PRACTICE EXAM 21: 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 $\varphi' = 40°$ and a level ground surface. Using Rankine theory, what is the active earth pressure coefficient Ka?

A. 0.170
B. 0.193
C. 0.205
D. 0.217

2. A 7 m thick normally consolidated clay layer has Cc = 0.18 and initial void ratio e0 = 0.65. The effective overburden stress is 140 kPa and a foundation adds 75 kPa. What is the primary consolidation settlement?

A. 108 mm
B. 142 mm
C. 168 mm
D. 195 mm

3. The water table is at a depth of 6 m. Above the water table, the moist unit weight is 16.2 kN/m³, and below it the saturated unit weight is 18.8 kN/m³. At a total depth of 13 m, what is the effective vertical stress?

A. 160 kPa

B. 172 kPa
C. 185 kPa
D. 228 kPa

4. A strip footing at 1.3 m depth bears on saturated clay (φ=0) with cu = 52 kPa. Using Terzaghi bearing capacity factors (Nc=5.7, Nq=1.0) and a surcharge unit weight of 18 kN/m³, what is the ultimate bearing capacity?

A. 275 kPa
B. 298 kPa
C. 320 kPa
D. 342 kPa

5. A dry, cohesionless infinite slope has friction angle φ=29° and inclination β=19°. What is the factor of safety against sliding?

A. 1.42
B. 1.61
C. 1.78
D. 1.95

6. A 4.5 m tall wall retains cohesionless backfill with unit weight 19 kN/m³ and φ'=34°. Using Rankine theory, what is the total passive resultant force per unit length of wall?

A. 545 kN/m
B. 598 kN/m
C. 642 kN/m
D. 680 kN/m

7. A doubly-drained saturated clay layer 9 m thick has cv = 3.2 m²/yr. Using Tv=0.197 for 50% consolidation, how long does it take to reach 50% consolidation?

A. 385 days

B. 420 days
C. 455 days
D. 490 days

8. A submerged infinite slope of cohesionless soil ($c'=0$) has $\varphi'=27°$, slope angle $\beta=18°$, saturated unit weight $\gamma sat=19.6$ kN/m³, and $\gamma w=9.81$ kN/m³, with seepage parallel to the slope. What is the factor of safety?

A. 0.78
B. 0.85
C. 0.92
D. 0.99

9. A horizontal curve has a radius of 650 ft and a deflection angle of 38°. What is the curve length?

A. 378.5 ft
B. 402.6 ft
C. 431.1 ft
D. 458.2 ft

10. For the same curve ($R=650$ ft, $\Delta=38°$), what is the middle ordinate distance?

A. 35.4 ft
B. 39.8 ft
C. 43.6 ft
D. 47.2 ft

11. A vertical curve has an initial grade $g1=+3.5\%$ and final grade $g2=-1.0\%$ over a 350 ft curve length. How far from the BVC does the high point occur?

A. 240 ft

B. 272.2 ft
C. 305 ft
D. 330 ft

12. For the horizontal curve with R=650 ft and Δ=38°, what is the long chord length?

A. 385.6 ft
B. 398.4 ft
C. 410.9 ft
D. 423.2 ft

13. A bridge foundation redesign requires confirming the actual soil density beneath an existing footing without removing it. Which method most directly provides this information without full excavation?

A. satellite imagery reviewed for the bridge site alone
B. in-situ testing such as standard penetration or cone penetration soundings adjacent to the footing
C. the original design drawings only, without field verification
D. general regional soil survey maps covering the wider area

14. A benchmark has an established elevation of 95.00 ft. A backsight rod reading of 5.34 ft is taken on the benchmark, and a foresight reading of 3.71 ft is taken to set a rough grade stake. What elevation is the stake set at?

A. 96.63 ft
B. 91.29 ft
C. 103.05 ft
D. 108.40 ft

15. What is the degree of curve (arc definition) for a horizontal curve with a 650 ft radius?

A. 6.95°

B. 7.68°
C. 8.81°
D. 9.60°

16. A fine-grained soil has a liquid limit LL=44 and plastic limit PL=20. Using the USCS plasticity chart, how should this soil be classified?

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

17. A concrete mix design specifies 280 lb/yd^3 of water and 622.2 lb/yd^3 of cement. What is the water-cement ratio?

A. 0.38
B. 0.45
C. 0.52
D. 0.60

18. What is the maximum permitted yield-to-tensile strength ratio for ASTM A992 structural steel?

A. 0.85
B. 0.90
C. 0.80
D. 0.95

19. A sawn lumber beam has a reference bending design value Fb=1600 psi. Applying a load duration factor CD=1.6 for wind loading and a size factor CF=1.0, what is the adjusted design value?

A. 2100 psi

B. 2280 psi
C. 2410 psi
D. 2560 psi

20. Which ASTM standard specifies procedures for measuring fresh concrete's temperature at the point of placement?

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

21. A soil sample has a void ratio e=0.68 and specific gravity Gs=2.70. What is the dry unit weight, using γw=9.81 kN/m^3?

A. 13.4 kN/m^3
B. 15.8 kN/m^3
C. 17.6 kN/m^3
D. 19.2 kN/m^3

22. What is the minimum specified yield strength for ASTM A1035 Grade 100 reinforcing steel?

A. 60 ksi
B. 75 ksi
C. 80 ksi
D. 100 ksi

23. Two cross-section end areas along a roadway cut are 120 sf and 165 sf, separated by 150 ft. Using the average end area method, what is the earthwork volume in cubic yards?

A. 791.7 cy

B. 705.4 cy
C. 852.6 cy
D. 910.3 cy

24. A project requires 1,900 cy of select fill at a unit cost of $46/cy. What is the total material cost?

A. $74,800
B. $81,200
C. $87,400
D. $93,600

25. An owner expects to spend $680,000 six years from now on a facility upgrade. At an interest rate of 7.5% per year, what is the present worth of that expenditure?

A. $440,600
B. $465,200
C. $490,800
D. $512,300

26. A project has an earned value (EV) of $328,000 and actual cost (AC) of $375,000. What is the cost performance index (CPI)?

A. 0.95
B. 1.05
C. 1.12
D. 0.87

27. A concrete slab measures 50 ft by 40 ft at a thickness of 0.55 ft. What is the concrete volume in cubic yards?

A. 32.4 cy

B. 36.8 cy
C. 40.7 cy
D. 44.9 cy

28. Using a parametric cost-per-square-foot estimate of $155/sf for a 27,000 sf building, what is the estimated construction cost?

A. $3,900,000
B. $4,185,000
C. $4,450,000
D. $4,700,000

29. A production line has fixed costs of $105,000, a variable cost of $31 per unit, and sells each unit at $58. How many units must be sold to break even?

A. 3,250
B. 3,520
C. 3,700
D. 3,889

30. A schedule shows earned value EV=$392,000 and planned value PV=$358,000. What is the schedule performance index (SPI)?

A. 1.09
B. 0.95
C. 1.18
D. 0.88

31. An activity has an early start (ES) of day 25 and a duration of 8 days. What is its early finish (EF)?

A. 29

B. 33
C. 37
D. 41

32. Using the PERT three-point estimate with optimistic time to=5 days, most likely tm=9 days, and pessimistic tp=17 days, what is the expected activity duration?

A. 8.2 days
B. 9.0 days
C. 9.7 days
D. 10.5 days

33. An activity has ES=10 and LS=22. What is its total float?

A. 6
B. 8
C. 10
D. 12

34. A critical path consists of four sequential activities with durations of 11, 9, 14, and 6 days. What is the total critical path duration?

A. 34 days
B. 40 days
C. 46 days
D. 52 days

35. A paving crew completes 4,500 linear feet of curb and gutter in 15 working days. What is the crew's production rate?

A. 300 ft/day

B. 270 ft/day
C. 240 ft/day
D. 330 ft/day

36. A task requires 5 workers for 16 days. What is the total resource-days (worker-days) required for this task?

A. 60
B. 70
C. 80
D. 90

37. An activity has a normal cost of $26,000 over 13 days and a crash cost of $41,000 over 8 days. What is the crash cost per day?

A. $3,000
B. $3,400
C. $3,800
D. $4,200

38. In cast-in-place bridge deck construction on precast girders, which of the following represents the correct order of field operations?

A. pour deck concrete, set girders, install deck forms, then place reinforcement
B. place reinforcement, set girders, pour the deck, then install forms
C. install forms, pour the deck, set girders, then place reinforcement
D. set girders, install deck forms, place reinforcement, then pour deck concrete

39. An activity has an early finish of day 17, and the earliest successor activity's early start is day 30. What is this activity's free float?

A. 9
B. 13
C. 16
D. 19

40. Resource leveling that extends the overall project duration to smooth out peak resource demand is more accurately termed—

A. resource allocation across multiple concurrent project activities
B. resource float remaining within the schedule's existing slack
C. resource-constrained scheduling, or resource smoothing with a schedule time impact
D. critical path compression through overtime or added resources

41. A field density test shows a dry density of 118 pcf, while the laboratory maximum dry density (standard Proctor) is 125 pcf. What is the percent relative compaction?

A. 88.2%
B. 91.6%
C. 94.4%
D. 97.8%

42. Which ASTM standard specifies the slump test for evaluating fresh concrete consistency?

A. ASTM C143
B. ASTM C231
C. ASTM C39
D. ASTM C42

43. For an ASTM A325 high-strength bolt installed by the turn-of-nut method, with a bolt length not exceeding four diameters and both connected surfaces normal to the bolt axis, what nut rotation from snug-tight is required?

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

44. Which of the following is typically outside the scope of a materials testing laboratory's responsibilities on a construction project?

A. performing concrete cylinder compression tests
B. approving design changes to the structure
C. performing soil compaction (density) tests
D. performing steel weld inspections

45. What is the primary reason for limiting the free-fall height of concrete during placement into deep, narrow formwork?

A. to reduce the total volume of concrete needed for the placement
B. to shorten the required curing time afterward
C. to eliminate the need for reinforcement within the element
D. to prevent segregation of coarse aggregate from the mortar during the fall

46. Using the Nurse-Saul maturity function with a constant temperature-datum difference of 21°C sustained for 55 hours, what is the concrete's maturity index?

A. 980 °C-hr
B. 1155 °C-hr
C. 1280 °C-hr
D. 1400 °C-hr

47. Which statement about the maturity method is TRUE?

A. it eliminates the need for any strength verification testing
B. it is applicable universally without any mixture-specific calibration
C. it estimates strength based on the concrete's temperature-time history combined with a calibration curve
D. it only applies to concrete cured above 90°F

48. A sand cone field density test removes 3.3 lb of soil from a hole with a volume of 0.027 cf. The soil's moisture content is 8%. What is the dry unit weight?

A. 113.2 pcf
B. 105.4 pcf
C. 120.8 pcf
D. 127.6 pcf

49. A 1/4-in fillet weld uses E70 electrode (Fexx=70 ksi). What is its nominal strength per inch of weld length?

A. 5.8 kip/in
B. 7.4 kip/in
C. 9.1 kip/in
D. 10.8 kip/in

50. If reinforcing steel placement is found not to match the approved shop drawings prior to concrete placement, what is the standard next step?

A. pour concrete anyway since rebar position rarely matters
B. document the deviation and proceed without engineer review
C. reduce the design load rating to match the as-placed conditions
D. notify the engineer of record and correct the placement before the pour proceeds

51. A slab is designed for dead load D=48 psf and live load L=62 psf. Using the basic ASCE 7 load combination U=1.2D+1.6L, what is the factored design load?

A. 157 psf
B. 168 psf
C. 179 psf
D. 190 psf

52. A beam experiences a bending moment $M=850$ kip-in at a section where $c=7$ in and $I=290$ in^4. What is the extreme fiber bending stress?

A. 15.4 ksi
B. 17.8 ksi
C. 20.5 ksi
D. 23.1 ksi

53. An axially loaded member carries $P=140$ kip through a cross-sectional area of 7 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 390 kip and measures 9.5 ft by 11.5 ft in plan. What is the resulting bearing pressure on the soil?

A. 3.57 ksf
B. 3.20 ksf
C. 2.95 ksf
D. 3.85 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 $K_z=0.85$, $K_{zt}=1.0$, $K_d=0.85$, and $V=100$ mph, what is the velocity pressure?

A. 14.2 psf
B. 18.5 psf
C. 22.6 psf
D. 26.3 psf

56. A beam has shear force V=42 kip, first moment of area Q=44 in^3, moment of inertia I=780 in^4, and web thickness b=8 in. What is the shear stress at that location?

A. 235 psi
B. 265 psi
C. 296 psi
D. 325 psi

57. A column has an effective length factor K=1.0, unbraced length L=24 ft, and radius of gyration r=3.6 in. What is the slenderness ratio KL/r?

A. 65
B. 72
C. 76
D. 80

58. A retaining wall has a resisting moment of 880 kip-ft and an overturning moment of 410 kip-ft. What is the factor of safety against overturning?

A. 1.85
B. 2.15
C. 2.40
D. 2.65

59. A column has a tributary floor area of 23 ft by 27 ft, and the floor is designed for a live load of 85 psf. What is the total live load carried by this column?

A. 52.8 kip
B. 47.5 kip
C. 58.2 kip
D. 63.6 kip

60. Under AISC 360, which chapter provides design provisions for prying action and other force-related connection design checks not otherwise covered?

A. Chapter H
B. Chapter I
C. Chapter J
D. Chapter D

61. Using the rational method $Q=C \cdot i \cdot A$ with a runoff coefficient $C=0.33$, rainfall intensity $i=3.6$ in/hr, and drainage area $A=16$ acres, what is the peak discharge?

A. 15.4 cfs
B. 19.0 cfs
C. 22.8 cfs
D. 26.5 cfs

62. An open channel has Manning's $n=0.011$, flow area $A=9$ sf, hydraulic radius $R=1.1$ ft, and slope $S=0.008$. Using Manning's equation (USCS form with 1.49), what is the flow rate?

A. 92.6 cfs
B. 104.8 cfs
C. 116.2 cfs
D. 128.5 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 700 ft and slope of 0.022, what is the time of concentration?

A. 5.3 min
B. 6.8 min
C. 8.2 min
D. 9.6 min

64. A detention pond must temporarily store runoff where peak inflow is 48 cfs, allowable peak outflow is 20 cfs, and the storm duration is 2 hours. Using a simplified triangular hydrograph approximation, what storage volume is required?

A. 1.65 ac-ft
B. 1.98 ac-ft
C. 2.10 ac-ft
D. 2.31 ac-ft

65. A storm sewer pipe with a 27-in diameter carries a flow of 14 cfs. What is the flow velocity in the pipe, assuming it flows full?

A. 2.5 fps
B. 2.9 fps
C. 3.2 fps
D. 3.5 fps

66. A broad-crested weir outlet has a discharge coefficient C=3.1, crest length L=4.8 ft, and head H=1.25 ft. Using Q=C·L·H^1.5, what is the discharge through the weir?

A. 17.4 cfs
B. 20.8 cfs
C. 23.6 cfs
D. 26.1 cfs

67. A 2-leg sling supports a 6,800 lb load, with each leg oriented at 48° from horizontal. What is the tension in each leg?

A. 4,575 lb
B. 4,100 lb
C. 4,900 lb
D. 5,300 lb

68. A crane operator notices the load chart lists lower capacities for the same radius when operating 'over the side' compared to 'over the rear.' This difference primarily reflects—

A. engine power output differences depending on lift orientation used
B. ground surface bearing differences present at each lift orientation
C. the narrower effective tipping line when lifting over the side
D. wind direction alone being the sole governing capacity factor

69. A dewatering system must handle 210 gpm of inflow, and each wellpoint has a discharge capacity of 13 gpm. What is the minimum number of wellpoints required?

A. 14
B. 17
C. 19
D. 22

70. An excavator has a bucket capacity of 2.0 cy, a fill factor of 0.88, a cycle time of 21 seconds, and operates at 50 minutes of effective work per hour. What is its production rate?

A. 205 cy/hr
B. 225 cy/hr
C. 238 cy/hr
D. 251 cy/hr

71. Using the Engineering News Record (ENR) pile driving formula Qu=2E/(S+0.1), with driving energy E=24,000 ft-lb and set S=0.35 in per blow, and applying a factor of safety of 6, what is the allowable pile capacity?

A. 13.2 kip
B. 15.6 kip
C. 17.8 kip
D. 20.4 kip

72. Two cross-section end areas along a roadway cut are 165 sf and 220 sf, separated by 185 ft. Using the average end area method, what is the cut volume in cubic yards?

A. 1,319.0 cy
B. 1,450.2 cy
C. 1,580.6 cy
D. 1,690.4 cy

73. A choker hitch rated capacity table typically shows the LOWEST rated capacity at which of the following choke angle conditions?

A. 180 degrees (a straight line)
B. 150 degrees
C. 135 degrees
D. the smallest angle listed on the table

74. A crane boom is 105 ft long and raised to an angle of 58° from horizontal. Ignoring boom point offset, what is the resulting horizontal working radius?

A. 48.2 ft
B. 55.6 ft
C. 61.4 ft
D. 67.8 ft

75. A sump pump must handle a seepage inflow of 60 gpm, and standard practice applies a safety factor of 1.5 for pump sizing. What minimum pump capacity should be selected?

A. 70 gpm
B. 80 gpm
C. 90 gpm
D. 100 gpm

76. A loader has a cycle time of 2.2 minutes per load. A truck's full haul-dump-return cycle takes 15.4 minutes. How many trucks are needed to keep the loader continuously working?

A. 7
B. 9
C. 11
D. 13

77. A pile's static capacity analysis gives skin friction resistance Qs=145 kip and end bearing resistance Qp=85 kip. Applying a factor of safety of 2.5, what is the allowable pile capacity?

A. 68 kip
B. 78 kip
C. 84 kip
D. 92 kip

78. An embankment requires 7,600 cy of soil measured in the bank (natural, undisturbed) condition, and the borrow soil has a shrinkage factor of 0.91 relating compacted volume to bank volume. What compacted fill volume results from excavating this bank volume?

A. 6,916 cy
B. 6,200 cy
C. 7,400 cy
D. 8,000 cy

79. A crane outrigger imposes a load of 48,000 lb on the ground, and the allowable soil bearing pressure is 3,000 psf. What minimum outrigger pad area is required?

A. 12.4 sf
B. 14.2 sf
C. 16.0 sf
D. 18.5 sf

80. Using the ACI 347 formwork lateral pressure formula for columns, Cw=150+9000R/T, with a placement rate R=9 ft/hr and concrete temperature T=72°F, what is the design lateral pressure?

A. 980 psf
B. 1,275 psf
C. 1,420 psf
D. 1,560 psf

81. A scaffold platform will support 6 workers averaging 200 lb each, 1,900 lb of stored material, and 210 lb of tools and equipment. What is the total design load on the platform?

A. 2,850 lb
B. 3,050 lb
C. 3,180 lb
D. 3,310 lb

82. A reshore below a freshly poured slab has a tributary area of 8 ft by 8 ft, and the slab's dead load is 108 psf. What load is transferred to this reshore, using a simplified tributary-area method?

A. 6,200 lb
B. 6,912 lb
C. 7,500 lb
D. 8,100 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 58,000 lb vertically, what minimum lateral bracing force must be provided?

A. 890 lb
B. 1,020 lb
C. 1,160 lb
D. 1,300 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 $K_a=0.31$, $\gamma=120$ pcf, and excavation depth $H=23$ ft, what is the peak apparent pressure?

A. 556 psf
B. 610 psf
C. 665 psf
D. 720 psf

85. The number of shore and reshore levels that must remain engaged beneath a fresh concrete pour depends primarily on—

A. the color of the concrete mix used on the project
B. the rate of strength gain of the concrete and the construction loading sequence
C. the contractor's preferred crew size for that week
D. the ambient humidity alone at the time of the pour

86. Absent motorized concrete buggies, ACI 347 sets the minimum combined dead and live design load for horizontal formwork at not less than—

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

87. A supported scaffold is 20 ft tall with a 6 ft base width. Per OSHA 29 CFR 1926 Subpart L, is guying, tying, or bracing automatically required based on the height-to-base ratio?

A. No, since 3.3:1 is below the 4:1 threshold
B. Yes, since all scaffolds over 15 ft require restraint
C. Yes, since the ratio exceeds 3:1
D. No, since restraint is never required for scaffolds under 25 ft

88. A slab load of 140 psf acts on an 8.5 ft by 8.5 ft tributary area, and the load is assumed to split equally among three engaged support levels. What load does each level carry, using this simplified method?

A. 2,650 lb
B. 2,950 lb
C. 3,100 lb
D. 3,372 lb

89. A diagonal brace oriented at 41° from horizontal resists a horizontal thrust of 9,800 lb. What is the resulting axial force in the brace?

A. 10,600 lb
B. 11,400 lb
C. 12,100 lb
D. 12,985 lb

90. A 14-ft-deep trench is excavated in Type B soil at OSHA's maximum allowable slope of 1:1 (horizontal:vertical). What is the horizontal offset at the top of the excavation, measured from the trench bottom edge?

A. 10 ft
B. 14 ft
C. 18 ft
D. 22 ft

91. Per ASCE 37, temporary structures and bracing are generally designed with a shorter mean recurrence interval (MRI) for wind than a permanent structure. This shorter MRI is justified specifically by—

A. the contractor's cost preferences for the project's overall bracing system
B. the crane manufacturer's technical specifications for that specific model
C. its substantially shorter exposure period versus a permanent structure's service life
D. the project's overall budget size and financial constraints involved

92. Compared to horizontal shoring, vertical formwork such as wall and column forms can generally be stripped much earlier because it—

A. carries only the fresh concrete's own lateral pressure rather than the structure's self-weight
B. is always made of a stronger material than horizontal formwork
C. is never subject to ACI 347 provisions at all
D. requires no engineering judgment for removal timing whatsoever

93. A shoring post has an allowable capacity of 6,500 lb at an unbraced length of 15 ft. If lateral bracing reduces the unbraced length to 7.5 ft, and capacity scales inversely with the square of unbraced length (Euler-type behavior), what is the new allowable capacity?

A. 19,500 lb
B. 22,750 lb
C. 26,000 lb
D. 29,250 lb

94. A braced excavation is 21 ft deep in clay with undrained shear strength $c_u=1{,}450$ psf and unit weight $\gamma=124$ 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. 2.5
B. 2.8
C. 3.0
D. 3.2

95. Per OSHA 29 CFR 1926 Subpart L, at what point does a scaffold requiring a competent-person inspection need to be re-inspected?

A. only once, immediately at the time of initial erection
B. before each shift and after any integrity-affecting event
C. only after severe weather events occur at the site
D. only when an entirely new crew arrives on site

96. Per MUTCD guidance, for a temporary lane closure with a 12-ft lane width and posted speed of 42 mph (using $L=WS^2/60$ for speeds under 45 mph), what taper length is required?

A. 353 ft
B. 390 ft
C. 420 ft
D. 460 ft

97. Per OSHA 29 CFR 1926 Subpart X, side rails of an extension ladder must extend how far above the point of support when used to access an upper landing?

A. 1 ft
B. 2 ft
C. 2.5 ft
D. 3 ft

98. Per MUTCD Part 6, a work zone's speed limit reduction, if used, is typically implemented within which TTC zone component?

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

99. A competent person assigned to a project must be able to identify hazards specific to which of the following?

A. only excavation work, regardless of other site activities underway
B. only fall hazards present on scaffolds specifically
C. the specific type of work or hazard category assigned to them
D. any hazard on any construction site nationwide, without exception

100. Per MUTCD guidance, which combination of conditions most strongly supports the use of positive protection devices in a given work zone?

A. low speed and low volume with no worker exposure to traffic
B. high speed, high volume, and prolonged worker exposure to adjacent traffic
C. moderate speed with no work occurring at night
D. any location where cones are already in short supply

Practice Exam 21: Answer Key and Explanations

1. D — Rankine active pressure for a level, cohesionless backfill is $Ka = \tan^2(45° - \varphi'/2)$. With $\varphi' = 40°$, this is $\tan^2(25°) \approx 0.217$. This higher friction angle produces one of the smaller Ka values examined across these problems, since dense, strong sand needs comparatively little lateral thrust to reach its active state.

2. B — Primary settlement is $Sc = [Cc \cdot H/(1+e0)] \cdot \log10[(p0+\Delta p)/p0]$. Substituting, $Sc = (0.18 \times 7/1.65) \cdot \log10(215/140) = 0.764 \times 0.186 \approx 0.142$ m, or 142 mm. This relatively modest settlement reflects a low compression index applied to a thick clay layer under a moderate added stress relative to its existing overburden pressure at the site. Local overconsolidation would reduce this settlement estimate further here.

3. A — Total stress at 13 m is $\sigma = (16.2 \times 6) + (18.8 \times 7) = 97.2 + 131.6 = 228.8$ kPa. Pore pressure develops only below the water table: $u = 9.81 \times 7 \approx 68.7$ kPa. Effective stress is $\sigma' = 228.8 - 68.7 \approx 160$ kPa. Option D is the total stress alone, without pore pressure subtracted out.

4. C — For $\varphi = 0$ conditions, $qult = cu \cdot Nc + q \cdot Nq$. The surcharge is $q = 18 \times 1.3 = 23.4$ kPa, so $qult = 52 \times 5.7 + 23.4 \times 1.0 = 296.4 + 23.4 \approx 320$ kPa. Omitting the surcharge term would understate ultimate capacity by ignoring the confinement the overlying soil provides at footing depth.

5. B — For a dry infinite slope of cohesionless soil, FS = $\tan\varphi/\tan\beta$, since slice weight cancels out of both driving and resisting terms. Here FS = $\tan(29°)/\tan(19°) = 0.554/0.344 \approx 1.61$. This ratio depends only on the friction and slope angles, not on slope height, soil unit weight, or failure surface depth.

6. D — Passive coefficient is $K_p = \tan^2(45°+\varphi'/2) = \tan^2(62°) \approx 3.537$. The resultant passive force is $P_p = 0.5 \cdot K_p \cdot \gamma \cdot H^2 = 0.5\times3.537\times19\times4.5^2 \approx 680$ kN/m, acting one-third of the wall height above the base, since passive resistance grows with the square of wall height and backfill unit weight combined here. Wall embedment depth strongly influences the magnitude of this force.

7. C — With double drainage, the drainage path length is $H_{dr} = H/2 = 4.5$ m. Time factor relates as $t = T_v \cdot H_{dr}^2/c_v = 0.197\times20.25/3.2 \approx 1.247$ yr, which converts to $1.247\times365 \approx 455$ days. Using the full 9 m thickness instead of the halved drainage path would substantially overstate this required time.

8. A — With seepage parallel to the slope, FS = $(\gamma'/\gamma_{sat})\cdot(\tan\varphi'/\tan\beta)$. The buoyant unit weight is $\gamma' = 19.6-9.81 \approx 9.79$ kN/m³, giving a ratio of 0.4995. Combined with $\tan(27°)/\tan(18°) \approx 1.568$, FS $\approx 0.4995\times1.568 \approx 0.78$, roughly half the equivalent dry slope's factor of safety without seepage present here. Higher friction angles would proportionally increase this safety factor value.

9. C — Curve length is $L = R\cdot\Delta(\text{radians}) = 650\times(38\times\pi/180) = 650\times0.66323 \approx 431.1$ ft. This arc-based formula gives the actual station-to-station distance traveled along the curve, distinct from the shorter chord distance connecting the PC and PT endpoints of this same curve's geometry. Sharper curves at the same radius yield shorter overall curve lengths.

10. A — Middle ordinate is $M = R\cdot(1-\cos(\Delta/2))$. With $\Delta/2 = 19°$, $\cos(19°) = 0.94552$, so $M = 650\times(1-0.94552) = 650\times0.05448 \approx 35.4$ ft. This sharp 38-degree deflection angle at a relatively small radius produces one of the larger middle ordinate values seen across these problems. Sharper deflection angles at this radius increase this offset value.

11. B — The high point on a crest vertical curve occurs where $x = L\cdot g_1/(g_1-g_2)$. Here $x = 350\times3.5/(3.5-(-1.0)) = 1{,}225/4.5 \approx 272.2$ ft from the BVC. Because the incoming grade is far steeper than the outgoing grade, this point falls well past the curve's geometric midpoint of 175 ft along its length.

12. D — The long chord connecting the PC and PT is $C = 2R\cdot\sin(\Delta/2)$. With $\Delta/2 = 19°$, $\sin(19°) = 0.32557$, giving $C = 2\times650\times0.32557 \approx 423.2$ ft. As expected, this is noticeably shorter than the 431.1 ft arc length computed earlier for this sharper curve's actual geometry and radius. Chord and arc lengths converge as deflection angles grow smaller here.

13. B — Satellite imagery, original drawings, and regional survey maps all describe surface conditions or assumptions from years earlier, none of which confirms today's actual soil density beneath this specific footing. In-situ testing methods like standard penetration or cone penetration soundings taken adjacent to the footing directly measure current subsurface density without requiring full excavation of the foundation.

14. A — Height of instrument is HI = benchmark elevation + backsight = 95.00 + 5.34 = 100.34 ft. The stake elevation is then HI minus the foresight: 100.34 − 3.71 = 96.63 ft. This differential leveling procedure carries a known elevation from the fixed benchmark out to new grade stakes across the construction site.

15. C — By the arc definition, degree of curve is $D = 5729.58/R$. With $R = 650$ ft, $D = 5729.58/650 \approx 8.81°$. This relatively large degree of curve reflects the small radius and sharp 38-degree deflection examined here, compared to the gentler, wider-radius alignments seen in earlier roadway design examples shown.

16. D — Plasticity index is $PI = LL-PL = 24$. The A-line value at $LL=44$ is $0.73\times(44-20) = 17.5$, and since $PI=24$ 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 classification instead.

17. B — Water-cement ratio is the water weight divided by cement weight: $280/622.2 \approx 0.45$. This moderate-to-low ratio typically produces good strength and durability, while still remaining workable enough for placement without requiring aggressive water-reducing admixtures beyond what standard practice would normally call for on this type of project. Higher ratios would reduce strength but improve overall mix workability.

18. A — ASTM A992 caps the yield-to-tensile strength ratio at 0.85, in addition to specifying minimum yield and tensile strength values for the material. This ratio limit ensures adequate ductility and a meaningful margin between yield and ultimate strength, which is important for predictable inelastic behavior during seismic events or overload conditions.

19. D — Adjusted design values multiply the reference value by all applicable adjustment factors: $F_b' = F_b\times C_D\times C_F = 1600\times1.6\times1.0 = 2560$ psi. Wind loading's short duration justifies the largest common duration factor of 1.6, substantially increasing the member's adjusted allowable bending capacity for this particular load case and duration. Snow load duration alone would yield a smaller adjustment factor.

20. C — ASTM C1064 specifies the procedure for measuring fresh concrete temperature at the time and point of placement, since temperature affects both workability during finishing and the rate of subsequent strength gain. C39 tests hardened cylinder strength, C143 measures slump, and C231 measures air content, each a distinct property tested. Age at testing significantly affects the measured strength result obtained.

21. B — Dry unit weight relates to void ratio and specific gravity by $\gamma_d = G_s\cdot\gamma_w/(1+e) = 2.70\times9.81/1.68 \approx 15.8$ kN/m³. This moderate void ratio produces a dry unit weight between the denser and looser samples examined in earlier problems, illustrating how compaction effort directly shifts this fundamental soil property. A looser soil sample would yield a lower unit weight here.

22. D — ASTM A1035 Grade 100 is a low-carbon chromium reinforcing steel with a minimum specified yield strength of 100 ksi, substantially higher than conventional Grade 60 bar. This high-strength material allows reduced bar congestion and lighter reinforcing cages in heavily loaded elements, though it requires different design provisions than conventional mild steel reinforcement.

23. A — The average end area method computes volume as $V = [(A_1+A_2)/2]\times L = [(120+165)/2]\times150 = 21{,}375$ cf. Converting to cubic yards by dividing by 27 gives approximately 791.7 cy. This remains the standard hand-calculation approach for earthwork quantity takeoff between surveyed cross sections along a roadway segment. Longer segment lengths would proportionally increase this computed volume figure.

24. C — Unit cost estimating multiplies quantity by unit price: 1,900×\$46 = \$87,400. 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 specific fill material specification called for on this particular earthwork project overall. Bulk purchasing discounts could further reduce this baseline material cost.

25. A — Present worth of a single future amount is $P = F/(1+i)^n = 680{,}000/(1.075)^6 = 680{,}000/1.5433 \approx \$440{,}600$. 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 economic decision-making purposes across alternatives being evaluated. Higher discount rates would further reduce this present-worth result value.

26. D — Cost performance index is $CPI = EV/AC = 328{,}000/375{,}000 \approx 0.87$. A CPI below 1.0 indicates the project is spending more than the value of work actually completed, signaling a cost overrun trend that warrants management attention before it grows further as remaining work is performed and eventually billed. A higher actual cost would further reduce this performance index value.

27. C — Volume is length times width times thickness: 50×40×0.55 = 1,100 cf. Dividing by 27 cf per cubic yard gives approximately 40.7 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 concrete pour operation.

28. B — Parametric estimating multiplies a unit rate by a project parameter: 27,000 sf × \$155/sf = \$4,185,000. 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: $105{,}000/(58-31) = 105{,}000/27 \approx 3{,}889$ units. Below this quantity the operation runs at a loss, and above it, each additional unit contributes \$27 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. A — Schedule performance index is $SPI = EV/PV = 392{,}000/358{,}000 \approx 1.09$. An SPI above 1.0 indicates the project is ahead of its planned schedule, since more value has been earned by this point than was originally planned for this stage of the project's overall timeline and work sequence. A lower planned value would raise this schedule performance ratio further.

31. B — In the CPM forward pass, early finish equals early start plus duration: $EF = ES + \text{Duration} = 25 + 8 = 33$. This value becomes the early start for any successor activity that depends solely on this one, propagating forward through the network toward the earliest possible project completion date achievable.

32. C — PERT expected time is $t_e = (t_o + 4 \cdot t_m + t_p)/6 = (5 + 36 + 17)/6 = 58/6 \approx 9.7$ days. Weighting the most likely estimate four times as heavily as the optimistic and pessimistic bounds reflects the right-skewed distribution typical of real-world construction activity durations encountered on most projects.

33. D — Total float is the difference between late start and early start: TF = LS − ES = 22 − 10 = 12. 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. B — Since these activities occur sequentially with no overlap along the critical path, total duration is simply their sum: 11+9+14+6 = 40 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 four durations.

35. A — Production rate for a linear (line-of-balance) schedule is distance divided by time: 4,500 ft / 15 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 overtake slower ones working ahead of them on the alignment.

36. C — Total resource-days is the product of the number of workers and the duration: 5 workers × 16 days = 80 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. A — Crash cost slope is the change in cost divided by the change in duration: (41,000−26,000)/(13−8) = 15,000/5 = $3,000 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 an overall project schedule.

38. D — Precast girders must be erected first to provide the support structure, followed by installing deck forms spanning between the girders, then placing reinforcement within those forms, and finally pouring the deck concrete over the completed forms and reinforcement. Reversing any of these steps would leave the deck without proper support or containment.

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) = 30 − 17 = 13. Unlike total float, this value depends only on the immediate downstream activity, not on the project's overall late-date calculations elsewhere.

40. C — True resource leveling that accepts a longer project duration in exchange for a steadier, more manageable resource demand is properly called resource-constrained scheduling, distinguishing it from simple resource smoothing that stays within existing float without extending the finish date. Critical path compression instead shortens the schedule, the opposite objective entirely.

41. C — Relative compaction is the field dry density divided by the laboratory maximum dry density, expressed as a percentage: (118/125)×100 ≈ 94.4%. 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. A — ASTM C143 defines the slump test, in which a cone-shaped mold of fresh concrete is filled, rodded, and lifted, with the resulting settlement measured as the slump value. C231 measures air content, C39 tests hardened cylinder strength, and C42 governs drilled core sampling, each addressing an entirely different concrete property.

43. D — The RCSC Specification's turn-of-nut method requires the smallest nut rotation, 1/3 turn beyond snug-tight, for this baseline case of a short bolt with both connected surfaces normal to the bolt axis. Longer bolts or sloped connected surfaces each require progressively more rotation to reach the specified pretension across the joint.

44. B — Materials testing laboratories perform physical testing of concrete, soil, and steel to verify conformance with specifications, but approving design changes is a design decision reserved for the engineer of record. Confusing testing verification with design authority would improperly extend the laboratory's role beyond its actual technical function on the project.

45. D — Unassisted concrete free-fall through deep, narrow formwork allows the heavier coarse aggregate to separate from the mortar and cement paste, producing segregation and honeycombing in the finished element. Limiting the fall height, or using a tremie or elephant trunk instead, keeps the mix uniform as it descends into the formwork.

46. B — The Nurse-Saul maturity index accumulates temperature above a datum over time: $M(t) = \Sigma(T-T0)\cdot\Delta t$. With a constant 21°C difference sustained for 55 hours, $M = 21\times55 = 1{,}155$ °C-hours. This index is later compared against a mixture-specific calibration curve to estimate the concrete's in-place strength at that particular age and time.

47. C — The maturity method converts a concrete's measured temperature-time history into an estimated compressive strength, but only when combined with a calibration curve developed specifically for that mixture being placed. It doesn't eliminate verification testing entirely, doesn't apply universally without calibration, and isn't restricted to any particular curing temperature range like 90°F.

48. A — Wet unit weight is the weight of soil removed divided by the hole volume: $3.3/0.027 \approx 122.2$ pcf. Converting to dry unit weight using the moisture content, $\gamma d = \gamma wet/(1+w) = 122.2/1.08 \approx 113.2$ pcf. This field value is compared against the laboratory Proctor curve to check the relative compaction achieved.

49. B — 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=0.25 in, $Rn = 0.6\times70\times0.707\times0.25 \approx 7.4$ kip/in, the smallest fillet weld size examined among all the weld problems in this exam so far shown.

50. D — Rebar placement deviations from approved shop drawings must be brought to the engineer of record's attention and corrected before concrete is placed, since reinforcement position directly affects the element's structural capacity and cover requirements. Pouring anyway, proceeding without review, or retroactively adjusting the load rating all skip this necessary verification step.

51. A — The factored load combination applies separate load factors before summing: $U = 1.2(48) + 1.6(62) = 57.6 + 99.2 \approx 157$ 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 buildings.

52. C — The flexure formula gives bending stress as $\sigma = M \cdot c/I = 850 \times 7/290 \approx 20.5$ 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.

53. D — Axial stress is force divided by cross-sectional area: $\sigma = P/A = 140/7 = 20.0$ 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 condition.

54. A — Assuming a concentric load and uniform pressure distribution, bearing pressure equals load divided by footing area: $q = P/(B \times L) = 390/(9.5 \times 11.5) \approx 3.57$ 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 load.

55. B — Substituting directly: $qz = 0.00256 \times 0.85 \times 1.0 \times 0.85 \times 100^2 = 0.00256 \times 0.7225 \times 10{,}000 \approx 18.5$ 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 surfaces per ASCE 7 provisions and tables. Taller structures in rougher terrain would further raise this pressure value.

56. C — Shear stress is given by the shear flow formula $\tau = VQ/(Ib) = (42{,}000 \times 44)/(780 \times 8) = 1{,}848{,}000/6{,}240 \approx 296$ 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. D — Slenderness ratio is KL/r, using consistent units for length. Converting L to inches: 24 ft × 12 = 288 in, so $KL/r = (1.0 \times 288)/3.6 = 80$. This ratio helps determine whether the column's compressive strength is governed by inelastic or elastic Euler buckling behavior under AISC Chapter E design provisions.

58. B — Factor of safety against overturning is the ratio of resisting moment to overturning moment: $FS = 880/410 \approx 2.15$. This comfortably exceeds the commonly required minimum of roughly 1.5 to 2.0, confirming the wall's weight and geometry provide ample resistance to the lateral earth pressure driving rotation about the toe.

59. A — Tributary area load is the product of tributary area and design load intensity: $23 \times 27 \times 85 = 52{,}785$ lb, or about 52.8 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. C — AISC 360 Chapter J covers connections, joints, and fasteners in detail, including prying action checks on bolted connections and other force-related connection design provisions not addressed elsewhere. Chapter H covers combined member forces, Chapter I covers composite members, and Chapter D covers tension members, none of which address connection-specific design checks like prying.

61. B — The rational method combines runoff coefficient, rainfall intensity, and drainage area directly: $Q = C \cdot i \cdot A = 0.33 \times 3.6 \times 16 \approx 19.0$ cfs, with units already arranged to give cfs directly without conversion.

This remains the standard peak-flow method for small drainage areas typically under a few hundred acres in storm sewer design.

62. C — Manning's equation is $Q = (1.49/n)\cdot A\cdot R^{(2/3)}\cdot S^{(1/2)}$. Substituting: $(1.49/0.011)\times 9\times(1.1)^{0.667}\times(0.008)^{0.5} \approx 135.5\times 9\times 1.066\times 0.0894 \approx 116.2$ cfs. This relationship between channel roughness, geometry, and slope remains fundamental for sizing open channels, culverts, and storm sewers throughout civil design work generally performed by engineers. Steeper channel slopes would further increase this computed flow capacity here.

63. A — Substituting into the Kirpich formula: $Tc = 0.0078\times(700)^{0.77}\times(0.022)^{-0.385} \approx 0.0078\times 155.1\times 4.35 \approx 5.3$ 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 a moderately steep drainage basin. Flatter watershed slopes would substantially lengthen this computed travel time.

64. D — A simplified storage estimate is $V \approx 0.5\times(Qin-Qout)\times duration = 0.5\times(48-20)\times 7{,}200$ sec = 100,800 cf. Converting to acre-feet by dividing by 43,560 gives about 2.31 ac-ft. This preliminary approximation is typically refined afterward with detailed stage-storage-discharge routing for the final detention basin design and outlet. Longer storm durations would proportionally increase this required storage volume.

65. D — Velocity is flow rate divided by cross-sectional area: $V = Q/A$. With a 27-in (2.25-ft) diameter pipe, $A = \pi\times(1.125)^2 \approx 3.98$ sf, so $V = 14/3.98 \approx 3.5$ fps. This falls comfortably within typical self-cleansing velocity criteria of 2 to 3 fps or higher, helping prevent sediment buildup in the pipe.

66. B — Substituting into the weir formula: $Q = 3.1\times 4.8\times(1.25)^{1.5} = 14.88\times 1.398 \approx 20.8$ 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 developed sites overall. Longer crest lengths would proportionally increase this discharge capacity value.

67. A — Each leg carries half the total load, resolved along its angle: $T = (Load/2)/\sin(angle) = 3{,}400/\sin(48°) = 3{,}400/0.7431 \approx 4{,}575$ lb. This 48-degree angle sits close to the practical minimum working angle often cited in rigging references, producing meaningfully higher leg tension than steeper angles would for the same load.

68. C — A crane's tipping line geometry changes with lifting direction, and lifting over the side typically presents a narrower effective tipping line than lifting over the rear, where the counterweight provides more favorable stabilizing moment. This reduced stability over the side, not engine power, ground conditions, or wind alone, explains the lower rated capacity shown.

69. B — Dividing total required flow by per-wellpoint capacity gives $210/13 \approx 16.15$, which must be rounded up to 17 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.

70. D — Cycles per hour at full time is 3,600/21 ≈ 171.4, giving a theoretical output of 171.4×2.0×0.88 ≈ 301.7 cy/hr. Applying the 50/60 efficiency factor for actual working minutes reduces this to about 251 cy/hr, reflecting realistic production once operational delays are properly accounted for on the job site. Higher fill factors would further increase this hourly production rate.

71. C — Ultimate capacity is Qu = 2E/(S+0.1) = 2×24,000/(0.35+0.1) = 48,000/0.45 ≈ 106,667 lb. Applying the ENR formula's typical factor of safety of 6 gives allowable capacity: Qa = 106,667/6 ≈ 17.8 kip. This small set per blow indicates hard driving resistance and a higher allowable pile capacity. Larger driving energy inputs would proportionally raise this allowable capacity.

72. A — Applying the average end area method: V = [(165+220)/2]×185 = 192.5×185 ≈ 35,612.5 cf. Converting to cubic yards by dividing by 27 gives about 1,319.0 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 cut volume figure.

73. D — Choker hitch derate tables reduce rated capacity as the choke angle tightens, since a sharper bend concentrates more stress in the sling body wrapping the load. The smallest choke angle listed on any given manufacturer's table therefore always corresponds to the lowest rated capacity shown, with capacity improving steadily as the angle opens toward 180 degrees.

74. B — Horizontal radius is the boom length multiplied by the cosine of its angle from horizontal: R = L·cos(θ) = 105×cos(58°) = 105×0.5299 ≈ 55.6 ft. This relatively steep boom angle produces a smaller working radius relative to boom length than the shallower angles examined in earlier crane geometry problems shown previously.

75. C — Required pump capacity is the anticipated inflow multiplied by the safety factor: 60×1.5 = 90 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 assumed.

76. A — 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: 15.4/2.2 = 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 between successive hauling cycles.

77. D — Ultimate capacity is the sum of skin friction and end bearing: Qult = Qs+Qp = 145+85 = 230 kip. Dividing by the factor of safety gives allowable capacity: Qallow = 230/2.5 = 92 kip. This static computation is typically confirmed in the field with a load test or a dynamic pile driving formula check afterward.

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: 7,600×0.91 ≈ 6,916 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. C — Required pad area is the outrigger load divided by the allowable bearing pressure: 48,000/3,000 = 16.0 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 + (9,000×9)/72 = 150 + 1,125 = 1,275 psf. This fast 9 ft/hr placement rate combined with moderately warm 72°F concrete produces a substantial formwork pressure, requiring correspondingly robust form ties, walers, and bracing to safely resist the fresh concrete's lateral thrust on this pour.

81. D — Total design load is the sum of all anticipated loads on the platform: (6×200) + 1,900 + 210 = 1,200 + 1,900 + 210 = 3,310 lb. This total must be checked against the scaffold's rated capacity for its assigned duty classification before workers and materials occupy the platform simultaneously during construction operations.

82. B — Tributary area load is the product of tributary area and load intensity: 8×8×108 = 6,912 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 beneath the fresh pour above.

83. C — Applying the 2% minimum lateral force provision: 0.02×58,000 = 1,160 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. A — Substituting values: p = 0.65×0.31×120×23 = 0.2015×120×23 ≈ 556 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 at similar sites and depths shown. Deeper excavations proportionally increase this peak apparent pressure value here.

85. B — How many shore and reshore levels must remain engaged depends on how quickly the concrete gains strength relative to how fast new floors are poured above it, since faster construction sequences load lower floors sooner while they're still relatively weak. Crew size, mix color, and humidity alone don't drive this structural engineering determination.

86. C — ACI 347 establishes a floor value for formwork design loads independent of the computed dead and live loads, requiring a minimum combined design load of 100 psf when motorized carts or buggies aren't used, rising to 125 psf when they are. This minimum guards against underestimating construction loads during placement operations.

87. A — This scaffold's height-to-base ratio is 20/6 ≈ 3.3:1, which stays below OSHA's 4:1 threshold that triggers a mandatory guying, tying, or bracing requirement for supported scaffolds. There is no separate 15-ft or 25-ft absolute height rule; the 4:1 ratio itself is the controlling criterion under this OSHA provision shown. Taller or narrower scaffolds would raise this computed ratio further.

88. D — Total tributary load is $140 \times 8.5 \times 8.5 \approx 10{,}115$ lb. Splitting this equally among the three simultaneously engaged support levels gives $10{,}115/3 \approx 3{,}372$ 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 review. Fewer engaged support levels would increase each level's carried load.

89. D — The brace's axial force must have a horizontal component equal to the thrust it resists: $F \cdot \cos(41°) = 9{,}800$ lb, so $F = 9{,}800/\cos(41°) \approx 12{,}985$ lb. As the brace angle becomes shallower relative to horizontal, the axial force required to resist a given horizontal thrust increases correspondingly and noticeably in magnitude.

90. B — A 1:1 slope means the horizontal offset equals the vertical depth: offset = depth×slope ratio = $14 \times 1 = 14$ ft. OSHA 29 CFR 1926 Subpart P assigns this maximum slope to Type B soil, while the less stable Type C soil would require a flatter 1.5:1 slope at this same excavation depth.

91. C — A shorter mean recurrence interval for construction-phase wind design reflects that a temporary structure is exposed for only weeks or months, far less than a permanent structure's decades-long service life, making the rare, extreme design wind event statistically less likely to occur during that brief window. Cost, equipment, and budget don't justify this reduction.

92. A — Vertical elements like wall and column forms resist only the fresh concrete's lateral pressure during placement, not the concrete's own weight once it has set, so they can be stripped once the surface can resist minor damage. Horizontal shoring, by contrast, must actually carry the slab's self-weight and construction loads until adequate strength develops.

93. C — Euler-type buckling capacity scales inversely with the square of unbraced length. Halving the length from 15 ft to 7.5 ft, a factor of 2, increases capacity by $2^2 = 4$ times: $6{,}500 \times 4 = 26{,}000$ lb. This strong sensitivity to bracing spacing is why intermediate lateral bracing so effectively boosts shoring post capacity.

94. D — Substituting into the heave stability formula: $FS = (5.7 \times 1{,}450)/(124 \times 21) = 8{,}265/2{,}604 \approx 3.2$. 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. B — OSHA requires a competent person to inspect scaffolds for visible defects before each work shift begins, and again after any occurrence, such as a storm or impact, that could have affected the scaffold's structural integrity. A single initial inspection or inspection triggered only by weather or crew changes wouldn't catch problems arising in between.

96. A — For posted speeds under 45 mph, MUTCD taper length is $L = WS^2/60$, where W is the offset width in feet and S is the posted speed in mph: $L = 12 \times 1{,}764/60 \approx 353$ ft. This formula produces a shorter taper than the $L=WS$ formula used at highway speeds of 45 mph and above.

97. D — OSHA requires the side rails of an extension ladder to extend at least 3 ft above the upper landing surface being accessed, giving a climber a stable, secure handhold as they step off the ladder onto the platform rather than reaching or stretching awkwardly at the very top rung of the ladder.

98. A — Regulatory speed reduction signs, when used in a work zone, are typically posted within the advance warning area, giving approaching drivers notice of the reduced speed limit before they reach the transition area, buffer space, and activity area that follow it in the standard TTC zone sequence downstream and beyond.

99. C — OSHA's competent person designation is scoped to the specific type of work or hazard category the individual is assigned to oversee, such as excavation, scaffolding, or another area, requiring specialized knowledge relevant to that scope. It doesn't require universal expertise across every possible hazard on every construction site nationwide, without exception.

100. B — Positive protection devices are warranted where the combination of high speed, high traffic volume, and prolonged worker exposure to adjacent live traffic creates the greatest risk of a serious vehicle intrusion into the work space. Low-exposure conditions, moderate daytime-only work, or simple equipment shortages don't drive this safety-based engineering determination.