

California Civil Seismic Principles

Solution key

April 6, 2026

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1. When analyzing a structure with a "Rigid Diaphragm", how is the lateral force distributed to the vertical resisting elements?

- A. Equally to all vertical elements
- B. Based on the tributary area of each element
- C (correct). Based on relative stiffness of vertical elements**
- D. Based on the height of each element

Rationale: Forces are distributed based on the relative stiffness of the vertical elements, accounting for both translation and torsion.

2. Which ASCE 7-16 parameter accounts for the importance of a facility to the community (e.g., a hospital vs. a storage shed) when determining the design seismic base shear?

- A. The Overstrength Factor (Ω_0)
- B. The Redundancy Factor (ρ)
- C. The Deflection Amplification Factor (C_d)
- D (correct). The Seismic Importance Factor (I_e)**

Rationale: The Seismic Importance Factor (I_e) is used to increase the design forces for critical facilities (Risk Categories III and IV) to ensure a higher level of performance during an earthquake.

3. In Modal Response Spectrum Analysis, the base shear (V) must be scaled if it is less than what percentage of the base shear (V) calculated using the ELF procedure?

- A. 85%
- B. 75%
- C. 50%
- D (correct). 100%**

Rationale: Per Section 12.9.1.4.1, if the modal base shear is less than 100% of the ELF base shear, it must be scaled up to 100% of the ELF value.

4. For the Equivalent Lateral Force procedure, the fundamental period T shall NOT exceed the product of the coefficient C_u and the approximate period T_a . What is the purpose of this $C_u * T_a$ limit?

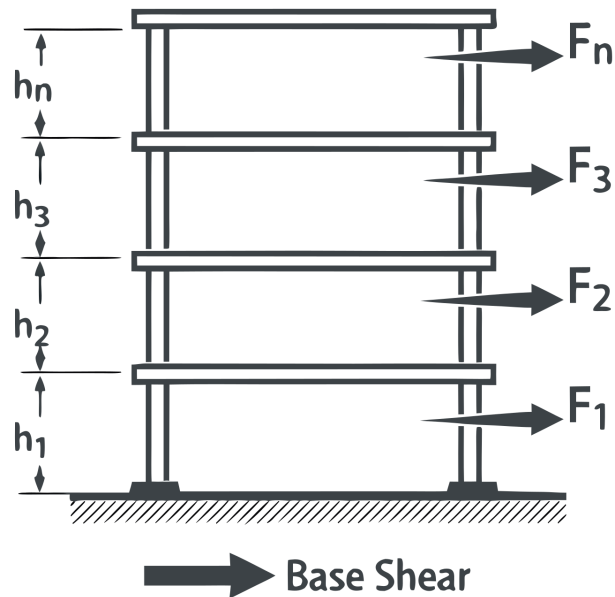
- A. Decreases the base shear for tall buildings
- B. Limits the weight of the structure
- C (correct). Prevents an unsafely low design base shear**
- D. Allows for a more flexible design

Rationale: The limit prevents the use of an unrealistically long period (which would result in an unsafely low base shear) derived from overly flexible analytical models.

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5. According to ASCE 7-16 Section 12.8.3 and the provided vertical distribution diagram, for a structure with a fundamental period $T \leq 0.5$ seconds, what is the value of the exponent k used to calculate the vertical distribution factor C_{vx} ?



- A. $k = T$
- B. $k = 2.0$
- C. $k = 0.5$
- D (correct). $k = 1.0$**

Rationale: Per ASCE 7-16 Section 12.8.3, k is an exponent related to the structure period. For $T \leq 0.5$ s, $k = 1$; for $T \geq 2.5$ s, $k = 2$; and for periods between 0.5 and 2.5 s, k is determined by linear interpolation.

6. For the design of architectural components (e.g., heavy suspended ceilings), the seismic design force F_p is calculated as a function of the component's weight (W_p) and what other critical factor at the point of attachment?

- A. The total square footage of the component
- B. The distance to the nearest active fault
- C (correct). The height of the attachment relative to the building height (z/h)**
- D. The structural material of the primary frame (steel vs concrete)

Rationale: The component amplification factor (a_p) and the height factor ($1 + 2z/h$) dictate the force F_p , representing how accelerations increase at higher elevations within the building.

7. In the vertical distribution of forces, what does the variable " w_x " represent?

- A (correct). Portion of total effective seismic weight at level x**
- B. Wind pressure at level x
- C. Live load at level x
- D. Total height of the level x

Rationale: w_x is the portion of the total effective seismic weight (W) assigned to level x .

8. True or False: All welding of seismic force-resisting elements must be performed by certified welders and is subject to special inspection.

- A. Only required for full-penetration welds
- B. False
- C. Only applies to SDC F

D (correct). True

Rationale: True. AWS D1.8 (Seismic Welding Supplement) and IBC requirements mandate certification and continuous or periodic special inspection.

9. When using the ELF procedure, the seismic response coefficient C_s is a function of the Response Modification Coefficient (R). What does R represent?

- A. Soil site class factor
- B. The stiffness of the foundation
- C. Building height multiplier

D (correct). Ductility and overstrength of the system

Rationale: R accounts for the ductility and overstrength of the specific lateral force-resisting system.

10. When a structure has a Re-entrant Corner irregularity, ASCE 7-16 Section 12.3.3.4 requires that the design forces be increased by what percentage for the design of the connection between the diaphragm and the vertical elements?

- A. 10%
- B. 50%

C (correct). 25%

- D. 100%

Rationale: Connections of diaphragms to vertical elements must be designed for a 25% increase in force when certain irregularities (like re-entrant corners) are present in SDC D, E, or F.

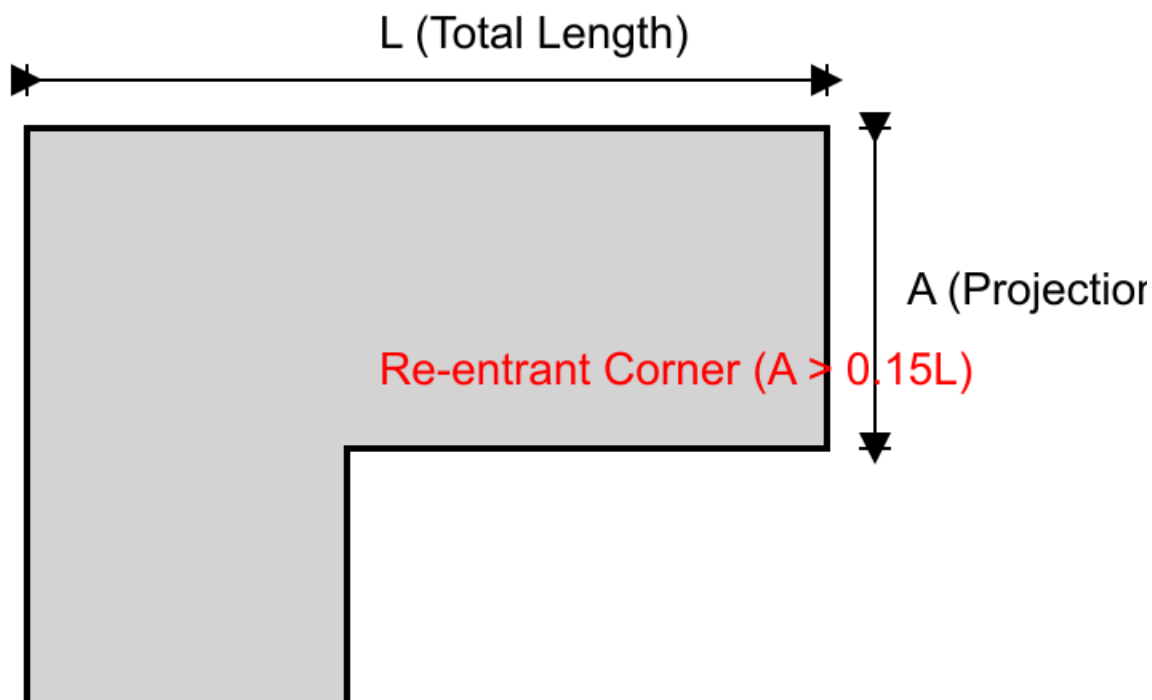
11. True or False: Orthogonal effects (loading in two perpendicular directions simultaneously) must be considered for all structures in SDC C.

A (correct). False

- B. True
- C. Only for essential facilities
- D. Only for wood structures

Rationale: False. Orthogonal effects are mandatory for structures in SDC D, E, or F with certain irregularities, but generally not for regular SDC C structures.

12. Based on ASCE 7-16 Table 12.3-1 and the provided plan view, at what projection percentage (A/L) is a Re-entrant Corner Irregularity (Type 2) classified as existing in the structure?



Ex:
On

- A (correct). 15%
- B. 10%
- C. 20%
- D. 25%

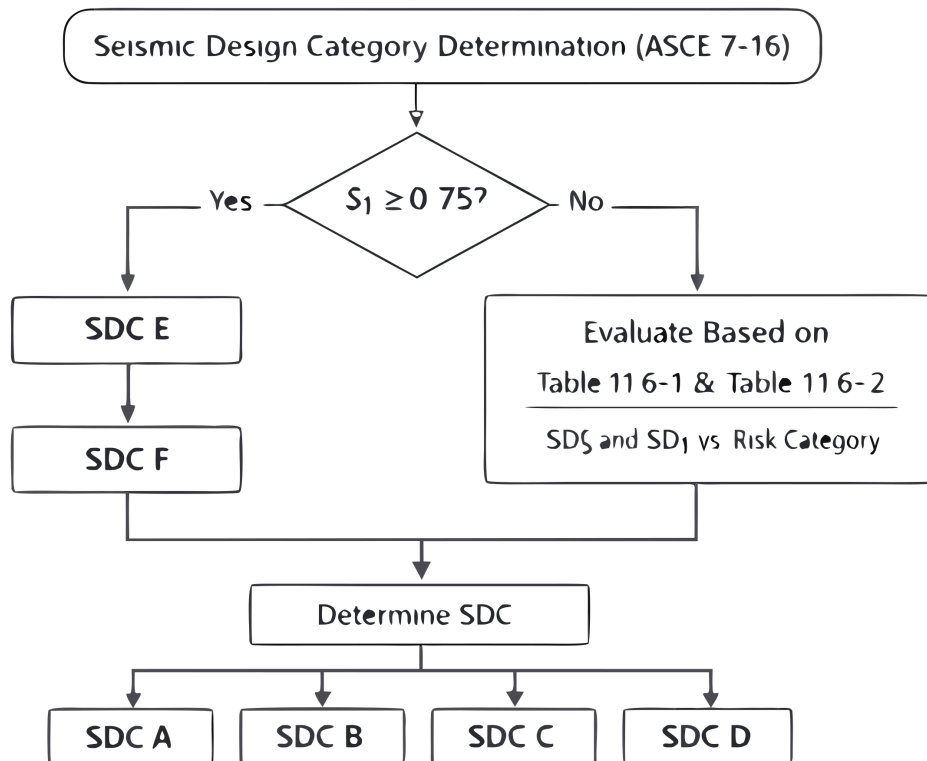
Rationale: According to ASCE 7-16 Table 12.3-1, a Re-entrant Corner Irregularity (Type 2) exists where both plan projections (A) of the structure beyond a re-entrant corner are greater than 15 percent of the plan dimension (L) of the structure in the given direction.

13. Which Risk Category is assigned to "essential facilities" such as hospitals, fire stations, and police stations?

- A (correct). Risk Category IV**
- B. Risk Category III
- C. Risk Category II
- D. Risk Category I

Rationale: According to ASCE 7-16 Table 1.5-1, Risk Category IV is reserved for essential facilities.

14. Based on ASCE 7-16 Table 11.6-1 and the provided flowchart, what is the Seismic Design Category (SDC) for a Risk Category II structure where the short period design spectral response acceleration (Sds) is determined to be 0.55g?



- A. SDC B
- B. SDC C
- C (correct). SDC D**
- D. SDC A

Rationale: According to Table 11.6-1, for Risk Categories I, II, and III, a value of Sds >= 0.50g results in the assignment of Seismic Design Category D.

15. True or False: According to ASCE 7-16, the base shear V must be distributed vertically using a linear triangular distribution ($k=1$) for all buildings, regardless of height.

- A. Only for Risk Category IV buildings
- B (correct). False**
- C. Only for SDC A buildings
- D. True

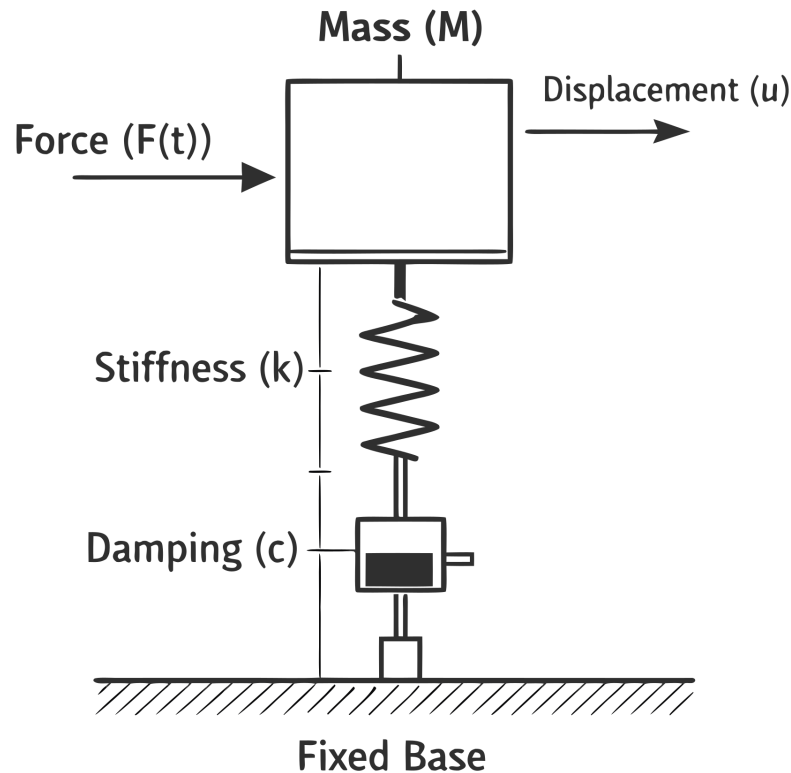
Rationale: False. The vertical distribution factor exponent (k) is 1 for short buildings ($T \leq 0.5s$), but increases up to 2 for taller buildings ($T \geq 2.5s$) to account for higher mode effects.

16. Per ASCE 7-16 Section 12.8.1.1, the seismic response coefficient C_s shall NOT be less than which of the following?

- A. $0.01 * SD1 * I_e$
- B. $SDS / (R/I_e)$
- C. $0.2 * SDS$
- D (correct). $0.044 * SDS * I_e$**

Rationale: ASCE 7-16 Eq. 12.8-5 specifies a minimum C_s value of $0.044 * SDS * I_e$.

17. The diagram represents a Single Degree of Freedom (SDOF) dynamic system. In seismic engineering, the fundamental natural period (T) of this simple system is calculated as a function of its Mass (M) and which other labeled property?



- A. Damping (c)
- B (correct). Stiffness (k)**
- C. Force (F)
- D. Velocity (v)

Rationale: The fundamental natural period of an SDOF system is determined by the formula $T = 2 * \pi * \sqrt{M/k}$, where M is the mass and k is the lateral stiffness.

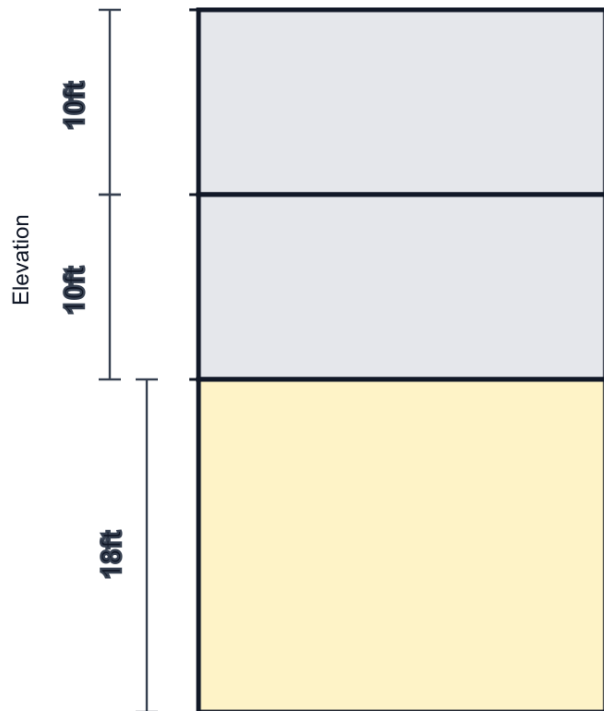
18. What is the "Overstrength Factor" (Ω_0) used for in seismic design?

- A. Decrease the spectral acceleration
- B. Increase the design base shear for the entire building
- C. Account for live load reductions

D (correct). Design critical elements for the maximum deliverable force

Rationale: It is used to design critical elements (like columns supporting discontinuous walls) for the maximum force that can be delivered by the system.

19. According to ASCE 7-16, a Soft Story Irregularity (Type 1a) is defined to exist where the lateral stiffness of a story is less than what percentage of the stiffness of the story above?

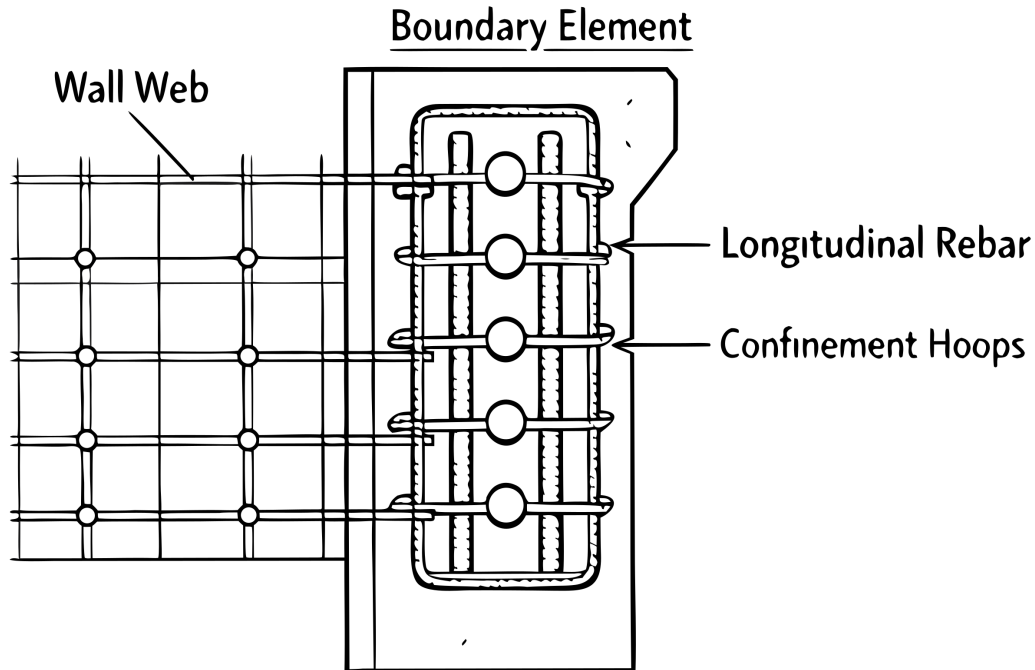


Elevation (story heights shown — Type 1a soft story relates lateral stiffness between adjacent levels)

- A. 80%
- B. 90%
- C. 50%
- D (correct). 70%**

Rationale: A soft story exists when the lateral stiffness is less than 70% of the story above (or less than 80% of the average stiffness of the three stories above).

20. The provided cross-section shows a Special Boundary Element at the edge of a concrete shear wall. What is the primary structural purpose of the closely spaced transverse confinement hoops shown in this boundary element?



- A. To increase the pure flexural tensile strength of the wall
- B (correct). To provide confinement for the concrete and prevent buckling of longitudinal reinforcement**
- C. To reduce the overall weight of the boundary element
- D. To serve as the primary shear transfer mechanism across horizontal construction joints

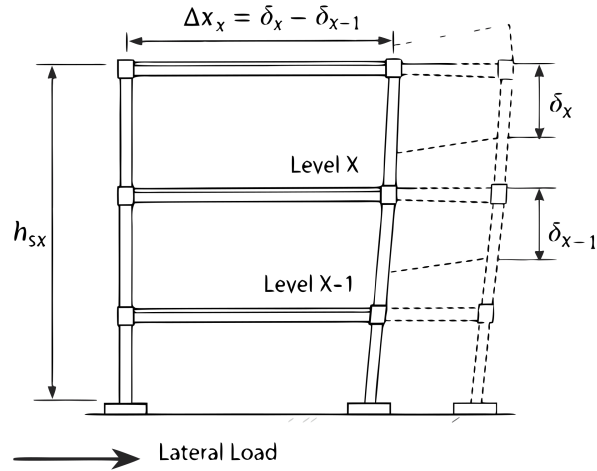
Rationale: Confinement reinforcement in boundary elements is critical for maintaining the concrete's compressive strength and ductility under severe cyclic lateral loads, preventing the longitudinal rebar from buckling.

21. A "Flexible Diaphragm" is typically defined as a diaphragm made of which material?

- A. Concrete slab
- B. Composite deck
- C (correct). Wood-sheathed or unfilled metal deck**
- D. Steel plate

Rationale: Wood-sheathed diaphragms or unfilled metal decks are typically classified as flexible diaphragms.

22. Based on the provided drift diagram, the interstory drift (Δ) is calculated as the difference between the deflections at the top and bottom of the story under consideration. According to ASCE 7-16, for most Risk Category II structures, what is the typical allowable story drift limit (Δ_a) for a story height h_{sx} ?

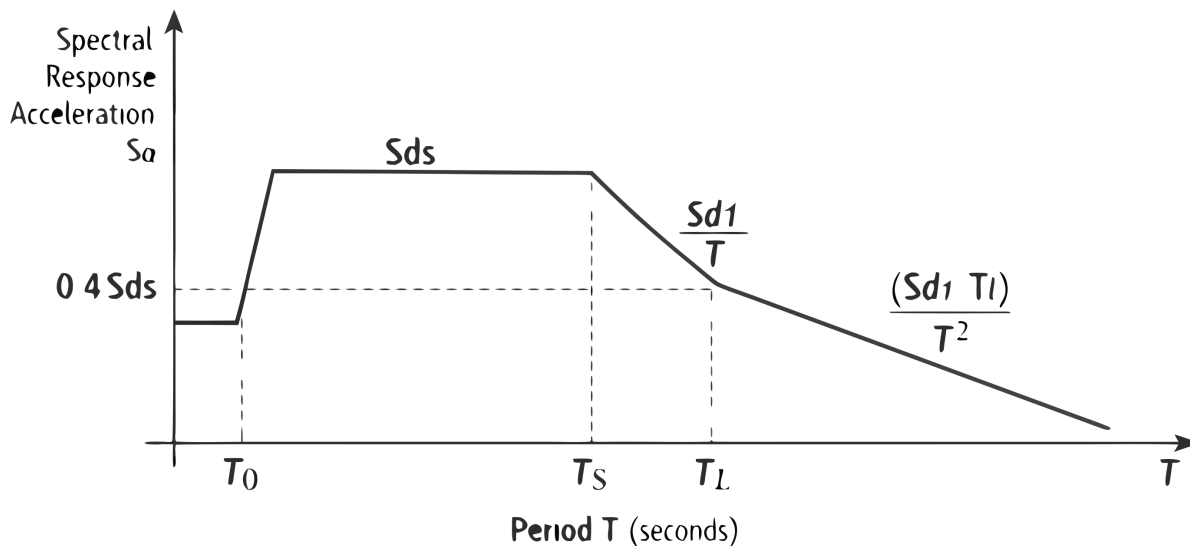


- A. $0.010 * h_{sx}$
- B. $0.025 * h_{sx}$
- C (correct). $0.020 * h_{sx}$**
- D. $0.015 * h_{sx}$

Rationale: Per ASCE 7-16 Table 12.12-1, the allowable story drift for most Risk Category II buildings is 0.020 times the story height ($0.020 * h_{sx}$).

23. According to ASCE 7-16 Section 11.4.6 and the provided diagram, for a period T such that $T_0 \leq T \leq T_s$, what is the design spectral response acceleration S_a ?

ASCE 7-16 Horizontal Design Response Spectrum

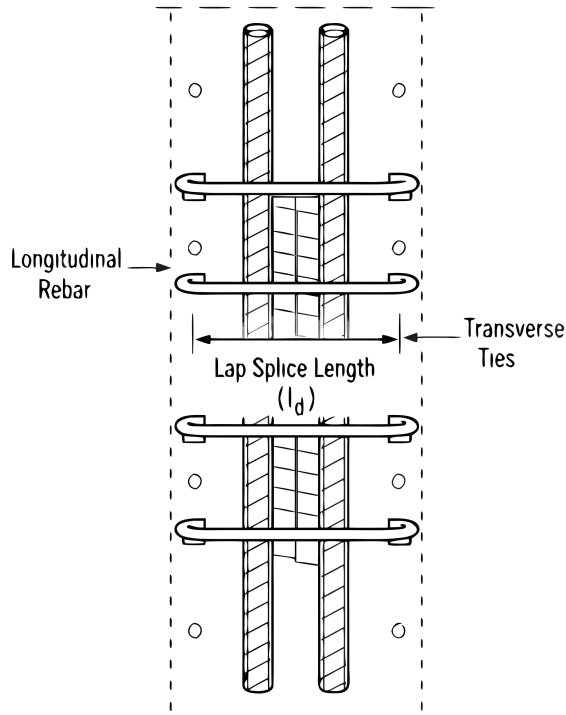


- A. $(S_d1 * T1) / T^2$
- B. S_d1 / T
- C. $S_{ds} [0.4 + 0.6 (T / T_0)]$
- D (correct). S_{ds}**

Rationale: Per Section 11.4.6 and Figure 11.4-1, for periods between T_0 and T_s , the design spectral response acceleration is constant and equal to S_{ds} .

24. The provided detail drawing shows a lap splice for longitudinal column rebar in a concrete Special Moment Frame. According to ACI 318 (referenced by ASCE 7), lap splices in special moment frame columns must be enclosed within what type of reinforcement?

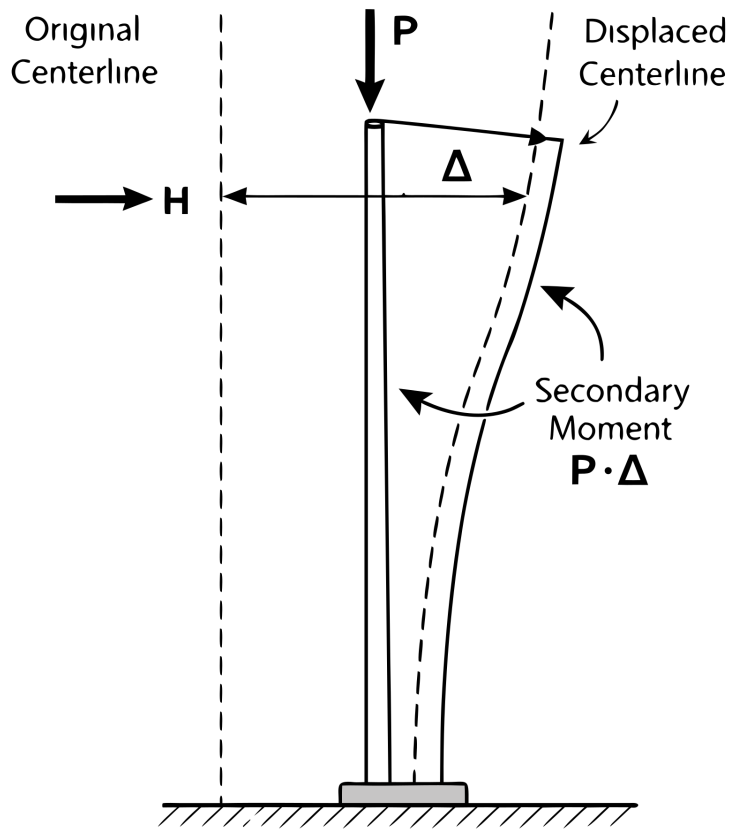
Class B Lap Splice of Longitudinal Rebar



- A (correct). Closely spaced transverse ties or hoops**
- B. Additional longitudinal rebars clustered together
- C. Heavy gauge welded wire mesh
- D. A solid steel jacket casing

Rationale: ACI 318 requires that lap splices in Special Moment Frame columns must be fully enclosed by closely spaced transverse ties or hoops over the entire lap length to prevent the spliced bars from buckling or bursting out of the concrete under cyclic loading.

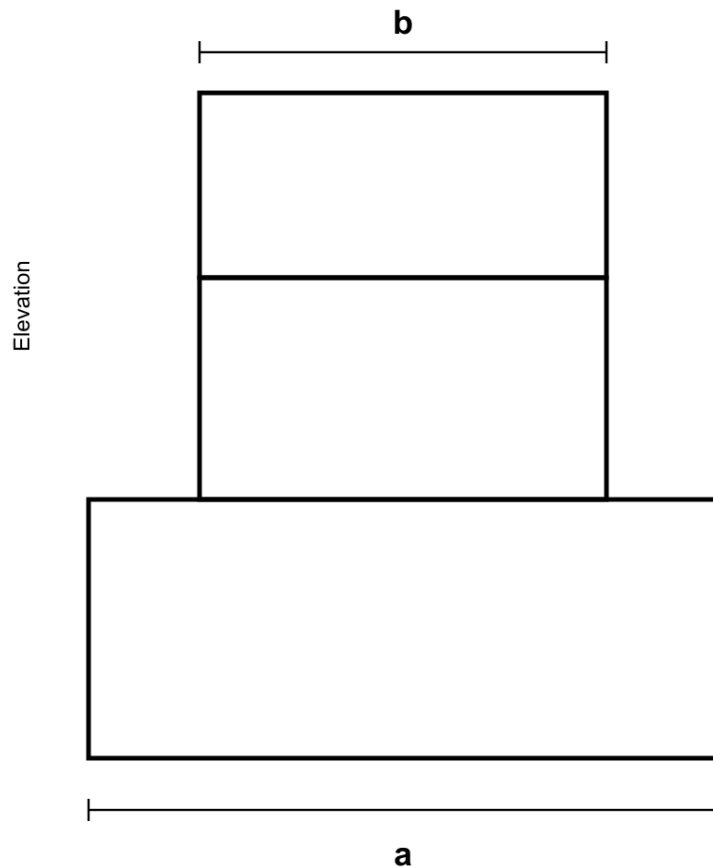
25. The provided diagram illustrates the P-Delta effect. According to ASCE 7-16 Section 12.8.7, P-Delta effects on story shears and moments do NOT need to be considered when the stability coefficient (θ) is equal to or less than:



- A. 0.05
- B. 0.25
- C. 0.15
- D (correct). 0.10**

Rationale: Per ASCE 7-16 Section 12.8.7, P-Delta effects need not be considered where the stability coefficient (θ) as determined by Eq. 12.8-16 is equal to or less than 0.10.

26. According to ASCE 7-16 Table 12.3-2, a Vertical Geometric Irregularity (Type 4) exists when the horizontal dimension of the seismic force-resisting system in any story is more than what percentage of that in an adjacent story?



$a > 130\%$ of b (adjacent horizontal dimensions)

- A. 110%
- B. 125%
- C. 150%
- D (correct). 130%**

Rationale: Type 4 irregularity exists when the horizontal dimension of the lateral force-resisting system in any story is more than 130% of that in an adjacent story.

27. The design spectral response acceleration parameter for short periods (SDS) is defined as what fraction of the MCER parameter SMS?

- A. 1.0
- B (correct). 2/3**
- C. 1/2
- D. 3/4

Rationale: Per ASCE 7-16 Section 11.4.5, Eq. 11.4-3, SDS is calculated as 2/3 of SMS.

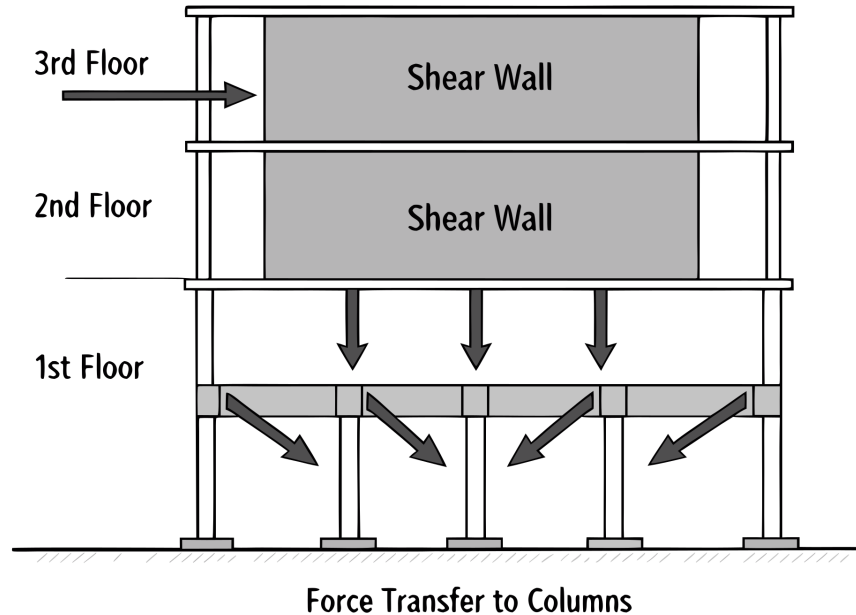
28. On the design response spectrum, the period T_s is defined by the ratio of which two parameters?

- A. SDS / SD1
- B. $0.2 * SD1 / SDS$
- C. SD1 / T
- D (correct). SD1 / SDS**

Rationale: Per ASCE 7-16 Section 11.4.6, $T_s = SD1 / SDS$.

29. The elevation diagram shows a shear wall terminating at the second floor, with forces transferring into columns below. According to ASCE 7-16 Table 12.3-2, this is classified as an In-Plane Discontinuity in Vertical Lateral Force-Resisting Element (Type 4) irregularity. Under what condition is this irregularity considered to exist?

In-Plane Discontinuity in Vertical Lateral Force-Resisting Element (Type 4 Vertical Irregularity)



- A. When the columns below have a greater stiffness than the wall
- B (correct). When the offset is greater than the length of the element**
- C. When the offset is greater than the story height
- D. When the wall is thicker than the columns below

Rationale: Per ASCE 7-16 Table 12.3-2, Type 4 irregularity exists where there is an in-plane offset of the lateral force-resisting elements greater than the length of those elements or a reduction in stiffness of the resisting element in the story below.

30. When calculating the seismic base shear using the Equivalent Lateral Force (ELF) procedure, what is the default Response Modification Coefficient (R) for an Ordinary Steel Moment Frame?

- A. 5.0
- B. 8.0
- C (correct). 3.5**
- D. 1.5

Rationale: Per ASCE 7-16 Table 12.2-1, the R value for an Ordinary Steel Moment Frame is 3.5.

31. Which analysis procedure accounts for the timing of modal peaks using the Square Root of the Sum of the Squares (SRSS) or Complete Quadratic Combination (CQC)?

- A (correct). Modal Response Spectrum Analysis**
- B. Simplified Procedure
- C. Linear Static Analysis
- D. Equivalent Lateral Force Procedure

Rationale: These are modal combination rules used in the Modal Response Spectrum Analysis procedure.

32. In the Equivalent Lateral Force Procedure, what does "W" represent in the base shear formula $V = C_s * W$?

- A. Wall Load
- B. Wind Load
- C (correct). Effective Seismic Weight**
- D. Working Stress

Rationale: Per ASCE 7-16 Section 12.8, W is the effective seismic weight of the structure, which includes the total dead load and other specific applicable loads.

33. True or False: ASCE 7-16 requires specific seismic detailing for structures assigned to Seismic Design Category A.

- A. Only for structures over 5 stories
- B. Only for essential facilities
- C. True
- D (correct). False**

Rationale: False. SDC A represents the lowest seismic risk and generally requires only a basic lateral force path with minimal detailing provisions.

34. According to ASCE 7-16, when is the Dynamic Analysis (Modal Response Spectrum) procedure required instead of the Equivalent Lateral Force (ELF) procedure?

- A (correct). Tall or highly irregular structures**
- B. All structures in SDC A
- C. Any structure with a rigid diaphragm
- D. Simple 1-story buildings

Rationale: ELF is generally restricted to regular structures or short, simple irregular structures; dynamic analysis is required for tall or highly irregular structures in higher SDCs.

35. For concrete Special Moment Frames, what is the maximum allowed spacing of transverse reinforcement (hoops) within the plastic hinge region?

- A. 8 times the bar diameter
- B (correct). Smallest of $d/4$, 6 bar diameters, or a specified formula**
- C. Constant 12 inches
- D. $d/2$ or 12 inches

Rationale: Per ACI 318 (referenced by ASCE 7), spacing is limited to the smallest of $d/4$, 6 times the bar diameter, or a specified formula.

36. In the vertical load path, what is the primary function of a collector (drag strut)?

- A (correct). Transfer diaphragm forces to vertical resisting elements**
- B. Support vertical gravity loads only
- C. Resist uplift from wind forces
- D. Distribute live loads evenly across the floor

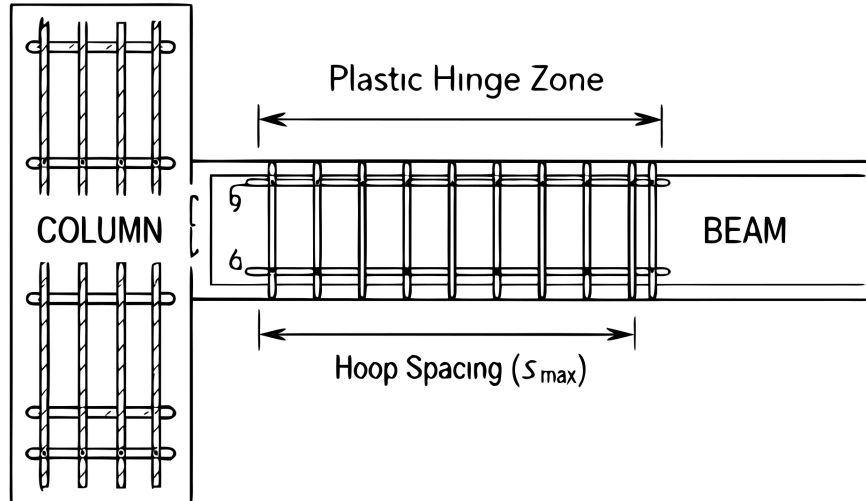
Rationale: Collectors are members used to transfer diaphragm inertia forces to the vertical elements of the seismic force-resisting system (walls or frames).

37. The redundancy factor (ρ) is used to account for the reliability of the lateral force-resisting system. What is the typical range of values for ρ ?

- A. 1.5 or 2.0
- B. 1.2 to 1.5
- C. 0.5 to 1.0
- D (correct). 1.0 or 1.3**

Rationale: The redundancy factor ρ is either 1.0 or 1.3 per Section 12.3.4.

38. Based on the provided detail of a Special Moment Frame (SMF) beam-column joint, what is the length of the critical plastic hinge zone where closely spaced transverse reinforcement (hoops) must be provided?



- A. 1.5 times the beam depth ($1.5h$)
- B. 3 times the beam depth ($3h$)
- C (correct). 2 times the beam depth ($2h$)**
- D. The clear span of the beam divided by 4 ($L/4$)

Rationale: In Special Moment Frames, the plastic hinge region is defined as twice the beam depth ($2h$) measured from the face of the supporting column.

39. What is the minimum specified concrete compressive strength (f'_c) for structures assigned to SDC D, E, or F?

- A. 4,000 psi
- B. 5,000 psi
- C. 2,500 psi
- D (correct). 3,000 psi**

Rationale: Per ACI 318, the minimum f'_c for special seismic systems is typically 3,000 psi (21 MPa).

40. Which document is the primary reference for the seismic detailing of structural steel buildings in the United States?

- A. ACI 318
- B. NDS
- C. ASCE 41
- D (correct). AISC 341**

Rationale: AISC 341, Seismic Provisions for Structural Steel Buildings.

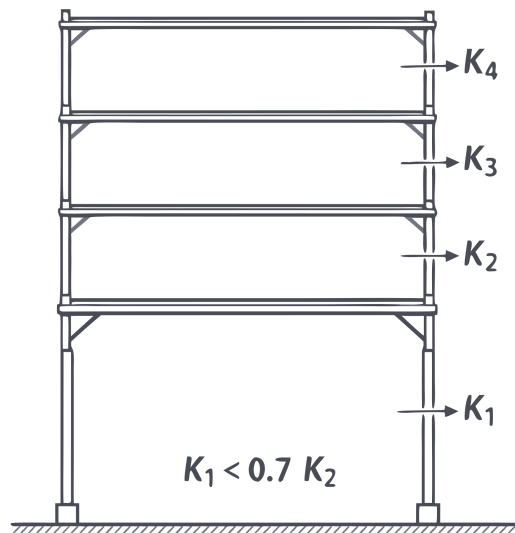
41. What is the maximum allowable value for the stability coefficient (θ) in P-Delta analysis?

- A (correct). 0.25
- B. 0.10
- C. 1.0
- D. 0.50

Rationale: Per Section 12.8.7, θ shall not exceed θ_{max} (typically 0.25) or the structure is considered potentially unstable.

42. Based on the provided elevation diagram indicating $K_1 < 0.7 * K_2$, what type of structural irregularity is present according to ASCE 7-16 Table 12.3-2?

Soft Story Irregularity (Type 1a / 1b)



- A. Weak Story Irregularity
- B. In-Plane Discontinuity
- C (correct). Soft Story Irregularity
- D. Vertical Geometric Irregularity

Rationale: Per ASCE 7-16 Table 12.3-2, a Soft Story Irregularity (Type 1a) exists if the lateral stiffness of a story is less than 70% of that in the story above.

43. Which retrofit technique is most effective at reducing the seismic demand on a stiff, brittle structure?

- A. Installing viscous dampers
- B. Adding concrete shear walls
- C. Adding braced frames
- D (correct). Base isolation

Rationale: Base isolation lengthens the fundamental period of the structure, shifting it away from the high-acceleration region of the response spectrum and reducing seismic demand.

44. What is the required hook angle for a "Seismic Hook" used in the transverse reinforcement of a ductile concrete member?

- A. 180 degrees
- B (correct). 135 degrees**
- C. 90 degrees
- D. 45 degrees

Rationale: A seismic hook must have a minimum bend of 135 degrees plus an extension.

45. For a structure with a fundamental period $T \geq 2.5$ seconds, what is the value of the exponent k used for the vertical distribution of seismic forces?

- A (correct). 2.0**
- B. 2.5
- C. 1.0
- D. 1.5

Rationale: Per ASCE 7-16 Section 12.8.3, $k = 2$ for structures with $T \geq 2.5$ seconds.

46. When calculating story drift, the displacements determined from an elastic analysis (δ_{xe}) must be multiplied by which factor?

- A (correct). C_d / I_e**
- B. 1.5
- C. R / I_e
- D. Ω_0

Rationale: Per Section 12.8.6, the design story drift is amplified by the factor C_d / I_e to account for inelastic response.

47. For the design of nonstructural components, the horizontal seismic force (F_p) is calculated using which ASCE 7-16 chapter?

- A. Chapter 12
- B. Chapter 15
- C. Chapter 11
- D (correct). Chapter 13**

Rationale: Chapter 13 of ASCE 7-16 governs the seismic design of nonstructural components.

48. True or False: ASCE 41-17 is the primary standard used for the seismic evaluation and retrofit of existing buildings.

- A. Only applies to new construction
- B. Only applies to bridges
- C. False
- D (correct). True**

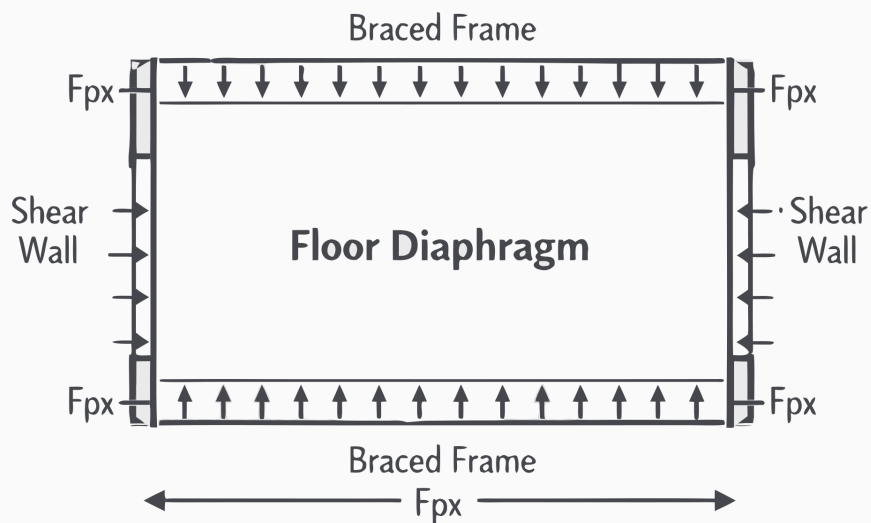
Rationale: True. ASCE 41 is the industry standard for performance-based seismic engineering of existing structures.

49. What is the primary objective of seismic retrofitting an existing building to a "Life Safety" performance level?

- A. Ensure zero architectural damage
- B. Maintain full functionality
- C (correct). Prevent total collapse**
- D. Eliminate all seismic forces

Rationale: The Life Safety performance level aims to prevent total collapse and ensure occupants can exit safely, though the building may sustain significant structural damage.

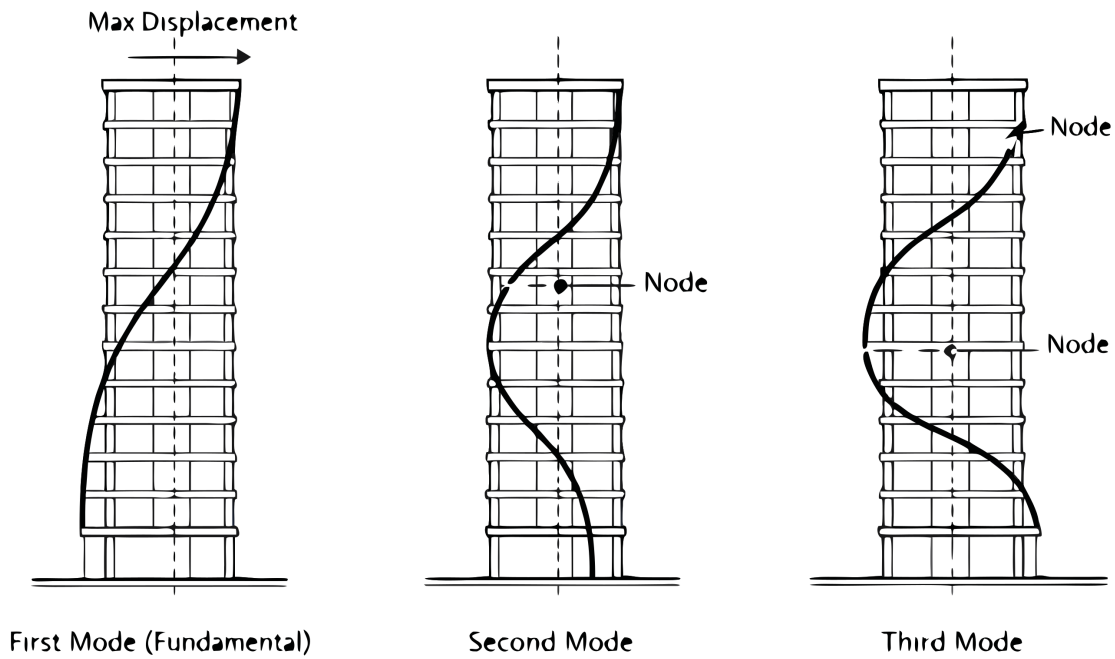
50. According to ASCE 7-16 Section 12.10.1.1 and the provided diaphragm diagram, the seismic design force for diaphragms (F_{px}) shall NOT be less than which of the following limits?



- A. $0.1 S_{ds} * l_e * w_{px}$
- B (correct). $0.2 S_{ds} * l_e * w_{px}$**
- C. $0.4 S_{ds} * l_e * w_{px}$
- D. $0.3 S_{ds} * l_e * w_{px}$

Rationale: Per ASCE 7-16 Section 12.10.1.1, Eq. 12.10-2 stipulates that the diaphragm design force F_{px} must be between a minimum of $0.2 * S_{ds} * l_e * w_{px}$ and a maximum of $0.4 * S_{ds} * l_e * w_{px}$.

51. The diagram shows the first three vibration modes of a building. When performing a Modal Response Spectrum Analysis per ASCE 7-16 Section 12.9.1, the analysis must include a sufficient number of modes to obtain a combined modal mass participation of at least:



A (correct). 90 percent

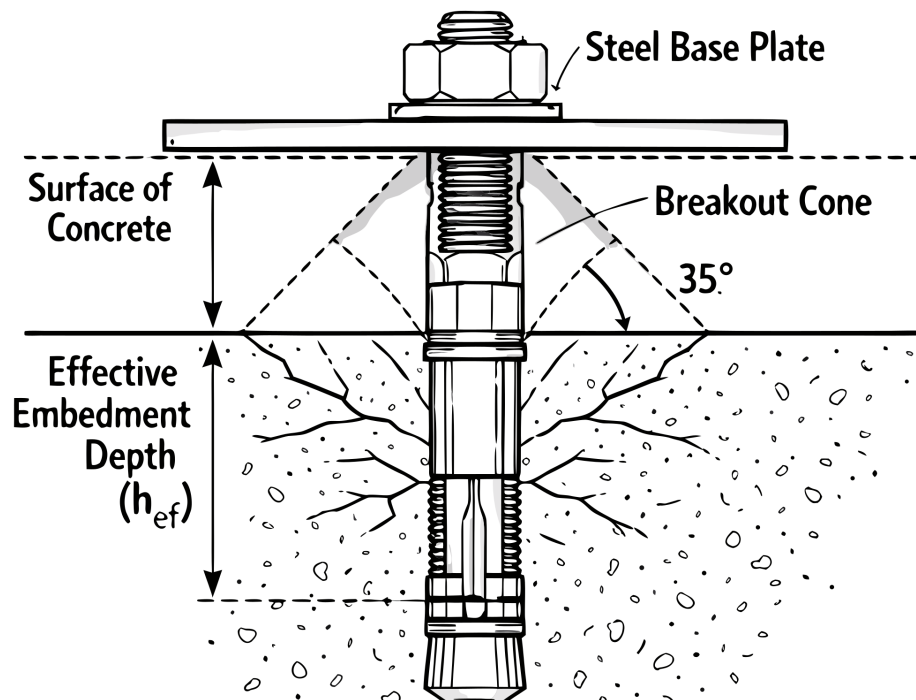
B. 100 percent

C. 75 percent

D. 80 percent

Rationale: Per ASCE 7-16 Section 12.9.1.1, the analysis shall include a sufficient number of modes to obtain a combined modal mass participation of at least 90 percent of the actual mass in each of the horizontal directions.

52. The detail drawing shows a post-installed mechanical expansion anchor. Which dimension correctly identifies the 'effective embedment depth' (h_{ef}) used for calculating concrete breakout strength in tension?



- A (correct). The depth from the concrete surface to the deepest point of load transfer (the expansion mechanism)
- B. The thickness of the base plate plus the washer and nut
- C. The total overall length of the steel anchor bolt
- D. The distance from the concrete surface to the bottom of the drilled hole

Rationale: The effective embedment depth (h_{ef}) for an expansion anchor is the distance from the concrete surface to the deepest point where the load is transferred to the concrete (the gripping mechanism), not the total length of the anchor.

53. In masonry shear walls, what is the purpose of "Grouting" the cells containing reinforcement?

- A (correct). To bond the reinforcement to the masonry units
- B. To prevent moisture intrusion
- C. To provide a smooth finish for painting
- D. To reduce the weight of the wall

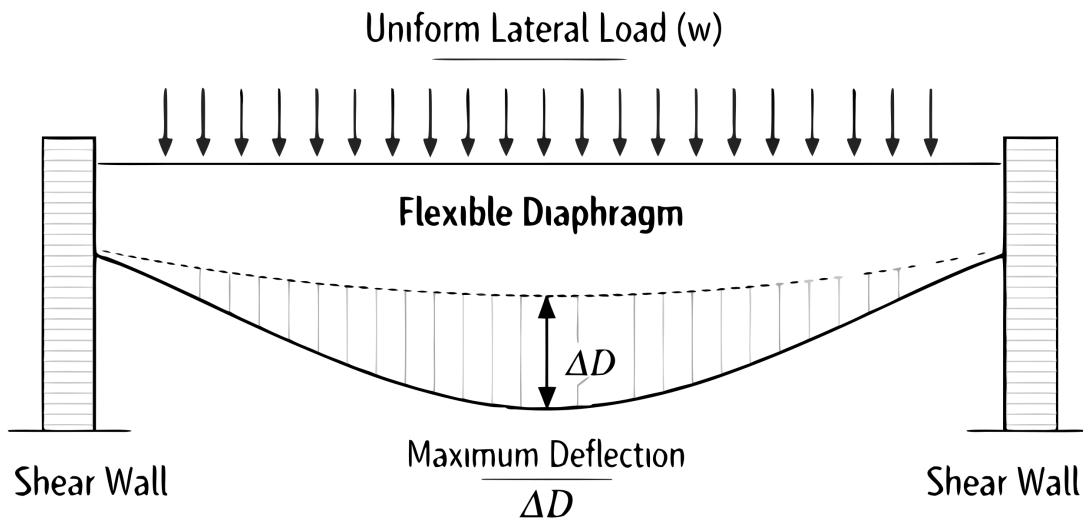
Rationale: Grout bonds the reinforcement to the masonry units, allowing the assembly to act as a composite structural element.

54. For wood-frame shear walls, which component is critical for transferring uplift forces between floors?

- A (correct). Hold-downs (tie-downs)
- B. Anchor bolts only
- C. Shear transfer plates
- D. Drag struts

Rationale: Hold-downs (tie-downs) are used to resist the overturning moments and transfer uplift forces to the foundation or floor below.

55. Based on the provided plan view of a roof diaphragm bending under a lateral load, ASCE 7-16 classifies a diaphragm as "Flexible" when its maximum lateral deflection (Δ_D) exceeds what value relative to the average drift of the vertical elements?



- A. More than 1.5 times the average drift

- B. More than 3 times the average drift
- C. More than 0.5 times the average drift
- D (correct). More than 2 times the average drift**

Rationale: According to ASCE 7-16 Section 12.3.1.3, a diaphragm is considered flexible when the maximum lateral deflection of the diaphragm is more than two times the average story drift of the associated vertical lateral force-resisting elements.