Assignment 2: Problem Statement

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Semester 2021-22-II
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CE 629A: Earthquake Analysis and Design of Structures
Assignment #2: Response of Inelastic SDF Systems
Due Thursday, January 27, 2022

Problem 1 [20 + extra credit]

Determine the response of an elastic perfectly plastic (EPP) SDF system with $T_n = 0.5$ sec, $\zeta = 0\%$, and $R_y = 8$ to the El Centro ground motion that you used in Assignment #1. Use $\Delta t = 0.005$ sec for numerical integration of the equation of motion. Perform the analysis for a duration of ground motion duration (t_{dur}) plus 20 sec, where $\ddot{u}_g(t) = 0$ for $t \geq t_{dur}$ (i.e., zero padding at the end of the accelerogram). Plot the following:

(i) Time history of normalized deformation $\frac{u(t)}{u_y}$,

(ii) time history of normalized resisting force $f_s(t)/f_y$,

(iii) normalized force $\left(\frac{f_s(t)}{f_y}\right)$ and normalized deformation $\left(\frac{u(t)}{u_y}\right)$ hysteretic response for the entire duration of the simulation, and

(iv) redo plot (iii) for the free vibration response only (i.e., when $t \geq t_{dur}$).

From the above results determine the ductility demand (μ) and normalized permanent (residual) deformation $\left(\frac{u_p}{u_y}\right)$.

Note: You can receive extra credit as noted below.

Method	Extra credit
Central difference method	0
KR-α method	10
Newmark's average acceleration with Newton-Raphson or modified Newton-Raphson iteration	20
All the above algorithms with comparison of results for (i)-(iv)	40

Problem 2 [20]

Redo Problem #1 but for a bilinear plastic (BP) system with post-yield stiffness ratio $\alpha = 0.05$.

Problem 3 [20]

Redo Problem #1 but for a bilinear elastic (BE) system with post-yield stiffness ratio $\alpha = 0.05$.

Problem 4 [35+45=80]

Consider the three types of force-deformation behaviour studied in Problems 1-3 (i.e., EPP, BP, and BE) and the same El Centro ground motion.

Part-A

For each of the three types of force-deformation behaviour, determine and plot the following:

(i) constant-R_y ductility spectra, i.e., a plot of μ vs T_n for a given value of R_y; and,

(ii) constant-R_y residual deformation spectra, i.e, a plot of $\frac{u_p}{u_y}$ vs T_n for a given value of R_y.

Consider $\zeta = 5\%$, $R_y = 1, 2, 4, 6$, and 8. Use a range of 0.02 sec to 50 sec for T_n. Plot the data in log-log scale. Comment on your results. You will get a total of 6 plots, and your first plot corresponding to the EPP force-deformation behaviour should be similar to Figure 7.4.5 of Chopra.

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Part-B

Now, for each of $R_y = 2, 4, 6$ and 8, compare the constant-R_y ductility spectra and constant-R_y residual deformation spectra for the EPP, BP and BE force-deformation behaviour. Comment on your results. You will get a total of 8 plots here.

Note: *For Problems 2-4, use an appropriate time-stepping method of your choice.*