Seismic Resistant Design of Steel Structures

Homework #1 Due: 3/12/2018

1. Read the reference papers shown in Item 3 below. Please write down, at least, three different types of equation (from reference 1), which show the relationship between ductility ratio, μ, nonlinear displacement ratio, C_R ($C_R = \frac{S_d^{inelastic}}{S_d^{elastic}}$), and strength reduction factor, R ($R = \frac{mS_a^{elastic}}{F_y}$).
2. Please utilize the file "ResponseSpectrum.xls" in the folder of this homework. There are five elastic acceleration response spectra with 5% damping ratio and their associated nonlinear displacement response spectra with the strength reduction factor R equal to 3 and 5. The F_y shown in that Excel file is the yield strength of single degree of freedom systems.

Please answer following questions:

a. What are the peak ground accelerations (PGA) shown in these five acceleration response spectra? (The unit of the acceleration response spectra is g).

b. Please normalize these five acceleration response spectra to spectral acceration=0.33g for the shortest period. Then, plot these five acceleration response spectra in one figure, in which the abscissa is the vibration periods varying from 0 to 6 seconds.

c. Refer to the latest edition of the Taiwan Seismic Building Code, explain the meanings of α_y, F_u and constant 1.4 shown in the equation $\frac{V}{W} = \frac{S_{aD}}{1.4\alpha_y F_u}$.

d. According to the Taiwan Seismic Building Code, please plot three curves to show the relationships of V/W vs. T, V^*/W vs. T and V_M/W vs. T. Please use the following data while plot these three curves:
I=1.0, $\alpha_y = 1.0, S_1^D = 0.48, S_S^D = 0.78, S_1^M = 0.55$ and $S_S^M = 0.88$. F_u is computed for the special moment resisting frame (R=4.8). T is the vibration period varying from 0 to 6 seconds.

e. First, please calculate the averaged acceleration response spectra for the five acceleration response spectra mentioned in Question 2b. Second, divide the averaged acceleration response spectrum by the corresponding value of V/W obtained from Question 2d. Finally, please compare those quotients with the value of $1.4\alpha_y F_u$ and discuss the trend of variation of those quotients while the vibration period varies from 0 to 6 seconds.

f. Please plot each one, and the average, of the five linear displacement response spectra ($S_d^{elastic}$) by using the five normalized linear acceleration

response spectra found in Question 2b. (*Hint*: assume $PS_a = S_a$)

g. Please use $S_d^{elastic}$ obtained from Question 2f and $S_d^{inelastic}$ given in the file "ResponseSpectrum.xls" to plot their ratio $C_R = S_d^{inelastic} / S_d^{elastic}$ as R equal to 3 and 5. Please compare the computed C_R with the deflection amplification factors suggested in References 2 and 3.

3. References:

(1) Miranda, E. and Bertero V., 1994, Evaluation of strength reduction factors for earthquake resistant design, *Earthquake Spectra*, 10(2), 357-379.

(2) Chia-Ming Uang and Ahmed Maarouf, (1994), Deflection amplification factor for seismic design provisions, *Journal of Structural Engineering*, Vol. 120, No. 8.

(3) Chia-Ming Uang (1991), Establishing R(or R_w) and C_d factors for building seismic provisions, *Journal of Structural Engineering*, Vol. 117, No. 1.