LECTURE 10 - EARTHQUAKE GROUND MOTION LINEAR RESPONSE

CE 225

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RESPONSE QUANTITIES

MAXIMUM DEFORMATION RESPONSE

EOM: $m\ddot{u} + c\dot{u} + ku = -m\ddot{u}_g \longrightarrow$

Response is only dependent on ζ and ω_n :

**Now, we want max acceleration and max velocity.

RESPONSE QUANTITIES

MAXIMUM ACCELERATION RESPONSE

Assume no damping ($\zeta = 0$):

What about damping?

RESPONSE QUANTITIES

MAXIMUM VELOCITY RESPONSE

Assume no damping ($\zeta = 0$):

For no base motion: $\ddot{u} + \omega_n^2 u = 0 \quad \longrightarrow$

With base motion: $\ddot{u}^t + \omega_n^2 u = 0 \quad \longrightarrow$

But, we still define Pseudo-Velocity:

- Ok estimation
- Less important $\rightarrow$ we calculate drift from "D", and base shear from "A".
- Damping still has relatively little effect on accuracy of pseudo-velocity

RESPONSE SPECTRA

EXAMPLE SPECTRA

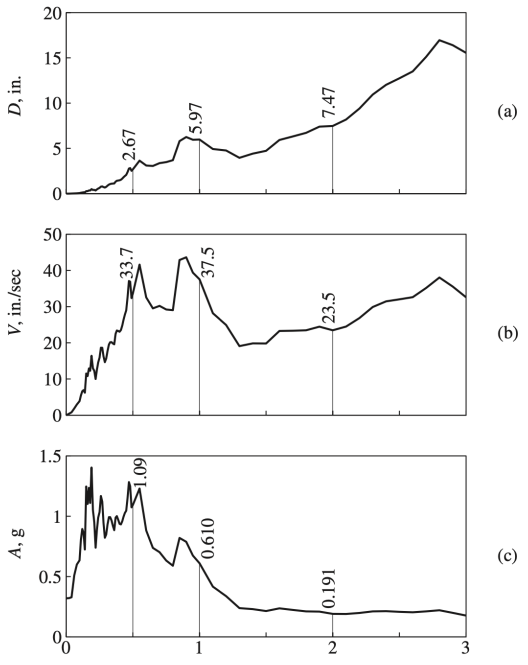

Figure 6.6.2 Response spectra ($\zeta = 0.02$) for El Centro ground motion: (a) deformation response spectrum; (b) pseudo-velocity response spectum; (c) pseudo-acceleration response spectrum.

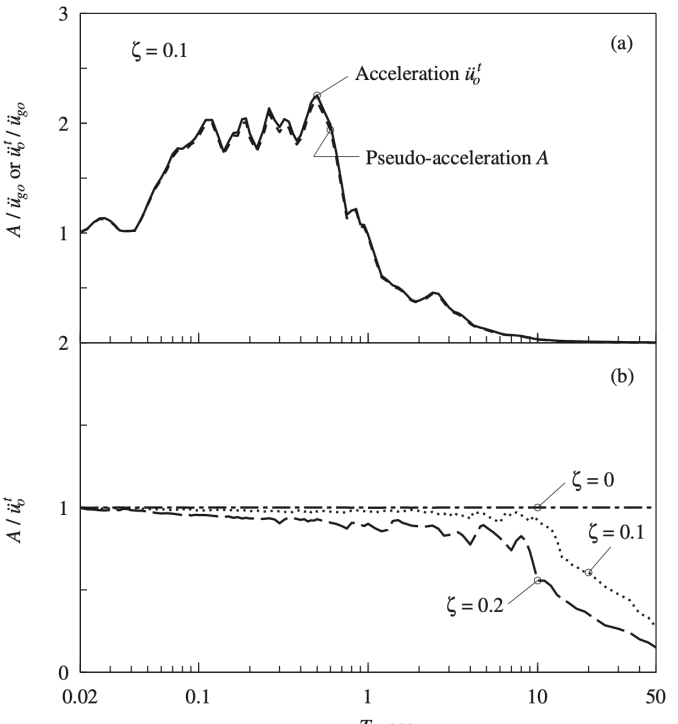

Figure 6.12.2 (a) Comparison between pseudo-acceleration and acceleration response spectra; $\zeta = 10\%$; (b) ratio $A/\ddot{u}_o^t$ for $\zeta = 0$, 10, and 20%.

RESPONSE SPECTRA

TRIPARTITE SPECTRA

Solve EOM to find maximum diplacement, i.e. Spectral Deformation, D

Then assume max responses can be approximated by:

$$\begin{cases} V = \omega_n D \\ A = \omega_n^2 D \ (= \omega_n V) \end{cases}$$

Plot maximum responses as Tripartite Spectrum (see Lecture 4)

RESPONSE SPECTRA

HOW TO CREATE RESPONSE SPECTRA

- Solve response at every T_n of interest (e.g. $T_n = [0.02 : 0.02 : 20]$ sec)
  - Solve using convolution or Numerical Methods (Chap. 5)
- Plot maximum response for each T_n on one graph.
- Repeat for different levels of damping.
- Each suite of response spectra (for different damping levels) defines the maximum response of any (linear) structure to a given earthquake.

RESPONSE SPECTRA

EXAMPLE TRIPARTITE SPECTRA

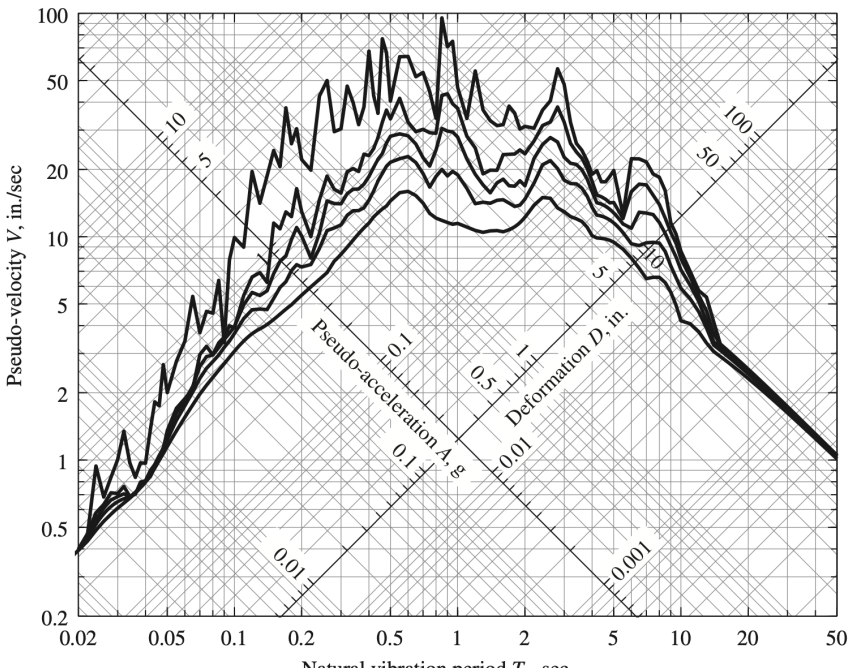

Figure 6.6.4 Combined D–V–A response spectrum for El Centro ground motion; $\zeta = 0$, 2, 5, 10, and 20%.

STRUCTURAL EXAMPLE

DEFINITION OF STRUCTURAL RESPONSE PARAMETERS

STRUCTURAL EXAMPLE

FRAME STRUCTURE

Given:

Loading = El Centro Ground Motion

$$m = \frac{10 \text{ kips}}{386 \text{ in/s}^2}; \quad EI = 0.025 \text{ kip - in}^2; \quad \zeta = 5\%$$

Determine: Max base shear & max column shears

STRUCTURAL EXAMPLE

FRAME STRUCTURE