PRACTICE EXAM 20: 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 $\varphi' = 27°$ and a level ground surface. Using Rankine theory, what is the active earth pressure coefficient Ka?

A. 0.300
B. 0.333
C. 0.353
D. 0.376

2. A 3.8 m thick normally consolidated clay layer has Cc = 0.32 and initial void ratio e0 = 0.95. The effective overburden stress is 100 kPa and a foundation adds 120 kPa. What is the primary consolidation settlement?

A. 178 mm
B. 214 mm
C. 246 mm
D. 278 mm

3. The water table is at a depth of 2.5 m. Above the water table, the moist unit weight is 17.5 kN/m³, and below it the saturated unit weight is 19.2 kN/m³. At a total depth of 10 m, what is the effective vertical stress?

A. 88 kPa
B. 101 kPa
C. 114 kPa
D. 187 kPa

4. A strip footing at 1.1 m depth bears on saturated clay (φ=0) with cu = 42 kPa. Using Terzaghi bearing capacity factors (Nc=5.7, Nq=1.0) and a surcharge unit weight of 17.5 kN/m³, what is the ultimate bearing capacity?

A. 259 kPa
B. 280 kPa
C. 300 kPa
D. 320 kPa

5. A dry, cohesionless infinite slope has friction angle φ=27° and inclination β=18°. What is the factor of safety against sliding?

A. 1.57
B. 1.42
C. 1.30
D. 1.18

6. A 3.6 m tall wall retains cohesionless backfill with unit weight 18.6 kN/m³ and φ'=30°. Using Rankine theory, what is the total passive resultant force per unit length of wall?

A. 298 kN/m
B. 330 kN/m
C. 362 kN/m
D. 395 kN/m

7. A doubly-drained saturated clay layer 6.5 m thick has cv = 2.8 m²/yr. Using Tv=0.197 for 50% consolidation, how long does it take to reach 50% consolidation?

A. 235 days
B. 271 days
C. 298 days
D. 325 days

8. A submerged infinite slope of cohesionless soil (c'=0) has φ'=33°, slope angle β=24°, saturated unit weight γ_{sat}=20.2 kN/m³, and γ_w=9.81 kN/m³, with seepage parallel to the slope. What is the factor of safety?

A. 0.55
B. 0.63
C. 0.69
D. 0.75

9. A horizontal curve has a radius of 900 ft and a deflection angle of 32°. What is the curve length?

A. 502.7 ft
B. 465.3 ft
C. 538.4 ft
D. 570.1 ft

10. For the same curve (R=900 ft, Δ=32°), what is the middle ordinate distance?

A. 24.6 ft
B. 28.3 ft
C. 31.5 ft
D. 34.9 ft

11. A vertical curve has an initial grade $g_1=+2.5\%$ and final grade $g_2=-1.5\%$ over a 480 ft curve length. How far from the BVC does the high point occur?

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

12. For the horizontal curve with R=900 ft and Δ=32°, what is the long chord length?

A. 452.6 ft
B. 475.8 ft
C. 496.1 ft
D. 518.4 ft

13. A slope stability remediation project must confirm the depth to bedrock across a hillside before designing soil nail wall anchors. Which method most directly establishes this information?

A. geotechnical borings advanced to refusal on bedrock
B. a windshield survey of visible rock outcrops in the area
C. historical topographic maps of the surrounding region
D. contractor experience gathered from nearby unrelated projects

14. A benchmark has an established elevation of 155.00 ft. A backsight rod reading of 4.62 ft is taken on the benchmark, and a foresight reading of 5.18 ft is taken to set a rough grade stake. What elevation is the stake set at?

A. 150.36 ft
B. 154.44 ft
C. 159.62 ft
D. 164.80 ft

15. What is the degree of curve (arc definition) for a horizontal curve with a 900 ft radius?

A. 5.12°
B. 5.74°
C. 6.37°
D. 6.95°

16. A fine-grained soil has a liquid limit LL=48 and plastic limit PL=26. 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 300 lb/yd³ of water and 545.5 lb/yd³ of cement. What is the water-cement ratio?

A. 0.40
B. 0.48
C. 0.55
D. 0.63

18. What is the minimum specified yield strength for ASTM A572 Grade 65 structural steel?

A. 65 ksi
B. 50 ksi
C. 60 ksi
D. 70 ksi

19. A sawn lumber beam has a reference bending design value Fb=1250 psi. Applying a load duration factor CD=1.15 for snow load and a size factor CF=1.0, what is the adjusted design value?

A. 1310 psi
B. 1438 psi
C. 1560 psi
D. 1685 psi

20. Which ASTM standard specifies the procedure for compression testing of molded concrete cylinders?

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

21. A soil sample has a void ratio e=0.42 and specific gravity Gs=2.68. What is the dry unit weight, using $\gamma w=9.81$ kN/m^3?

A. 14.2 kN/m^3
B. 15.8 kN/m^3
C. 17.0 kN/m^3
D. 18.5 kN/m^3

22. What is the minimum specified yield strength for ASTM A996 Grade 60 reinforcing steel, produced from axle or rail steel?

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

23. Two cross-section end areas along a roadway cut are 100 sf and 155 sf, separated by 170 ft. Using the average end area method, what is the earthwork volume in cubic yards?

A. 802.8 cy
B. 720.5 cy
C. 865.4 cy
D. 910.2 cy

24. A project requires 2,800 cy of topsoil at a unit cost of $32/cy. What is the total material cost?

A. $76,200
B. $82,900
C. $89,600
D. $96,300

25. An owner expects to spend $550,000 five years from now on a facility upgrade. At an interest rate of 6.5% per year, what is the present worth of that expenditure?

A. $355,200
B. $378,600
C. $395,400
D. $401,400

26. A project has an earned value (EV) of $480,000 and actual cost (AC) of $445,000. What is the cost performance index (CPI)?

A. 1.08
B. 0.95
C. 1.15
D. 0.88

27. A concrete slab measures 44 ft by 66 ft at a thickness of 0.5 ft. What is the concrete volume in cubic yards?

A. 41.5 cy
B. 47.2 cy
C. 53.8 cy
D. 59.6 cy

28. Using a parametric cost-per-square-foot estimate of $175/sf for a 22,000 sf building, what is the estimated construction cost?

A. $3,500,000
B. $3,850,000
C. $4,150,000
D. $4,400,000

29. A production line has fixed costs of $60,000, a variable cost of $16 per unit, and sells each unit at $36. How many units must be sold to break even?

A. 2,650
B. 3,000
C. 3,350
D. 3,700

30. A schedule shows earned value EV=$465,000 and planned value PV=$430,000. What is the schedule performance index (SPI)?

A. 0.92
B. 0.98
C. 1.08
D. 1.16

31. An activity has an early start (ES) of day 12 and a duration of 15 days. What is its early finish (EF)?

A. 27
B. 30
C. 33
D. 36

32. Using the PERT three-point estimate with optimistic time to=7 days, most likely tm=10 days, and pessimistic tp=19 days, what is the expected activity duration?

A. 9.5 days
B. 10.2 days
C. 10.6 days
D. 11.0 days

33. An activity has ES=20 and LS=29. What is its total float?

A. 5
B. 9
C. 13
D. 17

34. A critical path consists of four sequential activities with durations of 10, 13, 8, and 11 days. What is the total critical path duration?

A. 30 days
B. 35 days
C. 39 days
D. 42 days

35. A paving crew completes 3,900 linear feet of curb and gutter in 13 working days. What is the crew's production rate?

A. 260 ft/day
B. 280 ft/day
C. 300 ft/day
D. 320 ft/day

36. A task requires 9 workers for 13 days. What is the total resource-days (worker-days) required for this task?

A. 117
B. 104
C. 126
D. 135

37. An activity has a normal cost of $32,000 over 15 days and a crash cost of $50,000 over 9 days. What is the crash cost per day?

A. $2,600
B. $3,000
C. $3,400
D. $3,800

38. In building a suspended concrete slab on metal deck, which of the following represents the correct order of field operations?

A. install the metal deck, place shear studs, place reinforcement, then pour concrete
B. pour concrete, install the deck, place reinforcement, then weld shear studs
C. place reinforcement, pour concrete, install the deck, then weld shear studs
D. weld shear studs, pour concrete, install the deck, then place reinforcement

39. An activity has an early finish of day 22, and the earliest successor activity's early start is day 38. What is this activity's free float?

A. 8
B. 11
C. 13
D. 16

40. A schedule shows two non-critical activities competing for the same crew during the same week. Resource leveling can resolve this conflict without delaying the project only if—

A. both activities are shortened by half their duration
B. the crew works two shifts simultaneously that week
C. at least one of the activities has enough float to shift outside that week
D. the two activities are combined into a single task

41. A field density test shows a dry density of 126 pcf, while the laboratory maximum dry density (standard Proctor) is 132 pcf. What is the percent relative compaction?

A. 95.5%
B. 91.2%
C. 88.6%
D. 98.7%

42. Which ASTM standard governs obtaining and testing drilled or sawed concrete cores and beams?

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

43. For an ASTM A325 high-strength bolt installed by the turn-of-nut method, with a bolt length between 4 and 8 diameters and one connected surface sloped more than 1:20 from perpendicular to the bolt axis, what nut rotation from snug-tight is required?

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

44. Which party is generally responsible for correcting nonconforming work identified during a QA inspection, at no additional cost to the owner?

A. the independent testing laboratory
B. the owner's representative
C. the contractor performing the work
D. the design engineer of record

45. What is the primary function of a screed during concrete flatwork placement?

A. to add air entrainment to the concrete mix
B. to strike off and level the concrete surface to the desired grade
C. to accelerate hydration at the concrete surface
D. to eliminate the need for finishing tools afterward

46. Using the Nurse-Saul maturity function with a constant temperature-datum difference of 19°C sustained for 65 hours, what is the concrete's maturity index?

A. 980 °C-hr
B. 1080 °C-hr
C. 1150 °C-hr
D. 1235 °C-hr

47. Which of the following would most directly invalidate a maturity method strength prediction for a given concrete placement?

A. using a calibration curve developed for a different concrete mixture
B. recording temperature readings every 30 minutes instead of every hour
C. using a slightly different sensor brand from the one used to build the curve
D. placing the concrete during daytime rather than at night

48. A sand cone field density test removes 3.7 lb of soil from a hole with a volume of 0.030 cf. The soil's moisture content is 10%. What is the dry unit weight?

A. 98.6 pcf
B. 105.4 pcf
C. 112.1 pcf
D. 119.8 pcf

49. A 5/8-in fillet weld uses E70 electrode (Fexx=70 ksi). What is its nominal strength per inch of weld length?

A. 13.2 kip/in
B. 15.8 kip/in
C. 18.6 kip/in
D. 21.4 kip/in

50. If a batch of delivered ready-mix concrete fails the field slump test upon arrival, what is the standard next step before the load may be used?

A. automatically reject and return the entire load
B. allow limited on-site water addition within mix design limits, re-test, then place if passing
C. accept the load regardless, since slump is only a minor property
D. reduce the specified slump retroactively to match the delivered batch

51. A slab is designed for dead load D=42 psf and live load L=58 psf. Using the basic ASCE 7 load combination U=1.2D+1.6L, what is the factored design load?

A. 143 psf
B. 156 psf
C. 168 psf
D. 180 psf

52. A beam experiences a bending moment $M=930$ kip-in at a section where $c=7.5$ in and $I=340$ in^4. What is the extreme fiber bending stress?

A. 14.6 ksi
B. 16.8 ksi
C. 18.4 ksi
D. 20.5 ksi

53. An axially loaded member carries $P=99$ kip through a cross-sectional area of 6.6 in^2. What is the axial stress?

A. 15.0 ksi
B. 17.5 ksi
C. 20.0 ksi
D. 22.5 ksi

54. A footing carries a column load of 500 kip and measures 12 ft by 14 ft in plan. What is the resulting bearing pressure on the soil?

A. 2.45 ksf
B. 2.70 ksf
C. 2.98 ksf
D. 3.20 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 $K_z=0.92$, $K_{zt}=1.0$, $K_d=0.85$, and $V=115$ mph, what is the velocity pressure?

A. 21.6 psf
B. 26.5 psf
C. 30.2 psf
D. 33.9 psf

56. A beam has shear force V=50 kip, first moment of area Q=55 in^3, moment of inertia I=920 in^4, and web thickness b=9.5 in. What is the shear stress at that location?

A. 245 psi
B. 275 psi
C. 295 psi
D. 315 psi

57. A column has an effective length factor K=1.0, unbraced length L=14 ft, and radius of gyration r=2.2 in. What is the slenderness ratio KL/r?

A. 68
B. 76
C. 84
D. 92

58. A retaining wall has a resisting moment of 690 kip-ft and an overturning moment of 345 kip-ft. What is the factor of safety against overturning?

A. 2.00
B. 2.25
C. 2.50
D. 2.75

59. A column has a tributary floor area of 20 ft by 25 ft, and the floor is designed for a live load of 95 psf. What is the total live load carried by this column?

A. 36.2 kip
B. 41.8 kip
C. 47.5 kip
D. 52.9 kip

60. Under AISC 360, which chapter provides design provisions specifically for composite members, such as concrete-filled steel tubes?

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

61. Using the rational method $Q=C \cdot i \cdot A$ with a runoff coefficient $C=0.42$, rainfall intensity $i=3.8$ in/hr, and drainage area $A=20$ acres, what is the peak discharge?

A. 22.4 cfs
B. 26.8 cfs
C. 29.5 cfs
D. 31.9 cfs

62. An open channel has Manning's $n=0.016$, flow area $A=16$ sf, hydraulic radius $R=1.7$ ft, and slope $S=0.0035$. Using Manning's equation (USCS form with 1.49), what is the flow rate?

A. 125.6 cfs
B. 140.2 cfs
C. 154.8 cfs
D. 168.3 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 1,100 ft and slope of 0.012, what is the time of concentration?

A. 7.2 min
B. 9.4 min
C. 11.1 min
D. 12.8 min

64. A detention pond must temporarily store runoff where peak inflow is 55 cfs, allowable peak outflow is 24 cfs, and the storm duration is 2.25 hours. Using a simplified triangular hydrograph approximation, what storage volume is required?

A. 2.15 ac-ft
B. 2.55 ac-ft
C. 2.88 ac-ft
D. 3.20 ac-ft

65. A storm sewer pipe with a 21-in diameter carries a flow of 12 cfs. What is the flow velocity in the pipe, assuming it flows full?

A. 4.1 fps
B. 5.0 fps
C. 5.8 fps
D. 6.5 fps

66. A broad-crested weir outlet has a discharge coefficient C=3.0, crest length L=5.5 ft, and head H=1.5 ft. Using Q=C·L·H^1.5, what is the discharge through the weir?

A. 22.4 cfs
B. 25.8 cfs
C. 28.2 cfs
D. 30.3 cfs

67. A 2-leg sling supports an 11,000 lb load, with each leg oriented at 52° from horizontal. What is the tension in each leg?

A. 6,100 lb
B. 6,500 lb
C. 6,980 lb
D. 7,400 lb

68. A crane's rated capacity chart shows lower values as boom length increases at a constant radius. This behavior primarily reflects—

A. the longer boom's reduced structural stiffness and increased bending under load
B. the crane's engine generating less power at longer boom lengths
C. ground bearing pressure changing as a function of boom length
D. wind exposure being the sole governing factor in every case

69. A dewatering system must handle 260 gpm of inflow, and each wellpoint has a discharge capacity of 14 gpm. What is the minimum number of wellpoints required?

A. 14
B. 16
C. 17
D. 19

70. An excavator has a bucket capacity of 2.75 cy, a fill factor of 0.82, a cycle time of 24 seconds, and operates at 48 minutes of effective work per hour. What is its production rate?

A. 271 cy/hr
B. 245 cy/hr
C. 295 cy/hr
D. 320 cy/hr

71. Using the Engineering News Record (ENR) pile driving formula Qu=2E/(S+0.1), with driving energy E=20,000 ft-lb and set S=0.55 in per blow, and applying a factor of safety of 6, what is the allowable pile capacity?

A. 7.6 kip
B. 8.9 kip
C. 10.3 kip
D. 11.8 kip

72. Two cross-section end areas along an embankment are 195 sf and 250 sf, separated by 165 ft. Using the average end area method, what is the fill volume in cubic yards?

A. 1,210.4 cy
B. 1,359.7 cy
C. 1,480.2 cy
D. 1,600.5 cy

73. Rigging references typically limit the standard choker hitch derate table to choke angles no smaller than approximately—

A. 60 degrees
B. 120 degrees
C. 30 degrees
D. 150 degrees

74. A crane boom is 130 ft long and raised to an angle of 42° from horizontal. Ignoring boom point offset, what is the resulting horizontal working radius?

A. 82.4 ft
B. 89.7 ft
C. 96.6 ft
D. 103.2 ft

75. A sump pump must handle a seepage inflow of 145 gpm, and standard practice applies a safety factor of 1.5 for pump sizing. What minimum pump capacity should be selected?

A. 217.5 gpm
B. 190 gpm
C. 240 gpm
D. 260 gpm

76. A loader has a cycle time of 3 minutes per load. A truck's full haul-dump-return cycle takes 27 minutes. How many trucks are needed to keep the loader continuously working?

A. 5
B. 6
C. 7
D. 9

77. A pile's static capacity analysis gives skin friction resistance Qs=220 kip and end bearing resistance Qp=140 kip. Applying a factor of safety of 2.5, what is the allowable pile capacity?

A. 120 kip
B. 144 kip
C. 165 kip
D. 180 kip

78. An embankment requires 13,500 cy of soil measured in the bank (natural, undisturbed) condition, and the borrow soil has a shrinkage factor of 0.83 relating compacted volume to bank volume. What compacted fill volume results from excavating this bank volume?

A. 9,800 cy
B. 10,400 cy
C. 11,205 cy
D. 12,100 cy

79. A crane outrigger imposes a load of 90,000 lb on the ground, and the allowable soil bearing pressure is 4,500 psf. What minimum outrigger pad area is required?

A. 20.0 sf
B. 22.5 sf
C. 24.8 sf
D. 27.2 sf

80. Using the ACI 347 formwork lateral pressure formula for columns, $C_w=150+9000R/T$, with a placement rate $R=6$ ft/hr and concrete temperature $T=68°F$, what is the design lateral pressure?

A. 780 psf
B. 944 psf
C. 1,080 psf
D. 1,220 psf

81. A scaffold platform will support 5 workers averaging 200 lb each, 1,600 lb of stored material, and 190 lb of tools and equipment. What is the total design load on the platform?

A. 2,350 lb
B. 2,550 lb
C. 2,650 lb
D. 2,790 lb

82. A reshore below a freshly poured slab has a tributary area of 9.5 ft by 9.5 ft, and the slab's dead load is 98 psf. What load is transferred to this reshore, using a simplified tributary-area method?

A. 7,200 lb
B. 7,900 lb
C. 8,300 lb
D. 8,844 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 62,000 lb vertically, what minimum lateral bracing force must be provided?

A. 980 lb
B. 1,100 lb
C. 1,240 lb
D. 1,380 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 $K_a=0.29$, $\gamma=115$ pcf, and excavation depth $H=24$ ft, what is the peak apparent pressure?

A. 520 psf
B. 580 psf
C. 640 psf
D. 700 psf

85. A shoring design that assumes reshores below carry zero load, based on the incorrect belief that only the level directly above the fresh pour matters, will most likely—

A. always be conservative and safe regardless of actual conditions
B. match actual field conditions exactly in every scenario
C. underestimate the true load reaching lower reshored levels
D. have no effect on the shoring design outcome

86. Per ACI 347, what minimum combined dead and live load applies to horizontal formwork when motorized concrete carts are used?

A. 100 psf
B. 125 psf
C. 90 psf
D. 150 psf

87. A supported scaffold is 40 ft tall with a 9 ft base width. Per OSHA 29 CFR 1926 Subpart L, must this scaffold be restrained against tipping?

A. Yes, since its 4.4:1 ratio exceeds the 4:1 threshold
B. No, since 4.4:1 is close enough to be acceptable
C. No, restraint is only required above 50 ft in height
D. Yes, but only for scaffolds used exclusively by masons

88. A slab load of 155 psf acts on a 9 ft by 9 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. 2,450 lb
B. 2,800 lb
C. 3,050 lb
D. 3,139 lb

89. A diagonal brace oriented at 36° from horizontal resists a horizontal thrust of 8,800 lb. What is the resulting axial force in the brace?

A. 10,877 lb
B. 9,600 lb
C. 11,900 lb
D. 12,600 lb

90. An 18-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. 14 ft
B. 18 ft
C. 22 ft
D. 26 ft

91. Per ASCE 37, which factor is NOT typically part of determining the appropriate reduced design wind speed for a temporary structure?

A. the anticipated exposure duration during construction
B. the structure's importance and consequence of failure
C. the geographic location's wind climate
D. the contractor's preferred material supplier

92. Per common guidance, what minimum percentage of specified 28-day strength should horizontal formwork achieve before removal, when the concrete must support its own weight and construction loads, absent a specific engineering analysis?

A. 50%
B. 60%
C. 75%
D. 90%

93. A shoring post has an allowable capacity of 4,000 lb at an unbraced length of 20 ft. If lateral bracing reduces the unbraced length to 10 ft, and capacity scales inversely with the square of unbraced length (Euler-type behavior), what is the new allowable capacity?

A. 10,000 lb
B. 13,000 lb
C. 16,000 lb
D. 19,000 lb

94. A braced excavation is 19 ft deep in clay with undrained shear strength cu=1,250 psf and unit weight γ=118 pcf. Using a bearing capacity factor Nc=5.7, what is the factor of safety against bottom heave, FS=Nc·cu/(γ·H)?

A. 2.7
B. 3.2
C. 3.6
D. 4.0

95. Per OSHA 29 CFR 1926 Subpart L, what is the minimum required width for a scaffold platform used as a work surface?

A. 18 in
B. 14 in
C. 24 in
D. 12 in

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

A. 320 ft
B. 370 ft
C. 410 ft
D. 450 ft

97. Per OSHA 29 CFR 1926 Subpart X, what is the minimum clear distance required behind a fixed ladder's rungs for climbing space?

A. 4 in
B. 5 in
C. 6 in
D. 7 in

98. Per MUTCD Part 6, which TTC zone component includes devices such as signs warning drivers of the approaching work zone before any lane changes occur?

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

99. Which best describes the scope of a competent person's authority under OSHA regulations for excavation work?

A. limited to inspecting only the excavation's side slopes
B. limited to reviewing paperwork and permits only
C. broad enough to cover hazards and corrective action across adjacent areas
D. limited strictly to trenches deeper than 20 ft

100. Per MUTCD guidance, which of the following best describes when channelizing devices alone are generally considered adequate, without positive protection?

A. whenever the work duration exceeds one week
B. in lower-speed, lower-volume conditions with limited or brief worker exposure to traffic
C. on any interstate highway regardless of conditions
D. only when a flagger is not present on site

Practice Exam 20: Answer Key and Explanations

1. D — Rankine active pressure for a level, cohesionless backfill is $K_a = \tan^2(45° - \varphi'/2)$. With $\varphi' = 27°$, this is $\tan^2(31.5°) \approx 0.376$. This lower friction angle than in previous examples produces a larger Ka value, since weaker soil requires more lateral thrust to reach its active failure condition and design pressure.

2. B — Primary settlement is $S_c = [C_c \cdot H/(1+e_0)] \cdot \log_{10}[(p_0+\Delta p)/p_0]$. Substituting, $S_c = (0.32\times3.8/1.95)\cdot\log_{10}(220/100) = 0.624\times0.342 \approx 0.214$ m, or 214 mm. This sizeable settlement reflects a high compression index applied under a foundation load that more than doubles the existing overburden pressure at this particular site. Softer clay compressibility would further increase this settlement estimate here.

3. C — Total stress at 10 m is $\sigma = (17.5\times2.5) + (19.2\times7.5) = 43.75 + 144 = 187.75$ kPa. Pore pressure develops only below the water table: $u = 9.81\times7.5 \approx 73.6$ kPa. Effective stress is $\sigma' = 187.75 - 73.6 \approx 114$ kPa. Option D is the total stress alone, without pore pressure subtracted.

4. A — For $\varphi = 0$ conditions, $q_{ult} = c_u \cdot N_c + q \cdot N_q$. The surcharge is $q = 17.5\times1.1 \approx 19.3$ kPa, so $q_{ult} = 42\times5.7 + 19.3\times1.0 = 239.4 + 19.3 \approx 259$ kPa. Omitting the surcharge term would understate ultimate capacity by ignoring the confinement the overlying soil provides at footing depth.

5. A — 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 $FS = \tan(27°)/\tan(18°) = 0.510/0.325 \approx 1.57$. This ratio depends only on the friction and slope angles, not on slope height, soil unit weight, or failure surface depth.

6. C — Passive coefficient is $Kp = \tan^2(45°+\varphi'/2) = \tan^2(60°) = 3.0$. The resultant passive force is $Pp = 0.5 \cdot Kp \cdot \gamma \cdot H^2 = 0.5 \times 3.0 \times 18.6 \times 3.6^2 \approx 362$ 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. Wall embedment depth strongly influences the magnitude of this force.

7. B — With double drainage, the drainage path length is $Hdr = H/2 = 3.25$ m. Time factor relates as $t = Tv \cdot Hdr^2/cv = 0.197 \times 10.56/2.8 \approx 0.743$ yr, which converts to $0.743 \times 365 \approx 271$ days. Using the full 6.5 m thickness instead of the halved drainage path would substantially overstate this required time.

8. D — With seepage parallel to the slope, $FS = (\gamma'/\gamma sat) \cdot (\tan\varphi'/\tan\beta)$. The buoyant unit weight is $\gamma' = 20.2-9.81 \approx 10.39$ kN/m³, giving a ratio of 0.514. Combined with $\tan(33°)/\tan(24°) \approx 1.459$, $FS \approx 0.514 \times 1.459 \approx 0.75$, roughly half the equivalent dry slope's factor of safety without seepage present here. Higher friction angles would proportionally increase this computed safety factor.

9. A — Curve length is $L = R \cdot \Delta(\text{radians}) = 900 \times (32 \times \pi/180) = 900 \times 0.55851 \approx 502.7$ 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. D — Middle ordinate is $M = R \cdot (1-\cos(\Delta/2))$. With $\Delta/2 = 16°$, $\cos(16°) = 0.96126$, so $M = 900 \times (1-0.96126) = 900 \times 0.03874 \approx 34.9$ ft. This sharper 32-degree deflection angle produces a notably larger middle ordinate than the gentler curves examined in earlier problems at similar radii and geometry. Sharper deflection angles at this radius increase this offset value further.

11. B — The high point on a crest vertical curve occurs where $x = L \cdot g1/(g1-g2)$. Here $x = 480 \times 2.5/(2.5-(-1.5)) = 1{,}200/4.0 = 300$ ft from the BVC. Because the incoming grade is steeper than the outgoing grade, this point falls past the curve's geometric midpoint of 240 ft along its length. Symmetric grades would instead place the high point at midpoint.

12. C — The long chord connecting the PC and PT is $C = 2R \cdot \sin(\Delta/2)$. With $\Delta/2 = 16°$, $\sin(16°) = 0.27564$, giving $C = 2 \times 900 \times 0.27564 \approx 496.1$ ft. As expected, this is noticeably shorter than the 502.7 ft arc length computed earlier for this sharper curve's actual geometry and radius. Chord and arc lengths converge as deflection angles grow smaller.

13. A — Visible outcrops, topographic maps, and contractor recollections from other sites can only suggest a general sense of subsurface conditions, none of which reliably confirms depth to bedrock at this specific hillside. Geotechnical borings advanced to refusal directly measure that depth at each boring location, giving the design engineer real, site-specific data for the anchors.

14. B — Height of instrument is HI = benchmark elevation + backsight = 155.00 + 4.62 = 159.62 ft. The stake elevation is then HI minus the foresight: 159.62 − 5.18 = 154.44 ft. This differential leveling procedure carries a known elevation from the fixed benchmark out to new grade stakes across the site.

15. C — By the arc definition, degree of curve is $D = 5729.58/R$. With $R = 900$ ft, $D = 5729.58/900 \approx 6.37°$. This moderately large degree of curve reflects the sharper 32-degree deflection curve examined at this radius, compared to the gentler alignments seen in earlier wider-radius roadway design examples. Wider-radius curves would produce a correspondingly smaller degree value here.

16. D — Plasticity index is $PI = LL-PL = 22$. The A-line value at $LL=48$ is $0.73\times(48-20) = 20.4$, and since $PI=22$ 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. C — Water-cement ratio is the water weight divided by cement weight: $300/545.5 \approx 0.55$. This moderate ratio balances workability during placement against strength and durability requirements, and is a common target for typical structural concrete under normal exposure conditions without severe environmental or chemical attack concerns present. Higher ratios would reduce strength but improve overall mix workability.

18. A — ASTM A572 Grade 65 has a minimum specified yield strength of 65 ksi, one of the higher-strength grades in the A572 family, which also includes Grade 42 and Grade 50. Higher grades like this one allow lighter member sizes for a given demand, at the cost of reduced ductility compared to lower grades.

19. B — Adjusted design values multiply the reference value by all applicable adjustment factors: $F_b' = F_b \times C_D \times C_F = 1250\times1.15\times1.0 \approx 1438$ psi. With the size factor equal to 1.0 here, the entire adjustment comes from the snow-load duration factor, unlike cases where both factors combine to shift the value further from the reference.

20. D — ASTM C39 governs the compression testing of molded concrete cylinders, the standard method used to determine the specified compressive strength f'c for project acceptance. C143 measures slump, C231 measures air content, and C1064 measures fresh concrete temperature, each addressing an entirely different property of the concrete tested. Age at testing significantly affects the measured strength result obtained.

21. D — Dry unit weight relates to void ratio and specific gravity by $\gamma_d = G_s \cdot \gamma_w/(1+e) = 2.68\times9.81/1.42 \approx 18.5$ kN/m³. This low void ratio indicates a very dense, well-compacted soil skeleton, producing one of the higher dry unit weight values examined across these geotechnical index property problems shown so far. A looser soil sample would yield a lower unit weight.

22. B — ASTM A996 governs reinforcing bars rolled from axle steel or rail steel rather than new billet steel, and its Grade 60 designation carries the same minimum 60 ksi yield strength as the more common A615 Grade 60 bar. This standard offers an alternative, often more economical, source of reinforcing steel meeting equivalent strength requirements.

23. A — The average end area method computes volume as $V = [(A_1+A_2)/2]\times L = [(100+155)/2]\times170 = 21{,}675$ cf. Converting to cubic yards by dividing by 27 gives approximately 802.8 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: $2{,}800 \times \$32 = \$89{,}600$. 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 specific topsoil quality specification called for on this landscaping and grading project overall. Bulk purchasing discounts could further reduce this baseline material cost.

25. D — Present worth of a single future amount is $P = F/(1+i)^n = 550{,}000/(1.065)^5 = 550{,}000/1.3701 \approx \$401{,}400$. 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 across competing project alternatives being evaluated. Higher discount rates would further reduce this present-worth result value.

26. A — Cost performance index is $CPI = EV/AC = 480{,}000/445{,}000 \approx 1.08$. A CPI above 1.0 indicates the project is spending less than the value of work actually completed, meaning it is currently running under budget relative to the earned value baseline established in the original cost management plan and forecast.

27. C — Volume is length times width times thickness: $44 \times 66 \times 0.5 = 1{,}452$ cf. Dividing by 27 cf per cubic yard gives approximately 53.8 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: 22,000 sf × \$175/sf = \$3,850,000. 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. B — Break-even quantity equals fixed cost divided by the contribution margin per unit: $60{,}000/(36-16) = 60{,}000/20 = 3{,}000$ units exactly. Below this quantity the operation runs at a loss, and above it, each additional unit contributes \$20 toward covering fixed costs and, past break-even, toward genuine profit for the business overall.

30. C — Schedule performance index is $SPI = EV/PV = 465{,}000/430{,}000 \approx 1.08$. 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 overall. A lower planned value would raise this schedule performance ratio further.

31. A — In the CPM forward pass, early finish equals early start plus duration: $EF = ES + \text{Duration} = 12 + 15 = 27$. 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. D — PERT expected time is te = (to + 4·tm + tp)/6 = (7 + 40 + 19)/6 = 66/6 = 11.0 days. Weighting the most likely estimate four times as heavily as the optimistic and pessimistic bounds reflects the right-skewed distribution typical of real-world construction activity durations encountered on most projects.

33. B — Total float is the difference between late start and early start: TF = LS − ES = 29 − 20 = 9. 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. D — Since these activities occur sequentially with no overlap along the critical path, total duration is simply their sum: 10+13+8+11 = 42 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. C — Production rate for a linear (line-of-balance) schedule is distance divided by time: 3,900 ft / 13 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. A — Total resource-days is the product of the number of workers and the duration: 9 workers × 13 days = 117 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. B — Crash cost slope is the change in cost divided by the change in duration: (50,000−32,000)/(15−9) = 18,000/6 = $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. A — The metal deck must be installed first to provide the working surface and stay-in-place formwork, followed by welding shear studs to develop composite action with the beams below, then placing reinforcement, and finally pouring concrete over the completed deck and reinforcement assembly to form the finished composite slab structure. Reversing any two of these steps would compromise structural integrity.

39. D — 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) = 38 − 22 = 16. Unlike total float, this value depends only on the immediate downstream activity, not on the project's overall late-date calculations elsewhere.

40. C — Resolving a resource conflict by shifting one activity's timing only works if that activity retains enough total float to move outside the conflicting week without pushing into its late dates. Absent sufficient float, the conflict can only be resolved by other means, such as adding resources, which may carry its own cost implications.

41. A — Relative compaction is the field dry density divided by the laboratory maximum dry density, expressed as a percentage: (126/132)×100 ≈ 95.5%. This result exceeds a typical specification requiring

90 to 95% relative compaction, confirming the field placement and compaction effort met or exceeded the earthwork requirements for this particular lift.

42. D — ASTM C42 governs obtaining and testing drilled or sawed cores and beams of concrete, the standard method used to directly evaluate in-place strength when standard cylinder breaks fall below the specified value. C39 tests standard molded cylinders, C143 measures slump, and C231 measures air content, each addressing a different property.

43. B — The RCSC Specification requires the largest nut rotation, 5/6 turn beyond snug-tight, when both a moderately long bolt length and a sloped connected surface combine, since the sloped surface demands extra elongation on top of what the bolt length alone would otherwise require to reach the specified bolt pretension value.

44. C — The contractor performing the work bears responsibility for correcting nonconforming work identified during quality assurance inspections, and this correction is generally performed at no additional cost to the owner under standard contract terms. The testing laboratory only identifies the deficiency, and the owner's representative and engineer of record oversee compliance rather than perform corrections themselves.

45. B — A screed is dragged across freshly placed concrete to strike off excess material and bring the surface to the correct grade and elevation, establishing a flat, level base before subsequent finishing operations like floating and troweling begin. It doesn't affect air content, hydration rate, or eliminate the need for further finishing work.

46. D — The Nurse-Saul maturity index accumulates temperature above a datum over time: $M(t) = \Sigma(T-T0)\cdot\Delta t$. With a constant 19°C difference sustained for 65 hours, $M = 19\times65 = 1{,}235$ °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. A — The entire maturity method depends on the calibration curve matching the actual mixture being placed, since cement type, water-cement ratio, and admixtures all shift the strength-maturity relationship for that mixture. Reading interval, sensor brand, and time of placement don't invalidate the method the way using an entirely wrong mixture's calibration curve would.

48. C — Wet unit weight is the weight of soil removed divided by the hole volume: $3.7/0.030 \approx 123.3$ pcf. Converting to dry unit weight using the moisture content, $\gamma d = \gamma wet/(1+w) = 123.3/1.10 \approx 112.1$ 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=0.625 in, $Rn = 0.6\times70\times0.707\times0.625 \approx 18.6$ kip/in, the largest fillet size examined among all the weld problems in this exam so far. Smaller weld sizes proportionally reduce this per-inch capacity value here.

50. B — Standard practice permits limited on-site water addition, within the water-cement ratio limits allowed by the approved mix design, followed by re-mixing and re-testing the slump before the load can be placed if it now passes. Immediate rejection, blanket acceptance, or retroactively changing the specification all skip this standard corrective sequence.

51. A — The factored load combination applies separate load factors before summing: $U = 1.2(42) + 1.6(58) = 50.4 + 92.8 \approx 143$ 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 buildings.

52. D — The flexure formula gives bending stress as $\sigma = M \cdot c/I = 930 \times 7.5/340 \approx 20.5$ 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. A — Axial stress is force divided by cross-sectional area: $\sigma = P/A = 99/6.6 = 15.0$ 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. C — Assuming a concentric load and uniform pressure distribution, bearing pressure equals load divided by footing area: $q = P/(B \times L) = 500/(12 \times 14) \approx 2.98$ 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 column load.

55. B — Substituting directly: $qz = 0.00256 \times 0.92 \times 1.0 \times 0.85 \times 115^2 = 0.00256 \times 0.782 \times 13{,}225 \approx 26.5$ 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.

56. D — Shear stress is given by the shear flow formula $\tau = VQ/(Ib) = (50{,}000 \times 55)/(920 \times 9.5) = 2{,}750{,}000/8{,}740 \approx 315$ 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: 14 ft × 12 = 168 in, so $KL/r = (1.0 \times 168)/2.2 \approx 76$. 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. A — Factor of safety against overturning is the ratio of resisting moment to overturning moment: $FS = 690/345 = 2.00$ exactly. 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. C — Tributary area load is the product of tributary area and design load intensity: $20 \times 25 \times 95 = 47{,}500$ lb, or 47.5 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 building structure.

60. D — AISC 360 Chapter I covers composite members, including concrete-filled steel tubes and encased composite columns, addressing the combined behavior of steel and concrete acting together structurally. Chapter E covers compression members alone, Chapter F covers flexural members alone, and Chapter H covers combined forces without addressing composite action specifically at all.

61. D — The rational method combines runoff coefficient, rainfall intensity, and drainage area directly: $Q = C \cdot i \cdot A = 0.42 \times 3.8 \times 20 \approx 31.9$ 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. A — Manning's equation is $Q = (1.49/n) \cdot A \cdot R^{(2/3)} \cdot S^{(1/2)}$. Substituting: $(1.49/0.016) \times 16 \times (1.7)^{0.667} \times (0.0035)^{0.5} \approx 93.1 \times 16 \times 1.425 \times 0.0592 \approx 125.6$ cfs. This relationship between channel roughness, geometry, and slope remains fundamental for sizing open channels, culverts, and storm sewers throughout civil site design and roadway drainage work generally performed by engineers. Steeper channel slopes would further increase this computed flow capacity.

63. B — Substituting into the Kirpich formula: $Tc = 0.0078 \times (1{,}100)^{0.77} \times (0.012)^{-0.385} \approx 0.0078 \times 219.9 \times 5.49 \approx 9.4$ 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 flat drainage basin. Flatter watershed slopes would substantially lengthen this computed travel time.

64. C — A simplified storage estimate is $V \approx 0.5 \times (Qin - Qout) \times duration = 0.5 \times (55 - 24) \times 8{,}100$ sec = 125,550 cf. Converting to acre-feet by dividing by 43,560 gives about 2.88 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. B — Velocity is flow rate divided by cross-sectional area: $V = Q/A$. With a 21-in (1.75-ft) diameter pipe, $A = \pi \times (0.875)^2 \approx 2.41$ sf, so $V = 12/2.41 \approx 5.0$ 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. D — Substituting into the weir formula: $Q = 3.0 \times 5.5 \times (1.5)^{1.5} = 16.5 \times 1.837 \approx 30.3$ 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 construction sites. Longer crest lengths would proportionally increase this discharge capacity value.

67. C — Each sling leg carries half the total load, resolved along its angle: $T = (Load/2)/\sin(angle) = 5{,}500/\sin(52°) = 5{,}500/0.788 \approx 6{,}980$ lb. This angle sits between the shallower and steeper examples examined in earlier sling tension problems, producing a leg tension that falls correspondingly between those two computed results shown previously.

68. A — A longer boom is inherently more flexible and subject to greater bending moments and buckling concerns under the same tip load, reducing its structural capacity compared to a shorter, stiffer boom at the same radius. Engine power, ground bearing pressure, and wind exposure all matter to crane operations, but none explains this particular structural capacity trend.

69. D — Dividing total required flow by per-wellpoint capacity gives $260/14 \approx 18.57$, which must be rounded up to 19 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. A — Cycles per hour at full time is $3{,}600/24 = 150$, giving a theoretical output of $150\times2.75\times0.82 \approx 338.25$ cy/hr. Applying the 48/60 efficiency factor for actual working minutes reduces this to about 271 cy/hr, reflecting realistic production once operational delays are properly accounted for on the active job site. Higher fill factors would further increase this hourly production rate.

71. C — Ultimate capacity is $Qu = 2E/(S+0.1) = 2\times20{,}000/(0.55+0.1) = 40{,}000/0.65 \approx 61{,}538$ lb. Applying the ENR formula's typical factor of safety of 6 gives allowable capacity: $Qa = 61{,}538/6 \approx 10.3$ kip. This larger set per blow indicates softer driving resistance than the earlier, harder-driving pile examples shown. Larger driving energy inputs would proportionally raise this allowable capacity.

72. B — Applying the average end area method: $V = [(195+250)/2]\times165 = 222.5\times165 \approx 36{,}712.5$ cf. Converting to cubic yards by dividing by 27 gives about 1,359.7 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 fill volume figure.

73. B — Standard choker hitch derating tables published by rigging manufacturers and references typically stop at a choke angle of about 120 degrees, since angles tighter than this fall outside the range the standard 75 to 80% derate was developed for. Below that angle, additional engineering judgment or manufacturer-specific data is required.

74. C — Horizontal radius is the boom length multiplied by the cosine of its angle from horizontal: $R = L\cdot\cos(\theta) = 130\times\cos(42°) = 130\times0.7431 \approx 96.6$ ft. This shallower boom angle than in prior examples produces a proportionally larger working radius relative to the boom's total physical length overall. Steeper boom angles would further shrink this computed working radius.

75. A — Required pump capacity is the anticipated inflow multiplied by the safety factor: $145\times1.5 = 217.5$ 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. D — 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: $27/3 = 9$ 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. B — Ultimate capacity is the sum of skin friction and end bearing: Qult = Qs+Qp = 220+140 = 360 kip. Dividing by the factor of safety gives allowable capacity: Qallow = 360/2.5 = 144 kip. This static computation is typically confirmed in the field with a load test or a dynamic pile driving formula check afterward.

78. C — With the shrinkage factor defined as compacted volume divided by bank volume, the resulting compacted volume is bank volume multiplied by that factor: 13,500×0.83 ≈ 11,205 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. A — Required pad area is the outrigger load divided by the allowable bearing pressure: 90,000/4,500 = 20.0 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 + (9,000×6)/68 ≈ 150 + 794.1 ≈ 944 psf. This moderate 6 ft/hr placement rate combined with warmer 68°F concrete, which sets somewhat faster, produces a formwork pressure lower than the cooler-concrete, faster-rate cases examined earlier, requiring correspondingly less robust bracing for this particular pour.

81. D — Total design load is the sum of all anticipated loads on the platform: (5×200) + 1,600 + 190 = 1,000 + 1,600 + 190 = 2,790 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. D — Tributary area load is the product of tributary area and load intensity: 9.5×9.5×98 ≈ 8,844 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: 0.02×62,000 = 1,240 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 = 0.65×0.29×115×24 = 0.1885×115×24 ≈ 520 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 depths and sites. Deeper excavations proportionally increase this peak apparent pressure value here.

85. C — Fresh concrete loads are actually redistributed downward through a connected chain of shores and reshores spanning several floor levels below the new pour, not absorbed entirely by the single level directly beneath it. Ignoring this redistribution underestimates the true load reaching those lower reshored levels, potentially leaving them under-designed for the actual demand.

86. B — ACI 347 sets a higher minimum design load floor of 125 psf for horizontal formwork when motorized carts or buggies are used, compared to the 100 psf minimum that applies without them. This higher value accounts for the additional dynamic impact and concentrated wheel loads that motorized placement equipment imposes on the deck.

87. A — This scaffold's height-to-base ratio is $40/9 \approx 4.4{:}1$, which exceeds OSHA's 4:1 threshold above which supported scaffolds must be guyed, tied, or braced against tipping over. There is no separate 50-ft absolute height exemption, and this restraint requirement applies to supported scaffolds generally, not just those used by masonry trades specifically.

88. D — Total tributary load is $155 \times 9 \times 9 \approx 12{,}555$ lb. Splitting this equally among the four simultaneously engaged support levels gives $12{,}555/4 \approx 3{,}139$ 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: $F \cdot \cos(36°) = 8{,}800$ lb, so $F = 8{,}800/\cos(36°) \approx 10{,}877$ lb. This shallower 36-degree angle requires a larger axial force to resist the same horizontal thrust than the steeper brace angles examined in earlier problems.

90. B — A 1:1 slope means the horizontal offset equals the vertical depth: offset = depth×slope ratio = $18 \times 1 = 18$ 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. D — ASCE 37's reduced wind speed determination is based on engineering factors: exposure duration, the consequence of failure or importance factor, and the local wind climate at the project's geographic location. A contractor's preferred material supplier is a procurement decision entirely unrelated to this wind speed determination and plays no role in it whatsoever.

92. C — Absent a project-specific engineering analysis justifying earlier removal, common guidance calls for horizontal formwork to remain in place until the supported concrete reaches roughly 75% of its specified 28-day strength, ensuring it can safely carry its own self-weight plus any remaining construction loads without risk of premature structural failure occurring.

93. C — Euler-type buckling capacity scales inversely with the square of unbraced length. Halving the length from 20 ft to 10 ft, a factor of 2, increases capacity by $2^2 = 4$ times: $4{,}000 \times 4 = 16{,}000$ lb. This strong sensitivity to bracing spacing is why intermediate lateral bracing so effectively boosts shoring post capacity.

94. B — Substituting into the heave stability formula: $FS = (5.7 \times 1{,}250)/(118 \times 19) = 7{,}125/2{,}242 \approx 3.2$. 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 entirely.

95. A — OSHA requires scaffold platforms used as work surfaces to be at least 18 inches wide, providing workers adequate footing and room to maneuver, carry materials, and use tools safely while elevated. Narrower platforms below this minimum increase the risk of a worker losing footing or a tool or material falling off the edge.

96. D — At exactly 45 mph, the threshold speed for the higher-speed taper formula, MUTCD taper length is $L = W \times S$, where W is the offset width in feet and S is the posted speed in mph: $L = 10 \times 45 = 450$ ft. This is the shortest taper length produced by the L=WS formula across its applicable speed range.

97. D — OSHA requires at least 7 inches of clear space behind the rungs, cleats, or steps of a fixed ladder, giving a climber's toes and feet adequate room to grip the rungs securely without the wall or structure behind interfering with proper foot placement while ascending or descending the fixed ladder safely.

98. A — The advance warning area is the first component encountered by approaching traffic, using warning signs to alert drivers to the upcoming work zone before any physical lane shift or taper begins. The transition area then physically shifts traffic, the buffer space provides a safety margin, and the activity area contains the actual work.

99. C — A competent person's authority under OSHA extends broadly across the excavation and its adjacent work areas, covering hazards from soil conditions, water accumulation, surcharge loads, and nearby structures, not just side slopes, paperwork review, or a narrow depth threshold. This breadth is necessary since excavation hazards can arise from many interacting factors.

100. B — Channelizing devices alone are generally considered adequate in lower-speed, lower-volume conditions where worker exposure to passing traffic is limited or brief, since the risk of a serious vehicle intrusion is correspondingly lower. Duration alone, highway classification alone, or flagger presence alone don't determine this threshold without considering speed, volume, and exposure together.