PRACTICE EXAM 18: 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 $\varphi' = 38°$ and a level ground surface. Using Rankine theory, what is the active earth pressure coefficient Ka?

A. 0.199
B. 0.238
C. 0.271
D. 0.305

2. A 4.5 m thick normally consolidated clay layer has Cc = 0.28 and initial void ratio e0 = 0.85. The effective overburden stress is 110 kPa and a foundation adds 90 kPa. What is the primary consolidation settlement?

A. 128 mm
B. 149 mm
C. 163 mm
D. 177 mm

3. The water table is at a depth of 4 m. Above the water table, the moist unit weight is 17 kN/m³, and below it the saturated unit weight is 19.5 kN/m³. At a total depth of 11 m, what is the effective vertical stress?

A. 136 kPa
B. 148 kPa
C. 159 kPa
D. 204 kPa

4. A strip footing at 1.4 m depth bears on saturated clay ($\varphi=0$) with cu = 55 kPa. Using Terzaghi bearing capacity factors (Nc=5.7, Nq=1.0) and a surcharge unit weight of 18.5 kN/m³, what is the ultimate bearing capacity?

A. 288 kPa
B. 314 kPa
C. 339 kPa
D. 362 kPa

5. A dry, cohesionless infinite slope has friction angle $\varphi=26°$ and inclination $\beta=17°$. What is the factor of safety against sliding?

A. 1.60
B. 1.42
C. 1.28
D. 1.15

6. A 4.2 m tall wall retains cohesionless backfill with unit weight 17.8 kN/m³ and $\varphi'=31°$. Using Rankine theory, what is the total passive resultant force per unit length of wall?

A. 398 kN/m
B. 445 kN/m
C. 490 kN/m
D. 538 kN/m

7. A doubly-drained saturated clay layer 7 m thick has cv = 3.5 m²/yr. Using Tv=0.197 for 50% consolidation, how long does it take to reach 50% consolidation?

A. 198 days
B. 252 days
C. 289 days
D. 320 days

8. A submerged infinite slope of cohesionless soil ($c'=0$) has $\varphi'=29°$, slope angle $\beta=19°$, saturated unit weight $\gamma_{sat}=19.5$ kN/m³, and $\gamma_w=9.81$ kN/m³, with seepage parallel to the slope. What is the factor of safety?

A. 0.58
B. 0.68
C. 0.74
D. 0.80

9. A horizontal curve has a radius of 750 ft and a deflection angle of 28°. What is the curve length?

A. 312.8 ft
B. 335.6 ft
C. 351.2 ft
D. 366.5 ft

10. For the same curve ($R=750$ ft, $\Delta=28°$), what is the middle ordinate distance?

A. 15.6 ft
B. 18.9 ft
C. 22.3 ft
D. 25.7 ft

11. A vertical curve has an initial grade $g1=+3.0\%$ and final grade $g2=-2.0\%$ over a 550 ft curve length. How far from the BVC does the high point occur?

A. 330 ft
B. 275 ft
C. 240 ft
D. 365 ft

12. For the horizontal curve with R=750 ft and Δ=28°, what is the long chord length?

A. 340.5 ft
B. 362.9 ft
C. 378.4 ft
D. 395.1 ft

13. A bridge widening project requires confirming the exact elevation of an existing pier foundation before designing new footings adjacent to it. Which method most directly provides this information?

A. test pits or exploratory excavation down to the existing foundation
B. satellite imagery of the bridge deck surface
C. traffic count data collected at the bridge site
D. a review of the original contractor's bid tabulation

14. A benchmark has an established elevation of 310.00 ft. A backsight rod reading of 6.18 ft is taken on the benchmark, and a foresight reading of 2.87 ft is taken to set a rough grade stake. What elevation is the stake set at?

A. 306.95 ft
B. 310.00 ft
C. 313.31 ft
D. 319.05 ft

15. What is the degree of curve (arc definition) for a horizontal curve with a 750 ft radius?

A. 6.42°
B. 7.64°
C. 8.51°
D. 9.20°

16. A fine-grained soil has a liquid limit LL=70 and plastic limit PL=30. Using the USCS plasticity chart, how should this soil be classified?

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

17. A concrete mix design specifies 325 lb/yd^3 of water and 541.7 lb/yd^3 of cement. What is the water-cement ratio?

A. 0.42
B. 0.51
C. 0.60
D. 0.69

18. What is the minimum specified yield strength Fy for ASTM A588 weathering structural steel?

A. 50 ksi
B. 42 ksi
C. 60 ksi
D. 36 ksi

19. A sawn lumber beam has a reference bending design value Fb=1100 psi. Applying a load duration factor CD=0.9 for permanent (dead) load and a size factor CF=1.15, what is the adjusted design value?

A. 950 psi
B. 1015 psi
C. 1080 psi
D. 1138 psi

20. Which ASTM test method evaluates the consistency of fresh concrete by measuring how far a molded specimen settles after the mold is lifted?

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

21. A soil sample has a void ratio $e=0.48$ and specific gravity $G_s=2.72$. What is the dry unit weight, using $\gamma_w=9.81$ kN/m³?

A. 14.6 kN/m³
B. 15.9 kN/m³
C. 16.8 kN/m³
D. 18.0 kN/m³

22. A structural drawing specifies epoxy-coated reinforcing steel per ASTM A775, Grade 60. What is the minimum specified yield strength?

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

23. Two cross-section end areas along a roadway cut are 110 sf and 175 sf, separated by 160 ft. Using the average end area method, what is the earthwork volume in cubic yards?

A. 720.6 cy
B. 844.4 cy
C. 910.2 cy
D. 985.7 cy

24. A project requires 2,100 cy of structural fill at a unit cost of $42/cy. What is the total material cost?

A. $88,200
B. $96,500
C. $104,800
D. $112,300

25. An owner expects to spend $450,000 four years from now on a facility upgrade. At an interest rate of 5% per year, what is the present worth of that expenditure?

A. $342,600
B. $370,200
C. $395,800
D. $418,900

26. A project has an earned value (EV) of $510,000 and actual cost (AC) of $480,000. What is the cost performance index (CPI)?

A. 0.89
B. 0.97
C. 1.06
D. 1.14

27. A concrete slab measures 62 ft by 38 ft at a thickness of 0.58 ft. What is the concrete volume in cubic yards?

A. 38.2 cy
B. 42.7 cy
C. 46.5 cy
D. 50.6 cy

28. Using a parametric cost-per-square-foot estimate of $195/sf for an 18,000 sf building, what is the estimated construction cost?

A. $3,510,000
B. $3,200,000
C. $3,780,000
D. $4,050,000

29. A production line has fixed costs of $95,000, a variable cost of $28 per unit, and sells each unit at $52. How many units must be sold to break even?

A. 3,520
B. 3,958
C. 4,310
D. 4,680

30. A schedule shows earned value EV=$425,000 and planned value PV=$395,000. What is the schedule performance index (SPI)?

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

31. An activity has an early start (ES) of day 16 and a duration of 13 days. What is its early finish (EF)?

A. 23
B. 25
C. 27
D. 29

32. Using the PERT three-point estimate with optimistic time to=6 days, most likely tm=9 days, and pessimistic tp=18 days, what is the expected activity duration?

A. 8.5 days
B. 9.2 days
C. 10.0 days
D. 10.8 days

33. An activity has ES=15 and LS=24. What is its total float?

A. 5
B. 9
C. 12
D. 16

34. A critical path consists of four sequential activities with durations of 7, 10, 9, and 12 days. What is the total critical path duration?

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

35. A paving crew completes 5,400 linear feet of curb and gutter in 18 working days. What is the crew's production rate?

A. 220 ft/day
B. 250 ft/day
C. 275 ft/day
D. 300 ft/day

36. A task requires 8 workers for 12 days. What is the total resource-days (worker-days) required for this task?

A. 72
B. 96
C. 108
D. 120

37. An activity has a normal cost of $35,000 over 16 days and a crash cost of $59,000 over 10 days. What is the crash cost per day?

A. $3,200
B. $3,600
C. $4,000
D. $4,400

38. In a driven pile foundation installation, which of the following represents the correct sequence of field operations?

A. survey and layout pile locations, drive the piles, cut off pile heads, then cast the pile cap
B. cast the pile cap, drive the piles, survey and layout locations, then cut off pile heads
C. cut off pile heads, survey and layout locations, drive the piles, then cast the pile cap
D. drive the piles, cast the pile cap, survey and layout locations, then cut off pile heads

39. An activity has an early finish of day 15, and the earliest successor activity's early start is day 28. What is this activity's free float?

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

40. A project manager wants to delay a non-critical activity by 5 days to free up a crew for another task elsewhere. This delay is safe for the overall schedule only if—

A. the activity's duration is reduced first
B. the crew agrees to work overtime later to make up time
C. the activity has no predecessors in the network
D. the activity's total float is at least 5 days

41. A field density test shows a dry density of 112 pcf, while the laboratory maximum dry density (standard Proctor) is 119 pcf. What is the percent relative compaction?

A. 89.3%
B. 94.1%
C. 97.6%
D. 101.2%

42. Which ASTM standard specifies the procedure for obtaining and testing drilled concrete cores to evaluate in-place strength when cylinder breaks are questioned?

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, where the bolt length exceeds 12 diameters, what nut rotation from snug-tight is generally required?

A. 1 full turn
B. 1/2 turn
C. 2/3 turn
D. 1/3 turn

44. Which document typically defines the specific frequency and types of field and laboratory tests required for a given material on a project?

A. the contractor's daily log
B. the owner's insurance policy
C. the project specifications' quality control and testing section
D. the surveyor's field notes

45. What is the primary reason cold joints must be avoided between successive concrete placements within the same structural element?

A. they reduce the required curing time for the element
B. they improve the concrete's final surface color uniformity
C. they create a weak plane with poor bond between the two placements
D. they eliminate the need for control joints elsewhere in the slab

46. Using the Nurse-Saul maturity function with a constant temperature-datum difference of 22°C sustained for 50 hours, what is the concrete's maturity index?

A. 850 °C-hr
B. 950 °C-hr
C. 1020 °C-hr
D. 1100 °C-hr

47. A calibration curve relates maturity index to compressive strength for a specific concrete mixture. Once established, how is it typically used in the field during construction?

A. embedded temperature sensors track maturity in real time, which is converted to estimated strength via the curve

B. it replaces the need for any cylinder breaks on the entire project

C. it is used only once, at the very start of the pour

D. it applies universally to every concrete mixture used on the project

48. A sand cone field density test removes 3.9 lb of soil from a hole with a volume of 0.032 cf. The soil's moisture content is 11%. What is the dry unit weight?

A. 101.4 pcf

B. 109.8 pcf

C. 116.2 pcf

D. 122.7 pcf

49. A 7/16-in fillet weld uses E70 electrode (Fexx=70 ksi). What is its nominal strength per inch of weld length?

A. 9.1 kip/in

B. 10.8 kip/in

C. 13.0 kip/in

D. 15.2 kip/in

50. If a welded connection fails visual inspection due to undersized fillet welds, what is the standard next step before acceptance or rejection is decided?

A. the welder must add additional weld metal to bring the weld to the specified size, then re-inspect

B. accept the connection since undersize is only a minor cosmetic issue

C. reduce the connection's design capacity retroactively to match the deficiency

D. replace the entire structural member regardless of the deficiency's actual extent

51. A slab is designed for dead load D=50 psf and live load L=65 psf. Using the basic ASCE 7 load combination U=1.2D+1.6L, what is the factored design load?

A. 132 psf
B. 144 psf
C. 156 psf
D. 164 psf

52. A beam experiences a bending moment $M=810$ kip-in at a section where $c=6.5$ in and $I=310$ in^4. What is the extreme fiber bending stress?

A. 14.2 ksi
B. 17.0 ksi
C. 19.6 ksi
D. 22.1 ksi

53. An axially loaded member carries $P=105$ kip through a cross-sectional area of 7 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 350 kip and measures 8.5 ft by 10.5 ft in plan. What is the resulting bearing pressure on the soil?

A. 2.85 ksf
B. 3.20 ksf
C. 3.55 ksf
D. 3.92 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 $K_z=0.98$, $K_{zt}=1.0$, $K_d=0.85$, and $V=125$ mph, what is the velocity pressure?

A. 24.6 psf
B. 28.9 psf
C. 33.3 psf
D. 37.8 psf

56. A beam has shear force V=44 kip, first moment of area $Q=41 \text{ in}^3$, moment of inertia $I=760 \text{ in}^4$, and web thickness b=7.5 in. What is the shear stress at that location?

A. 265 psi
B. 316 psi
C. 350 psi
D. 385 psi

57. A column has an effective length factor K=1.0, unbraced length L=16 ft, and radius of gyration r=2.4 in. What is the slenderness ratio KL/r?

A. 68
B. 74
C. 80
D. 88

58. A retaining wall has a resisting moment of 780 kip-ft and an overturning moment of 395 kip-ft. What is the factor of safety against overturning?

A. 1.97
B. 2.24
C. 2.50
D. 2.76

59. A column has a tributary floor area of 26 ft by 30 ft, and the floor is designed for a live load of 75 psf. What is the total live load carried by this column?

A. 44.6 kip
B. 49.8 kip
C. 54.2 kip
D. 58.5 kip

60. Under AISC 360, which chapter specifically addresses the design of connections, including bolts and welds?

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

61. Using the rational method $Q=C \cdot i \cdot A$ with a runoff coefficient $C=0.55$, rainfall intensity $i=2.6$ in/hr, and drainage area $A=25$ acres, what is the peak discharge?

A. 26.2 cfs
B. 30.8 cfs
C. 35.8 cfs
D. 40.5 cfs

62. An open channel has Manning's $n=0.017$, flow area $A=18$ sf, hydraulic radius $R=2.0$ ft, and slope $S=0.003$. Using Manning's equation (USCS form with 1.49), what is the flow rate?

A. 137.2 cfs
B. 152.6 cfs
C. 168.4 cfs
D. 183.9 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 900 ft and slope of 0.018, what is the time of concentration?

A. 5.2 min
B. 6.9 min
C. 8.4 min
D. 10.1 min

64. A detention pond must temporarily store runoff where peak inflow is 70 cfs, allowable peak outflow is 30 cfs, and the storm duration is 1.75 hours. Using a simplified triangular hydrograph approximation, what storage volume is required?

A. 2.15 ac-ft
B. 2.48 ac-ft
C. 2.71 ac-ft
D. 2.89 ac-ft

65. A storm sewer pipe with a 36-in diameter carries a flow of 25 cfs. What is the flow velocity in the pipe, assuming it flows full?

A. 2.4 fps
B. 2.9 fps
C. 3.2 fps
D. 3.5 fps

66. A broad-crested weir outlet has a discharge coefficient C=2.9, crest length L=4.5 ft, and head H=1.6 ft. Using Q=C·L·H^1.5, what is the discharge through the weir?

A. 19.8 cfs
B. 23.2 cfs
C. 26.4 cfs
D. 29.6 cfs

67. A 2-leg sling supports a 9,000 lb load, with each leg oriented at 60° from horizontal. What is the tension in each leg?

A. 4,600 lb
B. 5,196 lb
C. 5,700 lb
D. 6,100 lb

68. A crane's tipping line is defined by the outermost points of contact between the machine, or its outriggers, and the ground. A load is considered stable against tipping as long as—

A. the resultant of all vertical forces, machine weight plus load, falls within the tipping line
B. the load is lifted perfectly vertically with absolutely no swing
C. the boom is fully retracted throughout the entire lift
D. the wind speed stays below 20 mph at all times

69. A dewatering system must handle 400 gpm of inflow, and each wellpoint has a discharge capacity of 22 gpm. What is the minimum number of wellpoints required?

A. 16
B. 19
C. 22
D. 25

70. An excavator has a bucket capacity of 3.5 cy, a fill factor of 0.75, a cycle time of 28 seconds, and operates at 50 minutes of effective work per hour. What is its production rate?

A. 281 cy/hr
B. 255 cy/hr
C. 305 cy/hr
D. 330 cy/hr

71. Using the Engineering News Record (ENR) pile driving formula Qu=2E/(S+0.1), with driving energy E=28,000 ft-lb and set S=0.3 in per blow, and applying a factor of safety of 6, what is the allowable pile capacity?

A. 15.8 kip
B. 18.4 kip
C. 20.9 kip
D. 23.3 kip

72. Two cross-section end areas along a roadway cut are 160 sf and 225 sf, separated by 190 ft. Using the average end area method, what is the cut volume in cubic yards?

A. 1,150.8 cy
B. 1,250.4 cy
C. 1,354.6 cy
D. 1,480.2 cy

73. A basket hitch, in which a sling cradles the load with both ends attached to the hook and the sling body passing under the load, typically provides rated capacity that is—

A. identical to a choker hitch configuration
B. always reduced to 25% of the vertical rating regardless of angle
C. dependent only on the load's total weight, not the sling angle
D. increased relative to a vertical hitch, but reduced as the angle between the sling legs narrows

74. A crane boom is 110 ft long and raised to an angle of 48° from horizontal. Ignoring boom point offset, what is the resulting horizontal working radius?

A. 62.4 ft
B. 68.1 ft
C. 73.6 ft
D. 79.8 ft

75. A sump pump must handle a seepage inflow of 130 gpm, and standard practice applies a safety factor of 1.5 for pump sizing. What minimum pump capacity should be selected?

A. 195 gpm

B. 170 gpm
C. 215 gpm
D. 240 gpm

76. A loader has a cycle time of 4 minutes per load. A truck's full haul-dump-return cycle takes 32 minutes. How many trucks are needed to keep the loader continuously working?

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

77. A pile's static capacity analysis gives skin friction resistance Qs=195 kip and end bearing resistance Qp=105 kip. Applying a factor of safety of 2.5, what is the allowable pile capacity?

A. 96 kip
B. 120 kip
C. 138 kip
D. 156 kip

78. An embankment requires 11,000 cy of soil measured in the bank (natural, undisturbed) condition, and the borrow soil has a shrinkage factor of 0.90 relating compacted volume to bank volume. What compacted fill volume results from excavating this bank volume?

A. 9,900 cy
B. 8,700 cy
C. 10,450 cy
D. 11,200 cy

79. A crane outrigger imposes a load of 82,000 lb on the ground, and the allowable soil bearing pressure is 3,800 psf. What minimum outrigger pad area is required?

A. 16.2 sf
B. 18.5 sf
C. 19.9 sf
D. 21.6 sf

80. Using the ACI 347 formwork lateral pressure formula for columns, Cw=150+9000R/T, with a placement rate R=10 ft/hr and concrete temperature T=65°F, what is the design lateral pressure?

A. 1,180 psf
B. 1,360 psf
C. 1,535 psf
D. 1,710 psf

81. A scaffold platform will support 6 workers averaging 200 lb each, 2,000 lb of stored material, and 180 lb of tools and equipment. What is the total design load on the platform?

A. 2,950 lb
B. 3,380 lb
C. 3,650 lb
D. 3,900 lb

82. A reshore below a freshly poured slab has a tributary area of 8.5 ft by 8.5 ft, and the slab's dead load is 105 psf. What load is transferred to this reshore, using a simplified tributary-area method?

A. 7,586 lb
B. 6,800 lb
C. 8,200 lb
D. 8,900 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 72,000 lb vertically, what minimum lateral bracing force must be provided?

A. 1,080 lb
B. 1,220 lb
C. 1,350 lb
D. 1,440 lb

84. For a braced excavation in sand with an apparent earth pressure diagram per Terzaghi-Peck, $p=0.65 \cdot K_a \cdot \gamma \cdot H$, with $K_a=0.28$, $\gamma=118$ pcf, and excavation depth $H=26$ ft, what is the peak apparent pressure?

A. 470 psf
B. 558 psf
C. 615 psf
D. 670 psf

85. A shoring analysis for a multi-level building must account for the fact that fresh concrete placed on an upper floor transfers load down through—

A. the shores on that single floor only, with no effect on floors below
B. the exterior cladding system exclusively
C. a chain of shores and reshores connecting multiple floor levels below the fresh pour
D. the building's permanent lateral bracing system only

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

A. 75 psf
B. 90 psf
C. 110 psf
D. 125 psf

87. A supported scaffold is 30 ft tall with a 6.5 ft base width. Per OSHA 29 CFR 1926 Subpart L, is this scaffold within the unrestrained height-to-base limit?

A. Yes, since 4.6:1 is below the regulatory limit
B. Yes, because base width alone determines the requirement
C. No, since 4.6:1 exceeds the 4:1 threshold requiring restraint
D. No, but only because the scaffold exceeds 25 ft in total height

88. A slab load of 145 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. 3,492 lb
B. 4,150 lb
C. 4,800 lb
D. 5,300 lb

89. A diagonal brace oriented at 38° from horizontal resists a horizontal thrust of 7,200 lb. What is the resulting axial force in the brace?

A. 7,900 lb
B. 8,500 lb
C. 9,137 lb
D. 9,800 lb

90. A 20-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. 15 ft
B. 20 ft
C. 25 ft
D. 30 ft

91. Per ASCE 37, which of the following construction-stage loads must be explicitly considered in the design of temporary structures, in addition to reduced wind loads?

A. only the dead load of permanent materials already installed

B. only seismic loads at full in-service magnitude

C. only the crane's self-weight while sitting idle

D. loads from erection equipment, construction materials storage, and out-of-plumb tolerances during erection

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

A. 75%

B. 50%

C. 60%

D. 90%

93. A shoring post has an allowable capacity of 5,000 lb at an unbraced length of 16 ft. If lateral bracing reduces the unbraced length to 8 ft, and capacity scales inversely with the square of unbraced length (Euler-type behavior), what is the new allowable capacity?

A. 20,000 lb

B. 15,000 lb

C. 25,000 lb

D. 30,000 lb

94. A braced excavation is 20 ft deep in clay with undrained shear strength $cu=1{,}300$ psf and unit weight $\gamma=122$ pcf. Using a bearing capacity factor $Nc=5.7$, what is the factor of safety against bottom heave, $FS=Nc\cdot cu/(\gamma\cdot H)$?

A. 2.6

B. 3.0
C. 3.4
D. 3.8

95. Per OSHA 29 CFR 1926 Subpart L, scaffold planking must be able to support, without failure, its own weight plus at least how many times the maximum intended load?

A. 2 times
B. 3 times
C. 2.5 times
D. 4 times

96. Per MUTCD guidance, for a temporary lane closure with a 12-ft lane width and posted speed of 35 mph (using $L=WS^2/60$ for speeds under 45 mph), what taper length is required?

A. 185 ft
B. 215 ft
C. 245 ft
D. 275 ft

97. Per OSHA 29 CFR 1926 Subpart X, a portable ladder used to access an upper landing surface must extend at least how far above that surface?

A. 2 ft
B. 3 ft
C. 4 ft
D. 5 ft

98. Per MUTCD Part 6, which temporary traffic control (TTC) zone component contains the actual work space, workers, equipment, and material storage?

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

99. If a designated competent person identifies an imminent hazard during an excavation inspection, what authority does that role carry under OSHA 29 CFR 1926?

A. the authority to file a report only, with no power to stop work
B. the authority to recommend, but not require, corrective action
C. the authority to immediately halt work in the affected area until the hazard is corrected
D. the authority to fine the contractor directly for the violation

100. Per MUTCD guidance, which scenario would most strongly favor using positive protection devices over channelizing devices alone?

A. a low-speed parking lot restriping project
B. a one-hour daytime utility locate with a flagger present
C. a rural two-lane road with negligible traffic volume
D. a high-speed urban freeway zone with extended worker traffic exposure

Practice Exam 18: Answer Key and Explanations

1. B — Rankine active pressure for a level, cohesionless backfill is $K_a = \tan^2(45° - \varphi'/2)$. With $\varphi' = 38°$, this is $\tan^2(26°) \approx 0.238$. This continues the trend of decreasing Ka with increasing friction angle, since stronger soil needs less lateral thrust to reach its active failure state and design pressure.

2. D — Primary consolidation settlement is $S_c = [C_c \cdot H/(1+e_0)] \cdot \log_{10}[(p_0+\Delta p)/p_0]$. Substituting, $S_c = (0.28 \times 4.5/1.85) \cdot \log_{10}(200/110) = 0.681 \times 0.260 \approx 0.177$ m, or 177 mm. This reflects a moderate compression index applied over a fairly thick clay layer under a substantial added stress relative to its existing overburden pressure at the site. Softer clay compressibility would further increase this settlement value.

3. A — Total stress at 11 m is $\sigma = (17\times4) + (19.5\times7) = 68 + 136.5 = 204.5$ kPa. Pore pressure develops only below the water table: $u = 9.81\times7 \approx 68.7$ kPa. Effective stress is $\sigma' = 204.5 - 68.7 \approx 136$ kPa. Option D is the total stress alone, without pore pressure subtracted.

4. C — For $\varphi = 0$ conditions, $q_{ult} = c_u \cdot N_c + q \cdot N_q$. The surcharge is $q = 18.5\times1.4 \approx 25.9$ kPa, so $q_{ult} = 55\times5.7 + 25.9\times1.0 = 313.5 + 25.9 \approx 339$ kPa. Omitting the surcharge term, as in option B, understates capacity by ignoring the confinement the overlying soil provides.

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 in the equation entirely. Here $FS = \tan(26°)/\tan(17°) = 0.488/0.306 \approx 1.60$. This ratio depends only on the friction and slope angles, not on slope height or soil unit weight.

6. C — Passive coefficient is $K_p = \tan^2(45°+\varphi'/2) = \tan^2(60.5°) \approx 3.129$. The resultant passive force is $P_p = 0.5\cdot K_p\cdot\gamma\cdot H^2 = 0.5\times3.129\times17.8\times4.2^2 \approx 490$ kN/m, acting one-third of the wall height above the base, since passive resistance grows with the square of wall height and embedment depth combined. Wall embedment depth strongly influences the magnitude of this force.

7. B — With double drainage, the drainage path length is $H_{dr} = H/2 = 3.5$ m. Time factor relates as $t = T_v\cdot H_{dr}^2/c_v = 0.197\times12.25/3.5 = 0.6895$ yr, which converts to $0.6895\times365 \approx 252$ days. Using the full 7 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 $\gamma' = 19.5-9.81 \approx 9.69$ kN/m³, giving a ratio of 0.497. Combined with $\tan(29°)/\tan(19°) \approx 1.610$, $FS \approx 0.497\times1.610 \approx 0.80$, roughly half the equivalent dry slope's factor of safety examined without seepage present. Higher friction angles would proportionally increase this safety factor value.

9. D — Curve length is $L = R\cdot\Delta(\text{radians}) = 750\times(28\times\pi/180) = 750\times0.4887 \approx 366.5$ 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 roadway curve. Sharper curves at the same radius yield shorter overall lengths.

10. C — Middle ordinate is $M = R\cdot(1-\cos(\Delta/2))$. With $\Delta/2 = 14°$, $\cos(14°) = 0.9703$, so $M = 750\times(1-0.9703) = 750\times0.0297 \approx 22.3$ ft. A sharper curve at this radius, compared to smaller deflection angles seen previously, produces a proportionally larger middle ordinate offset value. Sharper deflection angles at this radius increase this offset value.

11. A — The high point on a crest vertical curve occurs where $x = L\cdot g_1/(g_1-g_2)$. Here $x = 550\times3.0/(3.0-(-2.0)) = 1{,}650/5.0 = 330$ ft from the BVC. Because the incoming grade is steeper than the outgoing grade, this point falls past the curve's geometric midpoint of 275 ft along its length. Symmetric grades would instead place the high point at midpoint.

12. B — The long chord connecting the PC and PT is $C = 2R\cdot\sin(\Delta/2)$. With $\Delta/2 = 14°$, $\sin(14°) = 0.24192$, giving $C = 2\times750\times0.24192 \approx 362.9$ ft. As expected, this is slightly shorter than the 366.5 ft arc length computed earlier for this same curve's geometry and radius. Chord and arc lengths converge as deflection angles grow smaller.

13. A — Satellite imagery only shows surface conditions, traffic counts describe usage patterns, and a bid tabulation reflects cost information rather than physical geometry. Only test pits or exploratory excavation down to the existing pier foundation can directly and reliably confirm its actual as-built elevation and condition before new adjacent footings are designed.

14. C — Height of instrument is HI = benchmark elevation + backsight = 310.00 + 6.18 = 316.18 ft. The stake elevation is then HI minus the foresight: 316.18 − 2.87 = 313.31 ft. This differential leveling procedure carries a known elevation from the fixed benchmark out to new grade stakes across the site.

15. B — By the arc definition, degree of curve is D = 5729.58/R. With R = 750 ft, D = 5729.58/750 ≈ 7.64°. This larger degree of curve compared to the wider-radius curves examined earlier reflects a sharper, more tightly curving alignment for this particular roadway segment's design radius and geometry. Wider-radius curves would produce a correspondingly smaller degree value.

16. D — Plasticity index is PI = LL−PL = 40. The A-line value at LL=70 is 0.73×(70−20) = 36.5, and since PI=40 plots above the A-line with LL≥50, the soil classifies as CH. A PI falling below this A-line value at the same liquid limit would instead indicate an MH classification. A lower plasticity index would instead indicate a silt classification.

17. C — Water-cement ratio is the water weight divided by cement weight: 325/541.7 ≈ 0.60. This moderate ratio balances workability during placement against strength and durability requirements, and is a common target for structural concrete under normal exposure conditions without severe environmental or chemical attack concerns present at the site. Higher ratios would reduce strength but improve overall mix workability.

18. A — ASTM A588 has a minimum specified yield strength of 50 ksi, matching common A992 material, but with an alloy composition that forms a stable, protective oxide layer allowing the steel to weather without painting in many exposure conditions. This makes it popular for exposed bridge girders and other unpainted steel applications.

19. D — Adjusted design values multiply the reference value by all applicable adjustment factors: Fb' = Fb×CD×CF = 1100×0.9×1.15 ≈ 1139 psi. Permanent load duration actually reduces the design value below reference, since CD=0.9 is less than 1.0, unlike short-duration loads such as wind, which increase adjusted capacity instead of reducing it.

20. B — ASTM C143 defines the slump test, in which a cone-shaped mold of fresh concrete is filled, rodded, and then lifted, and the amount the concrete settles is measured as the slump. C39 tests hardened cylinder strength, C231 measures entrained air content, and C1064 measures fresh concrete temperature, each a distinct property.

21. D — Dry unit weight relates to void ratio and specific gravity by $\gamma d = Gs \cdot \gamma w/(1+e) = 2.72 \times 9.81/1.48 \approx 18.0$ kN/m³. This relatively low void ratio indicates a dense, well-compacted soil skeleton, producing a higher dry unit weight than the looser samples with larger void ratios examined in earlier geotechnical problems. A looser soil sample would yield a lower unit weight value.

22. C — ASTM A775 governs the epoxy coating applied to reinforcing bars to resist corrosion, typically in bridge decks and other chloride-exposed elements, but the underlying bar's minimum yield strength still follows its base grade designation. A Grade 60 bar under this coating standard retains the standard 60 ksi minimum yield strength.

23. B — The average end area method computes volume as $V = [(A1+A2)/2]\times L = [(110+175)/2]\times 160 =$ 22,800 cf. Converting to cubic yards by dividing by 27 gives approximately 844.4 cy. This remains the standard hand-calculation approach for earthwork quantity takeoff between surveyed cross sections along a roadway alignment segment. Longer segment lengths would proportionally increase this computed volume.

24. A — Unit cost estimating multiplies quantity by unit price: 2,100×$42 = $88,200. 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 compaction and gradation specification called for on this fill project. Bulk purchasing discounts could further reduce this baseline cost figure.

25. B — Present worth of a single future amount is $P = F/(1+i)^n = 450{,}000/(1.05)^4 = 450{,}000/1.2155 \approx \$370{,}200$. This single-payment present-worth factor allows costs occurring at different points in time to be compared fairly on a common present-value basis for engineering economic decision-making purposes across alternatives. Higher discount rates would further reduce this present-worth result.

26. C — Cost performance index is $CPI = EV/AC = 510{,}000/480{,}000 \approx 1.06$. 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. D — Volume is length times width times thickness: $62\times 38\times 0.58 \approx 1{,}367.1$ cf. Dividing by 27 cf per cubic yard gives approximately 50.6 cy. This slab-on-grade takeoff is routinely used to order the correct number of ready-mix truck loads and plan crew workload for the day of the scheduled pour. Thicker slab sections would proportionally increase this computed volume.

28. A — Parametric estimating multiplies a unit rate by a project parameter: 18,000 sf × $195/sf = $3,510,000. 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: $95{,}000/(52-28) = 95{,}000/24 \approx 3{,}958$ units. Below this quantity the operation runs at a loss, and above it, each additional unit contributes $24 toward covering fixed costs and, past break-even, toward genuine profit for the business. Higher fixed costs would raise this break-even threshold correspondingly.

30. A — Schedule performance index is $SPI = EV/PV = 425{,}000/395{,}000 \approx 1.08$. 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 overall project timeline and work sequence. A lower planned value would raise this schedule performance ratio.

31. D — In the CPM forward pass, early finish equals early start plus duration: EF = ES + Duration = 16 + 13 = 29. This value becomes the early start for any successor activity depending solely on this one, propagating forward through the network toward the earliest possible project completion date achievable.

32. C — PERT expected time is te = (to + 4·tm + tp)/6 = (6 + 36 + 18)/6 = 60/6 = 10.0 days. Weighting the most likely estimate four times as heavily as the optimistic and pessimistic bounds reflects the right-skewed distribution typical of real construction activity durations encountered on most projects.

33. B — Total float is the difference between late start and early start: TF = LS − ES = 24 − 15 = 9. This represents how many days the activity's start can slip without delaying the overall project completion date, assuming this float isn't shared with or consumed by other activities on the same path.

34. A — Since these activities occur sequentially with no overlap along the critical path, total duration is simply their sum: 7+10+9+12 = 38 days. The critical path is the longest chain of dependent activities through the network, and it alone sets the shortest possible achievable project completion date given these four durations.

35. D — Production rate for a linear (line-of-balance) schedule is distance divided by time: 5,400 ft / 18 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 site.

36. B — Total resource-days is the product of the number of workers and the duration: 8 workers × 12 days = 96 worker-days. This fixed labor quantity can be redistributed across different crew sizes and durations during resource leveling without changing the total amount of work actually performed on this particular task.

37. C — Crash cost slope is the change in cost divided by the change in duration: (59,000−35,000)/(16−10) = 24,000/6 = $4,000 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 the overall project schedule.

38. A — Pile locations must first be surveyed and laid out so the driving rig knows exactly where to position each pile, followed by driving the piles to their required depth or resistance, then cutting the pile heads to the design elevation, and only then casting the pile cap over the trimmed pile group.

39. C — 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) = 28 − 15 = 13. Unlike total float, this value depends only on the immediate downstream activity, not on the project's overall late-date calculations.

40. D — A delay is only safe from a scheduling standpoint if it stays within the activity's available total float; delaying it by 5 days requires that float to be at least 5 days, or the delay will push into the critical path and extend the project's overall completion date beyond its current baseline.

41. B — Relative compaction is the field dry density divided by the laboratory maximum dry density, expressed as a percentage: (112/119)×100 ≈ 94.1%. 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.

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 fresh concrete air content, each an entirely different property.

43. A — The RCSC Specification's turn-of-nut method requires progressively more rotation as bolt length increases, since longer bolts need greater elongation to reach the specified pretension across their full length. For bolts exceeding 12 diameters in length, the required rotation beyond snug-tight increases to a full turn, the largest value on the table.

44. C — The project specifications' quality control and testing section is the contract document that establishes exactly which tests are required for each material, how frequently they must be performed, and what acceptance criteria apply on the project. The other documents listed each serve an entirely different purpose unrelated to defining testing requirements.

45. C — A cold joint forms when fresh concrete is placed against concrete that has already begun to set, preventing the two placements from properly bonding and consolidating together as a monolithic mass. This creates a plane of weakness within the element that can act as a path for water infiltration and reduced structural continuity.

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 22°C difference sustained for 50 hours, $M = 22\times50 = 1{,}100$ °C-hours. This index is later compared against a mixture-specific calibration curve to estimate the concrete's in-place strength at that age and time.

47. A — Once a mixture-specific calibration curve is established, embedded temperature sensors or loggers continuously track the concrete's temperature history in real time, and this maturity index is converted through the curve into an estimated in-place strength value. Cylinder breaks are still typically retained for verification and specification acceptance purposes throughout the project.

48. B — Wet unit weight is the weight of soil removed divided by the hole volume: $3.9/0.032 \approx 121.9$ pcf. Converting to dry unit weight using the moisture content, $\gamma d = \gamma wet/(1+w) = 121.9/1.11 \approx 109.8$ pcf. This field value is compared against the laboratory Proctor curve to check 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 $w=0.4375$ in, $Rn = 0.6\times70\times0.707\times0.4375 \approx 13.0$ kip/in, between the smaller 3/8-in and larger 1/2-in weld sizes examined previously in this chapter. Smaller weld sizes proportionally reduce this per-inch capacity value.

50. A — An undersized fillet weld typically calls for adding weld metal, sometimes called back-welding or building up, to bring the weld up to its specified leg size, followed by re-inspection to confirm conformance. Silently accepting the deficiency, retroactively reducing capacity, or replacing the entire member all skip this standard corrective sequence.

51. D — The factored load combination applies separate load factors before summing: $U = 1.2(50) + 1.6(65) = 60 + 104 = 164$ 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. B — The flexure formula gives bending stress as $\sigma = M \cdot c/I = 810 \times 6.5/310 \approx 17.0$ 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 bending moment.

53. A — Axial stress is force divided by cross-sectional area: $\sigma = P/A = 105/7 = 15.0$ 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. D — Assuming a concentric load and uniform pressure distribution, bearing pressure equals load divided by footing area: $q = P/(B \times L) = 350/(8.5 \times 10.5) \approx 3.92$ 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 load. A larger footing area would proportionally reduce this bearing pressure.

55. C — Substituting directly: $q_z = 0.00256 \times 0.98 \times 1.0 \times 0.85 \times 125^2 = 0.00256 \times 0.833 \times 15{,}625 \approx 33.3$ 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 the structure's various surfaces and openings. Taller structures in rougher terrain would further raise this pressure.

56. B — Shear stress is given by the shear flow formula $\tau = VQ/(Ib) = (44{,}000 \times 41)/(760 \times 7.5) = 1{,}804{,}000/5{,}700 \approx 316$ 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. C — Slenderness ratio is KL/r, using consistent units for length. Converting L to inches: 16 ft × 12 = 192 in, so $KL/r = (1.0 \times 192)/2.4 = 80$. 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 and tables.

58. A — Factor of safety against overturning is the ratio of resisting moment to overturning moment: $FS = 780/395 \approx 1.97$. This is just below the commonly cited target range of roughly 2.0, suggesting the design should be reviewed to confirm it still meets the project's specified minimum overturning safety factor requirement.

59. D — Tributary area load is the product of tributary area and design load intensity: $26 \times 30 \times 75 = 58{,}500$ lb, or about 58.5 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 structure.

60. B — AISC 360 Chapter J covers connections, joints, and fasteners, providing the design provisions for bolts, welds, and the connecting elements that join structural members together at a joint. Chapter H addresses combined forces, Chapter F addresses flexural members alone, and Chapter D addresses tension members alone, each a distinct category.

61. C — The rational method combines runoff coefficient, rainfall intensity, and drainage area directly: $Q = C \cdot i \cdot A = 0.55 \times 2.6 \times 25 \approx 35.8$ 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: $(1.49/0.017) \times 18 \times (2.0)^{0.667} \times (0.003)^{0.5} \approx 87.6 \times 18 \times 1.588 \times 0.0548 \approx 137.2$ cfs. This relationship between channel roughness, geometry, and slope remains fundamental for sizing open channels, culverts, and storm sewers throughout civil site development and roadway drainage design work generally. Steeper channel slopes would further increase this computed flow capacity.

63. B — Substituting into the Kirpich formula: $Tc = 0.0078 \times (900)^{0.77} \times (0.018)^{-0.385} \approx 0.0078 \times 188.2 \times 4.70 \approx 6.9$ minutes. This empirical relationship estimates travel time for runoff from the hydraulically most distant point in the watershed, a key input for rational method peak flow discharge calculations in small drainage basins and watersheds. Flatter watershed slopes would substantially lengthen this computed travel time.

64. D — A simplified storage estimate is $V \approx 0.5 \times (Qin - Qout) \times duration = 0.5 \times (70 - 30) \times 6{,}300$ sec = 126,000 cf. Converting to acre-feet by dividing by 43,560 gives about 2.89 ac-ft. This preliminary approximation is typically refined afterward with detailed stage-storage-discharge routing for the final detention basin outlet design and grading plan. Longer storm durations would proportionally increase this required volume.

65. D — Velocity is flow rate divided by cross-sectional area: $V = Q/A$. With a 36-in (3-ft) diameter pipe, $A = \pi \times (1.5)^2 \approx 7.07$ sf, so $V = 25/7.07 \approx 3.5$ fps. This is within the typical self-cleansing velocity range of 2 to 3 fps or higher, helping prevent sediment buildup in the line.

66. C — Substituting into the weir formula: $Q = 2.9 \times 4.5 \times (1.6)^{1.5} = 13.05 \times 2.024 \approx 26.4$ 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. Longer crest lengths would proportionally increase this discharge capacity.

67. B — Each sling leg carries half the total load, resolved along its angle: $T = (Load/2)/\sin(angle) = 4{,}500/\sin(60°) = 4{,}500/0.866 \approx 5{,}196$ lb. This steeper 60° leg angle produces lower tension than shallower angles would for the same total load, since more of the tension acts vertically rather than horizontally in this case.

68. A — Stability against tipping depends on where the combined resultant of the machine's own weight and the suspended load falls relative to the tipping line formed by the outermost ground contact points. As long as this resultant stays within that line, the overturning moment cannot exceed the stabilizing moment, and the crane remains stable.

69. B — Dividing total required flow by per-wellpoint capacity gives $400/22 \approx 18.18$, 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 $3{,}600/28 \approx 128.6$, giving a theoretical output of $128.6\times3.5\times0.75 \approx 337.5$ cy/hr. Applying the 50/60 efficiency factor for actual working minutes reduces this to about 281 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. D — Ultimate capacity is $Qu = 2E/(S+0.1) = 2\times28{,}000/(0.3+0.1) = 56{,}000/0.4 = 140{,}000$ lb. Applying the ENR formula's typical factor of safety of 6 gives allowable capacity: $Qa = 140{,}000/6 \approx 23.3$ kip. A small set per blow like this indicates hard driving resistance and a higher allowable pile capacity. Larger driving energy inputs would proportionally raise this allowable capacity.

72. C — Applying the average end area method: $V = [(160+225)/2]\times190 = 192.5\times190 = 36{,}575$ cf. Converting to cubic yards by dividing by 27 gives about 1,354.6 cy. This method remains the standard hand-calculation approach for earthwork quantities along a linear alignment surveyed at regular cross-section intervals along its length. Longer alignment segments would proportionally increase this cut volume.

73. D — A basket hitch typically rates higher than a single vertical leg, since the sling effectively doubles up around the load, but that increased capacity is reduced as the included angle between the two legs of the basket narrows below vertical, since a narrower angle increases tension in each leg for a given load.

74. C — Horizontal radius is the boom length multiplied by the cosine of its angle from horizontal: $R = L\cdot\cos(\theta) = 110\times\cos(48°) = 110\times0.6691 \approx 73.6$ ft. This shallower boom angle produces a larger working radius relative to boom length than the steeper angles examined in earlier crane geometry problems shown previously.

75. A — Required pump capacity is the anticipated inflow multiplied by the safety factor: $130\times1.5 = 195$ 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. B — The number of trucks needed to match a loader's output equals the truck's total cycle time divided by the loader's cycle time: $32/4 = 8$ 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 cycles.

77. B — Ultimate capacity is the sum of skin friction and end bearing: Qult = Qs+Qp = 195+105 = 300 kip. Dividing by the factor of safety gives allowable capacity: Qallow = 300/2.5 = 120 kip. This static computation is typically confirmed in the field with a load test or dynamic pile driving formula check.

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: 11,000×0.90 = 9,900 cy. Soil always occupies less volume compacted into an embankment than in its natural bank state, which is why this factor stays below one.

79. D — Required pad area is the outrigger load divided by the allowable bearing pressure: 82,000/3,800 ≈ 21.6 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. C — Substituting directly: Cw = 150 + (9,000×10)/65 ≈ 150 + 1,384.6 ≈ 1,535 psf. This fast 10 ft/hr placement rate combined with cooler 65°F concrete, which sets more slowly, produces one of the higher formwork pressures examined so far in this chapter, requiring correspondingly stronger form ties and bracing. Slower placement rates would proportionally reduce this lateral pressure value.

81. B — Total design load is the sum of all anticipated loads on the platform: (6×200) + 2,000 + 180 = 1,200 + 2,000 + 180 = 3,380 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.

82. A — Tributary area load is the product of tributary area and load intensity: 8.5×8.5×105 ≈ 7,586 lb. This simplified single-level tributary method estimates the axial load carried by an individual reshore post, though detailed multi-level shoring analysis accounts for load sharing across several connected floor levels engaged below the pour. A larger tributary area would proportionally increase this transferred load.

83. D — Applying the 2% minimum lateral force provision: 0.02×72,000 = 1,440 lb. This notional lateral load accounts for out-of-plumb erection tolerances and accidental eccentricities in vertical formwork and shoring systems, and must be provided regardless of whether calculated wind or other lateral loads happen to be smaller than this baseline value.

84. B — Substituting values: p = 0.65×0.28×118×26 = 0.182×118×26 ≈ 558 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 rather than on classical earth pressure theory alone.

85. C — Because reshores are typically left in place under several previously poured floors rather than removed immediately, a fresh pour's load transfers down through a connected chain of shores and reshores spanning multiple levels below, not just the single floor directly beneath the new placement, requiring multi-level analysis rather than a single-floor check.

86. D — 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 formwork deck.

87. C — This scaffold's height-to-base ratio is $30/6.5 \approx 4.6:1$, which exceeds OSHA's 4:1 threshold above which supported scaffolds must be guyed, tied, or braced against tipping over. The requirement is triggered by this ratio itself, not by an absolute height threshold like 25 ft or by base width considered in isolation.

88. A — Total tributary load is $145\times8.5\times8.5 \approx 10{,}476$ lb. Splitting this equally among the three simultaneously engaged support levels gives $10{,}476/3 \approx 3{,}492$ 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. Fewer engaged support levels would increase each level's carried load.

89. C — The brace's axial force must have a horizontal component equal to the thrust it resists: $F\cdot\cos(38°) = 7{,}200$ lb, so $F = 7{,}200/\cos(38°) \approx 9{,}137$ 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 = $20\times1 = 20$ 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 depth.

91. D — ASCE 37 requires temporary structures and bracing to account for construction-stage loads beyond just reduced wind, including erection equipment reactions, stored construction materials, and out-of-plumb tolerances during erection. None of these loads are captured by the permanent structure's in-service dead, live, or seismic design load combinations used after completion. Ignoring these loads risks an unsafe temporary bracing design overall.

92. A — 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. A — Euler-type buckling capacity scales inversely with the square of unbraced length. Halving the length from 16 ft to 8 ft, a factor of 2, increases capacity by $2^2 = 4$ times: $5{,}000\times4 = 20{,}000$ lb. This strong sensitivity to bracing spacing is why intermediate lateral bracing so effectively boosts shoring capacity.

94. B — Substituting into the heave stability formula: $FS = (5.7\times1{,}300)/(122\times20) = 7{,}410/2{,}440 \approx 3.0$. 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.

95. D — OSHA requires scaffold planking and platform components to support their own weight plus at least four times the maximum intended load without failure. This substantial safety margin accounts for uneven load distribution, dynamic effects from workers moving on the platform, and the serious consequences of a plank failure occurring at height.

96. C — 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: $L = 12 \times 1{,}225/60 \approx 245$ ft. This formula produces a shorter taper than the L=WS formula used at highway speeds of 45 mph and above.

97. B — OSHA requires a portable ladder used to access an upper landing to extend at least 3 ft above that landing surface, giving workers a stable, secure handhold as they step from the ladder onto the platform rather than reaching or stretching awkwardly at the top rung where balance is most precarious.

98. A — The activity area is the TTC zone component that contains the actual work space where workers, equipment, and stored materials are located during construction operations. The advance warning area alerts approaching traffic beforehand, the buffer space provides a safety margin ahead of the work, and the termination area guides traffic back afterward.

99. C — OSHA's definition of a competent person specifically includes authorization from the employer to take prompt corrective action to eliminate hazards, which includes the authority to immediately halt work in the affected area until the identified hazard is corrected. This stop-work authority distinguishes a true competent person from someone who can only observe or recommend.

100. D — Positive protection devices provide physical containment against errant vehicles, a level of protection channelizing devices like cones or drums cannot offer. MUTCD guidance directs their use toward conditions combining high speed, high volume, and extended worker exposure to live traffic, exactly the profile of a long-duration high-speed urban freeway work zone.