SIMPLIFIED FREQUENCY CONTENT ESTIMATES OF EARTHQUAKE GROUND MOTIONS

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Parameters

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

\[
T_{ms} = \frac{\sum C_i^2 \cdot \left( \frac{1}{f_i} \right)}{\sum C_i^2} \quad \text{for } 0.25 \text{ Hz} \leq f_i \leq 20 \text{ Hz}
\]

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

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

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

\[
\begin{align*}
\ln(T_{ms}) &= \ln(C_1 + C_2 \cdot (M_w - 6) + C_3 \cdot R) + \varepsilon \quad \text{for } M_w \leq 7.25 \\
\ln(T_{ms}) &= \ln(C_1 + 1.25 \cdot C_2 + C_3 \cdot R) + \varepsilon \quad \text{for } 7.25 \leq M_w \leq 8.0 \\
\ln(T_p) &= \ln(C_1 + C_2 \cdot (M_w - 6) + C_3 \cdot R) + \varepsilon \quad \text{for all } M_w \\
\ln(T_o) &= \ln(C_1 + C_2 \cdot (M_w - 6) + C_3 \cdot R) + \varepsilon \quad \text{for all } M_w
\end{align*}
\]

\( \varepsilon \) is normally distributed with mean zero and standard deviation \( \sigma \). 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

<table>
<thead>
<tr>
<th></th>
<th>$C_1$</th>
<th>$C_2$</th>
<th>$C_3$</th>
<th>$\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{ms}$, rock</td>
<td>0.411</td>
<td>0.0837</td>
<td>0.00208</td>
<td>0.437</td>
</tr>
<tr>
<td>$T_{ms}$, soil</td>
<td>0.519</td>
<td>0.0837</td>
<td>0.00190</td>
<td>0.350</td>
</tr>
<tr>
<td>$T_p$, rock</td>
<td>0.202</td>
<td>0.0485</td>
<td>0.00104</td>
<td>0.589</td>
</tr>
<tr>
<td>$T_p$, soil</td>
<td>0.218</td>
<td>0.0485</td>
<td>0.00161</td>
<td>0.564</td>
</tr>
<tr>
<td>$T_{o}$, rock</td>
<td>0.213</td>
<td>0.0416</td>
<td>0.00146</td>
<td>0.461</td>
</tr>
<tr>
<td>$T_{o}$, soil</td>
<td>0.269</td>
<td>0.0416</td>
<td>0.00168</td>
<td>0.375</td>
</tr>
</tbody>
</table>

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

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

$$T_{ms, SCR} = 0.273 + [0.00184 - 0.000148 - (M_w - 6)^2] \cdot R \quad \text{for } 7.25 \leq M_w \leq 8.0$$

Tms for Active Plate-Margin Regions

![Graph showing Tms for Active Plate-Margin Regions](image)

![Graph showing Tms for Stable Continental Regions](image)