25 \cdot C_2 + C_3 \cdot R) + \varepsilon$ for $7.25 \le M_w \le 8.0$

$\ln(T_p) = \ln(C_1 + C_2 \cdot (M_w - 6) + C_3 \cdot R) + \varepsilon$ for all M_w

$\ln(T_o) = \ln(C_1 + C_2 \cdot (M_w - 6) + C_3 \cdot R) + \varepsilon$ for all M_w

ε is normally distributed with mean zero and standard deviation σ. The coefficients for these equations for both rock/shallow stiff soil and deep soil sites are presented in Table 3.

Table 3. Coefficients for Estimating Frequency Content Parameters

	C_1	C_2	C_3	σ
T_{ms}, rock	0.411	0.0837	0.00208	0.437
T_{ms}, soil	0.519	0.0837	0.00190	0.350
T_p, rock	0.202	0.0485	0.00104	0.589
T_p, soil	0.218	0.0485	0.00161	0.564
T_o, rock	0.213	0.0416	0.00146	0.461
T_o, soil	0.269	0.0416	0.00168	0.375

Theoretical Equations (Stable Continental Region)

An empirical model for stable continental regions was not possible due to the scarcity of strong motion recordings in this region. The equations that approximate the theoretical distance and magnitude relationships for T_{ms} on rock in stable continental regions (SCR) are

$$T_{ms,SCR} = 0.208+0.0523\cdot(M_w-6)+[0.00184-0.000148\cdot(M_w-8)^2]\cdot R \qquad \text{for } M_w \leq 7.25$$

$$T_{ms,SCR} = 0.273+[0.00184-0.000148\cdot(M_w-8)^2]\cdot R \qquad \text{for } 7.25 \leq M_w \leq 8.0$$

Tms for Active Plate-Margin Regions