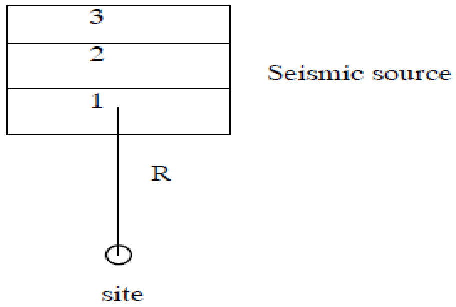
Homework Set 6

Probabilstic Seismic Hazard Analysis



Minimum Magnitude:

$m_0=$ 5

Maximum Magnitude:

$m_u=$ 7.4

Frequency-Magnitude Relationship

$$\log(\lambda_m) = 2.55 - 0.88m \qquad (1)$$

a= 2.550

b= 0.880

α= 2.550

β= 0.880

A. Divide the seismic source zone into a set of subsonic zone

Table 1. Parameters of Subzone

No.	1	2	3	∑

Area (km^2)	2000	1500	2500	6000
R_i (km)	20	30	40	

B. Calculate the occurrence rate of earthquakes with magnitude larger than minimum magnitude ɔm equation (1).

$v(m \geq 5) = N(m = 5) = e^{\alpha-\beta*m} =$ 0.15723717

C. Divide the magnitude range into a set subrange, then compute the probability density function of central magnitude of each subrange fromequation (2).

Probability Density Function:

$$f_M(m) = k\,\beta \exp(-\beta(m - m_0)) \qquad m_0 < m < m_u \tag{2}$$

$$k = [1 - e^{-\beta(m_u - m_o)}]^{-1} \tag{3}$$

k= 1.138

Table 2. Probability Density Function

m	5-5.4	5.4-5.8	5.8-6.2	6.2-6.6	6.6-7.0	7.0-7.4
m_{midj}	5.2	5.6	6	6.4	6.8	7.2
Δm	0.4	0.4	0.4	0.4	0.4	0.4
$f(m_{midj})$	0.84	0.59	0.415	0.29203902	0.2053852	0.144
$f(m_{midj})*\Delta m$	0.336	0.236	0.166	0.11681561	0.0821541	0.058

D. Makeup an acceleration attenuation table according to magnitude of table 2 and the attenuation

function of equation (4)

Acceleration Attenuation Function:

$$\ln y = 1.31 + 1.15m - 0.83\ln R - 0.0028R \qquad (unit : cm/sec^2) \tag{4}$$

where m is the magnitude of earthquake and R is the epicentral distance of the study site.

Table 3. Acceleration Attenuation Table

Distance(R)	Magnitude (m)					
km	5.2	5.6	6	6.4	6.8	7.2
20	0.115	0.183	0.289	0.45830835	0.7259943	1.15
30	0.08	0.127	0.201	0.31830377	0.5042167	0.799
40	0.061	0.097	0.154	0.24377119	0.3861516	0.612

E. Specified a set of acceleration values (Table 4)

Table 4. Specified Acceleration Values (g)

0.1	0.2	0.3	0.4	0.5	0.6	0.7

Now we compute the occurrence rate of specified acceleration values when earthquakes occur in different subzones.

The recurrence relationship is combined with statistical model of the ground acceleration attenuation relationship and earthquake occurrence (Poisson model) to relate the intensity of expected strong ground motion to its annual probability or occurrence rate of being exceeded. This can be calculated as:

$$P[\, y \geq Y\,] = v(m \geq m_0) \int_R \int_{m_0}^{m_u} P[\, y \geq Y/m, R]\, f(m)\, f(R)\; dm dR \tag{5}$$

where Y is the ground motion level we interest,

v(m>=m_0) is the occurrence rate of earthquakes with magnitude m>=m0,

P[y>=Y/m, R] is the conditional probability of y>=Y specified earthquake magnitude m and epicentral distance R,which is determined by the strong ground motion attenuation function,
f(m) is probability density function of earthquake magnitude m of seismic source zone,
and, f(R) is probability density function of distance which can be computed from the geometrical position of site respect to the seismic source zone.

$$P[y \geq Y] = \frac{v(m \geq m_0)}{S} \sum_{i=1}^{N} S_i \sum_{j=1}^{M} P[y \geq Y/m_j, R_i]\, f(m_j)\, (\Delta M) \tag{6}$$

where Si is area of subzone i, and S is total area of seismic source zone.

In equation (9), the value of P[y>Y]is the annual occurrence rate of the event of y>Y. The occurrence model of large earthquakes in a region is often described by a stationary Poisson random process, hence the probability of y > Y occurs at least one time in one year can be computed as:

$$P_{1yr}[y \geq Y] = 1 - e^{-P[y \geq Y]}$$

Acceleration	5.2			5.6			6			6.4			6.8			7.2		
(g)	20	30	40	20	30	40	20	30	40	20	30	40	20	30	40	20	30	40
0.1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
0.2	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1
0.3	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1
0.4	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	1	1
0.5	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1
0.6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1
0.7	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0

g	$P_i(y>Y)$			P(y>Y)	P_{1yr}
	20	30	40		
0.1	0.995	0.659	0.423	0.1058	0.1004
0.2	0.423	0.423	0.257	0.0556	0.0541
0.3	0.257	0.257	0.14	0.0327	0.0322
0.4	0.257	0.14	0.058	0.0227	0.0225
0.5	0.14	0.14	0.058	0.0166	0.0165
0.6	0.14	0.058	0.058	0.0134	0.0133
0.7	0.14	0.058	0	0.0096	0.0096

$$P[y \geq Y] = \frac{\nu(m \geq m_0)}{S} \sum_{i=1}^{N} S_i \sum_{j=1}^{M} P[y \geq Y/m_j, R_i]\, f(m_j) \qquad (6)$$

It is clear when the annul occurrence rate of y>Y is a very small value, it equals to the probability of the same event occurring in one year . Therefore:

$$P_{1yr}[y \geq Y] = P[y \geq Y]$$