CE-227 Midterm 1

2 - Performance Objectives

$$Pr = 1 - e^{\frac{-t}{RI}}$$

3 Linear Response

General

- **Pseudo acceleration**: absolute acceleration of a SDF system with $\zeta = 0$.
- **Spetral displacement**: *relative* displacement.
- **Viscous Damping**:
- **DBE** $= \frac{2}{3} MCE_R$
- MCE_R: roughly 2% exceedance in 50 yrs (ASCE 7).

ASCE 7 Design Spectrum

Damping Effects

Use in Design

placeholder

4 Nonlinear Response

General

$$R = \frac{f_{el}}{f_y} \quad \gamma = \frac{\Delta_{max}}{\Delta_{el}} \quad \mu = \frac{\Delta_{max}}{\Delta_y} \quad \eta = \frac{V_y}{m\ddot{u}_{g,mx}}$$

Generation

Trends

Zone A: $T << T_p$

$\mu = 0.5(1 - F/Q_y)^{-1}$

$\gamma = 0.5(R - R^2/2)^{-1}$

Zone B: $T > T_p$

$R = \sqrt{2\mu - 1}$

$\gamma = \frac{R^2+1}{2R}$

Zone C: $T >> T_p$

$\mu = R$

$\gamma = 1.0$

Code

Effects on response

placeholder

5 - Nonlinear SDOF

5.1 Nonlinear RSA (ASCE 7)

5.2 Equivalent Linearization

Iterative process where Δ_{max} is used to find $[K, \zeta]_{eff}$.

Used for base-isolated structures.

1. Apply P, obtain V_{base} (Pushover analysis)
2. Use T_0 and ζ find $\Delta_i = Sa(T_0, \zeta)T_0$

5.3 Capacity Spectrum

1. Guess ζ, find

5.4 Coefficient Method (ASCE 41)

$\delta_t = C_0 C_1 C_2 S_a \frac{T_e^2}{4\pi^2} g$

- $C_o(\Phi_n \Gamma)$: converts SDOF spectral displacement to MDOF roof displacement
- $C_1(\ \gamma)$: amplification for bilinear response
- C_2: amplification for pinched hysteresis, stiffness degradation, and strength deterioration
- $T_{\text{e}} = T_{\text{initial}} \sqrt{\text{k}_{\text{i}}/\text{ke}}$

$\mu_{\text{strength}} = \frac{S_a^e}{V_y/w} C_m$

$R_{\max} = \mu_{\max} = \frac{\Delta_d}{\Delta_y} + \frac{|\alpha_e|^{-h}}{4}$

$h = 1 + 0.15 \ln T_e$

$\alpha_e = \alpha_{P-\Delta} + \lambda(\alpha_2 - \alpha_{P-\Delta})$

$$\lambda = \begin{matrix} 0.8 \text{ if } S_{X1} \geq 0.6 \\ 0.2 \text{ if } S_{X1} \leq 0.6 \end{matrix}$$

6 - MDOF Analysis

1. Linear Static - ELF (ASCE 7)

2. Linear Dynamic - Modal RSA

1. Reduce spectrum by $\frac{I_e}{R}$
2. Conduct modal analysis subject to $V_b \geq V_{ELF}$

3. Nonlinear Static

1. Nonlinear RSA
2. Equivalent Linearization
3. Capacity Spectrum
4. Coefficient Method (ASCE 41)

MDOF -> SDOF

1. Bilinearize
2. plot V/M_n^* vs $D_1 = \frac{u_{roof}}{\Gamma \Phi_{roof,n}}$
3. $\omega = \sqrt{\frac{V_{yn}}{M_n^* D_{yn}}}$

7. Seismic Systems

Moment Frames

Force: V_{beam}, $[N, V, M]_{col}$, V_{jnt}
Displ: M_{beam}

$$Q_i \delta = \frac{2 M_p \delta n_{bays}}{(h_i + h_{i+1})/2}$$

Shear Walls

Force: N
Displ: M_{base}, V

Coupled Walls

Force: Wall - V, M
Displ: Link - V

CBFs

Force: Beam, col - N, V, M
Displ: Brace - N

BRBFs

EBFs

Force: Beam, column, **brace** - N, M
Displ: Link - V

Preliminary Design

SDOF - Method I

1. Guess T
2. Estimate V_b
3. Design members for strength
4. Check displacement limits
5. Validate period

SDOF - Method II

1. Find T_{max} for $\Delta_{allowed}$
2. Calc K_{min}
3. Calc min. strength, $V = Sa(T) \frac{\omega}{R/I_e}$
4. Consider capacity design limits
   - $M_p r = R_y C_{pr} F_y Z$
   - $\phi V_n \geq \frac{M_p}{h}$
5. Select Dimensions

Moment Frames

1. Find T
2. Find $V_b = Sa(T) \frac{\omega}{R/I_e}$
3. Find I_{min}:
   - $\delta = 7$
4. Find required flexural capacities
5. Select sections
6. Capacity design
   - Column N, V, M
   - Joints

~~Braced Frames~~

http://claudioperez.github.io/

Structural Characteristics				Analytical Procedure			
Performance Level	Fundamental Period, T	Regularity	Ratio of Column to Beam Strength	Linear Static	Linear Dynamic	Nonlinear Static	Nonlinear Dynamic
Immediate	$T \leq 3.5T_s^1$	Regular or Irregular	Any Condition	Permitted	Permitted	Permitted	Permitted
	$T > 3.5T_s^1$	Regular or Irregular	Any Conditions	Not Perrmitted	Permitted	Not Permitted	Permitted
Collapse Prevention	$T \leq 3.5T_s^1$	Regular [2]	Strong Column [3]	Permitted	Permitted	Permitted	Permitted
			Weak Column [3]	Not Permitted	Not Permited	Permitted	Permitted
		Irregular [2]	Any Conditions	Not Permitted	Not Permitted	Permitted	Permitted
	$T > 3.5T_s$	Regular	Strong Column [3]	Not Permitted	Permitted	Not Permitted	Permitted
			Weak Column [3]	Not Permitted	Not Permitted	Not Permitted	Permitted
		Irregular [2]	Any Conditions	Not Permitted	Not Permitted	Not Permitted	Permitted