5/13/2008 Taiki SAITO, BRI
revised 5/15/2008

Earthquake design spectrum in Chinese Design Code

List of seismic codes

TJ11-74 (1974), TJ11-78 (1978), GBJ11-89 (1989), GB50011-2001 (2001)

1. Earthquake load in GBJ11-89

A design acceleration response spectrum is obtained as follows:

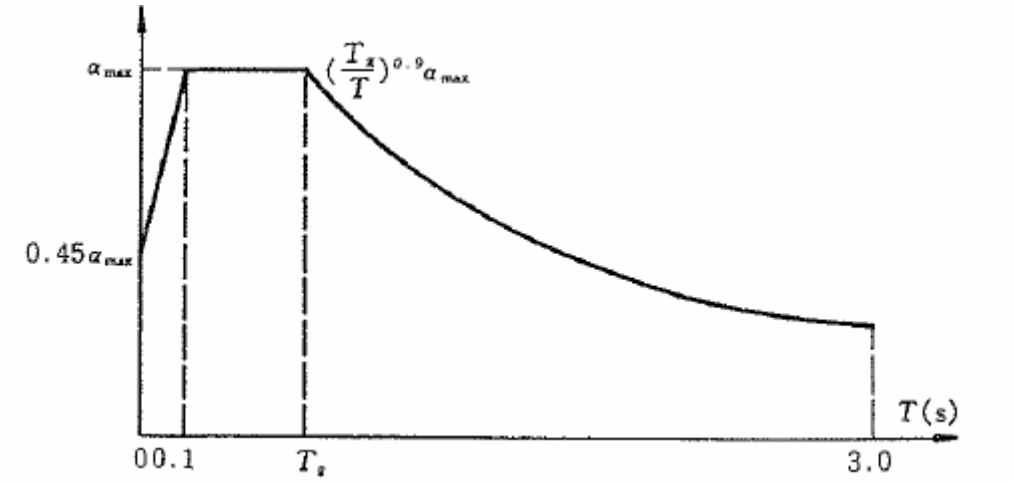


Figure 1. A design acceleration response spectrum (GBJ11-89)

where,

α_{max} : the maximum acceleration (G) determined from seismic intensity zone IV - IX

(a) Frequently occurred earthquakes

Intensity	Ⅵ	Ⅶ	Ⅷ	Ⅸ
α_{max}	0.04	0.08	0.16	0.32

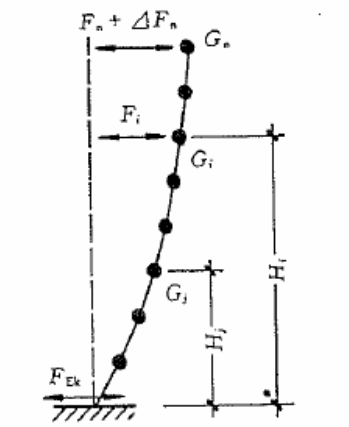
(b) Rare earthquakes

Intensity	Ⅶ	Ⅷ	Ⅸ
α_{max}	0.50	0.90	1.40

T_g : the period (sec) determined from site category I - IV

Near- or far-earthquake	Site category			
	Ⅰ	Ⅱ	Ⅲ	Ⅳ
Near-earthquake	0.20	0.30	0.40	0.65
Far-earthquake	0.25	0.40	0.55	0.85

Earthquake loads along the height of the building



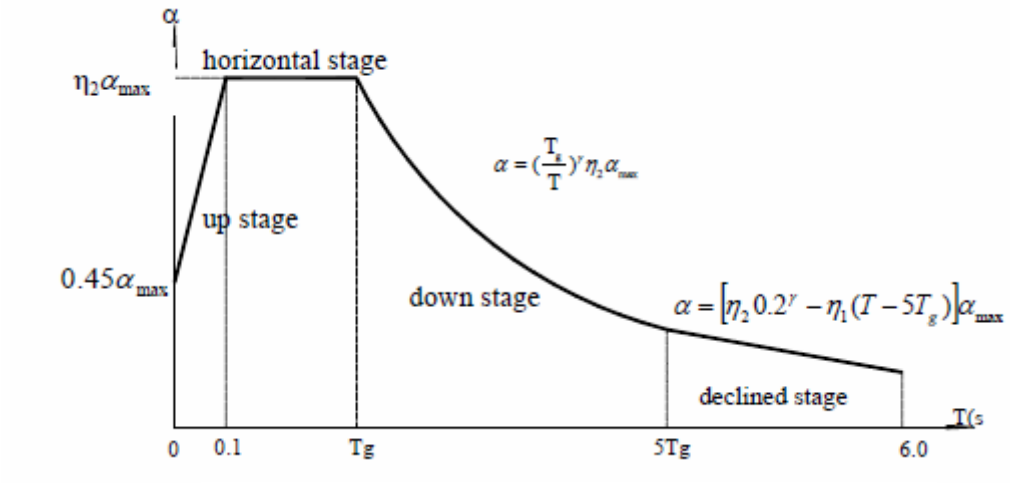
$$F_{Ek} = \alpha_1 G_{eq}$$

$$F_i = \frac{G_i H_i}{\sum_{j=1}^{n} G_j H_j} F_{Ek} \ (1 - \delta_n) \qquad (i = 1,\ 2 \cdots n)$$

$$\Delta F_n = \delta_n F_{Ek}$$

2. Earthquake load in GB50011-2001

A design acceleration response spectrum is obtained as follows:



$$\alpha = \begin{cases} (0.45 + \dfrac{\eta_2 - 0.45}{0.1} T)\alpha_{max} & T \le 0.1 \\ \eta_2 \alpha_{max} & 0.1 < T \le T_g \\ (\dfrac{T_g}{T})^{\gamma} \eta_2 \alpha_{max} & T_g < T \le 5T_g \\ [\eta_2 0.2^{\lambda} - \eta_1 (T - 5T_g)]\alpha_{max} & 5T_g < T \le 6.0 \end{cases}$$

Figure 2. A design acceleration response spectrum (GB50011-2001)

where,

η_1, η_2, γ : coefficients determined from damping ratio, ζ,

$$\eta_1 = 0.02 + (0.05 - \zeta)/8, \eta_1 \ge 0$$

$$\eta_2 = 1 + \frac{0.05 - \zeta}{0.06 + 1.7\zeta}, \eta_2 \ge 0.55$$

$$\gamma = 0.9 + \frac{0.05 - \zeta}{0.5 + 5\zeta}$$

α_{max} : the maximum acceleration (G) determined from seismic intensity zone IV - IX

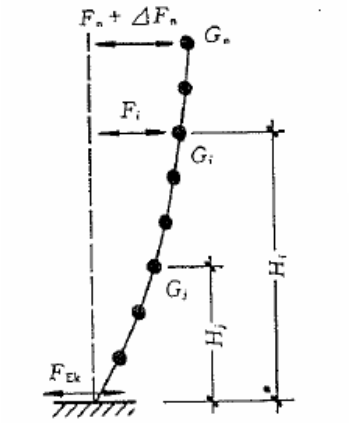
Fortification intensity		6	7	8	9
α_{max}	Frequently Occurred Earthquake	0.04	0.08(0.12)	0.16(0.24)	0.32
	Seldom Occurred Earthquake	0.28	0.50(0.72)	0.90(1.20)	1.40
	Design Basis Earthquake	0.05	0.10 (0.15)	0.20 (0.30)	0.40

Note: In the items of α_{max} the values in brackets are used for the regions which Design Basis Earthquake acceleration values are 0.15g or 0.30g..

T_g : the period (sec) determined from site category I - IV

Design earthquake	Site class			
	I	II	III	IV
Group 1	0.25	0.35	0.45	0.65
Group 2	0.30	0.40	0.55	0.75
Group 3	0.35	0.45	0.65	0.90

Earthquake loads along the height of the building



$$F_{Ek} = \alpha_1 G_{eq}$$

$$F_i = \frac{G_i H_i}{\sum_{j=1}^{n} G_j H_j} F_{Ek} \ (1 - \delta_n) \qquad (i = 1,\ 2 \cdots n)$$

$$\Delta F_n = \delta_n F_{Ek}$$

Seismic Intensity Zone

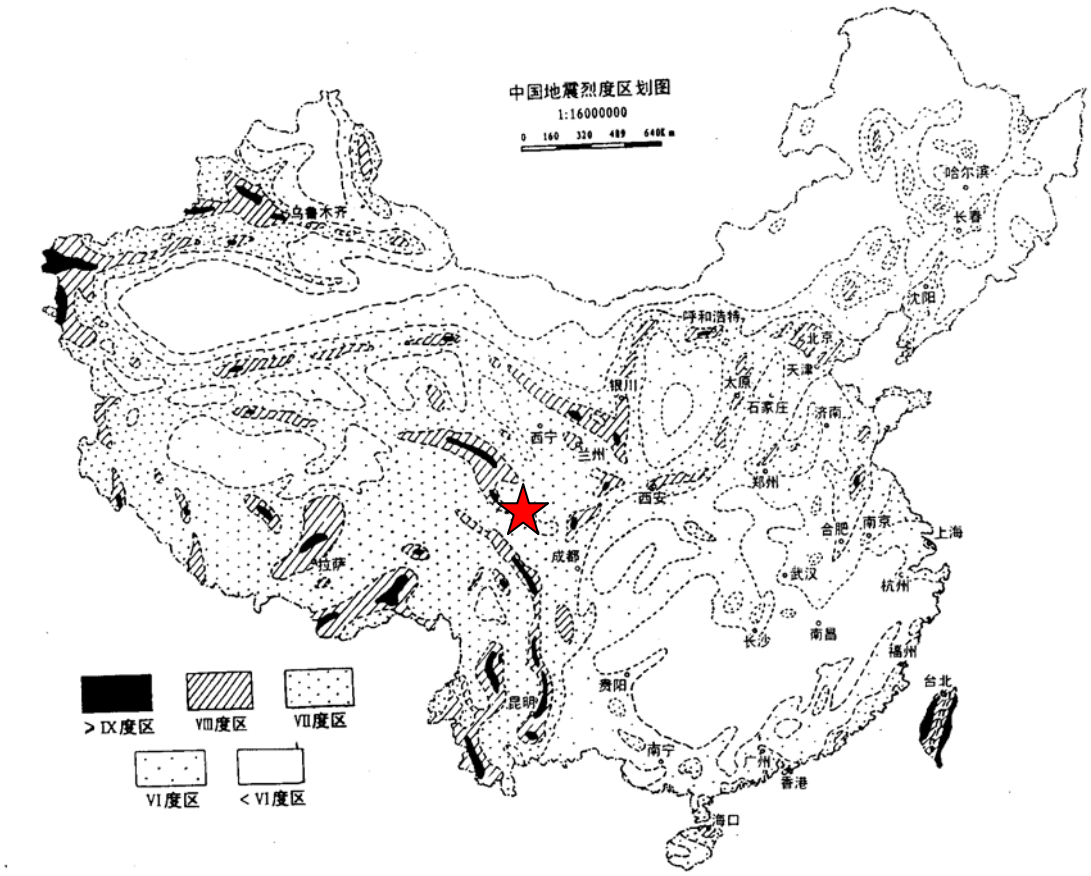


Figure 3. Seismic Intensity Zoning Map in China
(provided by Dr. Okawa, BRI)

The affected area of the Sichuan Earthquake on May 12, 2008 locates in Zone VII.

3. Example

Figure 4 compares the design acceleration response spectra for different seismic intensity zones IV-IX where the factor T_g is assumed to be 0.4sec.

Also, the dotted line in the Figure shows the design acceleration response spectrum of the Japanese seismic design code for soil type 1.

The difference between the design spectra among seismic intensity zones is very large; the spectrum of zone IX is 5 times larger than that of zone IV.

The design spectrum of zone IX exceeds Japanese one in the range of short natural period.

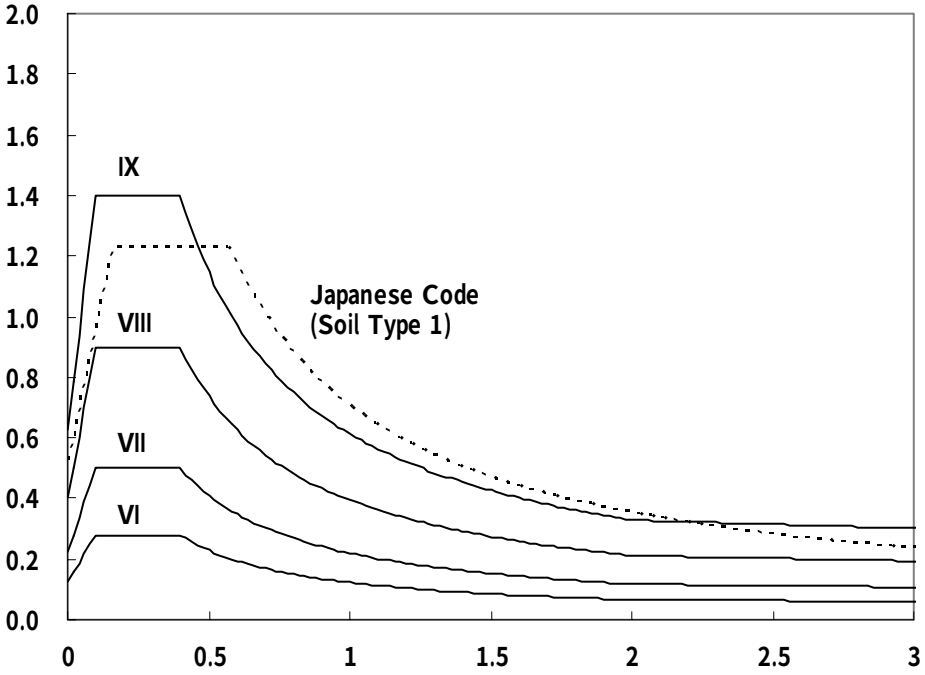


Figure 4 Comparison of design acceleration response spectra

The affected area of the Sichuan Earthquake on May 12, 2008 locates in Zone VII. Therefore, the earthquake load of the new buildings in that area corresponds to the half of the earthquake load of Japanese ones. Also it corresponds to the maximum ground acceleration 150-200gal.