PRACTICE EXAM 6: 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 $\varphi' = 37°$ and a level ground surface. Using Rankine theory, what is the active earth pressure coefficient Ka?

A. 0.249
B. 0.278
C. 0.302
D. 0.328

2. A 4.2 m thick normally consolidated clay layer has Cc = 0.25 and initial void ratio e0 = 0.80. The effective overburden stress is 105 kPa and a foundation adds 85 kPa. What is the primary consolidation settlement?

A. 118 mm
B. 132 mm
C. 150 mm
D. 168 mm

3. The water table is at a depth of 4.5 m. Above the water table, the moist unit weight is 16.5 kN/m³, and below it the saturated unit weight is 18.9 kN/m³. At a total depth of 12 m, what is the effective vertical stress?

A. 98 kPa
B. 116 kPa
C. 128 kPa
D. 142 kPa

4. A strip footing at 1.2 m depth bears on saturated clay (φ=0) with cu = 46 kPa. Using Terzaghi bearing capacity factors (Nc=5.7, Nq=1.0) and a surcharge unit weight of 17.8 kN/m^3, what is the ultimate bearing capacity?

A. 260 kPa
B. 284 kPa
C. 305 kPa
D. 328 kPa

5. A dry, cohesionless infinite slope has friction angle φ=28° and inclination β=19°. What is the factor of safety against sliding?

A. 1.35
B. 1.54
C. 1.68
D. 1.80

6. A 3.9 m tall wall retains cohesionless backfill with unit weight 18.4 kN/m^3 and φ'=30°. Using Rankine theory, what is the total passive resultant force per unit length of wall?

A. 345 kN/m
B. 382 kN/m
C. 420 kN/m
D. 458 kN/m

7. A doubly-drained saturated clay layer 7.2 m thick has cv = 2.6 m^2/yr. Using Tv=0.197 for 50% consolidation, how long does it take to reach 50% consolidation?

A. 285 days
B. 310 days
C. 335 days
D. 358 days

8. A submerged infinite slope of cohesionless soil ($c'=0$) has $\varphi'=30°$, slope angle $\beta=20°$, saturated unit weight $\gamma sat=19.4$ kN/m³, and $\gamma w=9.81$ kN/m³, with seepage parallel to the slope. What is the factor of safety?

A. 0.78
B. 0.85
C. 0.91
D. 0.97

9. A horizontal curve has a radius of 850 ft and a deflection angle of 25°. What is the curve length?

A. 320.4 ft
B. 345.8 ft
C. 370.9 ft
D. 398.6 ft

10. For the same curve ($R=850$ ft, $\Delta=25°$), what is the middle ordinate distance?

A. 16.8 ft
B. 20.1 ft
C. 23.6 ft
D. 26.8 ft

11. A vertical curve has an initial grade $g1=+2.6\%$ and final grade $g2=-1.4\%$ over a 380 ft curve length. How far from the BVC does the high point occur?

A. 247 ft
B. 210 ft
C. 285 ft
D. 320 ft

12. For the horizontal curve with R=850 ft and Δ=25°, what is the long chord length?

A. 335.6 ft
B. 348.2 ft
C. 358.4 ft
D. 367.9 ft

13. A dam rehabilitation project must confirm the extent of internal erosion (piping) within an earthen embankment before designing a remediation. Which method most directly provides this information?

A. satellite imagery of the dam crest
B. the original as-built construction drawings alone
C. geophysical surveys combined with exploratory borings and piezometer instrumentation
D. regional seismic hazard maps

14. A benchmark has an established elevation of 275.00 ft. A backsight rod reading of 3.82 ft is taken on the benchmark, and a foresight reading of 6.15 ft is taken to set a rough grade stake. What elevation is the stake set at?

A. 268.85 ft
B. 272.67 ft
C. 278.82 ft
D. 284.97 ft

15. What is the degree of curve (arc definition) for a horizontal curve with an 850 ft radius?

A. 5.42°
B. 5.95°
C. 6.30°
D. 6.74°

16. A fine-grained soil has a liquid limit LL=28 and plastic limit PL=17. Using the USCS plasticity chart, how should this soil be classified?

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

17. A concrete mix design specifies 305 lb/yd^3 of water and 436 lb/yd^3 of cement. What is the water-cement ratio?

A. 0.48
B. 0.55
C. 0.62
D. 0.70

18. What is the minimum specified yield strength for ASTM A709 Grade 50 steel, commonly specified for highway bridge girders?

A. 36 ksi
B. 42 ksi
C. 50 ksi
D. 65 ksi

19. A sawn lumber beam has a reference bending design value Fb=1400 psi. Applying a load duration factor CD=1.0 for normal (10-year) load duration and a size factor CF=1.05, what is the adjusted design value?

A. 1470 psi
B. 1620 psi
C. 1750 psi
D. 1890 psi

20. Fresh concrete temperature at the point of placement is measured per which ASTM standard?

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

21. A soil sample has a void ratio e=0.52 and specific gravity Gs=2.69. What is the dry unit weight, using γw=9.81 kN/m^3?

A. 13.8 kN/m^3
B. 15.2 kN/m^3
C. 16.4 kN/m^3
D. 17.4 kN/m^3

22. What is the minimum specified yield strength for ASTM A955 Grade 60 stainless steel reinforcing bars, often used in highly corrosive environments?

A. 40 ksi
B. 60 ksi
C. 75 ksi
D. 100 ksi

23. Two cross-section end areas along a roadway cut are 115 sf and 170 sf, separated by 160 ft. Using the average end area method, what is the earthwork volume in cubic yards?

A. 720.6 cy
B. 780.2 cy
C. 844.4 cy
D. 905.8 cy

24. A project requires 1,750 cy of structural fill at a unit cost of $44/cy. What is the total material cost?

A. $77,000
B. $84,500
C. $91,200
D. $98,600

25. An owner expects to spend $610,000 seven years from now on a facility upgrade. At an interest rate of 6% per year, what is the present worth of that expenditure?

A. $372,400
B. $405,700
C. $428,900
D. $452,300

26. A project has an earned value (EV) of $398,000 and actual cost (AC) of $365,000. What is the cost performance index (CPI)?

A. 0.92
B. 1.00
C. 1.09
D. 1.17

27. A concrete slab measures 42 ft by 62 ft at a thickness of 0.42 ft. What is the concrete volume in cubic yards?

A. 32.2 cy
B. 35.8 cy
C. 37.9 cy
D. 40.5 cy

28. Using a parametric cost-per-square-foot estimate of $168/sf for a 24,000 sf building, what is the estimated construction cost?

A. $4,032,000
B. $3,750,000
C. $4,300,000
D. $4,550,000

29. A production line has fixed costs of $72,000, a variable cost of $20 per unit, and sells each unit at $44. How many units must be sold to break even?

A. 2,650
B. 2,850
C. 3,000
D. 3,250

30. A schedule shows earned value EV=$318,000 and planned value PV=$295,000. What is the schedule performance index (SPI)?

A. 0.94
B. 1.08
C. 1.16
D. 0.87

31. An activity has an early start (ES) of day 14 and a duration of 10 days. What is its early finish (EF)?

A. 24
B. 27
C. 30
D. 33

32. Using the PERT three-point estimate with optimistic time to=4 days, most likely tm=6 days, and pessimistic tp=14 days, what is the expected activity duration?

A. 5.8 days
B. 6.4 days
C. 6.8 days
D. 7.0 days

33. An activity has ES=9 and LS=19. What is its total float?

A. 6
B. 10
C. 14
D. 18

34. A critical path consists of four sequential activities with durations of 9, 7, 13, and 10 days. What is the total critical path duration?

A. 30 days
B. 33 days
C. 36 days
D. 39 days

35. A paving crew completes 4,000 linear feet of curb and gutter in 16 working days. What is the crew's production rate?

A. 200 ft/day
B. 225 ft/day
C. 250 ft/day
D. 275 ft/day

36. A task requires 7 workers for 10 days. What is the total resource-days (worker-days) required for this task?

A. 70
B. 63
C. 77
D. 84

37. An activity has a normal cost of $24,000 over 11 days and a crash cost of $36,000 over 7 days. What is the crash cost per day?

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

38. In steel building erection, which of the following represents the correct order of field operations for a typical bay?

A. weld or bolt connections, plumb the frame, erect columns, then set beams
B. erect columns, set beams, plumb the frame, then bolt-up and weld connections
C. set beams, plumb the frame, erect columns, then weld connections
D. plumb the frame, erect columns, set beams, then weld connections

39. An activity has an early finish of day 19, and the earliest successor activity's early start is day 33. What is this activity's free float?

A. 8
B. 10
C. 12
D. 14

40. A construction schedule shows a resource peak during weeks 3-5 that exceeds the crew's available capacity. Shifting non-critical activities within their existing float to reduce this peak, without changing the finish date, is best described as—

A. crashing the schedule with added resources
B. fast-tracking overlapping activities out of sequence
C. resource leveling within available float, or resource smoothing
D. total float elimination across the network

41. A field density test shows a dry density of 122 pcf, while the laboratory maximum dry density (standard Proctor) is 129 pcf. What is the percent relative compaction?

A. 88.4%
B. 91.2%
C. 94.6%
D. 97.8%

42. Which ASTM standard governs obtaining and testing drilled concrete cores when cylinder breaks are disputed?

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 greater than 8 diameters but not exceeding 12 diameters, and both connected surfaces normal to the bolt axis, what nut rotation from snug-tight is required?

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

44. Which party typically has the authority to reject nonconforming work identified during a field inspection?

A. the owner's quality assurance representative or engineer of record
B. the material supplier's sales representative
C. the subcontractor performing the work being inspected
D. the equipment rental company

45. What is the primary reason for consolidating concrete around embedded conduits and inserts during placement?

A. to accelerate the curing process locally around the embedded item
B. to reduce the total amount of concrete used in the placement
C. to eliminate the need for later patching entirely
D. to eliminate voids and ensure the concrete fully encases the embedded item

46. Using the Nurse-Saul maturity function with a constant temperature-datum difference of 20°C sustained for 48 hours, what is the concrete's maturity index?

A. 820 °C-hr
B. 960 °C-hr
C. 1080 °C-hr
D. 1200 °C-hr

47. A maturity index reading alone, without a mixture-specific calibration curve, can tell a field engineer—

A. the exact compressive strength of the concrete at that time
B. whether the concrete has been properly consolidated during placement
C. only the accumulated temperature-time exposure, not an actual strength value
D. whether the correct water-cement ratio was used in the mixture

48. A sand cone field density test removes 4.0 lb of soil from a hole with a volume of 0.033 cf. The soil's moisture content is 9%. What is the dry unit weight?

A. 111.2 pcf
B. 104.6 pcf
C. 118.4 pcf
D. 125.0 pcf

49. A 3/4-in fillet weld uses E70 electrode (Fexx=70 ksi). What is its nominal strength per inch of weld length?

A. 15.8 kip/in
B. 18.2 kip/in
C. 20.1 kip/in
D. 22.3 kip/in

50. If a structural bolt is found loose during a post-tensioning inspection, what is the standard next step?

A. re-tension the bolt to the specified pretension using an approved method, then re-inspect
B. replace the entire connection regardless of the single bolt's actual condition
C. accept the connection since one loose bolt rarely governs its overall capacity
D. reduce the connection's design capacity retroactively to match the deficiency

51. A slab is designed for dead load D=40 psf and live load L=75 psf. Using the basic ASCE 7 load combination U=1.2D+1.6L, what is the factored design load?

A. 142 psf
B. 155 psf
C. 168 psf
D. 180 psf

52. A beam experiences a bending moment M=720 kip-in at a section where c=6 in and I=270 in^4. What is the extreme fiber bending stress?

A. 13.5 ksi
B. 16.0 ksi
C. 18.6 ksi
D. 21.2 ksi

53. An axially loaded member carries P=136 kip through a cross-sectional area of 8 in^2. What is the axial stress?

A. 13.5 ksi
B. 15.2 ksi
C. 17.0 ksi
D. 19.5 ksi

54. A footing carries a column load of 410 kip and measures 9 ft by 11 ft in plan. What is the resulting bearing pressure on the soil?

A. 4.14 ksf
B. 3.75 ksf
C. 3.40 ksf
D. 4.50 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 $K_z=0.90$, $K_{zt}=1.0$, $K_d=0.85$, and $V=110$ mph, what is the velocity pressure?

A. 19.8 psf
B. 23.7 psf
C. 27.4 psf
D. 30.6 psf

56. A beam has shear force $V=46$ kip, first moment of area $Q=48$ in^3, moment of inertia $I=850$ in^4, and web thickness $b=8.5$ in. What is the shear stress at that location?

A. 245 psi
B. 275 psi
C. 290 psi
D. 306 psi

57. A column has an effective length factor $K=1.0$, unbraced length $L=19$ ft, and radius of gyration $r=2.9$ in. What is the slenderness ratio KL/r?

A. 79
B. 86
C. 93
D. 100

58. A retaining wall has a resisting moment of 820 kip-ft and an overturning moment of 350 kip-ft. What is the factor of safety against overturning?

A. 1.85
B. 2.05
C. 2.20
D. 2.34

59. A column has a tributary floor area of 21 ft by 26 ft, and the floor is designed for a live load of 90 psf. What is the total live load carried by this column?

A. 42.6 kip
B. 49.1 kip
C. 54.8 kip
D. 60.2 kip

60. Which AISC 360 chapter governs the design of members subject to torsion in addition to other combined forces?

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

61. Using the rational method $Q=C \cdot i \cdot A$ with a runoff coefficient $C=0.40$, rainfall intensity $i=3.2$ in/hr, and drainage area $A=19$ acres, what is the peak discharge?

A. 20.6 cfs
B. 24.3 cfs
C. 27.8 cfs
D. 31.2 cfs

62. An open channel has Manning's $n=0.015$, flow area $A=11$ sf, hydraulic radius $R=1.3$ ft, and slope $S=0.006$. Using Manning's equation (USCS form with 1.49), what is the flow rate?

A. 100.8 cfs
B. 112.4 cfs
C. 124.6 cfs
D. 136.2 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 950 ft and slope of 0.014, what is the time of concentration?

A. 6.1 min
B. 7.0 min
C. 7.5 min
D. 7.9 min

64. A detention pond must temporarily store runoff where peak inflow is 44 cfs, allowable peak outflow is 19 cfs, and the storm duration is 2.25 hours. Using a simplified triangular hydrograph approximation, what storage volume is required?

A. 1.85 ac-ft
B. 2.10 ac-ft
C. 2.32 ac-ft
D. 2.55 ac-ft

65. A storm sewer pipe with a 20-in diameter carries a flow of 13 cfs. What is the flow velocity in the pipe, assuming it flows full?

A. 4.8 fps
B. 5.4 fps
C. 6.0 fps
D. 6.6 fps

66. A broad-crested weir outlet has a discharge coefficient C=3.2, crest length L=4 ft, and head H=1.35 ft. Using Q=C·L·H^1.5, what is the discharge through the weir?

A. 16.4 cfs
B. 20.1 cfs
C. 23.6 cfs
D. 26.2 cfs

67. A 2-leg sling supports a 9,500 lb load, with each leg oriented at 38° from horizontal. What is the tension in each leg?

A. 6,600 lb
B. 7,000 lb
C. 7,350 lb
D. 7,715 lb

68. A crane's load moment indicator (LMI) system alarms when the actual load moment approaches the machine's rated capacity. This system primarily protects against—

A. tipping over due to exceeding the crane's stability limit
B. structural failure of the boom due to metal fatigue alone
C. hydraulic fluid overheating during extended lifts
D. electrical system failures occurring in the operator's cab

69. A dewatering system must handle 230 gpm of inflow, and each wellpoint has a discharge capacity of 15 gpm. What is the minimum number of wellpoints required?

A. 12
B. 13
C. 15
D. 16

70. An excavator has a bucket capacity of 2.5 cy, a fill factor of 0.85, a cycle time of 22 seconds, and operates at 50 minutes of effective work per hour. What is its production rate?

A. 255 cy/hr
B. 290 cy/hr
C. 320 cy/hr

D. 350 cy/hr

71. Using the Engineering News Record (ENR) pile driving formula Qu=2E/(S+0.1), with driving energy E=25,000 ft-lb and set S=0.45 in per blow, and applying a factor of safety of 6, what is the allowable pile capacity?

A. 11.4 kip
B. 13.1 kip
C. 15.2 kip
D. 17.6 kip

72. Two cross-section end areas along a roadway cut are 155 sf and 210 sf, separated by 175 ft. Using the average end area method, what is the cut volume in cubic yards?

A. 1,182.9 cy
B. 1,290.4 cy
C. 1,385.6 cy
D. 1,460.2 cy

73. A wire rope sling's choker hitch derate accounts for stress concentration at the choke point. This concentration is most severe when—

A. the sling is new and fully lubricated
B. the load is centered directly beneath the hook
C. the choke angle is tight and the sling wraps sharply around the load
D. the lift height exceeds 20 feet

74. A crane boom is 120 ft long and raised to an angle of 54° from horizontal. Ignoring boom point offset, what is the resulting horizontal working radius?

A. 62.4 ft

B. 70.5 ft
C. 76.8 ft
D. 83.2 ft

75. A sump pump must handle a seepage inflow of 85 gpm, and standard practice applies a safety factor of 1.5 for pump sizing. What minimum pump capacity should be selected?

A. 95 gpm
B. 108 gpm
C. 118 gpm
D. 127.5 gpm

76. A loader has a cycle time of 2.5 minutes per load. A truck's full haul-dump-return cycle takes 17.5 minutes. How many trucks are needed to keep the loader continuously working?

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

77. A pile's static capacity analysis gives skin friction resistance Qs=185 kip and end bearing resistance Qp=110 kip. Applying a factor of safety of 2.5, what is the allowable pile capacity?

A. 98 kip
B. 118 kip
C. 132 kip
D. 146 kip

78. An embankment requires 9,000 cy of soil measured in the bank (natural, undisturbed) condition, and the borrow soil has a shrinkage factor of 0.89 relating compacted volume to bank volume. What compacted fill volume results from excavating this bank volume?

A. 6,900 cy
B. 7,500 cy
C. 8,010 cy
D. 8,600 cy

79. A crane outrigger imposes a load of 72,000 lb on the ground, and the allowable soil bearing pressure is 3,600 psf. What minimum outrigger pad area is required?

A. 14.6 sf
B. 16.8 sf
C. 18.4 sf
D. 20.0 sf

80. Using the ACI 347 formwork lateral pressure formula for columns, Cw=150+9000R/T, with a placement rate R=4 ft/hr and concrete temperature T=78°F, what is the design lateral pressure?

A. 612 psf
B. 720 psf
C. 840 psf
D. 950 psf

81. A scaffold platform will support 3 workers averaging 200 lb each, 1,100 lb of stored material, and 140 lb of tools and equipment. What is the total design load on the platform?

A. 1,520 lb
B. 1,680 lb
C. 1,840 lb
D. 2,000 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 100 psf. What load is transferred to this reshore, using a simplified tributary-area method?

A. 6,400 lb
B. 7,225 lb
C. 7,900 lb
D. 8,600 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 45,000 lb vertically, what minimum lateral bracing force must be provided?

A. 900 lb
B. 1,050 lb
C. 1,200 lb
D. 1,350 lb

84. For a braced excavation in sand with an apparent earth pressure diagram per Terzaghi-Peck, $p=0.65 \cdot Ka \cdot \gamma \cdot H$, with $Ka=0.30$, $\gamma=116$ pcf, and excavation depth $H=21$ ft, what is the peak apparent pressure?

A. 380 psf
B. 420 psf
C. 450 psf
D. 475 psf

85. A multi-story shoring and reshoring plan that omits the second reshore level below a fresh pour, when the specification requires it, most likely results in—

A. no structural consequence, since only the immediate level matters
B. overloading of the omitted level's actual load path, risking distress in that slab
C. reduced project cost with no offsetting structural risk at all
D. a faster schedule with no structural implications whatsoever

86. Absent motorized concrete buggies, what minimum combined dead and live load does ACI 347 require for horizontal formwork design?

A. 100 psf
B. 90 psf
C. 110 psf
D. 125 psf

87. A supported scaffold is 50 ft tall with a 10 ft base width. Per OSHA 29 CFR 1926 Subpart L, must this scaffold be restrained against tipping?

A. No, since 5:1 falls within acceptable engineering tolerance
B. No, restraint is optional above 40 ft in total height
C. Yes, but only if used by more than 4 workers
D. Yes, since its 5:1 ratio clearly exceeds the 4:1 threshold

88. A slab load of 150 psf acts on a 9.5 ft by 9.5 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. 3,600 lb
B. 4,050 lb
C. 4,512 lb
D. 5,100 lb

89. A diagonal brace oriented at 37° from horizontal resists a horizontal thrust of 8,000 lb. What is the resulting axial force in the brace?

A. 8,900 lb
B. 9,500 lb
C. 10,017 lb
D. 10,600 lb

90. A 9-ft-deep trench is excavated in Type A soil at OSHA's maximum allowable slope of 0.75:1 (horizontal:vertical). What is the horizontal offset at the top of the excavation, measured from the trench bottom edge?

A. 6.75 ft
B. 8.0 ft
C. 9.5 ft
D. 11.0 ft

91. Per ASCE 37, temporary bracing and shoring during a construction phase must be verified against loads corresponding to—

A. the final in-service condition only
B. that specific construction stage, not the completed structure's condition
C. the manufacturer's default assumptions only, without project-specific review
D. no verification is required for temporary construction elements

92. Vertical wall and column forms may generally be stripped earlier than horizontal slab shoring primarily because they—

A. are inspected less frequently than horizontal formwork systems
B. are always built from lighter materials than horizontal shoring
C. never require any engineering judgment before removal timing decisions
D. carry only fresh concrete's lateral pressure rather than the structure's self-weight

93. A shoring post has an allowable capacity of 4,500 lb at an unbraced length of 12 ft. If lateral bracing reduces the unbraced length to 6 ft, and capacity scales inversely with the square of unbraced length (Euler-type behavior), what is the new allowable capacity?

A. 13,500 lb
B. 15,750 lb
C. 16,900 lb

D. 18,000 lb

94. A braced excavation is 18 ft deep in clay with undrained shear strength cu=1,200 psf and unit weight γ=119 pcf. Using a bearing capacity factor Nc=5.7, what is the factor of safety against bottom heave, $FS=N_c \cdot c_u/(\gamma \cdot H)$?

A. 2.6
B. 2.9
C. 3.2
D. 3.5

95. Per OSHA 29 CFR 1926 Subpart L, a scaffold's guardrail top rail must be able to withstand a force of at least how much applied in any downward or outward direction?

A. 100 lb
B. 200 lb
C. 150 lb
D. 250 lb

96. Per MUTCD guidance, for a temporary lane closure with a 10-ft lane width and posted speed of 38 mph (using $L=WS^2/60$ for speeds under 45 mph), what taper length is required?

A. 241 ft
B. 275 ft
C. 310 ft
D. 340 ft

97. Per OSHA 29 CFR 1926 Subpart X, the maximum length permitted for a single-section portable ladder is generally—

A. 30 ft

B. 40 ft
C. 24 ft
D. 36 ft

98. Per MUTCD Part 6, which TTC zone component typically contains the longitudinal buffer space intended to reduce the consequences of a vehicle running through the taper?

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

99. The requirement that a competent person be present at an excavation site is best understood as—

A. a one-time certification with no ongoing site presence required afterward
B. an ongoing site-based responsibility requiring inspection and corrective authority throughout the work
C. a paperwork requirement satisfied by having a name listed on file
D. applicable only to excavations deeper than 20 feet

100. Per MUTCD guidance, which of the following would generally NOT be a primary factor in deciding to use positive protection devices in a work zone?

A. traffic speed at the work zone location
B. traffic volume passing through the work zone
C. duration and proximity of worker exposure to traffic
D. the manufacturer of the channelizing devices otherwise available

Practice Exam 6: Answer Key and Explanations

1. A — Rankine active pressure for a level, cohesionless backfill is $K_a = \tan^2(45° - \varphi'/2)$. With $\varphi' = 37°$, this is $\tan^2(26.5°) \approx 0.2490$. This higher friction angle produces one of the smaller Ka values among these problems, since dense, strong sand needs comparatively little lateral thrust to reach its active state.

2. C — Primary settlement is $S_c = [C_c \cdot H/(1+e_0)] \cdot \log_{10}[(p_0+\Delta p)/p_0]$. Substituting, $S_c = (0.25\times4.2/1.80)\cdot\log_{10}(190/105) = 0.583\times0.258 \approx 0.150$ m, or 150 mm. This moderate settlement reflects a typical compression index applied to a clay layer under an added stress comparable to the existing overburden pressure at the site. Softer clay compressibility would further increase this settlement estimate.

3. D — Total stress at 12 m is $\sigma = (16.5\times4.5) + (18.9\times7.5) = 74.25 + 141.75 = 216$ kPa. Pore pressure develops only below the water table: $u = 9.81\times7.5 \approx 73.6$ kPa. Effective stress is $\sigma' = 216 - 73.6 \approx 142$ kPa. Options A through C understate the value through incomplete or incorrect calculation.

4. B — For $\varphi = 0$ conditions, $q_{ult} = c_u \cdot N_c + q \cdot N_q$. The surcharge is $q = 17.8\times1.2 \approx 21.4$ kPa, so $q_{ult} = 46\times5.7 + 21.4\times1.0 = 262.2 + 21.4 \approx 284$ kPa. Omitting the surcharge term would understate ultimate capacity by ignoring the confinement the overlying soil provides at footing depth.

5. B — For a dry infinite slope of cohesionless soil, $FS = \tan\varphi/\tan\beta$, since slice weight cancels out of both driving and resisting terms. Here $FS = \tan(28°)/\tan(19°) = 0.532/0.344 \approx 1.54$. 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 $K_p = \tan^2(45°+\varphi'/2) = \tan^2(60°) = 3.0$. The resultant passive force is $P_p = 0.5\cdot K_p\cdot\gamma\cdot H^2 = 0.5\times3.0\times18.4\times3.9^2 \approx 420$ kN/m, acting one-third of the wall height above the base, since passive resistance grows with the square of wall height and backfill unit weight combined here. Wall embedment depth strongly influences the magnitude of this force.

7. D — With double drainage, the drainage path length is $H_{dr} = H/2 = 3.6$ m. Time factor relates as $t = T_v\cdot H_{dr}^2/c_v = 0.197\times12.96/2.6 \approx 0.981$ yr, which converts to $0.981\times365 \approx 358$ days. Using the full 7.2 m thickness instead of the halved drainage path would substantially overstate this required time.

8. A — With seepage parallel to the slope, $FS = (\gamma'/\gamma_{sat})\cdot(\tan\varphi'/\tan\beta)$. The buoyant unit weight is $\gamma' = 19.4-9.81 \approx 9.59$ kN/m³, giving a ratio of 0.494. Combined with $\tan(30°)/\tan(20°) \approx 1.586$, $FS \approx 0.494\times1.586 \approx 0.78$, roughly half the equivalent dry slope's factor of safety without seepage present here. Higher friction angles would proportionally increase this safety factor value.

9. C — Curve length is $L = R\cdot\Delta(\text{radians}) = 850\times(25\times\pi/180) = 850\times0.43633 \approx 370.9$ 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 lengths.

10. B — Middle ordinate is $M = R\cdot(1-\cos(\Delta/2))$. With $\Delta/2 = 12.5°$, $\cos(12.5°) = 0.97630$, so $M = 850\times(1-0.97630) = 850\times0.02370 \approx 20.1$ ft. This moderate offset reflects a curve of moderate sharpness relative to its radius, comparable to other mid-range curves examined so far. Sharper deflection angles at this radius increase this offset value.

11. A — The high point on a crest vertical curve occurs where $x = L \cdot g1/(g1-g2)$. Here $x = 380\times2.6/(2.6-(-1.4)) = 988/4.0 = 247$ ft from the BVC. Because the incoming grade is steeper than the outgoing grade, this point falls past the curve's geometric midpoint of 190 ft along its length. Symmetric grades would instead place the high point at midpoint.

12. D — The long chord connecting the PC and PT is $C = 2R\cdot\sin(\Delta/2)$. With $\Delta/2 = 12.5°$, $\sin(12.5°) = 0.21644$, giving $C = 2\times850\times0.21644 \approx 367.9$ ft. As expected, this is slightly shorter than the 370.9 ft arc length computed earlier for this same curve's geometry and radius. Chord and arc lengths converge as deflection angles grow smaller.

13. C — Satellite imagery, original drawings, and regional seismic maps each describe surface conditions or general regional context rather than the embankment's actual current internal condition. Combining geophysical surveys with exploratory borings and piezometer instrumentation directly investigates internal seepage paths, voids, and pore pressures, giving the engineer real data on the extent of piping.

14. B — Height of instrument is HI = benchmark elevation + backsight = 275.00 + 3.82 = 278.82 ft. The stake elevation is then HI minus the foresight: 278.82 − 6.15 = 272.67 ft. This differential leveling procedure carries a known elevation from the fixed benchmark out to new grade stakes across the construction site.

15. D — By the arc definition, degree of curve is $D = 5729.58/R$. With R = 850 ft, $D = 5729.58/850 \approx 6.74°$. This moderate degree of curve reflects a fairly typical arterial roadway alignment, sharper than the widest-radius curves but gentler than the tightest curves examined across these problems shown. Wider-radius curves produce a correspondingly smaller degree value here.

16. A — Plasticity index is PI = LL−PL = 11. The A-line value at LL=28 is $0.73\times(28-20) = 5.8$, and since PI=11 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. D — Water-cement ratio is the water weight divided by cement weight: $305/436 \approx 0.70$. This relatively high ratio typically indicates lower strength and durability compared to the lower ratios examined in earlier problems, though it also provides better workability, suitable for less demanding exposure conditions or lower-strength applications overall. Higher ratios reduce strength but improve overall mix workability further.

18. C — ASTM A709 Grade 50 has a minimum specified yield strength of 50 ksi and is the standard bridge-specific steel grade widely used for girders and other primary highway bridge members. A709 parallels A992 and A572 in strength but includes additional bridge-specific requirements like weldability and notch toughness testing standards. This grade replaced older A36 girders on many bridge projects.

19. A — Adjusted design values multiply the reference value by all applicable adjustment factors: $F_b' = F_b \times C_D \times C_F = 1400 \times 1.0 \times 1.05 = 1470$ psi. With the normal duration factor equal to 1.0, this is the baseline reference case against which shorter-duration loads like wind or snow would produce a further increased adjusted value overall.

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

21. D — Dry unit weight relates to void ratio and specific gravity by $\gamma_d = G_s \cdot \gamma_w/(1+e) = 2.69 \times 9.81/1.52 \approx 17.4$ kN/m³. This relatively low void ratio indicates a 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 A955 Grade 60 stainless steel reinforcing bars carry the same minimum 60 ksi yield strength as conventional A615 Grade 60 bar, but offer substantially better corrosion resistance for use in marine structures, bridge decks exposed to deicing salts, and other highly aggressive chloride environments where mild steel would corrode prematurely.

23. C — The average end area method computes volume as $V = [(A1+A2)/2] \times L = [(115+170)/2] \times 160 = 22{,}800$ 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 segment. Longer segment lengths would proportionally increase this computed volume.

24. A — Unit cost estimating multiplies quantity by unit price: 1,750×\$44 = \$77,000. This calculation is only as reliable as the underlying quantity takeoff and unit price data, both of which should reflect current market conditions and the specific fill specification called for on this particular earthwork project and site. Bulk purchasing discounts could further reduce this baseline material cost.

25. B — Present worth of a single future amount is $P = F/(1+i)^n = 610{,}000/(1.06)^7 = 610{,}000/1.5036 \approx \$405{,}700$. This single-payment present-worth factor allows costs occurring at different points in time to be compared fairly on a common present-value basis for economic decision-making purposes across alternatives being evaluated. Higher discount rates would further reduce this present-worth result.

26. C — Cost performance index is $CPI = EV/AC = 398{,}000/365{,}000 \approx 1.09$. 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: $42 \times 62 \times 0.42 \approx 1{,}093.7$ cf. Dividing by 27 cf per cubic yard gives approximately 40.5 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. Thicker slab sections would proportionally increase this computed volume.

28. A — Parametric estimating multiplies a unit rate by a project parameter: 24,000 sf × \$168/sf = \$4,032,000. 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. C — Break-even quantity equals fixed cost divided by the contribution margin per unit: $72{,}000/(44-20) = 72{,}000/24 = 3{,}000$ units exactly. 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. B — Schedule performance index is $SPI = EV/PV = 318{,}000/295{,}000 \approx 1.08$. 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. A lower planned value would raise this schedule performance ratio.

31. A — In the CPM forward pass, early finish equals early start plus duration: $EF = ES + \text{Duration} = 14 + 10 = 24$. 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 $t_e = (t_o + 4 \cdot t_m + t_p)/6 = (4 + 24 + 14)/6 = 42/6 = 7.0$ 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: $TF = LS - ES = 19 - 9 = 10$. 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: $9+7+13+10 = 39$ 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: 4,000 ft / 16 days = 250 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: 7 workers × 10 days = 70 worker-days. This fixed labor quantity can be redistributed across different crew sizes and durations during resource leveling without changing the total amount of work actually performed on this particular task.

37. A — Crash cost slope is the change in cost divided by the change in duration: $(36{,}000-24{,}000)/(11-7) = 12{,}000/4 = \$3{,}000$ 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. B — Columns must be erected first to provide vertical support points, followed by setting beams between them to form the bay, then plumbing and aligning the assembly within tolerance, and finally bolting up and welding connections to lock everything permanently in place. Welding before plumbing would prevent later alignment adjustments entirely.

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) = 33 − 19 = 14. Unlike total float, this value depends only on the immediate downstream activity, not on the project's overall late-date calculations elsewhere.

40. C — This scenario describes resource smoothing, a form of resource leveling that stays entirely within existing float and doesn't extend the project's finish date, distinguishing it from crashing, which adds resources to shorten duration, and fast-tracking, which overlaps sequential activities, both pursuing schedule compression rather than resource demand smoothing. Extending the finish date instead would be true resource leveling.

41. C — Relative compaction is the field dry density divided by the laboratory maximum dry density, expressed as a percentage: $(122/129)\times100 \approx 94.6\%$. 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 air content, each an entirely different property.

43. B — The RCSC Specification's turn-of-nut method scales required rotation with bolt length. For bolt lengths between 8 and 12 diameters, with both connected surfaces normal to the bolt axis, the required rotation beyond snug-tight is 2/3 turn, more than the 1/2 turn used for shorter bolts in this length range shown.

44. A — The owner's quality assurance representative or the engineer of record holds the contractual authority to reject nonconforming work identified during inspection, since acceptance decisions belong to the party responsible for verifying conformance with specifications. A supplier's sales representative, the performing subcontractor, or a rental company each lack this independent inspection authority.

45. D — Conduits, inserts, and other embedded items create shadow zones where fresh concrete can trap air voids or fail to fully consolidate, weakening the surrounding concrete and leaving the embedded item poorly bonded. Careful vibration around these items eliminates voids and ensures full encasement, which is essential for both structural integrity and corrosion protection.

46. B — The Nurse-Saul maturity index accumulates temperature above a datum over time: $M(t) = \Sigma(T-T0)\cdot\Delta t$. With a constant 20°C difference sustained for 48 hours, M = 20×48 = 960 °C-hours. This index is later compared against a mixture-specific calibration curve to estimate the concrete's in-place strength at that particular age and time.

47. C — Without a calibration curve linking maturity index to compressive strength for the specific mixture, a maturity reading only tells the engineer the concrete's accumulated temperature-time exposure, a raw number with no direct strength meaning on its own. Consolidation quality and water-cement ratio aren't captured by temperature history alone, regardless of calibration.

48. A — Wet unit weight is the weight of soil removed divided by the hole volume: 4.0/0.033 ≈ 121.2 pcf. Converting to dry unit weight using the moisture content, $\gamma d = \gamma wet/(1+w) = 121.2/1.09 \approx 111.2$ pcf. This field value is compared against the laboratory Proctor curve to check the relative compaction achieved.

49. D — 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=0.75 in, Rn = 0.6×70×0.707×0.75 ≈ 22.3 kip/in, the largest fillet weld size examined among all weld problems across these exams so far shown. Smaller weld sizes proportionally reduce this per-inch capacity value.

50. A — A loose bolt found during inspection is re-tensioned to the specified pretension using an approved method, such as turn-of-nut or a calibrated wrench, and then re-inspected to confirm proper tension has been achieved. Replacing the entire connection, silently accepting the deficiency, or retroactively reducing capacity all skip this standard corrective step.

51. C — The factored load combination applies separate load factors before summing: U = 1.2(40) + 1.6(75) = 48 + 120 = 168 psf. The larger factor applied to live load reflects its greater variability relative to dead load, and this combination typically governs strength design under ordinary gravity-only loading conditions for buildings.

52. B — The flexure formula gives bending stress as $\sigma = M\cdot c/I = 720\times6/270 = 16.0$ 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 moment.

53. C — Axial stress is force divided by cross-sectional area: $\sigma = P/A = 136/8 = 17.0$ ksi. This uniform distribution assumes the load passes through the section's centroid; any eccentricity would introduce additional bending stress that must be superimposed on this baseline axial value to find the true combined total stress condition.

54. A — Assuming a concentric load and uniform pressure distribution, bearing pressure equals load divided by footing area: q = P/(B×L) = 410/(9×11) ≈ 4.14 ksf. This value must be checked against the soil's allowable bearing capacity from a geotechnical report to confirm the footing is adequately sized for this applied load.

55. B — Substituting directly: $q_z = 0.00256 \times 0.90 \times 1.0 \times 0.85 \times 110^2 = 0.00256 \times 0.765 \times 12{,}100 \approx 23.7$ 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 $\tau = VQ/(Ib) = (46{,}000 \times 48)/(850 \times 8.5) = 2{,}208{,}000/7{,}225 \approx 306$ 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. A — Slenderness ratio is KL/r, using consistent units for length. Converting L to inches: 19 ft × 12 = 228 in, so $KL/r = (1.0 \times 228)/2.9 \approx 79$. 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. D — Factor of safety against overturning is the ratio of resisting moment to overturning moment: $FS = 820/350 \approx 2.34$. 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. B — Tributary area load is the product of tributary area and design load intensity: $21 \times 26 \times 90 = 49{,}140$ lb, or about 49.1 kip. This tributary area approach assumes the column collects load from half the distance to each adjacent column line, a standard simplification for gravity load distribution in a framed structure.

60. C — AISC 360 Chapter H covers members under combined forces and torsion, providing the interaction equations used when a member experiences torsion together with axial load, bending, or shear. Chapter D covers tension members alone, Chapter F covers flexural members alone, and Chapter I covers composite members, none addressing torsion directly.

61. B — The rational method combines runoff coefficient, rainfall intensity, and drainage area directly: $Q = C \cdot i \cdot A = 0.40 \times 3.2 \times 19 \approx 24.3$ 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: $(1.49/0.015) \times 11 \times (1.3)^{0.667} \times (0.006)^{0.5} \approx 99.3 \times 11 \times 1.191 \times 0.0775 \approx 100.8$ cfs. This relationship between channel roughness, geometry, and slope remains fundamental for sizing open channels, culverts, and storm sewers throughout civil design work generally performed by practicing civil engineers. Steeper channel slopes would further increase this computed flow capacity.

63. D — Substituting into the Kirpich formula: $T_c = 0.0078 \times (950)^{0.77} \times (0.014)^{-0.385} \approx 0.0078 \times 196.2 \times 5.17 \approx 7.9$ 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 this particular drainage basin. Flatter watershed slopes would substantially lengthen this computed travel time.

64. C — A simplified storage estimate is $V \approx 0.5\times(Q_{in}-Q_{out})\times\text{duration} = 0.5\times(44-19)\times 8{,}100$ sec = 101,250 cf. Converting to acre-feet by dividing by 43,560 gives about 2.32 ac-ft. This preliminary approximation is typically refined afterward with detailed stage-storage-discharge routing for the final detention basin design. Longer storm durations would proportionally increase this required volume.

65. C — Velocity is flow rate divided by cross-sectional area: $V = Q/A$. With a 20-in (1.667-ft) diameter pipe, $A = \pi\times(0.833)^2 \approx 2.18$ sf, so $V = 13/2.18 \approx 6.0$ 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. B — Substituting into the weir formula: $Q = 3.2\times4\times(1.35)^{1.5} = 12.8\times1.569 \approx 20.1$ cfs. This head-discharge relationship follows a power-law form across the operating depth range above the crest, and is commonly applied to outlet structures that control release rates from detention and retention basins on developed sites overall. Longer crest lengths would proportionally increase this discharge capacity.

67. D — Each sling leg carries half the total load, resolved along its angle: $T = (\text{Load}/2)/\sin(\text{angle}) = 4{,}750/\sin(38°) = 4{,}750/0.6157 \approx 7{,}715$ lb. This shallow 38-degree angle produces one of the highest leg tensions examined across these rigging problems, since so much of the tension acts horizontally rather than vertically here.

68. A — A load moment indicator continuously calculates the actual overturning moment created by the suspended load at its current radius and compares it against the crane's rated stability limit, alarming before that limit is exceeded. This directly protects against tipping, not fatigue, hydraulic overheating, or electrical failures, which are separate maintenance concerns entirely.

69. D — Dividing total required flow by per-wellpoint capacity gives $230/15 \approx 15.33$, which must be rounded up to 16 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. B — Cycles per hour at full time is $3{,}600/22 \approx 163.6$, giving a theoretical output of $163.6\times2.5\times0.85 \approx 347.7$ cy/hr. Applying the 50/60 efficiency factor for actual working minutes reduces this to about 290 cy/hr, reflecting realistic production once operational delays are properly accounted for on the job site. Higher fill factors would further increase this hourly production rate.

71. C — Ultimate capacity is $Q_u = 2E/(S+0.1) = 2\times25{,}000/(0.45+0.1) = 50{,}000/0.55 \approx 90{,}909$ lb. Applying the ENR formula's typical factor of safety of 6 gives allowable capacity: $Q_a = 90{,}909/6 \approx 15.2$ kip. This moderate set per blow gives a mid-range allowable capacity compared to other pile examples shown here. Larger driving energy inputs would proportionally raise this allowable capacity.

72. A — Applying the average end area method: $V = [(155+210)/2]\times175 = 182.5\times175 \approx 31{,}937.5$ cf. Converting to cubic yards by dividing by 27 gives about 1,182.9 cy. This method remains the standard hand-calculation approach for earthwork quantities along a linear alignment surveyed at regular cross-section intervals. Longer alignment segments would proportionally increase this cut volume.

73. C — Stress concentration at the choke point grows worse as the choke angle tightens and the sling wraps more sharply around the load, since a sharper bend radius increases localized stress in the wire rope. Sling condition, load centering, and lift height don't drive this specific mechanism the way the choke angle itself does.

74. B — Horizontal radius is the boom length multiplied by the cosine of its angle from horizontal: $R = L \cdot \cos(\theta) = 120 \times \cos(54°) = 120 \times 0.5878 \approx 70.5$ ft. This moderately steep boom angle produces a working radius that falls between the shallower and steeper angle examples examined in earlier crane geometry problems shown.

75. D — Required pump capacity is the anticipated inflow multiplied by the safety factor: $85 \times 1.5 = 127.5$ 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. A — The number of trucks needed to match a loader's output equals the truck's total cycle time divided by the loader's cycle time: $17.5/2.5 = 7$ trucks. This ensures a truck is arriving to load just as the previous one departs full, keeping the loader continuously productive rather than sitting idle between successive hauling cycles.

77. B — Ultimate capacity is the sum of skin friction and end bearing: $Q_{ult} = Q_s + Q_p = 185 + 110 = 295$ kip. Dividing by the factor of safety gives allowable capacity: $Q_{allow} = 295/2.5 = 118$ 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: $9{,}000 \times 0.89 = 8{,}010$ 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: $72{,}000/3{,}600 = 20.0$ 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. A — Substituting directly: $C_w = 150 + (9{,}000 \times 4)/78 \approx 150 + 461.5 \approx 612$ psf. This slower 4 ft/hr placement rate combined with warmer 78°F concrete, which sets faster, produces one of the lower formwork pressures examined across these problems, allowing lighter form ties and bracing for this particular pour and schedule.

81. C — Total design load is the sum of all anticipated loads on the platform: $(3 \times 200) + 1{,}100 + 140 = 600 + 1{,}100 + 140 = 1{,}840$ lb. This total must be checked against the scaffold's rated capacity for its assigned duty classification before workers and materials occupy the platform simultaneously during construction operations.

82. B — Tributary area load is the product of tributary area and load intensity: $8.5 \times 8.5 \times 100 \approx 7{,}225$ 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. A — Applying the 2% minimum lateral force provision: $0.02 \times 45{,}000 = 900$ 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. D — Substituting values: $p = 0.65 \times 0.30 \times 116 \times 21 = 0.195 \times 116 \times 21 \approx 475$ psf. The Terzaghi-Peck apparent pressure diagram is an empirical envelope rather than an actual triangular distribution, developed specifically for designing the struts and wales in braced excavation systems based on observed field pressures at similar sites and depths shown. Deeper excavations proportionally increase this peak apparent pressure value.

85. B — Load from a fresh pour is designed to redistribute down through every specified shore and reshore level below it, and omitting a required level forces that load onto a different path than the design assumed, risking overloading and structural distress in the slab meant to be protected by that omitted reshore level.

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

87. D — This scaffold's height-to-base ratio is $50/10 = 5:1$, well above OSHA's 4:1 threshold that triggers a mandatory guying, tying, or bracing requirement for supported scaffolds. There is no engineering tolerance exception, no 40-ft optional rule, and worker count doesn't factor into this ratio-based restraint requirement at all under this provision.

88. C — Total tributary load is $150 \times 9.5 \times 9.5 \approx 13{,}537.5$ lb. Splitting this equally among the three simultaneously engaged support levels gives $13{,}537.5/3 \approx 4{,}512$ lb per level. Actual shoring analysis typically uses stiffness-based distribution rather than an equal split, but this simplified method gives a reasonable preliminary estimate for review. Fewer engaged support levels would increase each level's carried load.

89. C — The brace's axial force must have a horizontal component equal to the thrust it resists: $F \cdot \cos(37°) = 8{,}000$ lb, so $F = 8{,}000/\cos(37°) \approx 10{,}017$ 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. A — A 0.75:1 slope means the horizontal offset equals 0.75 times the vertical depth: offset = depth×slope ratio = $9 \times 0.75 = 6.75$ ft. OSHA 29 CFR 1926 Subpart P permits this steepest slope, requiring the least excavated width, only for the most stable Type A soil classification found on a site.

91. B — ASCE 37 specifically requires temporary bracing and shoring to be verified against the loads applicable to that particular construction stage, since the structure's condition, applied loads, and available lateral resistance differ substantially from its final completed condition. Skipping this stage-specific verification could leave the temporary system inadequately designed for actual conditions.

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

93. D — Euler-type buckling capacity scales inversely with the square of unbraced length. Halving the length from 12 ft to 6 ft, a factor of 2, increases capacity by $2^2 = 4$ times: $4{,}500 \times 4 = 18{,}000$ lb. This strong sensitivity to bracing spacing is why intermediate lateral bracing so effectively boosts shoring post capacity.

94. C — Substituting into the heave stability formula: $FS = (5.7 \times 1{,}200)/(119 \times 18) = 6{,}840/2{,}142 \approx 3.2$. This factor of safety against basal heave in soft to medium clay is a critical check for deep braced excavations, since inadequate resistance can cause the excavation floor to rise and destabilize the surrounding bracing system. Weaker clay strength would proportionally reduce this safety factor.

95. B — OSHA requires scaffold guardrail top rails to withstand a force of at least 200 lb applied in any downward or outward direction without failure, ensuring the rail can actually arrest a worker who stumbles or leans against it. A rail rated for less than this force wouldn't reliably prevent a fall over the edge.

96. A — For posted speeds under 45 mph, MUTCD taper length is $L = WS^2/60$, where W is the offset width in feet and S is the posted speed in mph: $L = 10 \times 1{,}444/60 \approx 241$ ft. This formula produces a shorter taper than the $L=WS$ formula used at highway speeds of 45 mph and above.

97. A — Common practice and manufacturer guidance under OSHA's portable ladder provisions generally limit a single-section portable ladder to about 30 ft in length, since longer single-section ladders become unwieldy to transport, position, and use safely without excessive flex or instability during climbing, favoring multi-section extension ladders instead for greater heights. Physical handling limits, not just code minimums, drive this practice.

98. C — The buffer space is positioned between the transition area and the activity area specifically to provide a recovery zone, reducing the consequences if a vehicle fails to negotiate the taper and continues into the work zone before reaching the actual activity area. The other components serve earlier or later purposes in the sequence.

99. B — OSHA's competent person requirement is an ongoing, site-based responsibility, requiring daily inspections and after any hazard-increasing event, along with the authority to take prompt corrective action throughout the excavation work, not a one-time certification, paperwork exercise, or a rule limited to excavations exceeding an arbitrary depth threshold like 20 feet.

100. D — MUTCD guidance bases the positive protection decision on engineering factors: traffic speed, traffic volume, and the duration and proximity of worker exposure to passing traffic. Which manufacturer's channelizing devices happen to be available is a procurement detail entirely unrelated to this safety-driven engineering determination and plays no role in it.