

California Special Civil P.E. Seismic Principles Examination Statistics

Civil: Seismic (2½ hour)

Exam	% Passed	Cut off score	Total Score	Passing %
April 1997	46.5%	126	270	47%
October 1997	45.9%	130	274	47%
April 1998	33.3%	163	294	55%
October 1998	44.0%	139	294	47%
April 1999	35.8%	155	282	55%
October 1999	39.3%	168	289	58%
April 2000	37.5%	127	261	49%
October 2000	39.4%	148	288	51%
April 2001	37.3%	121	268	45%
October 2001	40.3%	150	294	51%
April 2002	39.6%	138	276	50%
October 2002	44.2%	136	287	47%
April 2003	37.1%	155	300	52%
October 2003	40.4%	136	281	48%
April 2004	35.6%	125	263	48%
October 2004	38.5%	154	300	51%
April 2005	39.8%	159	292	54%
October 2005	44.8%	164	295	56%
April 2006	37.4%	152	300	51%
October 2006	37.2%	142	263	54%
April 2007	36.7%	156	292	53%
October 2007	39.9%	177	292	61%
April 2008	36.3%	153	295	52%
October 2008	36.6%	151	285	53%
April 2009	39.5%	25	50	50%
October 2009	39.2%		Pass / Fail Only	

8.2 Diaphragm Types

DIAPHRAGM FLEXIBILITY

ASCE 7 – §12.3.1

The structural analysis shall consider the relative stiffnesses of diaphragms (floor and/or roof), and the vertical elements of the seismic force-resisting system (e.g., shear walls, braced frames, moment frames).

Unless a diaphragm can be idealized as either flexible or rigid ... the structural analysis shall explicitly include consideration of the stiffness of the diaphragm (i.e., semi-rigid modeling assumption).

FLEXIBLE DIAPHRAGM CONDITION

ASCE 7 – §12.3.1.1 & IBC §1613.6.1

Diaphragms constructed of wood structural panels or untopped steel decking (i.e., metal deck without concrete fill) are permitted to be idealized as flexible when occurring in:

- structures in which the vertical elements are steel (or composite steel and **concrete**) braced frames or concrete, masonry, steel, or composite shear walls
- one- and two-family residential buildings of light-frame construction
- other structures provided all of the following conditions are met:
 1. $\leq 1\frac{1}{2}$ inches nonstructural toppings placed over wood structural panel diaphragms, and
 2. Each line of vertical elements of the lateral-force-resisting system complies with the allowable story drift of ASCE 7 Table 12.12-1, and
 3. Vertical elements of the lateral-force-resisting system are light-framed shear walls sheathed with wood structural panels ... (or steel sheets), and
 4. Cantilever portions of wood structural panel diaphragms shall comply with IBC §2305.2.5

RIGID DIAPHRAGM CONDITION

ASCE 7 – §12.3.1.2

Diaphragms of concrete slabs (or concrete filled metal deck) with span-to-depth ratios 3 to 1 or less, may be considered as rigid ... provided no horizontal irregularities are present.

CALCULATED FLEXIBLE DIAPHRAGM CONDITION

ASCE 7 – §12.3.1.3

Diaphragms not satisfying the conditions to be considered flexible or rigid ... are permitted to be idealized as flexible where the computed maximum in-plane deflection of the diaphragm (under lateral load) is more than two times the average story drift of adjoining vertical elements of the seismic force-resisting system of the associated story under equivalent tributary lateral load.

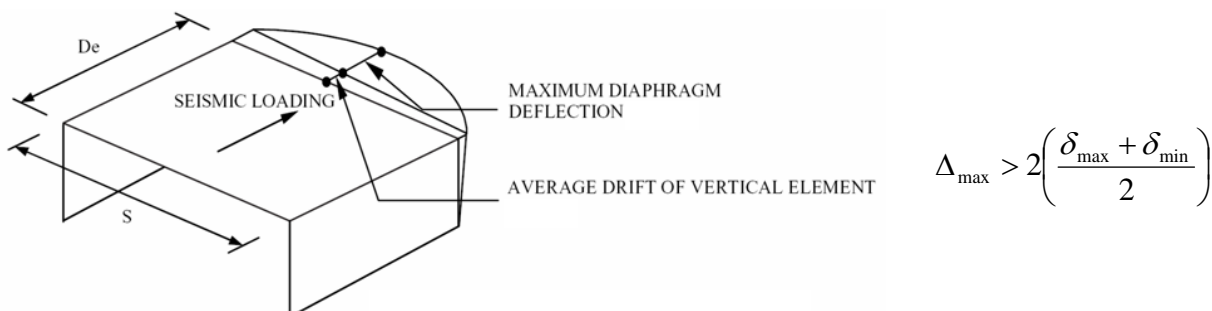


Figure 8.4 – Calculated Flexible Diaphragm Condition

DIAPHRAGM DEFLECTION

ASCE 7 – §12.12.2

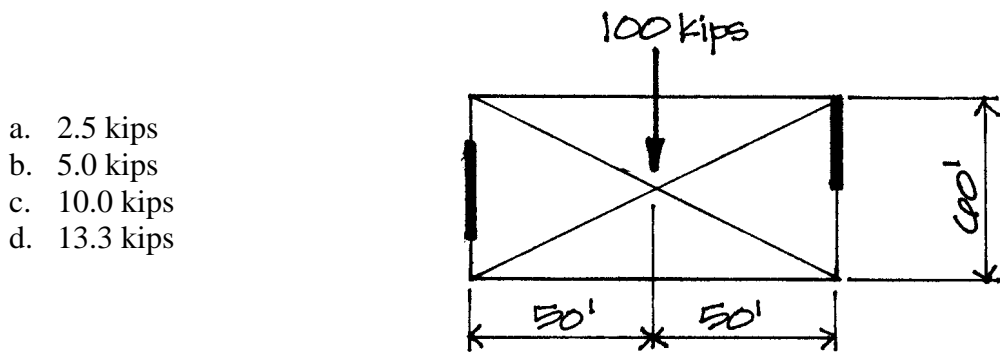
The deflection of the diaphragm ... shall not exceed the permissible deflection of the attached elements (e.g., bearing walls) ... which shall be that deflection that will permit the attached element to maintain its structural integrity under the individual loading and continue to support the prescribed loads.

- 4.21 What is the approximate fundamental period (T_a) of a 195 foot tall special steel moment frame (steel SMF) building?
- 1.04 second
 - 1.56 second
 - 1.90 second
 - 2.12 second
- 4.22 What is the approximate fundamental period (T_a) of a 35 foot tall *Dual System* building (w/ steel SMF's & reinforced concrete shear walls)?
- 0.48 second
 - 0.39 second
 - 0.35 second
 - 0.29 second
- 4.23 Given $T_S = 0.6$ second & Seismic Design Category D (SDC = D), which of the following structures would not be permitted the use of the *Equivalent Lateral Force* (ELF) procedure?
- A regular structure with $T = 2.4$ seconds
 - A 3-story light-frame irregular structure of Occupancy Category II
 - A regular structure with $T = 2.0$ seconds with Re-entrant corner irregularity
 - All of the above
 - Both a. & c.

An owner proposes to construct an office building of Seismic Design Category D using special steel concentrically braced frames (SCBF's) as the vertical seismic force-resisting elements (in both principal directions). Answer questions 4.24 to 4.27

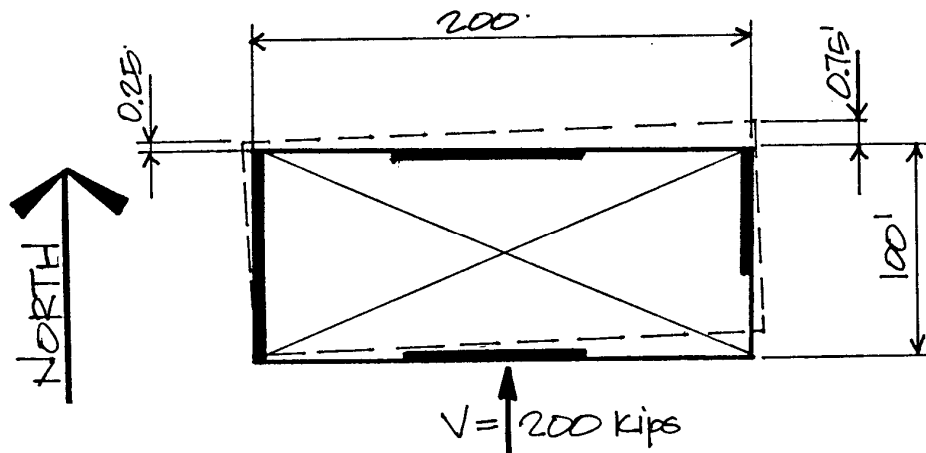
- 4.24 What *Response Modification Factor* (R) should be used for seismic design?
- 8
 - 7
 - 6
 - $3\frac{1}{4}$
- 4.25 What *System Overstrength Factor* (Ω_0) should be used for seismic design?
- 3
 - $2\frac{1}{2}$
 - 2
 - None of the above
- 4.26 What would be the height limit for this proposed building?
- No Limit
 - 160 feet
 - 100 feet
 - 35 feet
- 4.27 Assuming a building height of 140 feet, what is the approximate fundamental period (T_a) using *ASCE 7 – §12.8.2.1*?
- 1.5 seconds
 - 1.4 seconds
 - 1.2 seconds
 - 0.8 second

- 8.27 For the East-West direction, what is the inherent torsional moment (M_t)?
- 0 kip-ft
 - 1,500 kip-ft
 - 3,750 kip-ft
 - 5,250 kip-ft
- 8.28 For the East-West direction, what is the accidental torsion (M_{ta})?
- 0 kip-ft
 - $\pm 1,500$ kip-ft
 - $\pm 2,000$ kip-ft
 - $\pm 3,750$ kip-ft
- 8.29 For the East-West direction, what is the maximum total shear (direct + torsion) in Wall 1?
- 25 kips
 - 250 kips
 - 260 kips
 - 303 kips
- 8.30 Given the rigid diaphragm below. Each shear wall resists 50 kips neglecting accidental eccentricity. What is the wall torsional shear due to accidental torsion?



- 2.5 kips
- 5.0 kips
- 10.0 kips
- 13.3 kips

A 3-dimensional computer lateral analysis was performed on the single-story Office building assigned to SDC = D w/ a rigid diaphragm and steel eccentrically braced frames ($C_d = 4$), neglecting accidental eccentricity. Using a seismic base shear (V) of 200 kips, the story drift at the North-West and North-East corners of the structure are determined to be 0.25 inch and 0.75 inch respectively. Answer questions 8.31 through 8.33



PROBLEM	ANSWER	REFERENCE / SOLUTION
9.5	d	p. 1-122 & 2006 IBC p. 451 & 442, Table 2306.4.1 - footnote i & §2305.3.11 In <u>SDC = D, E or F</u> – 3x nominal studs and blocking required at all abutting joints where ASD unit wall shear > 350 plf ... panel joint and sill plate nailing shall be staggered ... and, 2x sill plate allowed when ASD unit wall shear < 600 plf (i.e., provide twice as many sill bolts) ←
9.6	b	p. 1-121 & 2006 IBC p. 439, Table 2305.3.4 - footnote a $h/w \leq 3.5$ maximum (requires reduction factor $2w/h$ for seismic) \therefore minimum $w = (h/3.5) = 10' / 3.5 = 2.86' \approx \underline{2'-10"}$ ←
9.7	a	p. 1-120, Wood structural panel horizontal diaphragms $V_{max} = w \cdot L / 2 = V / 2 = 33.6 \text{ kips} / 2 = 16.8 \text{ kips}$ for ASD, roof $v = (0.7 \cdot V_{max}) / d = 0.7(16.8 \text{ kips}) / 50' = 235 \text{ plf} \approx \underline{240 \text{ plf}}$ ←
9.8	b	p. 1-104, Drag force Maximum drag force occurs on right (i.e., East) wall line – 20' from South end of collector – for ASD, max $F_d = \text{roof } v(20') = (240 \text{ plf})(20') = 4,800 \text{ lbs} = \underline{4.8 \text{ kips}}$ ←
9.9	b	p. 1-125, Shear wall overturning $\rho = 1.0$ (given) $V_1 = V_2 = V / 2 = 33.6 \text{ kips} / 2 = 16.8 \text{ kips}$ $T = \frac{-0.7 \rho (V_1 \cdot h)}{b} = \frac{-0.7(1.0)(16.8)(10')}{30'} = -3.92 \text{ kips}$ \therefore for ASD, uplift $T = \underline{4.0 \text{ kips}}$ ←
9.10	b	p. 1-120, Wood structural panel horizontal diaphragms $V = C_S \cdot W = 0.196 \cdot W$ (given) For a single-story building – $w_s = f_{p1} = F_{p1} / L = C_S \cdot w_{p1}$ East-West: $w_s = 0.196 [(25 \text{ psf})(75') + (15 \text{ psf})(12'/2) \cdot 4 \text{ walls}] = 438 \text{ plf}$ $V_{max} = w_s \cdot L / 2 = (438 \text{ plf})(40') / 2 = 8,760 \text{ lbs}$ for ASD, roof $v = (0.7 \cdot V_{max}) / d = 0.7 \cdot (8,760) / 75' = 82 \text{ plf} \approx \underline{80 \text{ plf}}$ ←
9.11	a	2006 IBC p. 450, Table 2306.4.1 15/32" Structural I sheathing w/ 10d @ 6" o.c. = 340 plf 15/32" rated sheathing w/ 8d @ 4" o.c. = 380 plf > 340 plf ←
9.12	c	2006 IBC p. 446, Table 2306.3.1 Load parallel to continuous panel joints = Case 3 (weak direction) 19/32" sheathing w/ 10d @ 6" o.c. unblocked = 215 plf < 275 plf NG! 19/32" sheathing w/ 10d @ 6" o.c. blocked = 320 plf > 275 plf ←
9.13	d	p. 1-100, Flexible diaphragm analysis $V = C_S \cdot W$ For a single-story building – $w_s = f_{p1} = F_{p1} / L = C_S \cdot w_{p1}$ N-S: $w_s = 0.20[20 \text{ psf}(120') + (15 \text{ psf})(16'/2 + 2.5') \cdot 2 \text{ walls}] = \underline{543 \text{ plf}}$ ←

T_0	= control period equal to $0.2S_{D1}/S_{DS}$
T_S	= control period equal to S_{D1}/S_{DS}
V	= seismic base shear; total seismic design lateral force or shear at the base
V_x	= seismic design shear in story x as determined in <i>ASCE 7 – §12.8.4</i> or <i>§12.9.4</i>
v_s	= shear wave velocity at small shear strains (equal to 10^{-3} percent strain or less); see <i>IBC §1613.5.5</i> or <i>ASCE 7 – §20.4.1</i> (ft/sec)
\bar{v}_s	= <u>average</u> shear wave velocity at small shear strains in top 100 ft; see <i>IBC §1613.5.5</i> or <i>ASCE 7 – §20.3.3 & §20.4.1</i> (ft/sec)
v_{si}	= the shear wave velocity of any soil or rock layer i (between 0 and 100 ft); see <i>IBC §1613.5.5</i> or <i>ASCE 7 – §20.4.1</i> (ft/sec)
W	= effective seismic weight of the building as defined in <i>ASCE 7 – §12.7.2</i>
W_p	= component operating weight
w_i, w_n, w_x	= that portion of W that is located at or assigned to Level $i, n,$ or $x,$ respectively
w_{px}	= weight of the diaphragm and the elements tributary thereto at Level $x,$ including applicable portions of other loads defined in <i>ASCE 7 – §12.7.2</i>
z	= height in structure of point of attachment of component with respect to the base; see <i>ASCE 7 – §13.3.1</i>
β	= damping ratio
β	= ratio of shear demand to shear capacity for the story between Level x and $x - 1$
Δ	= design story drift as determined in <i>ASCE 7 – §12.8.6</i>
Δ_a	= <u>allowable</u> story drift as specified in <i>ASCE 7 – §12.12.1</i>
δ_{avg}	= the <u>average</u> of the displacements at the extreme points of the structure at Level $x;$ see <i>ASCE 7 – §12.8.4.3</i>
δ_i	= elastic deflection at Level i due to the applied lateral forces, $f,$ for use in <i>ASCE 7</i> equation (15.4-6)
δ_{max}	= maximum displacement at Level $x,$ considering torsion; see <i>ASCE 7 – §12.8.4.3</i>
δ_x	= deflection of Level x at the center of the mass at and above Level $x;$ see <i>ASCE 7</i> equation (12.8-15)
δ_{xe}	= <u>elastic</u> deflection of Level x at the center of the mass at and above Level x (determined by an elastic analysis); see <i>ASCE 7 – §12.8-6</i>
ϕ	= strength reduction factor used in Strength Design (SD) or Load and Resistance Factor Design (LRFD)
θ	= stability coefficient for P -delta effects as determined in <i>ASCE 7 – §12.8.7</i>
ρ	= a redundancy factor based on the extent of structural redundancy present in a building as defined in <i>ASCE 7 – §12.3.4</i>
Ω_0	= <u>overstrength</u> factor as defined in <i>ASCE 7 – Tables 12.2-1, 15.4-1 & 15.4-2</i>

APPENDIX C - Index

A

Accelerogram, 1-3
 Accidental eccentricity, 1-109
 Actual seismic forces, 1-49
 Aftershock, 1-1
 Allowable Stress Design (ASD), 1-67
 Alquist-Priolo Earthquake Fault Zoning Act, 1-172
 Analysis procedure selection, 1-43
 Anchor, *see Purlin Anchor*
 Anchorage
 of concrete or masonry structural walls, 1-79
 to flexible diaphragms, 1-79
 to wood diaphragms, 1-80
 Angular natural frequency (ω), 1-10
 Applied Technology Council, *see ATC*
 Architectural components, 1-75
 ATC, 1-158
 Attenuation, 1-7
 Authorities, 1-177

B

Base isolation, 1-44
 Base shear, 1-16
 Buildings - ASCE 7 equivalent lateral force (ELF), 1-47
 Nonbuilding structures similar to buildings, 1-89
 Nonbuilding NOT structures similar to buildings, 1-91
 Rigid nonbuilding structure, 1-88
 Bearing wall system, 1-34
 Blocked horizontal diaphragm, 1-119
 Blue Book, 1-161
 Boundary element, concrete, 1-96
 Braced frames, 1-34
 Building Codes, 1-157
 Building frame system, 1-34
 Building separation, 1-56

C

California Building Code (CBC), 1-160
 California Building Standards Code, 1-159
 California Existing Building Code (CEBC), 1-160
 California Historic Building Code (CHBC), 1-160
 Cantilever column system, 1-35
 Center of mass (CM), 1-108
 Center of rigidity (CR), 1-108
 Chord force, 1-103
 Circular frequency (ω), 1-10
 Civil Engineer, 1-178
 Collector, 1-103
 Elements, 1-69
 Combinations
 of framing systems in different directions, 1-38

 of framing systems in the same direction, 1-38
 Compatibility, 1-171
 Component, 1-71, 1-75, 1-76
 Amplification factor (a_p), 1-74
 Importance factor (I_p), 1-71
 Mechanical & electrical components, 1-76
 Response modification factor (R_p), 1-74
 Compression waves (P-waves), 1-3
 Concrete
 Diaphragms, 1-98, 1-99
 Moment frames with URM infill walls, 1-169
 Non-ductile frames and bridges, 1-164
 Precast structures, 1-165
 Shear walls, 1-143
 IMF, 1-142
 OMF, 1-143
 SMF, 1-141
 Structures, 1-141
 Tilt-up buildings, 1-166
 Wall rigidity, 1-105
 Configuration irregularities, 1-39
 Confinement, 1-145
 Construction documents, 1-18
 Continuity plate, 1-147
 Critical damping ($B_{critical}$), 1-11
 Crosstie, 1-142

D

Damage, *see Earthquake*
 Dampers, 1-44
 Damped period of vibration (T_d), 1-12
 Damping (B), 1-11
 Critical ($B_{critical}$), 1-11
 Ratio (β), 1-12
 Systems, 1-44
 Dead load (D), 1-66
 Deflection
 Cantilever wall, 1-105
 Fixed wall, 1-106
 of a level (δ_x), 1-53
 Design
 Spectral acceleration response parameters, 1-25
 Deformation compatibility, 1-56
 Diaphragm
 Design force (F_{px}), 1-95
 Flexible, 1-99, 1-100
 Loading, 1-101
 Rigid, 1-99, 1-107
 Types, 1-98
 Dip-slip fault, 1-2
 Discontinuity in capacity, *see Weak Story*
 Doubler plates, 1-148
 Drag