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To: Goutam Bagchi <GXB1@nrc.gov>
Date: Fri, Mar 31, 2000 7:45 AM
Subject: Technical Information

Goutam - Attached is a technical description of the equations, with a couple of examples, to calculate seismic hazard from a point source. This will help you better understand the essence of the seismic hazard process. Extension to area source calculations is nothing more than partitioning the area source to effectively small point sources, numerically integrating over magnitude and distance, and adjusting the activity rate by the ratio of areas.

I will send you a spread sheet early next week - after I make it more "abuser" friendly.

Have a good weekend.

Tom O'Hara

(See attached file: sheq.doc)

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Goutam – Here are the equations and assumptions used to analytically calculate seismic hazard from a point source. I will send you an Excel spreadsheet next week so that you can manipulate the inputs and see the effects of changing input paramaters, such as sigma. I suggest you do a hand calculation for the sample results below to better understand the details of the calculations.

Equations and sample calculation to estimate seismic hazard from a point source. See EPRI NP-4949 for equations – I wrote this report with Cornell & Veneziano about 10 years ago.

Assumptions:

Point source	
Distance (R)	100 km
Lower Bound Magnitude (m_0)	5.0
Upper Bound Magnitude (m_1)	6.5
Seismicity Parameters	$\beta = 2.3$ $\lambda = 0.1$
Frequency Magnitude	$\text{Log}(N_c) = 4.0 - 1.0*m$
Attenuation Model	$\text{Ln}(a) = 2.0 + 1.2*m - 1.0*\ln(R)$
Where:	$C_1 = 2.0$
	$C_2 = 1.2$, and
	$C_3 = -1.0$
Attenuation random uncertainty	$\sigma = 0.6$

Equation to estimate seismic hazard given the earthquake has occurred.

$$P[\ln(A) > a|m,R] = (1-k)\Phi^*(z/\sigma) + k\Phi^*(z'/\sigma) + kR^{\beta C3/C2}\exp(-a\beta/C_2 + \beta C_1/C_2 + \beta m_0 + \beta^2\sigma^2/2C_2^2)*$$

$$[\Phi^*((z-\beta^2\sigma^2/2)/\sigma) - [\Phi^*((z'-\beta^2\sigma^2/2)/\sigma)]$$

where: $k = 1/(1-\exp(-\beta(m_1 - m_0)))$

$z = a - C_1 - C_2 m_1 - C_3\ln(R)$

$z' = a - C_1 - C_2 m_0 - C_3\ln(R)$, and

$\Phi^*(\ )$ = the complementary cumulative of the standardized normal distribution.

Sample Results:

$a = \ln(125\text{ cm/sec2})$ = 4.828: P[A > a] = $9.42 \times 10^{-2} * \lambda$

9.42×10^{-3}

$a = \ln(1000\text{ cm/sec2})$ = 6.9078: P[A > a] = $3.45 \times 10^{-5} * \lambda$

3.45×10^{-6}

Note - P[A > a] = the conditional probability that the ground motion will exceed a given m, R (P[ln (A) > a|m,R]), where m ranges from m_0 to m_1, times the annual probability that an earthquake of size m_0 or greater occurs (λ).