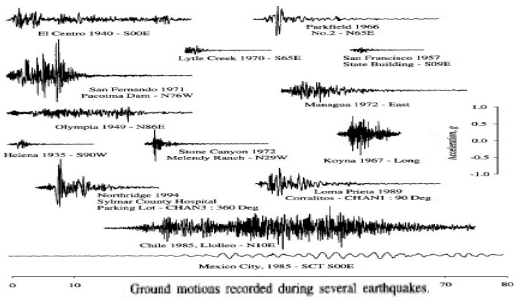
Seismic design of structures
Response spectra

Dr. Irfan-ul-Hassan



Ground motions recorded during several earthquakes.

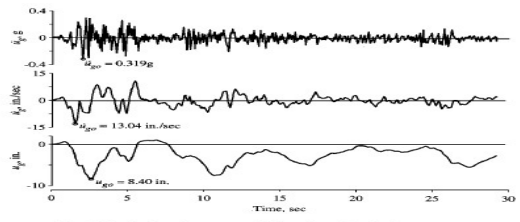
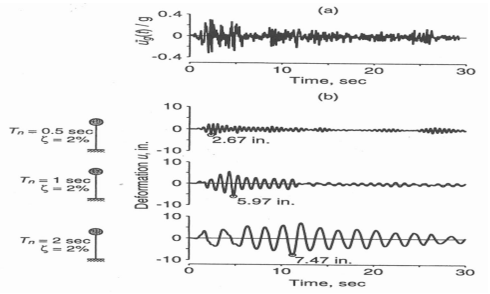
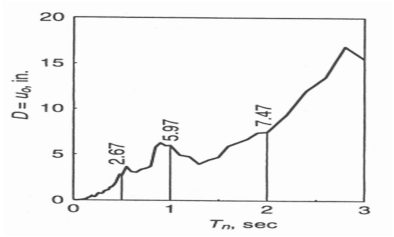


Figure 6.1.4 North–south component of horizontal ground acceleration recorded at the Imperial Valley Irrigation District substation, El Centro, California, during the Imperial Valley earthquake of May 18, 1940. The ground velocity and ground displacement were computed by integrating the ground acceleration.





RESPONSE hISTORY

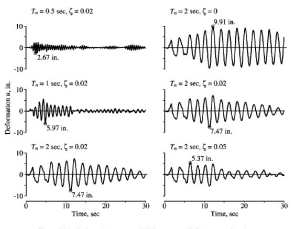


Figure 6.4.1 Deformation response of SDF systems to El Centro ground motion.

PSEUDO Acceleration response

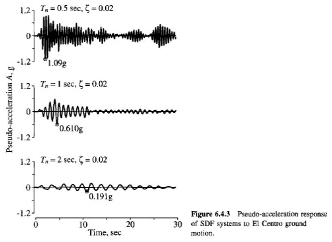


Figure 6.4.3 Pseudo-acceleration response of SDF systems to El Centro ground motion.

DEFORMAT

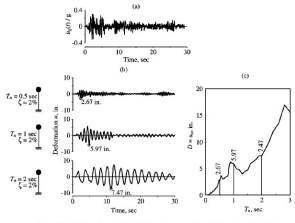


Figure 6.6.1 (a) Ground acceleration; (b) deformation response of three SDF systems with ζ = 2% and T_n = 0.5, 1, and 2 sec; (c) deformation response spectrum for ζ = 2%.

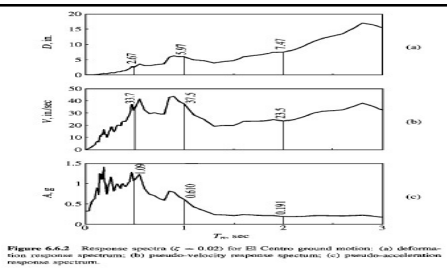


Figure 6.6.2 Response spectra (ζ = 0.02) for El Centro ground motion. (a) deformation response spectrum; (b) pseudo-velocity response spectrum; (c) pseudo-acceleration response spectrum.

Response spectra for acc, Vel, disp, [elcentro eq]

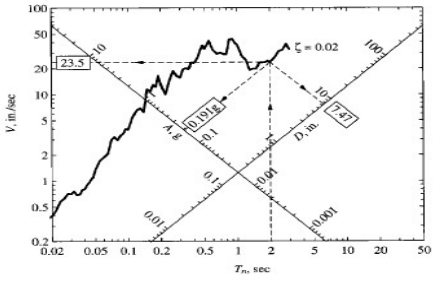


Figure 6.6.3 Combined D–V–A response spectrum for El Centro ground motion; $\zeta = 2\%$.

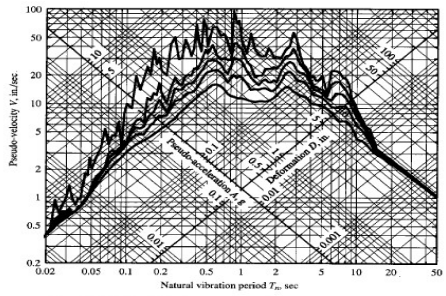


Figure 6.6.4 Combined D–V–A response spectrum for El Centro ground motion; ζ = 0, 2, 5, 10, and 20%.

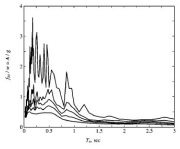
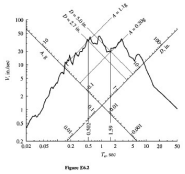
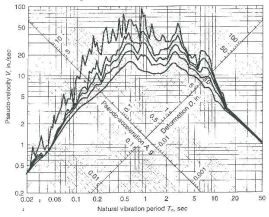


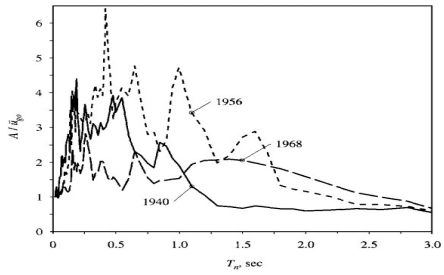
Figure 6.6.5 Normalized pseudo-acceleration, or base shear coefficient, response spectrum for El Centro ground motion; ζ = 0, 2, 5, 10, and 20%.

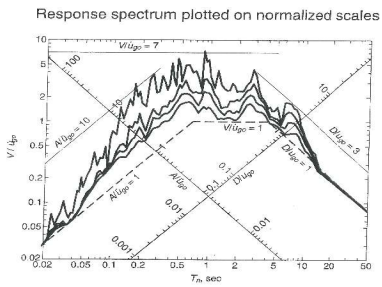
Elcentro response spectra



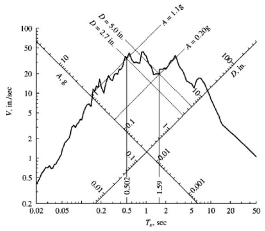
Response spectrum for El Centro ground motion
ζ = 0, 2, 5, 10, and 20%.



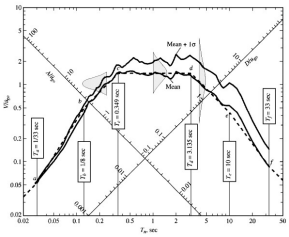


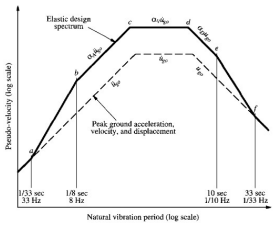


- For the given acceleration ug(t) , define acc. At suitable interval



A 12-ft-long vertical cantilever, a 4-in.-nominal-diameter standard steel pipe, supports a 5200-lb weight attached at the tip as shown in Fig. E6.2. The properties of the pipe are: outside diameter, $d_o = 4.500$ in., inside diameter $d_i = 4.026$ in., thickness $t = 0.237$ in., and second moment of cross-sectional area, $I = 7.23$ in^4, elastic modulus $E = 29,000$ ksi, and weight = 10.79 lb/foot length. Determine the peak deformation and bending stress in the cantilever due to the El Centro ground motion. Assume that $\xi = 2\%$.





1. Plot the three dashed lines corresponding to the peak values of ground acceleration $\ddot{u}_{go}$, velocity $\dot{u}_{go}$, and displacement u_{go} for the design ground motion.
2. Obtain from Table 6.9.1 or 6.9.2 the values for α_A, α_V, and α_D for the ζ selected.
3. Multiply $\ddot{u}_{go}$ by the amplification factor α_A to obtain the straight line b–c representing a constant value of pseudo-acceleration A.
4. Multiply $\dot{u}_{go}$ by the amplification factor α_V to obtain the straight line c–d representing a constant value of pseudo-velocity V.
5. Multiply u_{go} by the amplification factor α_D to obtain the straight line d–e representing a constant value of deformation D.
6. Draw the line $A = \ddot{u}_{go}$ for periods shorter than T_a and the line $D = u_{go}$ for periods longer than T_f.
7. The transition lines a–b and e–f complete the spectrum.

TABLE 6.9.1 AMPLIFICATION FACTORS: ELASTIC DESIGN SPECTRA

Damping, ζ (%)	Median (50 percentile)			One Sigma (84.1 percentile)		
	α_A	α_V	α_D	α_A	α_V	α_D
1	3.21	2.31	1.82	4.38	3.38	2.73
2	2.74	2.03	1.63	3.66	2.92	2.42
5	2.12	1.65	1.59	2.71	2.30	2.01
10	1.64	1.37	1.20	1.99	1.84	1.69
20	1.17	1.08	1.01	1.26	1.37	1.38

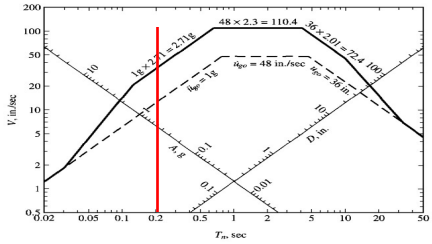
Source: N. M. Newmark and W. J. Hall, *Earthquake Spectra and Design*, Earthquake Engineering Research Institute, Berkeley, Calif., 1982, pp. 35 and 36.

TABLE 6.9.2 AMPLIFICATION FACTORS: ELASTIC DESIGN SPECTRA[a]

	Median (50 percentile)	One Sigma (84.1 percentile)
α_A	$3.21 - 0.68 \ln \zeta$	$4.38 - 1.04 \ln \zeta$
α_V	$2.31 - 0.41 \ln \zeta$	$3.38 - 0.67 \ln \zeta$
α_D	$1.82 - 0.27 \ln \zeta$	$2.73 - 0.45 \ln \zeta$

Source: N. M. Newmark and W. J. Hall, *Earthquake Spectra and Design*, Earthquake Engineering Research Institute, Berkeley, Calif., 1982, pp. 35 and 36.

[a]Damping ratio in percent.



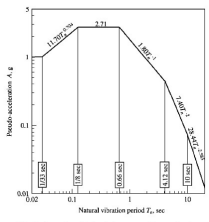
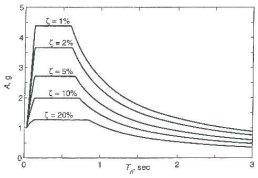
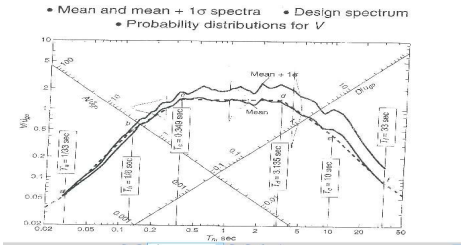


Figure 6.9.5 Elastic pseudo-acceleration design spectrum for ground motions with $\ddot{u}_{go}$ = 1g, $\dot{u}_{go}$ = 48 in./sec, and u_{go} = 36 in.; ζ = 5%.

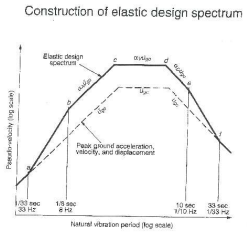
Pseudo–acceleration design spectrum

• $\ddot{u}_{go}$ = 1g, $\dot{u}_{go}$ = 48 in./sec, and u_{go} = 36 in. • ζ = 1, 2, 5, 10, 20%





Design Spectra



- Please read the text book for further clarification