PRACTICE EXAM 17: PE CIVIL — CONSTRUCTION SIMULATION (100 QUESTIONS)

This practice exam contains 100 multiple-choice and alternative-item-type questions modeled on the NCEES PE Civil: Construction depth exam. The actual computer-based exam is closed-book with electronic NCEES Reference Handbook and design-standard access, contains 80 questions, and allows 9 hours including a tutorial and optional break. Work every question; there is no penalty for guessing.

1. A retaining wall backfill consists of cohesionless sand with an effective friction angle φ' = 36° and a level ground surface. Using Rankine theory, what is the active earth pressure coefficient Ka?

A. 0.199
B. 0.226
C. 0.238
D. 0.260

2. A 6 m thick normally consolidated clay layer has Cc = 0.35 and initial void ratio e0 = 1.00. The effective overburden stress is 90 kPa and a foundation adds 110 kPa. What is the primary consolidation settlement?

A. 298 mm
B. 331 mm
C. 364 mm
D. 397 mm

3. The water table is at a depth of 2 m. Above the water table, the moist unit weight is 16.5 kN/m³, and below it the saturated unit weight is 18.5 kN/m³. At a total depth of 9 m, what is the effective vertical stress?

A. 87 kPa
B. 94 kPa
C. 101 kPa
D. 162 kPa

4. A strip footing at 1.0 m depth bears on saturated clay ($\varphi=0$) with cu = 45 kPa. Using Terzaghi bearing capacity factors (Nc=5.7, Nq=1.0) and a surcharge unit weight of 19 kN/m^3, what is the ultimate bearing capacity?

A. 276 kPa
B. 257 kPa
C. 295 kPa
D. 314 kPa

5. A dry, cohesionless infinite slope has friction angle $\varphi=30°$ and inclination $\beta=20°$. What is the factor of safety against sliding?

A. 1.22
B. 1.38
C. 1.46
D. 1.59

6. A 3.5 m tall wall retains cohesionless backfill with unit weight 18.5 kN/m^3 and $\varphi'=33°$. Using Rankine theory, what is the total passive resultant force per unit length of wall?

A. 320 kN/m
B. 384 kN/m
C. 442 kN/m
D. 495 kN/m

7. A doubly-drained saturated clay layer 5 m thick has cv = 2.5 m^2/yr. Using Tv=0.197 for 50% consolidation, how long does it take to reach 50% consolidation?

A. 180 days
B. 210 days
C. 245 days
D. 280 days

8. A submerged infinite slope of cohesionless soil ($c'=0$) has $\varphi'=32°$, slope angle $\beta=22°$, saturated unit weight $\gamma_{sat}=20$ kN/m³, and $\gamma_w=9.81$ kN/m³, with seepage parallel to the slope. What is the factor of safety?

A. 0.62
B. 0.71
C. 0.79
D. 0.88

9. A horizontal curve has a radius of 1,100 ft and a deflection angle of 15°. What is the curve length?

A. 245.3 ft
B. 262.7 ft
C. 275.4 ft
D. 288.0 ft

10. For the same curve ($R=1{,}100$ ft, $\Delta=15°$), what is the middle ordinate distance?

A. 6.8 ft
B. 8.1 ft
C. 9.4 ft
D. 10.9 ft

11. A vertical curve has an initial grade $g_1=+2.2\%$ and final grade $g_2=-1.8\%$ over a 450 ft curve length. How far from the BVC does the high point occur?

A. 247.5 ft
B. 210 ft
C. 180 ft
D. 275 ft

12. For the horizontal curve with R=1,100 ft and Δ=15°, what is the long chord length?

A. 268.4 ft
B. 287.2 ft
C. 301.6 ft
D. 315.9 ft

13. A DOT project widening an existing highway must locate an unknown abandoned utility line suspected beneath the shoulder before grading begins. Which method most reliably confirms the exact depth and horizontal position of the line?

A. vacuum excavation (potholing) at locations flagged by ground-penetrating radar
B. relying on the original 1960s as-built plans alone
C. aerial photogrammetry of the existing shoulder surface
D. a standalone soil resistivity survey with no physical verification

14. A benchmark has an established elevation of 180.00 ft. A backsight rod reading of 3.44 ft is taken on the benchmark, and a foresight reading of 7.92 ft is taken to set a rough grade stake. What elevation is the stake set at?

A. 172.08 ft
B. 179.86 ft
C. 175.52 ft
D. 191.36 ft

15. What is the degree of curve (arc definition) for a horizontal curve with a 1,100 ft radius?

A. 3.86°
B. 4.42°
C. 4.78°
D. 5.21°

16. A fine-grained soil has a liquid limit LL=38 and plastic limit PL=22. Using the USCS plasticity chart, how should this soil be classified?

A. CH — high-plasticity clay
B. CL — low-plasticity clay
C. ML — low-plasticity silt
D. MH — high-plasticity silt

17. A concrete mix design specifies 295 lb/yd^3 of water and 590 lb/yd^3 of cement. What is the water-cement ratio?

A. 0.50
B. 0.58
C. 0.66
D. 0.74

18. What is the minimum specified yield strength Fy for ASTM A36 structural steel?

A. 42 ksi
B. 46 ksi
C. 50 ksi
D. 36 ksi

19. A sawn lumber beam has a reference bending design value Fb=1300 psi. Applying a load duration factor CD=1.6 for wind loading and a size factor CF=1.05, what is the adjusted design value?

A. 1820 psi
B. 1985 psi
C. 2184 psi
D. 2350 psi

20. Which ASTM standard measures the temperature of freshly mixed concrete at the point of placement?

A. ASTM C39
B. ASTM C1064
C. ASTM C143
D. ASTM C231

21. A soil sample has a void ratio e=0.70 and specific gravity Gs=2.65. What is the dry unit weight, using $\gamma w=9.81\ kN/m^3$?

A. 12.6 kN/m^3
B. 13.8 kN/m^3
C. 14.5 kN/m^3
D. 15.3 kN/m^3

22. A structural drawing calling for weldable, seismic-application reinforcing steel specifies ASTM A706 Grade 60. What is its minimum specified yield strength?

A. 40 ksi
B. 50 ksi
C. 60 ksi
D. 75 ksi

23. Two cross-section end areas along a roadway cut are 95 sf and 145 sf, separated by 140 ft. Using the average end area method, what is the earthwork volume in cubic yards?

A. 622.2 cy
B. 705.4 cy
C. 780.6 cy
D. 850.1 cy

24. A project requires 3,200 cy of gravel base at a unit cost of $38/cy. What is the total material cost?

A. $108,400
B. $121,600
C. $134,900
D. $148,200

25. An owner expects to spend $620,000 six years from now on a facility upgrade. At an interest rate of 7% per year, what is the present worth of that expenditure?

A. $365,800
B. $389,600
C. $413,100
D. $438,900

26. A project has an earned value (EV) of $390,000 and actual cost (AC) of $420,000. What is the cost performance index (CPI)?

A. 0.85
B. 0.93
C. 1.02
D. 1.10

27. A concrete slab measures 48 ft by 32 ft at a thickness of 0.42 ft. What is the concrete volume in cubic yards?

A. 16.2 cy
B. 18.9 cy
C. 21.4 cy
D. 23.9 cy

28. Using a parametric cost-per-square-foot estimate of $165/sf for a 25,000 sf building, what is the estimated construction cost?

A. $4,125,000
B. $3,850,000
C. $4,400,000
D. $4,650,000

29. A production line has fixed costs of $80,000, a variable cost of $22 per unit, and sells each unit at $46. How many units must be sold to break even?

A. 2,560
B. 2,890
C. 3,120
D. 3,333

30. A schedule shows earned value EV=$355,000 and planned value PV=$390,000. What is the schedule performance index (SPI)?

A. 0.84
B. 0.91
C. 0.98
D. 1.06

31. An activity has an early start (ES) of day 20 and a duration of 11 days. What is its early finish (EF)?

A. 27
B. 29
C. 31
D. 33

32. Using the PERT three-point estimate with optimistic time to=5 days, most likely tm=8 days, and pessimistic tp=17 days, what is the expected activity duration?

A. 9.0 days
B. 9.8 days
C. 10.4 days
D. 11.0 days

33. An activity has ES=12 and LS=25. What is its total float?

A. 7
B. 10
C. 13
D. 16

34. A critical path consists of four sequential activities with durations of 8, 11, 6, and 13 days. What is the total critical path duration?

A. 38 days
B. 44 days
C. 50 days
D. 56 days

35. A paving crew completes 4,200 linear feet of curb and gutter in 14 working days. What is the crew's production rate?

A. 260 ft/day
B. 300 ft/day
C. 340 ft/day
D. 380 ft/day

36. A task requires 7 workers for 11 days. What is the total resource-days (worker-days) required for this task?

A. 56
B. 63
C. 70
D. 77

37. An activity has a normal cost of $30,000 over 14 days and a crash cost of $48,000 over 9 days. What is the crash cost per day?

A. $2,800
B. $3,200
C. $3,600
D. $4,000

38. In a typical mass earthwork operation, which of the following represents the correct sequence of field activities?

A. compact, place, spread, test
B. test, compact, place, spread
C. spread, test, compact, place
D. place, spread, compact, test

39. An activity has an early finish of day 21, and the earliest successor activity's early start is day 35. What is this activity's free float?

A. 8
B. 14
C. 18
D. 22

40. Delaying a non-critical activity's start within a resource leveling exercise never affects the project finish date, provided the delay does not exceed the activity's—

A. total float
B. crew size
C. material lead time
D. contract retainage percentage

41. A field density test shows a dry density of 124 pcf, while the laboratory maximum dry density (standard Proctor) is 131 pcf. What is the percent relative compaction?

A. 87.4%
B. 90.2%
C. 92.6%
D. 94.7%

42. Which ASTM standard measures the temperature of freshly mixed concrete at the time and point of placement?

A. ASTM C143
B. ASTM C231
C. ASTM C1064
D. ASTM C39

43. For an ASTM A325 high-strength bolt installed by the turn-of-nut method, with a bolt length not exceeding four diameters, but with one connected surface sloped not more than 1:20 from perpendicular to the bolt axis, what nut rotation from snug-tight is required?

A. 1/3 turn
B. 2/3 turn
C. 1/2 turn
D. 5/6 turn

44. Who is typically responsible for maintaining the project's overall quality management plan and coordinating between the testing laboratory, contractor, and engineer of record?

A. the owner's quality assurance manager
B. the concrete subcontractor's foreman
C. the surveying crew chief
D. the project's bonding company

45. What is the primary purpose of using a vibrator during concrete consolidation immediately after placement?

A. to eliminate entrapped air voids and achieve full consolidation around reinforcement
B. to accelerate the concrete's initial set time
C. to increase the water-cement ratio locally within the mix
D. to replace the need for proper curing afterward

46. Using the Nurse-Saul maturity function with a constant temperature-datum difference of 18°C sustained for 60 hours, what is the concrete's maturity index?

A. 780 °C-hr
B. 930 °C-hr
C. 1080 °C-hr
D. 1230 °C-hr

47. A maturity-strength calibration curve developed for one concrete mixture may NOT be reliably applied to a different mixture because—

A. maturity indices are always identical across different mixtures
B. ASTM requires a single universal curve for all concrete mixtures
C. temperature has no effect on early-age strength gain
D. cement type, water-cement ratio, and admixtures all change the strength-maturity relationship

48. A sand cone field density test removes 4.1 lb of soil from a hole with a volume of 0.034 cf. The soil's moisture content is 13%. What is the dry unit weight?

A. 98.2 pcf
B. 106.7 pcf
C. 114.3 pcf
D. 121.5 pcf

49. A 1/2-in fillet weld uses E70 electrode (Fexx=70 ksi). What is its nominal strength per inch of weld length?

A. 10.2 kip/in
B. 12.6 kip/in
C. 14.8 kip/in
D. 17.1 kip/in

50. If soil compaction test results fall below the specified minimum relative compaction, what is the standard next step before acceptance is granted?

A. immediately remove and replace all fill on the project regardless of extent
B. accept the lift since compaction specifications include a built-in tolerance
C. reduce the compaction specification retroactively to match the observed test results
D. rework, recompact, and retest the affected area per the project specification

51. A slab is designed for dead load D=45 psf and live load L=55 psf. Using the basic ASCE 7 load combination U=1.2D+1.6L, what is the factored design load?

A. 128 psf
B. 142 psf
C. 156 psf
D. 170 psf

52. A beam experiences a bending moment $M=540$ kip-in at a section where $c=5.5$ in and $I=180$ in^4. What is the extreme fiber bending stress?

A. 16.5 ksi
B. 18.8 ksi
C. 21.2 ksi
D. 23.6 ksi

53. An axially loaded member carries $P=150$ kip through a cross-sectional area of 7.5 in^2. What is the axial stress?

A. 14.0 ksi
B. 16.5 ksi
C. 18.0 ksi
D. 20.0 ksi

54. A footing carries a column load of 420 kip and measures 10 ft by 12 ft in plan. What is the resulting bearing pressure on the soil?

A. 3.5 ksf
B. 4.0 ksf
C. 4.4 ksf
D. 4.8 ksf

55. Using the simplified ASCE 7 velocity pressure equation $q_z=0.00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2$, with $K_z=0.87$, $K_{zt}=1.0$, $K_d=0.85$, and $V=110$ mph, what is the velocity pressure?

A. 17.6 psf
B. 20.3 psf
C. 22.9 psf
D. 25.8 psf

56. A beam has shear force V=52 kip, first moment of area $Q=48\ in^3$, moment of inertia $I=850\ in^4$, and web thickness b=8.5 in. What is the shear stress at that location?

A. 285 psi
B. 345 psi
C. 390 psi
D. 425 psi

57. A column has an effective length factor K=1.0, unbraced length L=20 ft, and radius of gyration r=3.1 in. What is the slenderness ratio KL/r?

A. 68
B. 77
C. 85
D. 93

58. A retaining wall has a resisting moment of 1,050 kip-ft and an overturning moment of 460 kip-ft. What is the factor of safety against overturning?

A. 1.85
B. 2.05
C. 2.28
D. 2.52

59. A column has a tributary floor area of 24 ft by 28 ft, and the floor is designed for a live load of 80 psf. What is the total live load carried by this column?

A. 41.2 kip
B. 46.5 kip
C. 50.1 kip
D. 53.8 kip

60. Which AISC 360 chapter governs the design of members subject to combined forces, such as simultaneous axial load and flexure?

A. Chapter H
B. Chapter D
C. Chapter F
D. Chapter E

61. Using the rational method $Q=C \cdot i \cdot A$ with a runoff coefficient $C=0.45$, rainfall intensity $i=3.5$ in/hr, and drainage area $A=18$ acres, what is the peak discharge?

A. 22.6 cfs
B. 28.3 cfs
C. 33.1 cfs
D. 37.9 cfs

62. An open channel has Manning's $n=0.012$, flow area $A=10$ sf, hydraulic radius $R=1.2$ ft, and slope $S=0.006$. Using Manning's equation (USCS form with 1.49), what is the flow rate?

A. 82.4 cfs
B. 94.7 cfs
C. 101.3 cfs
D. 108.6 cfs

63. Using the Kirpich equation Tc=0.0078·L^0.77·S^-0.385 (L in ft, S in ft/ft), with a flow path length of 650 ft and slope of 0.025, what is the time of concentration?

A. 3.1 min
B. 3.9 min
C. 4.7 min
D. 5.6 min

64. A detention pond must temporarily store runoff where peak inflow is 50 cfs, allowable peak outflow is 22 cfs, and the storm duration is 2.5 hours. Using a simplified triangular hydrograph approximation, what storage volume is required?

A. 2.89 ac-ft
B. 3.35 ac-ft
C. 3.68 ac-ft
D. 4.02 ac-ft

65. A storm sewer pipe with an 18-in diameter carries a flow of 10 cfs. What is the flow velocity in the pipe, assuming it flows full?

A. 4.1 fps
B. 4.9 fps
C. 5.7 fps
D. 6.5 fps

66. A broad-crested weir outlet has a discharge coefficient C=3.2, crest length L=6 ft, and head H=1.1 ft. Using Q=C·L·H^1.5, what is the discharge through the weir?

A. 16.4 cfs
B. 18.9 cfs
C. 20.6 cfs
D. 22.2 cfs

67. A 2-leg sling supports a 12,000 lb load, with each leg oriented at 55° from horizontal. What is the tension in each leg?

A. 7,325 lb
B. 6,500 lb
C. 7,900 lb
D. 8,450 lb

68. A tower crane's jib-tip capacity decreases as the trolley moves further out along the jib. This behavior directly reflects—

A. the crane's counterweight losing effectiveness over the life of the machine
B. the increasing overturning moment created by a longer lever arm as radius grows
C. hydraulic pressure loss within the hoist system at greater distances
D. wind loading effects only, independent of trolley position

69. A dewatering system must handle 280 gpm of inflow, and each wellpoint has a discharge capacity of 16 gpm. What is the minimum number of wellpoints required?

A. 18
B. 15
C. 21
D. 24

70. An excavator has a bucket capacity of 2.25 cy, a fill factor of 0.90, a cycle time of 20 seconds, and operates at 45 minutes of effective work per hour. What is its production rate?

A. 210 cy/hr
B. 235 cy/hr
C. 255 cy/hr
D. 273 cy/hr

71. Using the Engineering News Record (ENR) pile driving formula Qu=2E/(S+0.1), with driving energy E=22,000 ft-lb and set S=0.6 in per blow, and applying a factor of safety of 6, what is the allowable pile capacity?

A. 7.8 kip
B. 9.2 kip
C. 10.5 kip
D. 12.1 kip

72. Two cross-section end areas along an embankment are 210 sf and 270 sf, separated by 175 ft. Using the average end area method, what is the fill volume in cubic yards?

A. 1,385.2 cy
B. 1,555.6 cy
C. 1,690.3 cy
D. 1,820.7 cy

73. A wire rope sling's choker hitch rating is further reduced below the standard 75-80% derate when—

A. the load is perfectly balanced and centered
B. the sling is new and shows no visible wear
C. the lift height above ground is minimal
D. the choke angle is less than 120 degrees, tightening the wrap around the load

74. A crane boom is 140 ft long and raised to an angle of 55° from horizontal. Ignoring boom point offset, what is the resulting horizontal working radius?

A. 68.4 ft
B. 74.6 ft
C. 80.3 ft
D. 86.9 ft

75. A sump pump must handle a seepage inflow of 110 gpm, and standard practice applies a safety factor of 1.5 for pump sizing. What minimum pump capacity should be selected?

A. 165 gpm
B. 145 gpm
C. 185 gpm
D. 200 gpm

76. A loader has a cycle time of 3.5 minutes per load. A truck's full haul-dump-return cycle takes 24.5 minutes. How many trucks are needed to keep the loader continuously working?

A. 5
B. 7
C. 9
D. 11

77. A pile's static capacity analysis gives skin friction resistance Qs=210 kip and end bearing resistance Qp=130 kip. Applying a factor of safety of 2.5, what is the allowable pile capacity?

A. 108 kip
B. 122 kip
C. 136 kip
D. 150 kip

78. An embankment requires 9,500 cy of soil measured in the bank (natural, undisturbed) condition, and the borrow soil has a shrinkage factor of 0.88 relating compacted volume to bank volume. What compacted fill volume results from excavating this bank volume?

A. 8,360 cy
B. 7,600 cy
C. 9,050 cy
D. 9,800 cy

79. A crane outrigger imposes a load of 68,000 lb on the ground, and the allowable soil bearing pressure is 3,200 psf. What minimum outrigger pad area is required?

A. 15.4 sf
B. 17.8 sf
C. 19.6 sf
D. 21.2 sf

80. Using the ACI 347 formwork lateral pressure formula for columns, Cw=150+9000R/T, with a placement rate R=5 ft/hr and concrete temperature T=75°F, what is the design lateral pressure?

A. 580 psf
B. 750 psf
C. 910 psf
D. 1,040 psf

81. A scaffold platform will support 5 workers averaging 200 lb each, 1,800 lb of stored material, and 250 lb of tools and equipment. What is the total design load on the platform?

A. 2,450 lb
B. 2,700 lb
C. 2,900 lb
D. 3,050 lb

82. A reshore below a freshly poured slab has a tributary area of 10 ft by 10 ft, and the slab's dead load is 95 psf. What load is transferred to this reshore, using a simplified tributary-area method?

A. 7,800 lb
B. 8,600 lb
C. 9,500 lb
D. 10,400 lb

83. A minimum lateral bracing design provision requires lateral bracing force equal to 2% of the supported vertical load. For a formwork system supporting 48,000 lb vertically, what minimum lateral bracing force must be provided?

A. 960 lb
B. 1,120 lb
C. 1,280 lb
D. 1,440 lb

84. For a braced excavation in sand with an apparent earth pressure diagram per Terzaghi-Peck, $p=0.65 \cdot K_a \cdot \gamma \cdot H$, with $K_a=0.35$, $\gamma=110$ pcf, and excavation depth $H=22$ ft, what is the peak apparent pressure?

A. 460 psf
B. 551 psf
C. 610 psf
D. 665 psf

85. A shoring analysis that assumes a lower slab already carries its full design service load, before any reshore loads are added from above, will—

A. always be conservative regardless of actual site conditions
B. match field conditions exactly in every construction scenario
C. underestimate the true load on the lower slab
D. produce an inaccurate analysis unless the slab's actual pre-existing load is properly accounted for

86. Per ACI 347, absent motorized buggies, what is the minimum required combined dead and live load for horizontal formwork design?

A. 100 psf
B. 125 psf
C. 90 psf
D. 75 psf

87. A supported scaffold is 36 ft tall with an 8 ft base width. Per OSHA 29 CFR 1926 Subpart L, does this scaffold require guying, tying, or bracing, and why?

A. No, because 4.5:1 is below the regulatory threshold
B. No, because only scaffolds over 50 ft require restraint
C. Yes, because its 4.5:1 height-to-base ratio exceeds the 4:1 threshold
D. Yes, but only if it will be occupied by more than two workers

88. A slab load of 160 psf acts on a 10 ft by 10 ft tributary area, and the load is assumed to split equally among four engaged support levels. What load does each level carry, using this simplified method?

A. 3,200 lb
B. 4,000 lb
C. 4,800 lb
D. 5,600 lb

89. A diagonal brace oriented at 42° from horizontal resists a horizontal thrust of 11,000 lb. What is the resulting axial force in the brace?

A. 14,802 lb
B. 13,400 lb
C. 16,100 lb
D. 17,500 lb

90. A 10-ft-deep trench is excavated in Type A soil at OSHA's maximum allowable slope of 0.75:1 (horizontal:vertical). What is the horizontal offset at the top of the excavation, measured from the trench bottom edge?

A. 5 ft
B. 6 ft
C. 7 ft
D. 7.5 ft

91. Per ASCE 37, what minimum wind speed consideration applies to temporary structures and bracing during the construction period, compared to the permanent structure's design wind speed?

A. the same full-service design wind speed, with no reduction ever permitted
B. twice the permanent structure's design wind speed
C. a reduced wind speed may be used only if justified by the limited exposure period
D. zero wind load, since construction phases are assumed to occur entirely indoors

92. For vertical formwork such as wall or column forms that do not support other loads, common guidance permits earlier stripping once the concrete has reached sufficient strength to avoid surface damage, typically around what minimum compressive strength?

A. 1,000 psi
B. 500 psi
C. 2,000 psi
D. 2,500 psi

93. A shoring post has an allowable capacity of 7,000 lb at an unbraced length of 14 ft. If lateral bracing reduces the unbraced length to 7 ft, and capacity scales inversely with the square of unbraced length (Euler-type behavior), what is the new allowable capacity?

A. 28,000 lb
B. 21,000 lb
C. 35,000 lb
D. 42,000 lb

94. A braced excavation is 16 ft deep in clay with undrained shear strength c_u=1,100 psf and unit weight γ=115 pcf. Using a bearing capacity factor N_c=5.7, what is the factor of safety against bottom heave, $FS = N_c \cdot c_u / (\gamma \cdot H)$?

A. 2.9
B. 3.4
C. 3.9
D. 4.3

95. Per OSHA 29 CFR 1926 Subpart L, at what scaffold platform height must a safe means of access, such as a ladder or stair tower, generally be provided rather than climbing cross braces?

A. 4 ft
B. 6 ft
C. 2 ft
D. 10 ft

96. Per MUTCD guidance, for a temporary lane closure with a 10-ft lane width and posted speed of 50 mph (using L=WS for speeds at or above 45 mph), what taper length is required?

A. 380 ft
B. 420 ft
C. 460 ft
D. 500 ft

97. Per OSHA 29 CFR 1926 Subpart M, at what height must fall protection generally be provided for workers on a low-slope roof?

A. 4 ft
B. 8 ft
C. 6 ft
D. 10 ft

98. Per MUTCD Part 6, which temporary traffic control (TTC) zone component is positioned first, farthest upstream from the work area, to alert drivers they are approaching a work zone?

A. the advance warning area
B. the buffer space
C. the activity area
D. the termination area

99. Under OSHA 29 CFR 1926, a competent person is defined as someone who is capable of identifying hazardous conditions AND—

A. holds a current professional engineering license
B. is designated by the labor union representative on site
C. has completed only a 10-hour OSHA outreach course
D. has authorization from the employer to take prompt corrective action to eliminate the hazards

100. Per MUTCD guidance, which factor is NOT typically part of the decision to use positive protection devices instead of channelizing devices in a work zone?

A. traffic speed
B. the contractor's preferred brand of barrier product
C. traffic volume
D. worker exposure duration and proximity to traffic

Practice Exam 17: Answer Key and Explanations

1. D — Rankine active pressure for a level, cohesionless backfill is $K_a = \tan^2(45° - \varphi'/2)$. With $\varphi' = 36°$, this is $\tan^2(27°) \approx 0.260$. This is smaller than the Ka value for a 30° or 34° friction angle, since a stronger soil skeleton needs less lateral thrust to reach its active state.

2. C — Primary consolidation settlement is $S_c = [C_c \cdot H/(1+e_0)] \cdot \log_{10}[(p_0+\Delta p)/p_0]$. Substituting, $S_c = (0.35\times6/2.00)\cdot\log_{10}(200/90) = 1.05\times0.347 \approx 0.364$ m, or 364 mm. This is a substantial settlement, reflecting the high compression index and large added stress relative to the modest original overburden pressure already present at this particular site before construction begins. Local overconsolidation effects would reduce this settlement estimate somewhat.

3. B — Total stress at 9 m is $\sigma = (16.5\times2) + (18.5\times7) = 33 + 129.5 = 162.5$ kPa. Pore pressure develops only below the water table: $u = 9.81\times7 = 68.7$ kPa. Effective stress is $\sigma' = 162.5 - 68.7 \approx 94$ kPa. Option D is the total stress alone, without the pore pressure subtracted out.

4. A — For $\varphi = 0$ conditions, $q_{ult} = c_u \cdot N_c + q \cdot N_q$. The surcharge is $q = 19\times1.0 = 19$ kPa, so $q_{ult} = 45\times5.7 + 19\times1.0 = 256.5 + 19 \approx 276$ kPa. Omitting the surcharge term, as in option B, understates ultimate capacity by ignoring the confinement the overlying soil provides.

5. D — For a dry infinite slope of cohesionless soil, $FS = \tan\varphi/\tan\beta$, since slice weight cancels out of both the driving and resisting terms entirely from the equation. Here $FS = \tan(30°)/\tan(20°) = 0.577/0.364 \approx 1.59$. This ratio depends only on the friction and slope angles, not on slope height or unit weight.

6. B — Passive coefficient is $K_p = \tan^2(45°+\varphi'/2) = \tan^2(61.5°) \approx 3.412$. The resultant passive force is $P_p = 0.5 \cdot K_p \cdot \gamma \cdot H^2 = 0.5 \times 3.412 \times 18.5 \times 3.5^2 \approx 384$ kN/m, acting one-third of the wall height above the base. Passive resistance is far larger than active pressure for this same soil and wall geometry combined. Wall embedment depth strongly affects the magnitude of this resultant force.

7. A — With double drainage, the drainage path length is $H_{dr} = H/2 = 2.5$ m. Time factor relates as $t = T_v \cdot H_{dr}^2/c_v = 0.197 \times 6.25/2.5 = 0.4925$ yr, which converts to $0.4925 \times 365 \approx 180$ days. Using the full 5 m thickness instead of the halved drainage path would substantially overstate this required time.

8. C — With seepage parallel to the slope, $FS = (\gamma'/\gamma_{sat}) \cdot (\tan\varphi'/\tan\beta)$. The buoyant unit weight is $\gamma' = 20-9.81 = 10.19$ kN/m³, giving a ratio of 0.5095. Combined with $\tan(32°)/\tan(22°) \approx 1.547$, $FS \approx 0.5095 \times 1.547 \approx 0.79$, roughly half the equivalent dry slope's factor of safety examined earlier without seepage. Higher friction angles would proportionally increase this computed safety factor.

9. D — Curve length is $L = R \cdot \Delta(\text{radians}) = 1{,}100 \times (15 \times \pi/180) = 1{,}100 \times 0.2618 \approx 288.0$ ft. This arc-based formula is standard for circular horizontal curve layout, giving the actual station-to-station distance traveled along the curve rather than the shorter straight-line chord distance connecting its two endpoints. Sharper curves at the same radius yield shorter overall curve lengths.

10. C — Middle ordinate is $M = R \cdot (1-\cos(\Delta/2))$. With $\Delta/2 = 7.5°$, $\cos(7.5°) = 0.99144$, so $M = 1{,}100 \times (1-0.99144) = 1{,}100 \times 0.00856 \approx 9.4$ ft. This small offset reflects a gentle curve relative to its large radius, since sharper curves at the same radius produce larger middle ordinates. Sharper deflection angles at this radius would increase this offset value.

11. A — The high point on a crest vertical curve occurs where $x = L \cdot g_1/(g_1-g_2)$. Here $x = 450 \times 2.2/(2.2-(-1.8)) = 990/4.0 = 247.5$ ft from the BVC. Because the two grades differ in magnitude, this point falls past the curve's geometric midpoint rather than sitting exactly at the 225 ft station point.

12. B — The long chord connecting the PC and PT is $C = 2R \cdot \sin(\Delta/2)$. With $\Delta/2 = 7.5°$, $\sin(7.5°) = 0.13053$, giving $C = 2 \times 1{,}100 \times 0.13053 \approx 287.2$ ft. As expected, this is slightly shorter than the 288.0 ft arc length computed earlier for this same curve's geometry and radius. Chord and arc length converge as the deflection angle grows smaller.

13. A — As-built plans from decades earlier are often inaccurate or incomplete, and aerial photogrammetry or resistivity surveys alone can't physically confirm an underground utility's exact depth and position. Ground-penetrating radar first identifies likely locations, and vacuum excavation, or potholing, then physically exposes and confirms the utility without damaging it during verification.

14. C — Height of instrument is HI = benchmark elevation + backsight = 180.00 + 3.44 = 183.44 ft. The stake elevation is then HI minus the foresight: 183.44 − 7.92 = 175.52 ft. This differential leveling procedure carries a known elevation from a fixed benchmark out to new grade stakes across the site.

15. D — By the arc definition, degree of curve is $D = 5729.58/R$. With $R = 1{,}100$ ft, $D = 5729.58/1{,}100 \approx 5.21°$. Larger radius curves always produce smaller degrees of curve, since a gentler curve subtends a smaller central angle over the same standard 100-ft arc length used in this definition.

16. B — Plasticity index is $PI = LL - PL = 16$. The A-line value at $LL=38$ is $0.73 \times (38-20) = 13.1$, and since $PI=16$ plots above the A-line with $LL<50$, the soil classifies as CL. A PI falling below this A-line value at the same liquid limit would instead indicate an ML silt classification.

17. A — Water-cement ratio is the water weight divided by cement weight: $295/590 = 0.50$. This moderate ratio balances workability during placement against strength and durability requirements, and is a common target for structural concrete exposed to normal environmental conditions without severe freeze-thaw or aggressive chemical attack concerns present on site. Higher ratios would reduce strength but improve overall mix workability.

18. D — ASTM A36 specifies a minimum yield strength of 36 ksi, historically the default structural steel grade before A992 became standard for hot-rolled wide-flange shapes. A36 remains common today for plates, angles, and miscellaneous steel that don't require the higher strength of A572 or A992 material used in primary framing members.

19. C — Adjusted design values multiply the reference value by all applicable adjustment factors: $F_b' = F_b \times C_D \times C_F = 1300 \times 1.6 \times 1.05 = 2184$ psi. Wind loading's short duration justifies a much larger C_D factor than snow or occupancy live load, substantially increasing the member's adjusted allowable bending capacity under this particular load case and duration.

20. B — ASTM C1064 specifies the procedure for measuring fresh concrete temperature at the time and point of placement, which affects both workability during finishing and the rate of strength gain afterward. C39 tests hardened cylinder strength, C143 measures slump, and C231 measures entrained air content, each an entirely separate concrete property.

21. D — Dry unit weight relates to void ratio and specific gravity by $\gamma_d = G_s \cdot \gamma_w/(1+e) = 2.65 \times 9.81/1.70 \approx 15.3$ kN/m³. This higher void ratio than a well-compacted sample produces a looser soil skeleton, resulting in a somewhat lower dry unit weight than would be found in denser, better-compacted material at the same site.

22. C — ASTM A706 Grade 60 has a minimum specified yield strength of 60 ksi, matching common Grade 60 A615 bar, but with tighter controls on chemical composition and a limited yield-to-tensile strength ratio that make it suitable for welding and for ductile behavior in seismic detailing applications where A615 bar is not appropriate.

23. A — The average end area method computes volume as $V = [(A_1+A_2)/2] \times L = [(95+145)/2] \times 140 = 16{,}800$ cf. Converting to cubic yards by dividing by 27 gives approximately 622.2 cy. This remains the standard hand-calculation approach for earthwork quantity takeoff between surveyed cross sections along a linear roadway alignment. Longer segment lengths would proportionally increase this computed volume figure.

24. B — Unit cost estimating multiplies quantity by unit price: $3{,}200 \times \$38 = \$121{,}600$. This calculation is only as reliable as the underlying quantity takeoff and unit price data, both of which should reflect current market conditions and the gradation specification called for on this particular base course material and project. Bulk purchasing discounts could further reduce this baseline material cost.

25. C — Present worth of a single future amount is $P = F/(1+i)^n = 620{,}000/(1.07)^6 = 620{,}000/1.5007 \approx \$413{,}100$. This single-payment present-worth factor allows costs occurring at different points in time to be compared fairly on a common present-value basis for engineering economic decision-making purposes across competing project alternatives. Higher discount rates would further reduce this present-worth result value.

26. B — Cost performance index is $CPI = EV/AC = 390{,}000/420{,}000 \approx 0.93$. A CPI below 1.0 indicates the project is spending more than the value of work actually completed, signaling a cost overrun that warrants management attention before it grows further as the remaining scope of work is performed and billed.

27. D — Volume is length times width times thickness: $48 \times 32 \times 0.42 = 645.1$ cf. Dividing by 27 cf per cubic yard gives approximately 23.9 cy. This slab-on-grade takeoff is routinely used to order the correct number of ready-mix truck loads and plan crew workload for the day of the scheduled pour. Thicker slab sections would proportionally increase this computed volume figure.

28. A — Parametric estimating multiplies a unit rate by a project parameter: 25,000 sf × \$165/sf = \$4,125,000. This method is useful in early conceptual design before detailed quantities exist, trading precision for speed, with reliability depending heavily on how well the historical rate matches this project's scope and finish level overall.

29. D — Break-even quantity equals fixed cost divided by the contribution margin per unit: $80{,}000/(46-22) = 80{,}000/24 \approx 3{,}333$ units. Below this quantity the operation runs at a loss, and above it, each additional unit contributes \$24 toward covering fixed costs and, past break-even, toward genuine profit for the business. Higher fixed costs would raise this break-even threshold correspondingly higher.

30. B — Schedule performance index is $SPI = EV/PV = 355{,}000/390{,}000 \approx 0.91$. An SPI below 1.0 indicates the project is behind its planned schedule, since less value has been earned by this point than was originally planned, a signal that schedule recovery measures may soon become necessary to catch back up.

31. C — In the CPM forward pass, early finish equals early start plus duration: $EF = ES + \text{Duration} = 20 + 11 = 31$. This value becomes the early start for any successor activity depending solely on this one, propagating forward through the network toward the project's earliest possible completion date.

32. A — PERT expected time is $t_e = (t_o + 4 \cdot t_m + t_p)/6 = (5 + 32 + 17)/6 = 54/6 = 9.0$ days. Weighting the most likely estimate four times as heavily as the optimistic and pessimistic bounds reflects the right-skewed distribution typical of real construction activity durations encountered on most projects.

33. C — Total float is the difference between late start and early start: TF = LS − ES = 25 − 12 = 13. This represents how many days the activity's start can slip without delaying the overall project completion date, assuming the float isn't shared with or consumed by other activities on its path.

34. A — Since these activities occur sequentially with no overlap along the critical path, total duration is simply their sum: 8+11+6+13 = 38 days. The critical path is the longest chain of dependent activities through the network, and it alone sets the shortest possible achievable project completion date given these durations. Any single delayed activity along this path delays the whole project.

35. B — Production rate for a linear (line-of-balance) schedule is distance divided by time: 4,200 ft / 14 days = 300 ft/day. This rate defines the slope of the crew's line on a time-distance diagram, used to sequence multiple crews so faster crews don't catch up to and overtake slower ones ahead.

36. D — Total resource-days is the product of the number of workers and the duration: 7 workers × 11 days = 77 worker-days. This fixed labor quantity can be redistributed across different crew sizes and durations during resource leveling without changing the total amount of work actually performed on this particular task.

37. C — Crash cost slope is the change in cost divided by the change in duration: (48,000−30,000)/(14−9) = 18,000/5 = $3,600 per day. This slope tells the scheduler how much it costs to compress each day out of this activity, guiding which activities to crash first when accelerating the overall project. Steeper cost slopes indicate less economical candidates for schedule crashing.

38. D — Fill material must first be placed at the work face, then spread into a uniform lift of the specified loose thickness, then compacted with the appropriate equipment to achieve the required density, and only then tested to confirm the lift meets specification before the next lift can be placed on top.

39. B — Free float is the amount an activity can be delayed without affecting the early start of any successor: FF = (successor ES) − (this activity's EF) = 35 − 21 = 14. Unlike total float, this value depends only on the immediate downstream activity, not on the project's overall late-date calculations.

40. A — Total float represents the maximum amount an activity's start or finish can shift without pushing back the project's overall completion date. As long as a resource leveling shift stays within this float, the schedule's end date is unaffected; exceeding it would instead push the delay directly onto the critical path itself.

41. D — Relative compaction is the field dry density divided by the laboratory maximum dry density, expressed as a percentage: (124/131)×100 ≈ 94.7%. This result would typically satisfy a specification requiring 90 to 95% relative compaction, confirming the field placement and compaction effort met the earthwork requirements for this particular lift. Lower field densities would proportionally reduce this compaction percentage value.

42. C — ASTM C1064 specifies the procedure for measuring fresh concrete temperature at the point of placement, since temperature affects both workability during finishing and the rate of strength gain afterward. C143 measures slump, C231 measures air content, and C39 tests hardened cylinder strength, each an entirely separate concrete property being tested.

43. B — The RCSC Specification increases required nut rotation when a connected surface is sloped rather than perfectly normal to the bolt axis, since the sloped surface requires additional elongation to reach the specified pretension value. For this bolt length with one sloped surface, the required rotation beyond snug-tight is 2/3 turn.

44. A — The owner's quality assurance manager holds overall responsibility for the project's quality management plan and serves as the coordinating point between the independent testing laboratory, the contractor performing the work, and the engineer of record reviewing conformance. The other roles listed each handle a narrower operational function, not overall QA coordination.

45. A — Mechanical vibration releases entrapped air bubbles and allows fresh concrete to flow fully around reinforcing steel and into corners of the formwork, eliminating voids that would otherwise weaken the hardened element significantly. Vibration doesn't affect set time, alter the mix's water-cement ratio, or substitute for proper curing after placement is complete.

46. C — The Nurse-Saul maturity index accumulates temperature above a datum over time: $M(t) = \Sigma(T-T0)\cdot\Delta t$. With a constant 18°C difference sustained for 60 hours, $M = 18\times60 = 1{,}080$ °C-hours. This index is later compared against a mixture-specific calibration curve to estimate the concrete's in-place strength at that time. Higher sustained temperatures would proportionally increase this maturity index value.

47. D — The strength-maturity relationship depends on the specific mixture's cement type, water-cement ratio, and admixture content, all of which influence how quickly strength develops for a given accumulated temperature history over time. Because these factors vary between mixtures, a calibration curve is mixture-specific and cannot be reused for a different concrete design.

48. B — Wet unit weight is the weight of soil removed divided by the hole volume: $4.1/0.034 \approx 120.6$ pcf. Converting to dry unit weight using the moisture content, $\gamma d = \gamma wet/(1+w) = 120.6/1.13 \approx 106.7$ pcf. This field value is compared against the laboratory Proctor curve to check the relative compaction achieved.

49. C — Nominal fillet weld strength per unit length is $Rn = 0.6\cdot Fexx\cdot 0.707\cdot w$, where 0.707 converts the leg dimension to the effective throat. With Fexx=70 ksi and w=0.5 in, $Rn = 0.6\times70\times0.707\times0.5 \approx 14.8$ kip/in, larger than smaller fillet sizes since capacity scales directly with leg size and throat dimension. Smaller weld sizes proportionally reduce this per-inch capacity value.

50. D — A failed compaction test triggers rework of the affected area, typically additional passes with compaction equipment or moisture conditioning, followed by retesting to confirm the specified relative compaction is achieved on that lift. Full project-wide removal, silent acceptance, or retroactively lowering the specification all skip this standard corrective quality control sequence.

51. B — The factored load combination applies separate load factors before summing: $U = 1.2(45) + 1.6(55) = 54 + 88 = 142$ psf. The larger factor applied to live load reflects its greater variability relative to dead load, and this combination typically governs strength design under ordinary gravity-only loading conditions for most structures.

52. A — The flexure formula gives bending stress as $\sigma = M \cdot c/I = 540 \times 5.5/180 \approx 16.5$ ksi. This maximum normal stress occurs at the extreme fiber, the distance c from the neutral axis, and would be checked against the material's allowable bending stress to confirm the section's adequacy for this applied moment value.

53. D — Axial stress is force divided by cross-sectional area: $\sigma = P/A = 150/7.5 = 20.0$ ksi. This uniform distribution assumes the load passes through the section's centroid; any eccentricity would introduce additional bending stress that must be superimposed on this baseline axial value to find the true combined total stress state.

54. A — Assuming a concentric load and uniform pressure distribution, bearing pressure equals load divided by footing area: $q = P/(B \times L) = 420/(10 \times 12) = 3.5$ ksf. This value must be checked against the soil's allowable bearing capacity from a geotechnical report to confirm the footing is adequately sized for this applied column load.

55. C — Substituting directly: $q_z = 0.00256 \times 0.87 \times 1.0 \times 0.85 \times 110^2 = 0.00256 \times 0.7395 \times 12{,}100 \approx 22.9$ psf. This velocity pressure is then multiplied by pressure coefficients specific to the building's geometry, height, and exposure category to obtain the actual design wind pressures acting on its various surfaces per ASCE 7 tables. Taller structures in rougher terrain would further increase this pressure value.

56. B — Shear stress is given by the shear flow formula $\tau = VQ/(Ib) = (52{,}000 \times 48)/(850 \times 8.5) = 2{,}496{,}000/7{,}225 \approx 345$ psi. This formula gives shear stress at a horizontal plane within the section, generally maximum at the neutral axis where Q is largest, and vanishing at the section's extreme top and bottom fibers.

57. B — Slenderness ratio is KL/r, using consistent units for length. Converting L to inches: 20 ft × 12 = 240 in, so $KL/r = (1.0 \times 240)/3.1 \approx 77$. This ratio helps determine whether the column's compressive strength is governed by inelastic or elastic Euler buckling behavior under AISC Chapter E provisions and tables.

58. C — Factor of safety against overturning is the ratio of resisting moment to overturning moment: $FS = 1{,}050/460 \approx 2.28$. This exceeds the commonly required minimum of roughly 1.5 to 2.0, confirming the wall's weight and geometry provide adequate resistance to the lateral pressure driving rotation about its toe and footing.

59. D — Tributary area load is the product of tributary area and design load intensity: $24 \times 28 \times 80 = 53{,}760$ lb, or about 53.8 kip. This tributary area approach assumes the column collects load from half the distance to each adjacent column line, a standard simplification for gravity load distribution in a framed structure.

60. A — AISC 360 Chapter H covers members under combined forces and torsion, providing the interaction equations used when a member carries both axial load and bending simultaneously under service or factored conditions. Chapter D covers tension members alone, Chapter E covers compression members alone, and Chapter F covers flexural members alone.

61. B — The rational method combines runoff coefficient, rainfall intensity, and drainage area directly: $Q = C \cdot i \cdot A = 0.45 \times 3.5 \times 18 \approx 28.3$ cfs, with units already arranged to give cfs directly without conversion factors. This remains the standard peak-flow method for small drainage areas typically under a few hundred acres in storm sewer design.

62. D — Manning's equation is $Q = (1.49/n) \cdot A \cdot R^{(2/3)} \cdot S^{(1/2)}$. Substituting: $(1.49/0.012) \times 10 \times (1.2)^{0.667} \times (0.006)^{0.5} \approx 124.2 \times 10 \times 1.129 \times 0.0775 \approx 108.6$ cfs. This relationship between channel roughness, geometry, and slope remains fundamental for sizing open channels, culverts, and storm sewers throughout civil site development and roadway drainage design projects generally. Steeper channel slopes would further increase this computed flow capacity.

63. C — Substituting into the Kirpich formula: $T_c = 0.0078 \times (650)^{0.77} \times (0.025)^{-0.385} \approx 0.0078 \times 146.5 \times 4.14 \approx 4.7$ minutes. This empirical relationship estimates travel time for runoff from the hydraulically most distant point in the watershed, a key input for rational method peak flow discharge calculations in small drainage areas and watersheds. Flatter watershed slopes would substantially lengthen this computed travel time.

64. A — A simplified storage estimate is $V \approx 0.5 \times (Q_{in} - Q_{out}) \times \text{duration} = 0.5 \times (50 - 22) \times 9{,}000$ sec = 126,000 cf. Converting to acre-feet by dividing by 43,560 gives about 2.89 ac-ft. This preliminary approximation is typically refined afterward with detailed stage-storage-discharge routing for the final detention basin design and outlet structure. Longer storm durations would proportionally increase this required storage volume.

65. C — Velocity is flow rate divided by cross-sectional area: $V = Q/A$. With an 18-in (1.5-ft) diameter pipe, $A = \pi \times (0.75)^2 \approx 1.77$ sf, so $V = 10/1.77 \approx 5.7$ fps. This should be checked against minimum self-cleansing velocity criteria, typically 2 to 3 fps, to prevent sediment buildup in the line.

66. D — Substituting into the weir formula: $Q = 3.2 \times 6 \times (1.1)^{1.5} = 19.2 \times 1.154 \approx 22.2$ cfs. This head-discharge relationship follows a power-law form across the operating depth range above the crest, and is commonly applied to outlet structures that control release rates from detention and retention basins on a developed site. Longer crest lengths would proportionally increase this discharge capacity value.

67. A — Each sling leg carries half the total load, resolved along its angle: $T = (\text{Load}/2)/\sin(\text{angle}) = 6{,}000/\sin(55°) = 6{,}000/0.8192 \approx 7{,}325$ lb. A steeper 55° leg angle produces lower tension than a shallower angle would for the same load, since more of the tension acts vertically rather than horizontally in this case.

68. B — As the trolley moves outward, the load's lever arm about the tower grows longer, increasing the overturning moment for the same load weight being lifted. Because the crane's counterweight and structure can only resist a fixed maximum moment, capacity must decrease with radius to keep that moment within safe structural limits at all times.

69. A — Dividing total required flow by per-wellpoint capacity gives 280/16 = 17.5, which must be rounded up to 18 wellpoints since a fractional wellpoint cannot be installed on site. Rounding up rather than down ensures the system has adequate capacity for the full anticipated groundwater inflow with a reasonable working margin built in.

70. D — Cycles per hour at full time is 3,600/20 = 180, giving a theoretical output of 180×2.25×0.90 ≈ 364.5 cy/hr. Applying the 45/60 efficiency factor for actual working minutes reduces this to about 273 cy/hr, reflecting realistic production once operational delays and minor stoppages are properly accounted for on the job.

71. C — Ultimate capacity is Qu = 2E/(S+0.1) = 2×22,000/(0.6+0.1) = 44,000/0.7 ≈ 62,857 lb. Applying the ENR formula's typical factor of safety of 6 gives allowable capacity: Qa = 62,857/6 ≈ 10.5 kip. A larger set per blow here indicates softer driving resistance than in earlier pile examples shown. Larger driving energy inputs would proportionally raise this allowable capacity.

72. B — Applying the average end area method: V = [(210+270)/2]×175 = 240×175 = 42,000 cf. Converting to cubic yards by dividing by 27 gives about 1,555.6 cy. This method remains the standard hand-calculation approach for earthwork quantities along a linear alignment surveyed at regular cross-section intervals throughout the project. Longer alignment segments would proportionally increase this computed fill volume.

73. D — A choke angle below 120 degrees creates a sharper bend in the sling body as it wraps the load, concentrating additional stress beyond what the standard 75 to 80% derate already accounts for. Rigging references require further capacity reduction as this choke angle tightens, regardless of load balance, sling condition, or lift height.

74. C — Horizontal radius is the boom length multiplied by the cosine of its angle from horizontal: R = L·cos(θ) = 140×cos(55°) = 140×0.5736 ≈ 80.3 ft. A shallower boom angle than 60° or 65° produces a larger working radius for the same boom length, which load charts capture directly in their tables.

75. A — Required pump capacity is the anticipated inflow multiplied by the safety factor: 110×1.5 = 165 gpm. This margin accommodates fluctuations in groundwater inflow rate, pump wear over its service life, and intermittent surges, ensuring the excavation stays dry even under somewhat more severe conditions than the baseline design estimate originally assumed.

76. B — The number of trucks needed to match a loader's output equals the truck's total cycle time divided by the loader's cycle time: 24.5/3.5 = 7 trucks. This ensures a truck is arriving to load just as the previous one departs full, keeping the loader continuously productive rather than sitting idle.

77. C — Ultimate capacity is the sum of skin friction and end bearing: Qult = Qs+Qp = 210+130 = 340 kip. Dividing by the factor of safety gives allowable capacity: Qallow = 340/2.5 = 136 kip. This static computation is typically confirmed in the field with a load test or dynamic pile driving formula.

78. A — With the shrinkage factor defined as compacted volume divided by bank volume, the resulting compacted volume is bank volume multiplied by that factor: 9,500×0.88 = 8,360 cy. Soil always occupies less volume compacted into an embankment than in its natural bank state, which is why this factor stays below one.

79. D — Required pad area is the outrigger load divided by the allowable bearing pressure: $68{,}000/3{,}200 \approx 21.2$ sf. Undersized outrigger pads risk punching into soft ground or causing excessive differential settlement under one outrigger, which can destabilize the crane during a lift, making this bearing check routine in crane setup planning.

80. B — Substituting directly: $Cw = 150 + (9{,}000\times5)/75 = 150 + 600 = 750$ psf. A slower 5 ft/hr placement rate combined with warmer 75°F concrete, which sets faster, produces noticeably lower formwork pressure than a faster placement rate paired with cooler concrete would for the same column height and pour sequence.

81. D — Total design load is the sum of all anticipated loads on the platform: $(5\times200) + 1{,}800 + 250 = 1{,}000 + 1{,}800 + 250 = 3{,}050$ lb. This total must be checked against the scaffold's rated capacity for its assigned duty classification before workers and materials occupy the platform together.

82. C — Tributary area load is the product of tributary area and load intensity: $10\times10\times95 = 9{,}500$ lb. This simplified single-level tributary method estimates the axial load carried by an individual reshore post, though detailed multi-level shoring analysis accounts for load sharing across several connected floor levels engaged beneath the fresh pour.

83. A — Applying the 2% minimum lateral force provision: $0.02\times48{,}000 = 960$ lb. This notional lateral load accounts for out-of-plumb erection tolerances and accidental eccentricities in vertical formwork and shoring systems, and must be provided regardless of whether calculated wind or other lateral loads happen to be smaller than this baseline value.

84. B — Substituting values: $p = 0.65\times0.35\times110\times22 = 0.2275\times110\times22 \approx 551$ psf. The Terzaghi-Peck apparent pressure diagram is an empirical envelope rather than an actual triangular distribution, developed specifically for designing the struts and wales in braced excavation systems based on observed field pressures instead of classical theory. Deeper excavations proportionally increase this peak apparent pressure value here.

85. D — In practice, the lower slab's actual load at the time of loading may be well below its full design service load, since occupancy and finish loads haven't yet been applied during construction. Assuming full service load without verifying actual conditions produces an inaccurate shoring analysis, whether that assumption happens to be conservative or not.

86. A — ACI 347 sets a minimum design load floor of 100 psf for horizontal formwork when motorized carts or buggies are not used, regardless of the computed dead and live loads for a given placement. This minimum rises to 125 psf when motorized equipment is used, due to additional dynamic impact and wheel loads.

87. C — This scaffold's height-to-base ratio is $36/8 = 4.5{:}1$, which exceeds OSHA's 4:1 threshold above which supported scaffolds must be guyed, tied, or braced against tipping over. The requirement is based on this ratio alone, not on total height in isolation or on the number of workers occupying the platform at once.

88. B — Total tributary load is 160×10×10 = 16,000 lb. Splitting this equally among the four simultaneously engaged support levels gives 16,000/4 = 4,000 lb per level. Actual shoring analysis typically uses stiffness-based distribution rather than an equal split, but this simplified method gives a reasonable preliminary estimate for design review purposes.

89. A — The brace's axial force must have a horizontal component equal to the thrust it resists: $F \cdot \cos(42°) = 11{,}000$ lb, so $F = 11{,}000/\cos(42°) \approx 14{,}802$ lb. As the brace angle becomes shallower relative to horizontal, the axial force required to resist a given horizontal thrust increases correspondingly and substantially in magnitude.

90. D — A 0.75:1 slope means the horizontal offset equals 0.75 times the vertical depth: offset = depth×slope ratio = 10×0.75 = 7.5 ft. OSHA 29 CFR 1926 Subpart P permits this steepest slope, requiring the least excavated width, only for the most stable Type A soil classification found on a site.

91. C — ASCE 37 recognizes that a structure's limited exposure period during construction can justify using a reduced wind speed compared to its permanent in-service design wind speed. This reduction must be properly justified by the actual anticipated exposure duration and approved by both the owner and the engineer of record before use.

92. B — Vertical formwork such as wall and column forms carries no load other than the fresh concrete's own lateral pressure, so it can be stripped much earlier than horizontal shoring once the concrete reaches roughly 500 psi, enough strength to resist surface damage from stripping without needing to reach a load-bearing threshold.

93. A — Euler-type buckling capacity scales inversely with the square of unbraced length. Halving the length from 14 ft to 7 ft, a factor of 2, increases capacity by $2^2 = 4$ times: 7,000×4 = 28,000 lb. This strong sensitivity to bracing spacing is why intermediate lateral bracing so effectively boosts capacity.

94. B — Substituting into the heave stability formula: $FS = (5.7 \times 1{,}100)/(115 \times 16) = 6{,}270/1{,}840 \approx 3.4$. This factor of safety against basal heave in soft to medium clay is a critical check for deep braced excavations, since inadequate resistance can cause the excavation floor to rise and destabilize the surrounding bracing system. Weaker clay strength would proportionally reduce this safety factor value.

95. C — OSHA requires a safe means of access whenever a scaffold platform is more than 2 ft above or below a point of access, such as ladders, stair towers, or ramps, rather than allowing workers to climb the scaffold's cross braces. This low 2-ft trigger reflects how quickly climbing cross braces becomes hazardous.

96. D — For speeds at or above 45 mph, MUTCD taper length is $L = W \times S$, where W is the offset width in feet and S is the posted speed in mph: $L = 10 \times 50 = 500$ ft. This formula produces a longer, gentler taper appropriate for the higher operating speeds found on this facility.

97. C — OSHA's general construction fall protection trigger height of 6 ft applies to low-slope roofs just as it does to most other walking and working surfaces under Subpart M. Workers on a low-slope roof edge more than 6 ft above a lower level must be protected by guardrails, safety nets, or personal fall arrest systems.

98. A — The advance warning area is the first component encountered by approaching traffic, using signs and other devices to alert drivers to the upcoming work zone before they reach the transition area, buffer space, and activity area that follow it in sequence, and well before the termination area at the very end.

99. D — OSHA's definition of a competent person requires both the ability to identify existing and predictable hazards in the surroundings or working conditions, and employer-granted authority to take prompt corrective measures to eliminate those hazards. Neither a PE license, union designation, nor a specific training course alone satisfies this two-part regulatory definition.

100. B — MUTCD guidance bases the decision to use positive protection on engineering factors such as traffic speed, volume, and the duration and proximity of worker exposure to passing traffic. A contractor's brand preference for a particular barrier product is a procurement consideration entirely separate from this safety-driven engineering determination process. Engineering judgment, not brand preference, should always drive this safety decision.