PRACTICE EXAM 22: PE CIVIL - STRUCTURAL SIMULATION (100 QUESTIONS)

This expanded practice exam contains 100 four-option questions weighted to the NCEES PE Civil: Structural CBT specification effective before April 2027. The actual NCEES PE Civil exam contains 80 questions and provides 8 hours of exam time within a 9-hour appointment. To preserve the official six-minute-per-question pace, allow 10 hours for this 100-question simulation. Use the NCEES PE Civil Reference Handbook and the design standards listed for the current Civil: Structural exam. NCEES reports results as pass/fail and does not publish a fixed passing percentage.

1. A simply supported floor beam has a tributary width of 10 ft and supports a uniform floor load of 85 psf. What uniform line load acts on the beam?

A. 85 lb/ft
B. 425 lb/ft
C. 1,700 lb/ft
D. 850 lb/ft

2. A 24-ft simply supported beam carries a uniform service load of 1.8 kip/ft over its full span. What is the vertical reaction at each support?

A. 10.8 kip
B. 21.6 kip
C. 43.2 kip
D. 3.6 kip

3. A concrete slab is 8 in. thick and has a unit weight of 150 pcf. What is the slab self-weight expressed as a uniform pressure?

A. 100 psf

B. 150 psf
C. 75 psf
D. 1,200 psf

4. For this problem, use the load combination U = 1.2D + 1.6L. If D = 40 psf and L = 60 psf, what is U?

A. 100 psf
B. 112 psf
C. 144 psf
D. 160 psf

5. A roof snow calculation is defined for this problem by p = 0.7 Ce Ct Is pg. If Ce = 0.9, Ct = 1.0, Is = 1.0, and pg = 40 psf, what is p?

A. 25.2 psf
B. 28.0 psf
C. 36.0 psf
D. 22.7 psf

6. For this problem, compute velocity pressure from q = 0.00256 Kz Kzt Kd V^2 I. Use Kz = 0.85, Kzt = 1.0, Kd = 0.85, V = 120 mph, and I = 1.0. What is q?

A. 31.3 psf
B. 26.6 psf
C. 22.6 psf
D. 37.0 psf

7. A seismic base shear is defined for this problem as V = CsW. If Cs = 0.085 and the effective seismic weight W = 2,400 kip, what is V?

A. 28.30 kip

B. 188 kip
C. 240 kip
D. 204 kip

8. A uniform surcharge of 600 psf acts behind a 12-ft retaining wall. If the lateral pressure coefficient is Ka = 0.33, what lateral force per foot of wall results from the surcharge alone?

A. 198 lb/ft
B. 1,188 lb/ft
C. 2,376 lb/ft
D. 7,200 lb/ft

9. Soil behind a retaining wall has unit weight 120 pcf, active coefficient Ka = 0.30, and retained height 15 ft. What is the resultant active soil force per foot of wall, using Pa = 0.5 Ka gamma H^2?

A. 8,100 lb/ft
B. 5,400 lb/ft
C. 270 lb/ft
D. 4,050 lb/ft

10. A 30-kip truck axle is located 8 ft from the left support of a 24-ft simply supported bridge span. What is the left support reaction due to that axle?

A. 20 kip
B. 10 kip
C. 22 kip
D. 30 kip

11. A girder supports floor beams spaced at 12 ft. Each floor beam delivers a 36-kip end reaction to the girder. If that reaction is idealized as an equivalent uniform line load, what line load represents the beam reactions?

A. 432 kip/ft
B. 1.50 kip/ft
C. 3 kip/ft
D. 6 kip/ft

12. A steel deck weighs 3 psf and supports 4 in. of normal-weight concrete at 145 pcf. What combined dead-load pressure is carried before adding other permanent loads?

A. 48.3 psf
B. 51.3 psf
C. 148.0 psf
D. 583.0 psf

13. For this problem, a reduced live load is defined as L = L0(0.25 + 15/sqrt(KLLAT)). If L0 = 80 psf and KLLAT = 2,500 ft2, what is L?

A. 20 psf
B. 68 psf
C. 44 psf
D. 32 psf

14. A roof contains 5 in. of ponded rainwater. Using a water unit weight of 62.4 pcf, what uniform roof pressure does the water create?

A. 312.0 psf
B. 62.4 psf
C. 13.0 psf
D. 26.0 psf

15. A crane wheel load of 50 kip is increased by a stated impact factor of 25%. What design wheel load results for this problem?

A. 62.5 kip
B. 50.0 kip
C. 12.5 kip
D. 75.0 kip

16. Two identical roof girders share a total vertical gravity load of 180 kip equally. One girder also receives a 24-kip concentrated equipment load that is not shared. What total gravity load acts on that girder?

A. 90 kip
B. 114 kip
C. 102 kip
D. 204 kip

17. A member is checked using three stated load combinations: 1.4D; 1.2D + 1.6L; and 1.2D + 1.0W + 1.0L. If D = 30 kip, L = 50 kip, and W = 40 kip, what is the largest resulting factored load?

A. 126 kip
B. 42 kip
C. 116 kip
D. 130 kip

18. A simply supported 20-ft beam carries a 16-kip point load at midspan. What is the maximum bending moment?

A. 160 kip-ft
B. 80 kip-ft
C. 40 kip-ft
D. 320 kip-ft

19. A simply supported 18-ft beam carries 2.0 kip/ft uniformly over the span. What is the maximum bending moment?

A. 36 kip-ft
B. 162 kip-ft
C. 72 kip-ft
D. 81 kip-ft

20. A 14-ft simply supported beam carries a 3 kip/ft uniform load over the full span. What is the magnitude of the shear reaction at either support?

A. 42 kip
B. 10.50 kip
C. 21 kip
D. 6 kip

21. A tension member carries 120 kip through a gross area of 6.0 in2. What average axial stress is produced?

A. 720 ksi
B. 0.05 ksi
C. 20 ksi
D. 60 ksi

22. A 12-ft steel bar carries 60 kip in tension. Use A = 3.0 in2 and E = 29,000 ksi. What elongation results from delta = PL/(AE)?

A. 0.0993 in.
B. 0.0083 in.
C. 0.1986 in.
D. 0.0497 in.

23. A rectangular beam section has b = 10 in. and h = 18 in. What is its elastic section modulus S = bh^2/6 about the strong axis?

A. 4,860 in3

B. 540 in3
C. 270 in3
D. 9,720 in3

24. A beam has maximum moment M = 90 kip-ft and section modulus S = 600 in3. What maximum bending stress magnitude is produced?

A. 0.1 ksi
B. 18.0 ksi
C. 150.0 ksi
D. 1.8 ksi

25. A simply supported beam with a centered point load has P = 10 kip, L = 16 ft, E = 29,000 ksi, and I = 2,000 in4. Using delta = PL^3/(48EI), what midspan deflection is obtained?

A. 0.0127 in.
B. 0.0250 in.
C. 0.3050 in.
D. 0.0508 in.

26. A simply supported beam carries w = 0.20 kip/in. over a 120-in. span. If E = 29,000 ksi and I = 1,500 in4, use delta = 5wL^4/(384EI). What is the maximum deflection?

A. 0.0025 in.
B. 0.0248 in.
C. 0.1240 in.
D. 0.0124 in.

27. A pin-ended column has E = 29,000 ksi, I = 800 in4, and length L = 15 ft. Using Pcr = pi^2EI/L^2, what Euler critical load is obtained?

A. 7,067 kip
B. 3,534 kip
C. 14,134 kip
D. 589 kip

28. A solid circular shaft has torque T = 120 kip-in., radius c = 2 in., and polar moment J = 25.13 in4. Using tau = Tc/J, what maximum torsional shear stress results?

A. 4.78 ksi
B. 19.10 ksi
C. 9.55 ksi
D. 60.30 ksi

29. A column section has axial stress P/A = 6 ksi and bending stress magnitude Mc/I = 10 ksi at an extreme fiber. What is the maximum compressive stress when the effects add?

A. 4 ksi
B. 16 ksi
C. 10 ksi
D. 60 ksi

30. At a point in plane stress, sigma_x = 20 ksi, sigma_y = 4 ksi, and tau_xy = 6 ksi. Using sigma_1 = (sx+sy)/2 + sqrt(((sx-sy)/2)^2 + tau^2), what is the major principal stress?

A. 12.0 ksi
B. 16.0 ksi
C. 26.0 ksi
D. 22.0 ksi

31. A 40-ft steel member experiences a uniform temperature increase of 60 F. Using alpha = 6.5e-6/F, what free thermal elongation occurs?

A. 0.0156 in.
B. 1.8720 in.
C. 0.1872 in.
D. 0.0936 in.

32. A fully restrained steel bar experiences a 50 F temperature increase. Use E = 29,000 ksi and alpha = 6.5e-6/F. What thermal stress magnitude is produced from sigma = E alpha DeltaT?

A. 9.43 ksi
B. 18.85 ksi
C. 0.33 ksi
D. 4.71 ksi

33. A cantilever beam carries an end load P = 8 kip over a length L = 6 ft. What is the fixed-end moment magnitude?

A. 24 kip-ft
B. 48 kip-ft
C. 8 kip-ft
D. 288 kip-ft

34. A cantilever has w = 0.15 kip/in., L = 96 in., E = 29,000 ksi, and I = 1,200 in4. Using delta = wL^4/(8EI), what free-end deflection results?

A. 0.0458 in.
B. 0.0916 in.
C. 0.0057 in.
D. 0.3660 in.

35. In an ideal pin-jointed truss, two non-collinear members meet at an unloaded joint with no support reaction at that joint. What can be concluded about those two members?

A. Both carry equal tensile force.
B. Both carry equal compressive force.
C. Only the steeper member is zero-force.
D. Both are zero-force members.

36. Which structural system is statically indeterminate because equilibrium equations alone are insufficient to determine all reactions?

A. A simply supported beam with one pin and one roller.
B. A three-member triangular pin-jointed truss with proper supports.
C. A fixed-fixed beam under transverse loading.
D. A cantilever beam fixed at one end and free at the other.

37. For a simply supported 30-ft span, the influence-line ordinate for the left reaction at a load position 9 ft from the left support is (L-x)/L. What reaction is caused by a 20-kip moving point load at that location?

A. 6 kip
B. 20 kip
C. 12 kip
D. 14 kip

38. A detail experiences stress cycling between +18 ksi and -6 ksi. What is the stress range?

A. 12 ksi
B. 24 ksi
C. 6 ksi
D. 18 ksi

39. A 3/4-in.-diameter bolt bears on a 1/2-in.-thick plate under a 15-kip force. Using average bearing stress fb = P/(td), what stress is produced?

A. 40 ksi
B. 20 ksi
C. 30 ksi
D. 53.30 ksi

40. A rectangular column has area A = 20 in2, section modulus S = 80 in3, axial load P = 100 kip, and eccentricity e = 4 in. What maximum compressive stress is produced by P/A + Pe/S?

A. 5 ksi
B. 15 ksi
C. 10 ksi
D. 25 ksi

41. A rectangular beam has b = 12 in. and h = 24 in. What is its centroidal moment of inertia I = bh^3/12 about the strong axis?

A. 13,824 in4
B. 6,912 in4
C. 1,152 in4
D. 27,648 in4

42. What is the primary structural purpose of reshoring below a recently cast concrete floor?

A. To permanently replace the building's designed columns.
B. To eliminate the need to evaluate construction sequencing.
C. To increase concrete compressive strength by mechanical confinement.
D. To transfer construction loads through multiple levels while younger slabs gain adequate strength.

43. Fresh concrete exerts an idealized uniform lateral pressure of 900 psf on a 10-ft-long form panel that is 4 ft high. What total lateral force acts on the panel?

A. 9,000 lb
B. 2,250 lb
C. 36,000 lb
D. 900 lb

44. A scaffold platform is being planned for a construction operation. Which engineering action is most appropriate before workers and stored materials are placed on it?

A. Assume any erected scaffold can carry the same load as the permanent floor.
B. Verify the scaffold configuration and load capacity for the intended workers, tools, materials, and access conditions.
C. Load the platform first and inspect it only if noticeable deflection occurs.
D. Ignore material storage because only worker weight is relevant to scaffold loading.

45. During construction, what is the best role of a required special inspection?

A. Replace the contractor's responsibility for means and methods.
B. Observe or test specified work and document conformance with approved requirements.
C. Authorize undocumented field changes whenever construction is delayed.
D. Guarantee that every completed structural element has zero defects.

46. Excavation for a new basement is planned beside an existing shallow foundation. Which action best addresses the structural risk to the adjacent building?

A. Excavate to final depth first, then decide whether movement is acceptable.
B. Assume the neighboring foundation is unaffected because it is on a separate property.
C. Reduce construction documentation so the contractor can react informally in the field.
D. Evaluate excavation influence, support or underpinning needs, and monitoring before removing soil that supports the existing foundation.

47. A temporary steel erection scheme depends on partially completed framing for stability. What is the most appropriate engineering approach?

A. Remove temporary bracing as soon as any two beams are connected.

B. Rely on member self-weight to stabilize the incomplete frame against all lateral effects.

C. Provide and maintain the required temporary bracing until the permanent lateral system is complete and effective.

D. Assume the final structural analysis automatically proves every intermediate erection stage stable.

48. Which statement best distinguishes a shop drawing submittal from a request for information (RFI)?

A. A shop drawing shows proposed fabrication or installation details, while an RFI asks for clarification of information needed to proceed.

B. A shop drawing changes the design automatically, while an RFI never affects project decisions.

C. An RFI is a fabrication drawing, while a shop drawing is used only for payment documentation.

D. Both documents transfer the engineer's design responsibility to the contractor once submitted.

49. For normal-weight concrete, use Ec = 57,000 sqrt(f'c) psi. If f'c = 4,000 psi, what modulus Ec results?

A. 2,280 ksi

B. 3,605 ksi

C. 7,200 ksi

D. 57,000 ksi

50. Which concrete property most directly controls the initial slope of the stress-strain curve used for elastic deformation calculations?

A. Compressive strength alone.

B. Unit weight alone.

C. Modulus of elasticity.

D. Air content alone.

51. A reinforced concrete section contains six No. 8 bars, each with area 0.79 in2. What total reinforcing area is provided?

A. 3.95 in2
B. 5.53 in2
C. 0.79 in2
D. 4.74 in2

52. For structural steel, which statement correctly distinguishes yield strength from tensile strength?

A. Yield strength marks permanent deformation onset; tensile strength is the maximum stress reached in tension.
B. Yield strength is always greater than tensile strength for ductile structural steel.
C. Tensile strength is the elastic modulus measured before any yielding occurs.
D. The two terms are interchangeable because both describe only stiffness.

53. A steel coupon has axial stress of 18 ksi and corresponding elastic strain of 0.00062. What modulus E is indicated by E = stress/strain?

A. 11,160 ksi
B. 18 ksi
C. 0 ksi
D. 29,032 ksi

54. Why is wood generally modeled with different mechanical properties parallel and perpendicular to grain?

A. Wood is isotropic, but design tables intentionally create artificial directional differences.
B. Moisture content eliminates all directional behavior once lumber is dried.
C. Its cellular structure makes it orthotropic, so stiffness and strength depend strongly on loading direction relative to grain.
D. Only connection design depends on grain direction; member strength does not.

55. A masonry prism test is most directly used to characterize which property?

A. Compressive strength of the assembled masonry system.
B. Yield strength of reinforcing steel.
C. Elastic modulus of structural steel.
D. Moisture content of timber framing.

56. A soil has porosity n = 0.40. What is its void ratio e = n/(1-n)?

A. 0.400
B. 0.667
C. 1.500
D. 0.240

57. A soil sample has total weight 118 lb and total volume 1.50 ft3. What is its total unit weight?

A. 78.7 pcf
B. 177.0 pcf
C. 59.0 pcf
D. 118.0 pcf

58. For a soil bearing estimate, use qult = gamma Df Nq. If gamma = 120 pcf, Df = 4 ft, and Nq = 18, what ultimate bearing pressure results?

A. 2,160 psf
B. 4,320 psf
C. 8,640 psf
D. 38,880 psf

59. Which standard laboratory test most directly determines the compressive strength of a conventional concrete cylinder specimen?

A. Charpy impact testing with a notched specimen.

B. Direct tension testing of a steel coupon.
C. Sieve analysis of the hardened cylinder.
D. Axial compression to failure in a testing machine.

60. What material behavior is most directly evaluated by a Charpy V-notch test?

A. Concrete compressive strength.
B. Impact toughness and sensitivity to brittle fracture behavior.
C. Soil permeability under hydraulic gradient.
D. Masonry prism compressive strength.

61. In reinforced masonry, what is the primary role of grout placed in cells containing reinforcing bars?

A. Replace all mortar joints between masonry units.
B. Fill reinforced cells so bars and masonry can transfer forces and act together.
C. Prevent reinforcing steel from carrying any tension.
D. Serve only as architectural finish material on exposed faces.

62. What is a principal structural advantage of prestressing concrete before significant service load is applied?

A. It introduces beneficial compression that can reduce service-load tensile stress and cracking.
B. It eliminates all concrete compression under service loads.
C. It makes reinforcing or prestressing steel unnecessary in every member.
D. It guarantees zero deflection regardless of span and loading.

63. A singly reinforced rectangular concrete beam has b = 12 in., d = 20 in., As = 3.0 in2, fy = 60 ksi, and f'c = 4 ksi. Using a = As fy/(0.85 f'c b) and Mn = As fy(d-a/2), what is Mn?

A. 320.3 kip-ft
B. 133.5 kip-ft

C. 266.9 kip-ft
D. 300.0 kip-ft

64. For a concrete beam with nominal flexural strength Mn = 310 kip-ft, use phi = 0.90. What design flexural strength phiMn is available?

A. 310 kip-ft
B. 344 kip-ft
C. 248 kip-ft
D. 279 kip-ft

65. For a reinforced concrete beam, use Vc = 2 sqrt(f'c) bwd in pounds. If f'c = 4,000 psi, bw = 12 in., and d = 18 in., what Vc results?

A. 13.7 kip
B. 27.3 kip
C. 54.6 kip
D. 4.5 kip

66. For this problem, required development length is defined as ld = fy db/(25 sqrt(f'c)). Use fy = 60,000 psi, db = 1.0 in., and f'c = 4,000 psi. What ld results?

A. 37.9 in.
B. 18.9 in.
C. 75.9 in.
D. 15.2 in.

67. A tied concrete column has Ag = 144 in2 and Ast = 8 in2. For this problem use Pn = 0.85 f'c(Ag-Ast) + fyAst with f'c = 5 ksi and fy = 60 ksi. What is Pn?

A. 578 kip

B. 1,538 kip
C. 905 kip
D. 1,058 kip

68. A one-way slab strip is idealized as a simply supported 12-ft span carrying 0.45 kip/ft. Using Mmax = wL^2/8, what strip moment results?

A. 4.05 kip-ft
B. 16.20 kip-ft
C. 8.10 kip-ft
D. 64.80 kip-ft

69. A rectangular floor panel is supported by beams on all four sides and has comparable span lengths in both directions. What behavior is most consistent with two-way slab action?

A. The slab distributes significant bending and load to supports in both orthogonal directions.
B. The slab carries all load only to the two supports along its short edges.
C. The slab carries only axial compression with no flexural action.
D. The slab transfers load directly to columns without any plate action.

70. A square footing is 8 ft by 8 ft and supports a concentric service load of 320 kip. Neglect footing weight. What average soil bearing pressure is produced?

A. 40.0 ksf
B. 2.5 ksf
C. 5.0 ksf
D. 64.0 ksf

71. A 10-ft-wide footing carries P = 500 kip with eccentricity e = 0.50 ft about the footing centerline. For a one-foot strip, use qmax = (P/A)(1 + 6e/B), with A = 10 ft2. What is qmax?

A. 50 ksf
B. 65 ksf
C. 80 ksf
D. 35 ksf

72. A pile group contains six piles, each with allowable axial capacity 90 kip. If a stated group-efficiency factor of 0.85 applies, what allowable group capacity is used?

A. 540 kip
B. 76.50 kip
C. 635 kip
D. 459 kip

73. A retaining wall experiences a triangular lateral soil resultant of 18 kip/ft acting at H/3 above the base, where H = 12 ft. What overturning moment about the toe is caused by this soil force?

A. 216 kip-ft/ft
B. 54 kip-ft/ft
C. 72 kip-ft/ft
D. 6 kip-ft/ft

74. A retaining wall has total stabilizing vertical load W = 80 kip/ft, base friction coefficient mu = 0.50, and horizontal driving force P = 20 kip/ft. Using FS = muW/P, what sliding factor of safety results?

A. 4.0
B. 1.0
C. 0.5
D. 2.0

75. A compact steel beam has Fy = 50 ksi and plastic section modulus Zx = 120 in3. For this problem, take nominal plastic moment Mn = FyZx. What is Mn?

A. 500 kip-ft
B. 6,000 kip-ft
C. 250 kip-ft
D. 1,000 kip-ft

76. Why can inadequate lateral bracing reduce the flexural strength of a slender steel beam even when its cross section has adequate local strength?

A. Lateral bracing increases steel yield strength by changing the material chemistry.
B. The compression flange can move laterally and twist the member, producing lateral-torsional buckling before full flexural strength develops.
C. Without bracing, the beam carries only axial load and no bending moment.
D. Lateral bracing is relevant only to concrete beams, not structural steel.

77. A steel tension member has gross area Ag = 8.0 in2 and Fy = 50 ksi. Using phi = 0.90 and design yielding strength phiFyAg, what strength results?

A. 360 kip
B. 400 kip
C. 320 kip
D. 444 kip

78. A steel tension member has effective net area Ae = 5.5 in2 and Fu = 65 ksi. For this problem use phi = 0.75 for net-section rupture. What design rupture strength results?

A. 357.5 kip
B. 206.3 kip
C. 487.5 kip
D. 268.1 kip

79. A connection uses four bolts, each with stated design shear strength of 28 kip, and the load is shared equally. What total design shear strength is available?

A. 28 kip
B. 112 kip
C. 56 kip
D. 84 kip

80. For a fillet weld, use design strength phiRn = phi(0.6Fexx)(0.707wL). With phi = 0.75, Fexx = 70 ksi, weld size w = 0.25 in., and length L = 10 in., what strength results?

A. 74.2 kip
B. 111.4 kip
C. 55.7 kip
D. 39.4 kip

81. A steel column has E = 29,000 ksi, I = 450 in4, effective length KL = 180 in. Using Euler Pcr = pi^2EI/(KL)^2, what critical load results?

A. 3,975 kip
B. 7,950 kip
C. 1,988 kip
D. 331 kip

82. A member interaction check is defined as Pu/phiPn + Mu/phiMn <= 1.0. If Pu = 180 kip, phiPn = 600 kip, Mu = 90 kip-ft, and phiMn = 150 kip-ft, what interaction ratio results?

A. 0.30
B. 0.60
C. 1.50
D. 0.90

83. In a composite steel-concrete beam, what is the primary structural role of shear connectors between the steel beam and concrete slab?

A. Prevent all vertical shear from entering the steel web.
B. Transfer longitudinal interface shear so the slab and steel beam can act compositely in flexure.
C. Increase the concrete compressive strength by chemical treatment.
D. Eliminate the need for any flexural reinforcement or steel section.

84. A timber beam has allowable bending stress Fb = 1.2 ksi and section modulus S = 180 in3. What allowable bending moment is FbS?

A. 18 kip-ft
B. 216 kip-ft
C. 9 kip-ft
D. 36 kip-ft

85. A timber post carries 42 kip through a gross area of 36 in2. What average compressive stress acts on the section?

A. 0.86 ksi
B. 15.10 ksi
C. 1.17 ksi
D. 42.00 ksi

86. A wood connection requires 18 kip of design lateral resistance. Each fastener provides 4.5 kip of stated design resistance, and load sharing is equal. What minimum number of fasteners is required?

A. 3 fasteners
B. 5 fasteners
C. 6 fasteners
D. 4 fasteners

87. A masonry wall carries a concentric axial load of 72 kip over a net area of 120 in2. What average compressive stress is produced?

A. 60.00 ksi
B. 0.60 ksi
C. 0.17 ksi
D. 1.20 ksi

88. A masonry shear wall segment carries V = 48 kip. Using average shear stress v = V/(bd) with b = 8 in. and d = 120 in., what average shear stress results?

A. 0.400 ksi
B. 0.005 ksi
C. 0.050 ksi
D. 5.000 ksi

89. A diaphragm develops an in-plane bending moment of 600 kip-ft between its chord lines, which are 30 ft apart. Using chord force F = M/d, what chord force magnitude is required?

A. 18,000 kip
B. 10 kip
C. 20 kip
D. 30 kip

90. What is the primary purpose of a collector, or drag strut, in a lateral-force-resisting system?

A. Support only gravity loads from floor finishes.
B. Reduce the material yield strength so seismic forces are smaller.
C. Replace every diaphragm chord and boundary element in the structure.
D. Transfer diaphragm forces into vertical lateral-resisting elements where direct edge transfer is unavailable.

91. A chevron bracing bay has two identical braces at 45 degrees to the horizontal. If a 100-kip story shear is shared equally through the horizontal components of the two braces, what axial force acts in each brace?

A. 70.7 kip
B. 50.0 kip
C. 100.0 kip
D. 141.4 kip

92. A lateral frame resists an overturning moment of 1,200 kip-ft through a tension-compression couple separated by 24 ft. What axial force magnitude is required in each side of the couple?

A. 100 kip
B. 50 kip
C. 28.80 kip
D. 1,200 kip

93. A steel column transfers 420 kip concentrically through a 14 in. by 18 in. base plate. What average bearing pressure acts beneath the plate?

A. 23.30 ksi
B. 1.67 ksi
C. 30.00 ksi
D. 0.60 ksi

94. A base connection resists a 240 kip-ft moment using a tension-compression couple with 20 in. between the force resultants. Neglect axial load. What force magnitude is required in the tension anchor group?

A. 144 kip
B. 12 kip
C. 240 kip
D. 288 kip

95. A footing has width B = 8 ft and load eccentricity e = 0.75 ft. Using the effective-width approximation B' = B - 2e, what effective width results?

A. 7.2 ft
B. 5.0 ft
C. 8.8 ft
D. 6.5 ft

96. A rigid pile cap carries a concentric 480-kip vertical load supported by four identical piles with equal stiffness. Neglect cap weight and group effects. What axial load is assigned to each pile?

A. 480 kip
B. 240 kip
C. 120 kip
D. 60 kip

97. A drilled shaft has diameter 4 ft, embedded length 30 ft, and uniform unit side resistance fs = 0.60 ksf. Using Qs = perimeter x length x fs, what side resistance results?

A. 72.0 kip
B. 452.4 kip
C. 226.2 kip
D. 113.1 kip

98. A 12-ft-wide retaining-wall base carries a resultant vertical load P = 240 kip/ft with eccentricity e = 1.0 ft. Using qmax = P/B(1 + 6e/B), what maximum base pressure results?

A. 20 ksf
B. 10 ksf
C. 40 ksf
D. 30 ksf

99. For a reinforced concrete column, why are transverse ties or spiral reinforcement provided around the longitudinal bars?

A. They restrain longitudinal-bar buckling, confine the core, and help maintain the intended reinforcement cage and shear resistance.

B. They replace all longitudinal reinforcement under axial load.

C. They eliminate concrete cracking and crushing under every load combination.

D. They are used only to support formwork and have no structural function after curing.

100. Which connection-detailing choice most directly promotes ductile behavior in a lateral-force-resisting system?

A. Make the most brittle component intentionally weaker so it fails first.

B. Provide a clear yielding mechanism while proportioning surrounding connection components to avoid premature brittle failure.

C. Eliminate deformation capacity by maximizing connection stiffness regardless of load path.

D. Rely on field welding alone without verifying force transfer through the connected elements.

Practice Exam 22: Answer Key and Explanations

1. D — Multiply the area load by the tributary width: 85 psf times 10 ft equals 850 lb/ft. The 85 lb/ft choice omits tributary width, 425 lb/ft uses half the width, and 1,700 lb/ft doubles it. This conversion establishes the beam load before reactions or internal forces are calculated. Check the load path.

2. B — The total uniform load is 1.8 times 24, or 43.2 kip. Symmetry divides that load equally between the two simple supports, giving 21.6 kip per reaction. A 10.8-kip answer halves twice, 43.2 kip assigns the entire load to one support, and 3.6 kip ignores span length. Keep load units consistent.

3. A — Convert the 8-in. thickness to 0.667 ft, then multiply by 150 pcf. The result is 100 psf. Using 150 psf treats the slab as one foot thick, 75 psf uses only six inches, and 1,200 psf multiplies by inches without converting them to feet first. Verify tributary dimensions carefully. Separate pressure from force.

4. C — Apply the factors to the loads separately: 1.2 times 40 is 48 psf and 1.6 times 60 is 96 psf. Their sum is 144 psf. The distractors reflect using unfactored loads, applying only one factor correctly, or applying an excessive combined multiplier. Check whether the requested quantity is force, line load, pressure, or moment before choosing units.

5. A — Substitute the stated coefficients directly: 0.7 times 0.9 times 1.0 times 1.0 times 40 equals 25.2 psf. The 28.0-psf choice omits the exposure coefficient, 36.0 psf omits the 0.7 factor, and 22.7 psf applies an extra reduction not given in the problem. Keep tributary dimensions and units consistent so area loads become line loads only once.

6. B — Substitution gives 0.00256 times 0.85 times 0.85 times 120 squared, which is approximately 26.6 psf. The alternatives result from omitting one coefficient or using a different multiplier. Because velocity is squared, small changes in V have a larger effect than similar percentage changes in the linear coefficients. Check the load path.

7. D — Multiply the seismic coefficient by the effective weight: 0.085 times 2,400 kip equals 204 kip. The other choices correspond to dividing by the coefficient, using a lower rounded coefficient, or assuming ten percent of W. The calculation is a direct proportional relationship once Cs and W are established. Keep load units consistent.

8. C — The surcharge produces a uniform lateral pressure of 600 times 0.33, or 198 psf, over the full 12-ft wall height. Multiplying by height gives 2,376 lb/ft of wall. The 198 choice stops at pressure, 1,188 uses half the height, and 7,200 ignores Ka. Sign conventions matter less than consistent magnitudes when the question asks only for a load or reaction.

9. D — The triangular active pressure distribution has resultant 0.5Ka gamma H squared. Substitution gives 0.5 times 0.30 times 120 times 225, or 4,050 lb/ft. The 8,100 choice omits the triangular one-half factor, 5,400 uses an incorrect coefficient, and 270 confuses pressure with resultant force. Check whether the requested quantity is force, line load, pressure, or moment before choosing units.

10. A — For a point load on a simple span, the left reaction equals P times the distance from the load to the right support divided by the span. Thus 30 times 16 divided by 24 equals 20 kip. The other answers misplace the lever arm or assign the entire axle load to one support.

11. C — Divide the repeated point reaction by its spacing to obtain an equivalent average line load: 36 kip divided by 12 ft equals 3 kip/ft. Multiplying instead of dividing gives 432, while 1.5 and 6 kip/ft correspond to doubling or halving the tributary spacing incorrectly. A load-path sketch is often the fastest check against double-counting or missing tributary area.

12. B — Four inches is one-third of a foot, so the concrete contributes about 48.3 psf. Adding the 3-psf deck gives 51.3 psf. The 48.3 choice omits deck weight, 148 adds incompatible quantities, and 583 uses inches directly instead of converting the concrete thickness to feet. For load problems, separate characteristic loads first and combine them only after each component is correct.

13. C — The square root of 2,500 is 50, so the bracket equals 0.25 plus 15/50, or 0.55. Multiplying 80 psf by 0.55 gives 44 psf. The alternatives reflect dropping one term, using the unreduced load incorrectly, or misreading the square-root denominator. Sign conventions matter less than consistent magnitudes when the question asks only for a load or reaction.

14. D — Five inches of water is 5/12 ft. Multiplying by 62.4 pcf gives 26.0 psf. The 312-psf choice multiplies by inches without converting, 62.4 psf assumes one foot of water, and 13.0 psf uses half the actual depth. Water depth translates directly into pressure through unit weight. Separate pressure from force.

15. A — An impact increase of 25 percent means the design load is 1.25 times the static wheel load. Therefore, 50 times 1.25 equals 62.5 kip. The 50-kip answer ignores impact, 12.5 kip gives only the increment, and 75 kip incorrectly adds fifty percent rather than twenty-five percent. Keep tributary dimensions and units consistent so area loads become line loads only once.

16. B — Half of the shared 180-kip load is 90 kip. Adding the 24-kip equipment load assigned only to the selected girder gives 114 kip. The 90-kip choice omits equipment, 102 kip splits the equipment incorrectly, and 204 kip adds the full shared load to the equipment load. A load-path sketch is often the fastest check against double-counting or missing tributary area.

17. A — Evaluate every stated combination rather than assuming which governs. The three results are 42 kip, 116 kip, and 126 kip, so the third combination controls. The 130-kip distractor comes from adding unfactored loads, while the other options are actual but noncontrolling combination results. For load problems, separate characteristic loads first and combine them only after each component is correct.

18. B — For a centered point load on a simple span, the maximum moment occurs at midspan and equals PL/4. Substituting 16 kip and 20 ft gives 80 kip-ft. The 160 and 320 choices use incorrect divisors, while 40 kip-ft divides by eight instead of four. For member analysis, distinguish external reactions from internal shear, moment, axial force, and deformation.

19. D — The maximum moment for a simply supported beam under full-span uniform load is wL squared divided by eight. Using 2.0 kip/ft and 18 ft gives 81 kip-ft. The alternatives result from using reaction formulas, dividing by four, or using span rather than span squared. Symmetry can simplify many PE-style analysis questions, but it should be justified from loading and geometry.

20. C — The total load is 3 times 14, or 42 kip. Symmetry gives a 21-kip reaction at each support, which is also the maximum end shear magnitude. The 42-kip distractor assigns all load to one support; 10.5 and 6 kip result from unnecessary additional division. A quick free-body diagram is the best defense against sign errors and omitted reactions.

21. C — Average axial stress is force divided by area. Dividing 120 kip by 6.0 square inches gives 20 ksi because kip per square inch is ksi. The 720 choice multiplies rather than divides, 0.05 reverses the ratio, and 60 ksi uses an incorrect effective area. Check dimensions at the end: moments, stresses, rotations, and deflections require different units.

22. A — Convert the 12-ft length to 144 in. before using consistent kip-inch units. Then delta equals 60 times 144 divided by 3 times 29,000, giving about 0.0993 in. The distractors come from leaving length in feet, doubling the force effect, or using twice the area. The governing equation follows from equilibrium, compatibility, and the stated constitutive relationship.

23. B — For a rectangle about its strong centroidal axis, S equals bh squared divided by six. Substitution gives 10 times 18 squared divided by 6, or 540 in3. The 4,860-in3 choice is the moment of inertia, while 270 and 9,720 reflect incorrect divisors or doubling. For member analysis, distinguish external reactions from internal shear, moment, axial force, and deformation.

24. D — Convert 90 kip-ft to 1,080 kip-in., then divide by the section modulus of 600 in3. The resulting bending stress is 1.8 ksi. The 0.15-ksi answer omits the foot-to-inch conversion, while 18 and 150 ksi reflect decimal or unit errors rather than the flexure relation M/S. Verify the deformation units carefully.

25. B — Use inches consistently: the 16-ft span is 192 in. Substitution into PL cubed divided by 48EI gives 0.0254 in., which rounds to 0.025 in. The smaller distractor halves the response, the larger values reflect decimal or unit errors. Because span is cubed, a consistent length conversion is essential before evaluating deflection.

26. D — All quantities are already in compatible kip-inch units. Substituting them into 5wL to the fourth over 384EI gives approximately 0.0124 in. The distractors reflect dropping the factor of five, doubling the response, or moving the decimal one place. Deflection is especially sensitive to span because L appears to the fourth power.

27. A — Convert the 15-ft length to 180 in. and substitute into Euler's expression. The result is approximately 7,067 kip for the ideal pin-ended column. The 3,534 and 14,134 kip choices are roughly half and double the result, while 589 kip reflects a length-unit error. Critical load varies inversely with effective length squared.

28. C — Maximum torsional shear occurs at the outside radius and equals Tc/J. Using 120 kip-in., 2 in., and 25.13 in4 gives approximately 9.55 ksi. The 4.78 and 19.1 ksi answers halve or double the correct value, while 60.3 ksi results from using J incorrectly. For member analysis, distinguish external reactions from internal shear, moment, axial force, and deformation.

29. B — At the extreme fiber where axial compression and bending compression act in the same direction, the stresses add algebraically. Six plus ten gives 16 ksi compression. Four ksi represents the opposite extreme where bending relieves compression, 10 ksi ignores axial load, and 60 ksi multiplies the two stresses without physical basis.

30. D — The average normal stress is 12 ksi. The radius of Mohr's circle is the square root of 8 squared plus 6 squared, or 10 ksi. Adding the radius gives a major principal stress of 22 ksi. The distractors use only the average, the normal-stress difference, or an incorrect direct addition.

31. C — Free thermal elongation equals alpha times temperature change times length. Converting 40 ft to 480 in. and multiplying by 6.5e-6 per F and 60 F gives 0.1872 in. The distractors reflect leaving length in feet, shifting a decimal, or using half the temperature change. Check dimensions at the end: moments, stresses, rotations, and deflections require different units.

32. A — Full restraint converts the free thermal strain alpha DeltaT into stress E alpha DeltaT. Substitution gives 29,000 times 6.5e-6 times 50, or about 9.43 ksi. The 18.85 and 4.71 choices double or halve the result, while 0.325 ksi omits the elastic modulus effect. The governing equation follows from equilibrium, compatibility, and the stated constitutive relationship.

33. B — For an end-loaded cantilever, the fixed support must resist the load times its lever arm, so M equals PL. Eight kip times six feet gives 48 kip-ft. The 24-kip-ft answer incorrectly divides by two, 8 ignores the span, and 288 multiplies by the span twice. For member analysis, distinguish external reactions from internal shear, moment, axial force, and deformation.

34. A — The cantilever uniform-load deflection is wL to the fourth divided by 8EI. Substituting the stated compatible kip-inch units gives approximately 0.0458 in. The 0.0916-in. option doubles the response, 0.0057 in. adds another factor of eight, and 0.366 in. omits the denominator factor of eight. Span strongly influences cantilever deflection very significantly.

35. D — Joint equilibrium requires the vector sum of member forces to be zero. With only two non-collinear member directions and no external load or support reaction at the joint, the only solution is zero force in both members. Equal nonzero forces cannot cancel unless the members are collinear, so the geometric condition is essential.

36. C — A fixed-fixed beam has more reaction components than can be solved using planar equilibrium alone, so compatibility and stiffness relationships are required. A conventional pin-roller simple beam and a cantilever are externally determinate, while a stable basic triangular truss can be solved by equilibrium when its support and member arrangement is determinate.

37. D — The influence-line ordinate is 21/30, or 0.70, at the stated load position. Multiplying the 20-kip point load by 0.70 gives a 14-kip left reaction. The 6-kip answer is the right reaction, 20 kip ignores position, and 12 kip uses an incorrect ordinate. The governing equation follows from equilibrium, compatibility, and the stated constitutive relationship.

38. B — Stress range is the algebraic difference between maximum and minimum stress. Because the minimum is negative, the range is 18 minus negative 6, or 24 ksi. Twelve ksi is the mean stress, six ksi is only the compressive magnitude, and 18 ksi ignores the lower end of the cycle. Keep force and moment units distinct.

39. A — The projected bearing area is plate thickness times bolt diameter: 0.5 times 0.75 equals 0.375 in2. Dividing 15 kip by 0.375 in2 gives 40 ksi. The distractors use only one dimension, substitute an incorrect area, or apply a different denominator than the stated bearing model. Verify the deformation units carefully.

40. C — Direct axial stress is 100/20 = 5 ksi. The eccentric moment is 400 kip-in., which produces 400/80 = 5 ksi bending stress at the extreme fiber. Adding the compressive effects gives 10 ksi. The other choices omit one component or combine the terms by an incorrect operation. Compatibility also matters in indeterminate systems.

41. A — Using I = bh cubed divided by 12, the 12-in. width cancels the divisor and leaves 24 cubed, or 13,824 in4. The 6,912 and 27,648 choices are half and double the correct value, while 1,152 comes from squaring depth instead of cubing it. Check dimensions at the end: moments, stresses, rotations, and deflections require different units.

42. D — Reshoring provides an intentional temporary load path so construction loads are shared by floors and supports while recently cast slabs continue gaining strength. It does not replace permanent columns, change concrete material strength directly, or remove the need for sequence analysis. The engineer must consider timing, stiffness, load redistribution, and removal sequence.

43. C — The idealized pressure acts over 40 square feet of form area, so total force is 900 psf times 40 ft2, or 36,000 lb. The smaller distractors use only one panel dimension or report pressure instead of resultant force. Real formwork design also considers supports, ties, placement rate, and construction sequence.

44. B — Scaffold capacity must be matched to the actual intended loading and configuration before use. Workers, tools, stored materials, access loads, bracing, support conditions, and erection details can all affect demand and stability. Loading first and observing deflection is not a design check, and a temporary platform cannot be assumed equivalent to the permanent structure.

45. B — Special inspection provides targeted observation or testing of work identified by the applicable requirements and approved documents. It creates an independent record of whether specified materials and installation conditions conform. It does not transfer construction means-and-methods responsibility, authorize informal changes, or guarantee perfection. Nonconforming observations should be documented and resolved through the project process.

46. D — Removing soil near an existing footing can reduce confinement or support and may cause settlement, lateral movement, or instability. The risk should be evaluated before excavation, with underpinning, shoring, sequencing, and monitoring considered as needed. Waiting for movement to occur is reactive, and property boundaries do not interrupt the geotechnical or structural influence zone.

47. C — An incomplete frame may not yet have the diaphragms, connections, or lateral-force-resisting system assumed in the final design. Temporary bracing must therefore provide a stable load path during erection and remain until the permanent system can perform that function. Final-state adequacy alone does not demonstrate stability for every intermediate construction configuration.

48. A — Shop drawings communicate how specific items are proposed to be fabricated, assembled, or installed. An RFI is a question seeking clarification where the contract information is incomplete, conflicting, or uncertain. Neither document automatically transfers design responsibility or authorizes every change. Responses and reviews should remain consistent with the project roles and approved change process.

49. B — The square root of 4,000 is about 63.25. Multiplying by 57,000 gives about 3.605 million psi, or 3,605 ksi. The distractors reflect an incorrect square root, doubling the modulus, or failing to apply the strength term. The stated empirical expression estimates stiffness, not compressive strength itself. For phase-relation problems, draw the three-phase diagram and keep volumes and weights conceptually separate.

50. C — The modulus of elasticity relates stress to elastic strain and therefore controls predicted elastic shortening and deflection when a linear relationship is assumed. Compressive strength is a strength measure, unit weight affects loads, and air content influences durability and other properties. Those quantities may correlate with stiffness, but they are not the direct slope parameter.

51. D — Total steel area is the number of bars times the area of one bar. Six times 0.79 in2 equals 4.74 in2. The 0.79-in2 choice counts only one bar, while 3.95 and 5.53 in2 correspond to five or seven bars rather than the six stated. Match the property to the mechanism.

52. A — Yield strength identifies the stress level associated with the beginning of substantial inelastic behavior, while tensile strength is the peak engineering stress attained before necking and fracture progression. Elastic modulus instead describes stiffness. For typical ductile structural steels, tensile strength exceeds yield strength, so treating the two as interchangeable would distort strength and ductility checks.

53. D — In the elastic range, modulus equals stress divided by strain. Dividing 18 ksi by 0.00062 gives approximately 29,032 ksi. The 18-ksi option repeats the stress, 11,160 ksi results from multiplying rather than dividing by the small strain, and the tiny value reverses the stress-strain relationship. Strength and stiffness are different properties.

54. C — Wood's cellular structure is strongly directional. Fibers carry loads efficiently along the grain, while transverse behavior depends on weaker cell-wall and bonding mechanisms. That makes stiffness, compression, tension, and connection behavior direction dependent. Drying changes moisture-related properties but does not make wood isotropic, so grain orientation remains central to member and connection design.

55. A — A masonry prism contains masonry units and mortar arranged to represent the constructed assemblage, and compression testing provides a measure of masonry compressive strength. It does not test reinforcing-steel yield strength, structural-steel stiffness, or timber moisture. Using assemblage testing recognizes that unit, mortar, workmanship, and geometry together influence masonry behavior.

56. B — Void ratio is the volume of voids divided by the volume of solids, while porosity uses total volume in the denominator. Applying $e = n/(1-n)$ gives $0.40/0.60 = 0.667$. The 0.40 choice confuses porosity with void ratio, 1.50 inverts the denominator relationship, and 0.240 multiplies instead of divides. Match the property to the mechanism.

57. A — Unit weight is weight divided by total volume. Dividing 118 lb by 1.50 ft3 gives 78.7 pcf. The 177-pcf option multiplies instead of divides, 59.0 pcf uses an incorrect volume, and 118 pcf simply repeats the sample weight without accounting for the occupied volume. Keep material-test units consistent. Strength and stiffness are different properties.

58. C — The stated expression multiplies soil unit weight, footing depth, and bearing factor. Thus 120 times 4 times 18 equals 8,640 psf. The 2,160 and 4,320 options omit or halve one factor, while 38,880 arises from an excessive multiplier. The equation is used exactly as provided in this problem. Strength and stiffness are different properties.

59. D — Concrete cylinder compressive strength is obtained by loading the prepared specimen axially in compression and relating the maximum load to its cross-sectional area. Charpy testing evaluates impact toughness of metals, steel coupon tension tests metal stress-strain behavior, and sieve analysis characterizes particle-size distribution rather than hardened concrete compressive capacity. Specimen behavior must represent the design property.

60. B — The Charpy V-notch test measures the energy absorbed by a notched metal specimen during impact and is commonly used to assess toughness and brittle-fracture susceptibility. It is not a concrete compression, soil permeability, or masonry prism test. The notch and impact loading intentionally create a demanding fracture condition rather than a simple static strength measurement.

61. B — Grout fills designated masonry cells and surrounds reinforcement, providing contact and force transfer so the reinforced masonry can act as an integrated structural element. It does not replace bed and head joint mortar, eliminate tensile demand in reinforcement, or function merely as a finish. Proper placement and consolidation are important to achieving the intended load path.

62. A — Prestressing applies an initial compressive force and often an eccentric moment that counteracts tensile stresses produced by service loading. This can control cracking and improve serviceability for longer spans. It does not eliminate concrete compression, remove the need for steel, or guarantee zero deflection; time-dependent losses and load effects still require evaluation.

63. C — First compute a = 3 times 60 divided by 0.85 times 4 times 12, giving about 4.41 in. Then Mn = 180 kip times (20 - 2.21) in. = about 3,203 kip-in. Dividing by 12 gives 266.9 kip-ft. The distractors reflect incorrect compression-block depth or unit conversion. Strength alone does not ensure serviceability.

64. D — Design strength is the nominal strength multiplied by the stated resistance factor. Thus 0.90 times 310 kip-ft equals 279 kip-ft. The 310-kip-ft answer omits phi, 344 kip-ft effectively divides by phi, and 248 kip-ft applies an unnecessarily large reduction. Demand should be compared with the factored design strength, not nominal strength alone.

65. B — The square root of 4,000 is about 63.25. Multiplying by 2, the 12-in. web width, and the 18-in. effective depth gives about 27,324 lb, or 27.3 kip. The distractors halve or double that result, or mishandle the conversion from pounds to kips. Foundation reactions must remain physically consistent. Check the governing limit state.

66. A — Substitute the given values into the stated development-length expression. The denominator is 25 times the square root of 4,000, or about 1,581. Dividing 60,000 by that value gives approximately 37.9 in. The alternatives reflect halving, doubling, or using an incorrect square-root treatment. Detailing affects whether the assumed structural mechanism can actually develop under load, especially near connections and supports.

67. D — Concrete area excluding the steel is 136 in2. Its contribution is 0.85 times 5 times 136 = 578 kip, while the steel contributes 60 times 8 = 480 kip. Summing gives a nominal axial strength of 1,058 kip. The distractors omit one component or use an incorrect concrete area. Detailing must support the assumed load path.

68. C — For the stated simple-span idealization, maximum moment is wL squared divided by eight. Substituting 0.45 kip/ft and 12 ft gives 8.10 kip-ft per strip. The 4.05 and 16.2 choices halve or double the result, while 64.8 omits the division by eight. When several resistance components act together, verify the intended load path before summing their capacities.

69. A — Two-way action occurs when plate bending in both principal directions contributes materially to load transfer. Comparable spans and support on four sides make that behavior plausible. A one-way idealization sends load mainly across one span direction. Slabs still develop flexure, and direct column transfer does not eliminate plate action between supports.

70. C — A concentric load produces average pressure P/A. The footing area is 8 times 8 = 64 ft2, so 320 kip divided by 64 ft2 equals 5.0 ksf. The 40-ksf option divides by one dimension only, 2.5 ksf doubles the area, and 64 simply reports area rather than pressure. Foundation reactions must remain physically consistent.

71. B — The average pressure is 500/10 = 50 ksf. The eccentricity multiplier is 1 + 6(0.5)/10 = 1.30. Multiplying gives qmax = 65 ksf. The 50-ksf choice ignores eccentricity, 80 ksf uses an excessive multiplier, and 35 ksf corresponds to the opposite-edge pressure rather than the maximum. Check the governing limit state.

72. D — The sum of individual pile capacities is 6 times 90 = 540 kip. Applying the stated 0.85 group-efficiency factor gives 459 kip. The 540-kip choice ignores efficiency, 76.5 kip applies the factor to only one pile, and 635 kip incorrectly increases rather than reduces the summed capacity. Detailing must support the assumed load path.

73. C — The resultant of a triangular lateral pressure distribution acts one-third of the height above the base. For H = 12 ft, the lever arm is 4 ft. Multiplying 18 kip/ft by 4 ft gives 72 kip-ft per foot of wall. The alternatives use the full height, midheight, or divide rather than multiply.

74. D — Friction resistance is muW = 0.50 times 80 = 40 kip/ft. Dividing by the 20-kip/ft driving force gives a sliding factor of safety of 2.0. The 4.0 choice omits the friction coefficient, 1.0 uses only half the resistance, and 0.5 reports the coefficient itself. Foundation and retaining-wall checks require both structural resistance and a consistent soil-reaction model.

75. A — FyZx gives 50 kip/in2 times 120 in3 = 6,000 kip-in. Dividing by 12 converts to 500 kip-ft. The 6,000 choice fails to convert inches to feet, 250 halves the correct moment, and 1,000 doubles it. The stated expression applies only because the problem supplies the plastic-moment model directly. Foundation reactions must remain physically consistent.

76. B — A beam in major-axis flexure has a compression region that may buckle laterally while the section twists. Adequate bracing restrains this lateral-torsional mode and permits greater flexural resistance. Bracing does not change steel material yield strength, eliminate bending, or apply only to concrete. Stability and cross-sectional strength are separate design considerations.

77. A — Gross-section yielding strength is phiFyAg. Multiplying 0.90 by 50 ksi and 8.0 in2 gives 360 kip. The 400-kip choice omits phi, 320 kip uses a lower unstated factor, and 444 kip effectively divides by phi. A complete design would also check other applicable tension limit states. Detailing must support the assumed load path.

78. D — Net-section rupture strength is the stated phi times Fu times Ae. Multiplying 0.75 by 65 ksi and 5.5 in2 gives about 268.1 kip. The 357.5-kip choice omits phi, 206.3 kip applies an extra reduction, and 487.5 kip uses an incorrect area or multiplier. When several resistance components act together, verify the intended load path before summing their capacities.

79. B — With equal load sharing and the given per-bolt design strength, the group strength is four times 28 kip, or 112 kip. The alternatives represent one, two, or three bolts rather than all four. This summation is appropriate only because the problem states equal sharing and provides the already-reduced design strength per bolt.

80. C — The effective throat area is 0.707 times 0.25 times 10 = 1.7675 in2. Nominal shear strength is 0.6 times 70 times that area, and multiplying by phi = 0.75 gives about 55.7 kip. The alternatives omit phi, double the result, or use an incorrect throat factor. Foundation reactions must remain physically consistent.

81. A — Using the stated effective length directly, Euler's expression gives pi squared times 29,000 times 450 divided by 180 squared, or approximately 3,975 kip. The 7,950 and 1,988 kip choices are about double and half the result, while 331 kip reflects a length-unit error. Column stability is highly sensitive to effective length.

82. D — The axial term is 180/600 = 0.30 and the flexural term is 90/150 = 0.60. Their sum is 0.90, which satisfies the stated limit of 1.0. The 0.30 and 0.60 choices report only one term, while 1.50 adds denominators or ratios incorrectly. A component can have adequate nominal strength yet still fail a serviceability, stability, anchorage, or connection check.

83. B — Composite action requires the steel beam and concrete slab to develop compatible longitudinal deformation rather than freely slip at their interface. Shear connectors transfer the interface forces that make this possible. They do not remove all web shear, change concrete chemistry, or eliminate the need for the participating structural components and their required checks.

84. A — Multiplying 1.2 ksi by 180 in3 gives 216 kip-in. Dividing by 12 converts to 18 kip-ft. The 216 choice leaves the result in kip-in., while 9 and 36 kip-ft are half and double the correct value. The calculation uses the allowable stress value provided in the problem. Foundation and retaining-wall checks require both structural resistance and a consistent soil-reaction model.

85. C — Average compression stress is P/A. Dividing 42 kip by 36 in2 gives 1.17 ksi. The 0.857-ksi distractor reverses the ratio, 15.1 ksi multiplies dimensions incorrectly, and 42 ksi repeats the force value as though it were stress. Actual timber column design may also require stability adjustments. Foundation reactions must remain physically consistent.

86. D — Divide the required 18-kip resistance by 4.5 kip per fastener. The quotient is exactly 4, so four fasteners provide the required stated resistance. Three supply only 13.5 kip, while five and six exceed the minimum asked. Real connection design must also satisfy spacing, edge distance, and group-effect requirements. Check the governing limit state.

87. B — Average compressive stress equals axial force divided by net area. Seventy-two kip divided by 120 in2 equals 0.60 ksi. The 60-ksi choice mishandles the decimal and units, 0.167 ksi reverses or alters the ratio, and 1.20 ksi effectively uses half the stated area. A component can have adequate nominal strength yet still fail a serviceability, stability, anchorage, or connection check.

88. C — The resisting area in the stated average-stress model is 8 times 120 = 960 in2. Dividing 48 kip by 960 in2 gives 0.050 ksi. The 0.40-ksi choice uses only one dimension, 0.005 shifts the decimal, and 5.0 ksi is two orders of magnitude too large. When several resistance components act together, verify the intended load path before summing their capacities.

89. C — The diaphragm chord couple resists in-plane moment through two opposing axial forces separated by the chord distance. Dividing 600 kip-ft by 30 ft gives 20 kip. The 18,000-kip choice multiplies instead of divides, 10 kip uses twice the lever arm, and 30 kip confuses spacing with force. Foundation and retaining-wall checks require both structural resistance and a consistent soil-reaction model.

90. D — Collectors provide a deliberate in-plane load path from distributed diaphragm forces to shear walls, braced frames, or moment frames, especially where those elements do not align continuously with the diaphragm edge. They are not merely gravity members, do not change material strength, and do not automatically replace chords or other boundary-force components.

91. A — Each brace supplies a horizontal component F cos45, and the two components together equal 100 kip. Therefore F = 100/[2 cos45] = about 70.7 kip. The 50-kip choice ignores brace angle, 100 kip assigns the full shear to each brace, and 141.4 kip omits the factor of two. Check the governing limit state.

92. B — A force couple produces moment equal to one force times the separation between the equal and opposite forces. Dividing 1,200 kip-ft by 24 ft gives 50 kip in tension on one side and 50 kip in compression on the other. The distractors multiply, double, or simply repeat the moment value.

93. B — The base-plate area is 14 times 18 = 252 in2. Dividing the concentric 420-kip load by 252 in2 gives an average bearing pressure of 1.67 ksi. The 23.3 and 30.0-ksi answers divide by one plate dimension only, while 0.60 ksi uses an incorrect area. When several resistance components act together, verify the intended load path before summing their capacities.

94. A — Convert 240 kip-ft to 2,880 kip-in. Dividing by the 20-in. couple arm gives 144 kip in the tension side, with an equal opposite compression resultant. The 12-kip answer omits the foot-to-inch conversion, 240 repeats the moment magnitude, and 288 uses only a 10-in. lever arm. Foundation and retaining-wall checks require both structural resistance and a consistent soil-reaction model.

95. D — The effective-width approximation reduces the footing width by twice the eccentricity. Two times 0.75 ft is 1.5 ft, so B' = 8 - 1.5 = 6.5 ft. The other choices subtract only one eccentricity, subtract too much, or add eccentricity rather than reducing the effective contact width. Foundation reactions must remain physically consistent.

96. C — With a concentric load and four identical equally stiff piles, symmetry gives equal load sharing. Dividing 480 kip by four produces 120 kip per pile. The 480-kip answer assigns the total load to one pile, 240 kip divides by two, and 60 kip divides by eight without justification. Check the governing limit state.

97. C — Shaft perimeter is pi times 4 ft, or about 12.57 ft. Multiplying by 30 ft gives about 377 ft2 of side area; multiplying by 0.60 ksf gives approximately 226.2 kip. The distractors omit pi, double the resistance, or halve the mobilized side area. A component can have adequate nominal strength yet still fail a serviceability, stability, anchorage, or connection check.

98. D — Average pressure is P/B = 240/12 = 20 ksf. The linear eccentricity multiplier is 1 + 6/12 = 1.5, so q_{max} = 30 ksf. The 20-ksf answer ignores eccentricity, 10 ksf is the minimum edge pressure, and 40 ksf applies an excessive multiplier. When several resistance components act together, verify the intended load path before summing their capacities.

99. A — Transverse reinforcement performs several structural functions: it restrains longitudinal bars against local buckling, confines the concrete core, helps resist shear where applicable, and holds the cage in position. It does not replace longitudinal steel, prevent every form of concrete damage, or become structurally irrelevant after the concrete hardens. Connections require their own limit-state checks.

100. B — Ductile design seeks controlled inelastic deformation in intended yielding regions while protecting brittle or low-ductility failure modes such as fracture, pullout, or abrupt connection rupture. That requires a clear load path and capacity hierarchy. Simply maximizing stiffness or allowing a brittle component to fail first undermines the desired energy-dissipating mechanism.