PRACTICE EXAM 15: 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 $\varphi' = 30°$ and a level ground surface. Using Rankine theory, what is the active earth pressure coefficient Ka?

A. 0.500
B. 0.407
C. 0.373
D. 0.333

2. A 4 m thick normally consolidated clay layer has Cc = 0.30 and initial void ratio e0 = 0.90. The effective overburden stress is 100 kPa and a foundation adds 100 kPa. What is the primary consolidation settlement?

A. 150 mm
B. 190 mm
C. 220 mm
D. 260 mm

3. The water table is at the ground surface, and the saturated unit weight of soil below is 19 kN/m³. At a depth of 10 m, what is the effective vertical stress?

A. 190 kPa

B. 98 kPa

C. 92 kPa

D. 288 kPa

4. A strip footing at 1.5 m depth bears on saturated clay (φ=0) with cu = 50 kPa. Using Terzaghi bearing capacity factors (Nc=5.7, Nq=1.0) and a surcharge unit weight of 18 kN/m³, what is the ultimate bearing capacity?

A. 312 kPa

B. 285 kPa

C. 339 kPa

D. 258 kPa

5. A dry, cohesionless infinite slope has friction angle φ=32° and inclination β=25°. What is the factor of safety against sliding?

A. 1.19

B. 1.34

C. 1.52

D. 1.68

6. A 3 m tall wall retains cohesionless backfill with unit weight 18 kN/m³ and φ'=30°. Using Rankine theory, what is the total passive resultant force per unit length of wall?

A. 81 kN/m

B. 162 kN/m

C. 202 kN/m

D. 243 kN/m

7. A doubly-drained saturated clay layer 4 m thick has cv = 2 m²/yr. Using Tv=0.197 for 50% consolidation, how long does it take to reach 50% consolidation?

A. 144 days
B. 197 days
C. 288 days
D. 394 days

8. A submerged infinite slope of cohesionless soil ($c'=0$) has $\varphi'=30°$, slope angle $\beta=20°$, saturated unit weight $\gamma sat=20$ kN/m³, and $\gamma w=10$ kN/m³, with seepage parallel to the slope. What is the factor of safety?

A. 0.62
B. 0.71
C. 0.79
D. 0.91

9. A horizontal curve has a radius of 800 ft and a deflection angle of 24°. What is the curve length?

A. 290.4 ft
B. 335.1 ft
C. 378.6 ft
D. 402.1 ft

10. For the same curve ($R=800$ ft, $\Delta=24°$), what is the middle ordinate distance?

A. 10.2 ft
B. 14.6 ft
C. 17.5 ft
D. 21.3 ft

11. A vertical curve has an initial grade $g1=+2\%$ and final grade $g2=-3\%$ over a 600 ft curve length. How far from the BVC does the high point occur?

A. 240 ft
B. 300 ft
C. 360 ft
D. 200 ft

12. For the horizontal curve with R=800 ft and Δ=24°, what is the long chord length?

A. 290.1 ft
B. 310.5 ft
C. 321.8 ft
D. 332.7 ft

13. During a construction site investigation adjacent to an occupied building, which method is most appropriate for locating existing subsurface utilities before excavation begins?

A. boring logs from the original site geotechnical report alone
B. a visual walk-through survey of surface features only
C. electrical resistivity testing of the native soil
D. ground-penetrating radar combined with utility locating and potholing

14. A benchmark has an established elevation of 100.00 ft. A backsight rod reading of 5.62 ft is taken on the benchmark, and a foresight reading of 3.15 ft is taken to set a rough grade stake. What elevation is the stake set at?

A. 97.53 ft
B. 102.47 ft
C. 108.77 ft
D. 100.00 ft

15. What is the degree of curve (arc definition) for a horizontal curve with an 800 ft radius?

A. 5.73°
B. 6.44°
C. 7.16°
D. 8.02°

16. A fine-grained soil has a liquid limit LL=45 and plastic limit PL=25. 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 280 lb/yd^3 of water and 560 lb/yd^3 of cement. What is the water-cement ratio?

A. 0.35
B. 0.42
C. 0.50
D. 0.65

18. What is the specified minimum tensile strength Fu for ASTM A992 structural steel, commonly used in wide-flange shapes?

A. 65 ksi
B. 50 ksi
C. 58 ksi
D. 70 ksi

19. A sawn lumber beam has a reference bending design value Fb=1200 psi. Applying a load duration factor CD=1.25 for snow load and a size factor CF=1.1, what is the adjusted design value?

A. 1200 psi
B. 1320 psi
C. 1500 psi
D. 1650 psi

20. According to ASTM C39, at what standard age are concrete cylinder compressive strength specimens typically tested to determine f'c for acceptance?

A. 7 days
B. 28 days
C. 56 days
D. 90 days

21. A soil sample has a void ratio $e=0.65$ and specific gravity $G_s=2.68$. What is the dry unit weight, using $\gamma_w=9.81$ kN/m³?

A. 15.9 kN/m³
B. 13.2 kN/m³
C. 18.4 kN/m³
D. 20.6 kN/m³

22. A structural drawing specifies Grade 60 reinforcing steel per ASTM A615. What is the minimum specified yield strength?

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

23. Two cross-section end areas along a roadway cut are 120 sf and 160 sf, separated by 100 ft. Using the average end area method, what is the earthwork volume in cubic yards?

A. 420.0 cy
B. 518.5 cy
C. 610.2 cy
D. 700.0 cy

24. A project requires 2,500 cy of concrete at a unit cost of $145/cy. What is the total material cost?

A. $275,000
B. $312,500
C. $362,500
D. $410,000

25. An owner expects to spend $500,000 five years from now on a facility upgrade. At an interest rate of 8% per year, what is the present worth of that expenditure?

A. $275,000
B. $298,500
C. $315,800
D. $340,290

26. A project has an earned value (EV) of $450,000 and actual cost (AC) of $500,000. What is the cost performance index (CPI)?

A. 0.75
B. 0.83
C. 0.90
D. 1.11

27. A concrete slab measures 40 ft by 60 ft at a thickness of 0.5 ft. What is the concrete volume in cubic yards?

A. 32.0 cy
B. 44.4 cy
C. 55.6 cy
D. 66.7 cy

28. Using a parametric cost-per-square-foot estimate of $185/sf for a 20,000 sf building, what is the estimated construction cost?

A. $3,700,000
B. $3,200,000
C. $4,100,000
D. $4,450,000

29. A production line has fixed costs of $50,000, a variable cost of $15 per unit, and sells each unit at $35. How many units must be sold to break even?

A. 1,667
B. 2,000
C. 2,500
D. 3,333

30. A schedule shows earned value EV=$380,000 and planned value PV=$340,000. What is the schedule performance index (SPI)?

A. 0.89
B. 0.97
C. 1.05
D. 1.12

31. An activity has an early start (ES) of day 10 and a duration of 8 days. What is its early finish (EF)?

A. 16
B. 18
C. 20
D. 22

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. 7.0 days
B. 8.0 days
C. 6.3 days
D. 7.7 days

33. An activity has ES=10, EF=16 (duration 6), and LS=22, LF=28. What is its total float?

A. 4
B. 6
C. 9
D. 12

34. A critical path consists of four sequential activities with durations of 5, 8, 6, and 9 days. What is the total critical path duration?

A. 20 days
B. 28 days
C. 34 days
D. 40 days

35. A paving crew completes 2,400 linear feet of curb and gutter in 12 working days. What is the crew's production rate?

A. 200 ft/day
B. 150 ft/day
C. 175 ft/day
D. 225 ft/day

36. A task requires 5 workers for 8 days. What is the total resource-days (worker-days) required for this task?

A. 24
B. 32
C. 40
D. 48

37. An activity has a normal cost of $20,000 over 10 days and a crash cost of $32,000 over 6 days. What is the crash cost per day?

A. $3,000
B. $2,400
C. $3,600
D. $4,200

38. In cast-in-place concrete construction sequencing, which of the following represents the correct order of field operations?

A. pour, form, reinforce, strip
B. reinforce, pour, form, strip
C. form, reinforce, pour, strip
D. strip, form, pour, reinforce

39. An activity has an early finish of day 13, and the earliest successor activity's early start is day 25. What is this activity's free float?

A. 4
B. 6
C. 9
D. 12

40. Resource leveling that shifts non-critical activities within their available float to smooth labor demand, without extending the project's overall completion date, is possible only when—

A. the activity is on the critical path
B. the activity has float remaining that hasn't yet been consumed
C. the resource pool is unconstrained
D. the project uses a linear schedule

41. A field density test shows a dry density of 118 pcf, while the laboratory maximum dry density (standard Proctor) is 124 pcf. What is the percent relative compaction?

A. 88.7%
B. 91.4%
C. 95.2%
D. 98.6%

42. Which standard test method measures the workability and consistency of fresh concrete in the field?

A. ASTM C143 slump test
B. ASTM C39 compressive strength
C. ASTM C231 air content
D. ASTM C1064 temperature

43. For a 3/4-in ASTM A325 high-strength bolt installed by the turn-of-nut method in a slip-critical connection, with both connected surfaces normal to the bolt axis and a bolt length not exceeding four diameters, what nut rotation from snug-tight is required?

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

44. In a construction QA/QC program, which party typically performs independent third-party materials testing and inspection to verify specification conformance?

A. the general contractor's superintendent
B. an accredited independent testing laboratory
C. the project's design engineer of record
D. the owner's insurance carrier

45. According to standard concrete placement practice, what is the generally recommended maximum free-fall drop height for placing concrete without a chute or tremie, to avoid segregation?

A. 1 ft
B. 5 ft
C. 10 ft
D. 15 ft

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. 480 °C-hr
B. 640 °C-hr
C. 800 °C-hr
D. 960 °C-hr

47. The maturity method for estimating early-age concrete strength requires which of the following before it can be used to predict in-place strength?

A. a strength-maturity calibration curve developed for the specific mixture
B. a minimum 56-day cylinder break
C. a core sample from every placement
D. a rebound hammer calibration only

48. A sand cone field density test removes 3.2 lb of soil from a hole with a volume of 0.026 cf. The soil's moisture content is 12%. What is the dry unit weight?

A. 95.6 pcf
B. 102.3 pcf
C. 109.9 pcf
D. 118.4 pcf

49. A 5/16-in fillet weld uses E70 electrode (Fexx=70 ksi). What is its nominal strength per inch of weld length?

A. 6.5 kip/in
B. 9.3 kip/in
C. 12.1 kip/in
D. 14.8 kip/in

50. When a placed concrete element fails to meet the specified compressive strength based on 28-day cylinder breaks, what is the standard next step in the QA/QC process before rejection or acceptance is decided?

A. extract and test cores from the in-place element per ASTM C42
B. automatically reject and demolish the element without any further verification testing
C. accept the element without further testing or any additional verification
D. reduce the specified strength retroactively to match the observed cylinder break

51. A slab is designed for dead load D=40 psf and live load L=60 psf. Using the basic ASCE 7 load combination U=1.2D+1.6L, what is the factored design load?

A. 100 psf
B. 124 psf
C. 144 psf
D. 160 psf

52. A beam experiences a bending moment $M=600$ kip-in at a section where $c=6$ in and $I=200$ in^4. What is the extreme fiber bending stress?

A. 9 ksi
B. 12 ksi
C. 15 ksi
D. 18 ksi

53. An axially loaded member carries $P=90$ kip through a cross-sectional area of 6 in^2. What is the axial stress?

A. 15.0 ksi
B. 18.5 ksi
C. 22.0 ksi
D. 25.5 ksi

54. A footing carries a column load of 300 kip and measures 8 ft by 10 ft in plan. What is the resulting bearing pressure on the soil?

A. 2.50 ksf
B. 3.75 ksf
C. 4.60 ksf
D. 5.20 ksf

55. Using the simplified ASCE 7 velocity pressure equation $q_z=0.00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2$, with $K_z=0.85$, $K_{zt}=1.0$, $K_d=0.85$, and $V=115$ mph, what is the velocity pressure?

A. 14.8 psf
B. 18.3 psf
C. 21.5 psf
D. 24.5 psf

56. A beam has shear force V=40 kip, first moment of area Q=45 in^3, moment of inertia I=800 in^4, and web thickness b=8 in. What is the shear stress at that location?

A. 150 psi
B. 210 psi
C. 281 psi
D. 340 psi

57. A column has an effective length factor K=1.0, unbraced length L=15 ft, and radius of gyration r=2.5 in. What is the slenderness ratio KL/r?

A. 72
B. 86
C. 94
D. 108

58. A retaining wall has a resisting moment of 850 kip-ft and an overturning moment of 380 kip-ft. What is the factor of safety against overturning?

A. 1.65
B. 1.95
C. 2.24
D. 2.58

59. A column has a tributary floor area of 20 ft by 24 ft, and the floor is designed for a live load of 100 psf. What is the total live load carried by this column?

A. 28 kip
B. 36 kip
C. 42 kip
D. 48 kip

60. For a compact wide-flange beam-column subject to combined axial compression and flexure under AISC Chapter H, which interaction equation governs when $P_r/P_c \geq 0.2$?

A. H1-1b
B. H1-1a
C. H1-2
D. H1-3

61. Using the rational method $Q=C\cdot i\cdot A$ with a runoff coefficient $C=0.35$, rainfall intensity $i=3.2$ in/hr, and drainage area $A=15$ acres, what is the peak discharge?

A. 9.4 cfs
B. 12.6 cfs
C. 14.7 cfs
D. 16.8 cfs

62. An open channel has Manning's $n=0.013$, flow area $A=12$ sf, hydraulic radius $R=1.5$ ft, and slope $S=0.005$. Using Manning's equation (USCS form with 1.49), what is the flow rate?

A. 78.5 cfs
B. 102.3 cfs
C. 127.4 cfs
D. 156.8 cfs

63. Using the Kirpich equation $T_c=0.0078\cdot L^{0.77}\cdot S^{-0.385}$ (L in ft, S in ft/ft), with a flow path length of 800 ft and slope of 0.02, what is the time of concentration?

A. 4.2 min
B. 6.0 min
C. 8.3 min
D. 10.6 min

64. A detention pond must temporarily store runoff where peak inflow is 45 cfs, allowable peak outflow is 20 cfs, and the storm duration is 2 hours. Using a simplified triangular hydrograph approximation, what storage volume is required?

A. 2.07 ac-ft
B. 2.85 ac-ft
C. 3.42 ac-ft
D. 4.10 ac-ft

65. A storm sewer pipe with a 24-in diameter carries a flow of 15 cfs. What is the flow velocity in the pipe, assuming it flows full?

A. 3.2 fps
B. 4.8 fps
C. 6.1 fps
D. 7.4 fps

66. A broad-crested weir outlet has a discharge coefficient C=3.1, crest length L=4 ft, and head H=1.2 ft. Using Q=C·L·H^1.5, what is the discharge through the weir?

A. 9.8 cfs
B. 13.1 cfs
C. 16.3 cfs
D. 19.6 cfs

67. A 2-leg sling supports an 8,000 lb load, with each leg oriented at 45° from horizontal. What is the tension in each leg?

A. 5,657 lb
B. 4,800 lb
C. 6,400 lb
D. 7,200 lb

68. A mobile crane's load chart lists a maximum capacity of 40,000 lb at a 20-ft working radius on fully extended outriggers. If the required lift radius increases to 30 ft, what happens to the crane's safe lifting capacity?

A. it remains the same, since capacity is independent of radius
B. it increases due to a longer boom moment arm
C. it stays within 5% due to load chart tolerances
D. it decreases substantially, since capacity falls as radius increases

69. A dewatering system must handle 250 gpm of inflow, and each wellpoint has a discharge capacity of 15 gpm. What is the minimum number of wellpoints required?

A. 12
B. 14
C. 17
D. 20

70. An excavator has a bucket capacity of 2.5 cy, a fill factor of 0.85, a cycle time of 25 seconds, and operates at 50 minutes of effective work per hour. What is its production rate?

A. 180 cy/hr
B. 210 cy/hr
C. 235 cy/hr
D. 255 cy/hr

71. Using the Engineering News Record (ENR) pile driving formula Qu=2E/(S+0.1), with driving energy E=24,000 ft-lb and set S=0.5 in per blow, and applying a factor of safety of 6, what is the allowable pile capacity?

A. 13.3 kip
B. 18.6 kip
C. 22.4 kip
D. 26.7 kip

72. Two cross-section end areas along an embankment are 200 sf and 260 sf, separated by 150 ft. Using the average end area method, what is the fill volume in cubic yards?

A. 985.2 cy
B. 1,277.8 cy
C. 1,450.6 cy
D. 1,620.3 cy

73. When a wire rope sling is rigged in a choker hitch configuration rather than a vertical (straight) hitch, the rated capacity is typically—

A. unchanged from the vertical rating
B. reduced to about 75–80% of the vertical rating
C. increased due to friction grip on the load
D. reduced by half regardless of the choke angle

74. A crane boom is 100 ft long and raised to an angle of 60° from horizontal. Ignoring boom point offset, what is the resulting horizontal working radius?

A. 35 ft
B. 42 ft
C. 50 ft
D. 58 ft

75. A sump pump must handle a seepage inflow of 80 gpm, and standard practice applies a safety factor of 1.5 for pump sizing. What minimum pump capacity should be selected?

A. 120 gpm
B. 100 gpm
C. 140 gpm
D. 160 gpm

76. A loader has a cycle time of 3 minutes per load. A truck's full haul-dump-return cycle takes 18 minutes. How many trucks are needed to keep the loader continuously working?

A. 3
B. 4
C. 5
D. 6

77. A pile's static capacity analysis gives skin friction resistance Qs=150 kip and end bearing resistance Qp=90 kip. Applying a factor of safety of 2.5, what is the allowable pile capacity?

A. 96 kip
B. 108 kip
C. 120 kip
D. 132 kip

78. An embankment requires 10,000 cy of soil measured in the bank (natural, undisturbed) condition, and the borrow soil has a shrinkage factor of 0.85 relating compacted volume to bank volume. What compacted fill volume results from excavating this bank volume?

A. 7,200 cy
B. 7,900 cy
C. 8,500 cy
D. 9,200 cy

79. A crane outrigger imposes a load of 60,000 lb on the ground, and the allowable soil bearing pressure is 4,000 psf. What minimum outrigger pad area is required?

A. 10 sf
B. 15 sf
C. 20 sf
D. 25 sf

80. Using the ACI 347 formwork lateral pressure formula for columns, $C_w=150+9000R/T$, with a placement rate $R=6$ ft/hr and concrete temperature $T=70°F$, what is the design lateral pressure?

A. 480 psf
B. 650 psf
C. 790 psf
D. 921 psf

81. A scaffold platform will support 3 workers averaging 200 lb each, 1,200 lb of stored masonry material, and 150 lb of tools and equipment. What is the total design load on the platform?

A. 1,500 lb
B. 1,650 lb
C. 1,800 lb
D. 1,950 lb

82. A reshore below a freshly poured slab has a tributary area of 8 ft by 8 ft, and the slab's dead load is 100 psf. What load is transferred to this reshore, using a simplified tributary-area method?

A. 6,400 lb
B. 5,200 lb
C. 7,600 lb
D. 8,800 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 50,000 lb vertically, what minimum lateral bracing force must be provided?

A. 500 lb
B. 750 lb
C. 1,000 lb
D. 1,250 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 $K_a=0.33$, $\gamma=115$ pcf, and excavation depth $H=24$ ft, what is the peak apparent pressure?

A. 410 psf
B. 592 psf
C. 680 psf
D. 745 psf

85. When sequencing a multi-story concrete building, the shoring and reshoring design must ensure that the cumulative load transferred to a lower slab does not exceed—

A. that slab's actual in-place strength at the time of loading, accounting for early-age gain
B. the slab's specified 28-day design strength regardless of age
C. the shore manufacturer's rated capacity only
D. the formwork contractor's assumed safety factor only

86. Per ACI 347 guidance, what is the minimum required design value for the combined dead and live load on horizontal formwork, regardless of computed values, when motorized buggies are not used?

A. 50 psf
B. 75 psf
C. 90 psf

D. 100 psf

87. A supported scaffold is 32 ft tall with a base width of 6 ft. Per OSHA 29 CFR 1926 Subpart L, at what height-to-base-width ratio must a scaffold generally be restrained (guyed, tied, or braced) against tipping?

A. 2:1
B. 3:1
C. 4:1
D. 6:1

88. A slab load of 150 psf acts on a 10 ft by 10 ft tributary area, and the load is assumed to split equally among three engaged support levels (one shore and two reshores). What load does each level carry, using this simplified method?

A. 3,750 lb
B. 5,000 lb
C. 6,250 lb
D. 7,500 lb

89. A diagonal brace oriented at 40° from horizontal resists a horizontal thrust of 8,000 lb. What is the resulting axial force in the brace?

A. 10,443 lb
B. 9,200 lb
C. 11,600 lb
D. 12,800 lb

90. A 12-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. 8 ft
B. 12 ft
C. 16 ft
D. 18 ft

91. During steel erection, temporary bracing must be designed to resist which loads in addition to the permanent lateral system's in-service loads, per ASCE 37?

A. dead load only, without any allowance for wind or erection equipment
B. occupant live load only, excluding all temporary construction-phase loading conditions
C. construction loads, including wind, erection equipment, and out-of-plumb effects during the construction stage
D. seismic loads at the full in-service level only, ignoring construction-phase demands

92. Per common practice guided by ACI 347, formwork and shoring supporting a concrete slab may generally be removed once the in-place concrete has attained what minimum percentage of its specified 28-day compressive strength, absent a specific engineering analysis?

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

93. A shoring post has an allowable capacity of 8,000 lb at an unbraced length of 10 ft. If lateral bracing reduces the unbraced length to 5 ft, and capacity scales inversely with the square of unbraced length (Euler-type behavior), what is the new allowable capacity?

A. 32,000 lb
B. 16,000 lb
C. 24,000 lb
D. 40,000 lb

94. A braced excavation is 15 ft deep in clay with undrained shear strength cu=1,200 psf and unit weight γ=120 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. 2.1
B. 3.8
C. 4.6
D. 5.4

95. Per OSHA 29 CFR 1926 Subpart P, at what excavation depth does a protective system (sloping, shoring, or shielding) generally become required, absent stable rock conditions?

A. 3 ft
B. 4 ft
C. 4.5 ft
D. 5 ft

96. Per MUTCD guidance, for a temporary lane closure with a 12-ft lane width and posted speed of 55 mph (using L=WS for speeds at or above 45 mph), what taper length is required?

A. 480 ft
B. 570 ft
C. 660 ft
D. 750 ft

97. Per OSHA 29 CFR 1926 Subpart M, at what height above a lower level must fall protection generally be provided for construction workers on a walking or working surface?

A. 4 ft
B. 5 ft
C. 8 ft
D. 6 ft

98. Per MUTCD Part 6, what is the primary purpose of a temporary traffic control (TTC) zone's termination area?

A. to store construction equipment and materials overnight during an extended multi-day closure
B. to allow traffic to return to its normal path and geometry after passing the work area
C. to provide flagger staging only, separate from the approach and departure tapers
D. to house the buffer space vehicle only, separate from the termination taper itself

99. Under OSHA 29 CFR 1926 Subpart P, who is required to inspect an excavation daily and after any event that could increase hazards, such as a rainstorm, and has authority to stop work?

A. the excavation subcontractor's project manager
B. the owner's representative
C. a designated competent person
D. the site safety consultant, only if retained

100. Per MUTCD guidance, positive protection devices, such as concrete barrier, rather than channelizing devices alone are generally warranted in work zones with—

A. high-speed, high-volume traffic with significant exposure to workers and errant vehicles
B. low-speed residential streets only, with minimal traffic volume or exposure
C. daytime-only lane closures with flaggers present at all times
D. any closure under 24 hours regardless of speed

Practice Exam 15: Answer Key and Explanations

1. D — Rankine active pressure for a level, cohesionless backfill is $K_a = \tan^2(45° - \varphi'/2)$. With $\varphi' = 30°$, this is $\tan^2(30°) = 0.333$. The other options come from misapplying the half-angle or confusing active with passive geometry. This coefficient is the standard starting point for wall pressure and force calculations.

2. B — Primary consolidation settlement is $S_c = [C_c \cdot H/(1+e_0)] \cdot \log_{10}[(p_0+\Delta p)/p_0]$. Substituting the given values, $S_c = (0.30\times4/1.90)\cdot\log_{10}(200/100) = 0.632\times0.301 \approx 0.190$ m, or 190 mm. Smaller distractors typically come from omitting the $(1+e_0)$ denominator or misreading the stress ratio inside the logarithm. This one-dimensional consolidation formula governs long-term settlement of foundations on normally consolidated clay.

3. C — Total stress at 10 m is $\sigma = 19\times10 = 190$ kPa. Pore pressure with the water table at the surface is $u = 9.81\times10 = 98.1$ kPa. Effective stress is $\sigma' = \sigma - u = 190 - 98.1 \approx 92$ kPa. Options A and B are the total stress and pore pressure alone, not the effective value.

4. A — For $\varphi = 0$ conditions, $q_{ult} = c_u \cdot N_c + q \cdot N_q$. The surcharge is $q = 18\times1.5 = 27$ kPa, so $q_{ult} = 50\times5.7 + 27\times1.0 = 285 + 27 = 312$ kPa. Option B omits the surcharge term entirely, understating capacity. Including both cohesion and overburden terms is required for a correct Terzaghi solution.

5. B — For a dry infinite slope of cohesionless soil, $FS = \tan\varphi/\tan\beta$, since both the driving and resisting forces scale directly with slice weight. Here $FS = \tan(32°)/\tan(25°) = 0.625/0.466 = 1.34$. This ratio applies regardless of slope height because weight terms cancel out, leaving only the friction and slope angles.

6. D — Passive coefficient is $K_p = \tan^2(45°+\varphi'/2) = \tan^2(60°) = 3.0$. The resultant passive force is $P_p = 0.5\cdot K_p\cdot\gamma\cdot H^2 = 0.5\times3.0\times18\times3^2 = 243$ kN/m, acting one-third of the wall height up from the base. This triangular pressure distribution mirrors active pressure geometry but uses the larger passive coefficient, since passive resistance always exceeds active resistance for the same soil.

7. A — With double drainage, the drainage path length is $H_{dr} = H/2 = 2$ m. Time factor relates as $t = T_v\cdot H_{dr}^2/c_v = 0.197\times4/2 = 0.394$ yr, which converts to $0.394\times365 \approx 144$ days. Using the full thickness instead of the halved drainage path would overstate the time, as in option D.

8. C — With seepage parallel to the slope, $FS = (\gamma'/\gamma_{sat})\cdot(\tan\varphi'/\tan\beta)$. The buoyant unit weight is $\gamma' = 20-10 = 10$ kN/m³, giving a ratio of 0.5. Combined with $\tan(30°)/\tan(20°) = 1.586$, $FS = 0.5\times1.586 \approx 0.79$. Submergence roughly halves the safety factor compared to the dry case, reflecting reduced effective stress.

9. B — Curve length is $L = R\cdot\Delta(\text{radians}) = 800\times(24\times\pi/180) = 800\times0.41888 = 335.1$ ft. This arc-based formula is standard for circular horizontal curve layout in roadway design, giving the actual station-to-station distance a vehicle travels along the curve. Failing to convert the deflection angle from degrees to radians would produce a value far outside this plausible range.

10. C — Middle ordinate is $M = R\cdot(1-\cos(\Delta/2))$. With $\Delta/2 = 12°$, $\cos(12°) = 0.9781$, so $M = 800\times(1-0.9781) = 800\times0.0219 = 17.5$ ft. This represents the offset between the curve's midpoint and the long chord, and is used by field crews when checking sight distance or fitting a curve into constrained right-of-way width.

11. A — The high (or low) point on a vertical curve occurs where $x = L\cdot g_1/(g_1-g_2)$. Here $x = 600\times2/(2-(-3)) = 1200/5 = 240$ ft from the BVC. This is not the curve's midpoint because the grades are unequal; the high point shifts toward the flatter incoming grade in a crest curve.

12. D — The long chord connecting the PC and PT is $C = 2R\cdot\sin(\Delta/2)$. With $\Delta/2 = 12°$, $\sin(12°) = 0.2079$, giving $C = 2×800×0.2079 = 332.7$ ft. The chord is always slightly shorter than the arc length calculated for this same curve, since it cuts directly across rather than following the curved path between the two endpoints.

13. D — Boring logs and visual surveys don't reliably show buried utility locations, and resistivity testing addresses soil properties rather than utility mapping. Subsurface utility engineering practice combines ground-penetrating radar with electromagnetic locating and vacuum excavation (potholing) to confirm horizontal and vertical position before digging, minimizing the risk of utility strikes during construction.

14. B — Height of instrument is HI = benchmark elevation + backsight = 100.00 + 5.62 = 105.62 ft. The stake elevation is then HI minus the foresight: 105.62 − 3.15 = 102.47 ft. This differential leveling procedure is the standard field method for transferring a known benchmark elevation out to construction grade stakes across a project site.

15. C — By the arc definition, degree of curve is $D = 5729.58/R$. With R = 800 ft, D = 5729.58/800 = 7.16°. Degree of curve expresses radius in terms of the central angle subtended by a 100-ft arc, a convention still common in US highway and rail alignment design for describing curve sharpness.

16. A — Plasticity index is PI = LL−PL = 20. The A-line value at LL=45 is 0.73×(45−20) = 18.3, and since PI=20 plots above the A-line with LL<50, the soil classifies as CL. Falling below the A-line would indicate a silt (ML/MH), and LL≥50 would push it toward the high-plasticity CH group.

17. C — Water-cement ratio is simply the water weight divided by cement weight: 280/560 = 0.50. This ratio is the single most influential factor governing hardened concrete strength and permeability, with lower ratios generally producing higher strength and better durability at the expense of workability, which is why superplasticizing admixtures are often used to compensate when a low ratio is specified.

18. A — ASTM A992 specifies a minimum yield strength Fy of 50 ksi and a minimum tensile strength Fu of 65 ksi, along with a maximum yield-to-tensile ratio. This grade became the default specification for hot-rolled wide-flange (W-shape) members after replacing A36 as the standard structural steel grade for most building framing.

19. D — Adjusted design values are found by multiplying the reference value by all applicable adjustment factors: Fb' = Fb×CD×CF = 1200×1.25×1.1 = 1650 psi. Skipping either the load duration factor or the size factor, as in the smaller distractor options, understates the member's true adjusted bending capacity under this specific snow-load loading condition and member size combination.

20. B — ASTM C39 governs the compression testing procedure, and standard practice tests concrete cylinders at 28 days to determine the specified compressive strength f'c used for project acceptance. Seven-day breaks are commonly taken as an early indicator of the strength gain trend, but they are not the age used for final specification acceptance under most project specifications.

21. A — Dry unit weight relates to void ratio and specific gravity by $\gamma d = Gs\cdot\gamma w/(1+e) = 2.68×9.81/1.65 = 15.9$ kN/m^3. This phase relationship connects the solids' specific gravity and the void space present in the soil skeleton, and is fundamental to converting between index properties such as void ratio, porosity, and unit weight in routine geotechnical calculations.

22. D — ASTM A615 Grade 60 reinforcing bars have a minimum specified yield strength of 60 ksi, which has become the most common grade for cast-in-place concrete reinforcement in the United States. Grade 40 bars are still available for smaller applications, while Grade 75 and higher grades are used where reduced bar congestion is desired.

23. B — The average end area method computes volume as $V = [(A1+A2)/2]\times L = [(120+160)/2]\times 100 = 14{,}000$ cf. Converting to cubic yards by dividing by 27 gives 518.5 cy. This method is the standard hand-calculation approach for earthwork quantity takeoff between surveyed cross sections along a linear roadway alignment, and remains widely used despite modern digital terrain modeling tools.

24. C — Unit cost estimating simply multiplies quantity by unit price: 2,500×\$145 = \$362,500. This unit-cost method is the most common approach for pricing bid items with well-established market rates, and its accuracy depends entirely on the reliability of the quantity takeoff and how current the unit price data is relative to prevailing material and labor market conditions.

25. D — Present worth of a single future amount is $P = F/(1+i)^n = 500{,}000/(1.08)^5 = 500{,}000/1.4693 = \$340{,}290$. This single-payment present-worth factor is a core engineering economics tool for comparing costs and benefits that occur at different points in time on a common present-value basis, accounting for the time value of money over the analysis period.

26. C — Cost performance index is $CPI = EV/AC = 450{,}000/500{,}000 = 0.90$. A CPI below 1.0 indicates the project is spending more than the value of work actually completed, signaling a cost overrun trend. Option D inverts the ratio (AC/EV), which would mistakenly suggest the project is under budget when it is actually running over its planned cost.

27. B — Volume is length times width times thickness: $40\times 60\times 0.5 = 1{,}200$ cf. Dividing by 27 cf per cubic yard gives 44.4 cy. This straightforward quantity takeoff calculation for a slab-on-grade is a routine part of estimating concrete material needs, ordering ready-mix truck loads, and scheduling the placement crew and finishing operations for the pour.

28. A — Parametric estimating multiplies a unit rate by a project parameter: 20,000 sf × \$185/sf = \$3,700,000. This method is useful in early conceptual design when detailed quantities aren't yet available, trading precision for speed, and its reliability depends on how well the historical cost-per-square-foot data matches the current project's scope.

29. C — Break-even quantity equals fixed cost divided by the contribution margin per unit: $50{,}000/(35-15) = 50{,}000/20 = 2{,}500$ units. Below this quantity the project operates at a loss, and above it, each additional unit contributes \$20 toward profit. This is a standard engineering economic analysis tool used for resource selection and production-volume decisions.

30. D — Schedule performance index is $SPI = EV/PV = 380{,}000/340{,}000 = 1.118$, rounding to 1.12. An SPI above 1.0 indicates the project is ahead of its planned schedule, since more value has been earned than was planned for this point in time. This earned-value metric complements CPI in tracking overall project health.

31. B — In the CPM forward pass, early finish equals early start plus duration: EF = ES + Duration = 10 + 8 = 18. This calculation propagates forward through the network, with each successor activity's early start equal to the largest early finish among its predecessors, ultimately establishing the project's overall early completion date.

32. A — PERT expected time is te = (to + 4·tm + tp)/6 = (4 + 24 + 14)/6 = 42/6 = 7.0 days. Weighting the most likely estimate four times more heavily than the optimistic and pessimistic bounds accounts for the typically skewed distribution of activity durations seen in construction scheduling.

33. D — Total float is the difference between late and early start (or equivalently, late and early finish): TF = LS − ES = 22 − 10 = 12, which matches LF − EF = 28 − 16 = 12. An activity with this much float can slip up to 12 days without delaying the overall project.

34. B — Since these activities occur sequentially along the critical path with no overlap, the total duration is simply their sum: 5+8+6+9 = 28 days. The critical path represents the longest chain of dependent activities through the network and directly determines the shortest possible overall project duration, since any delay along this chain delays the entire project finish.

35. A — Production rate for a linear schedule, or line-of-balance method, is simply distance divided by time: 2,400 ft / 12 days = 200 ft/day. This rate becomes the slope of the crew's line on a time-distance diagram and is used to plan crew sequencing and check for conflicts between successive repetitive-unit activities on a linear construction project.

36. C — Total resource-days is the product of the number of workers and the duration: 5 workers × 8 days = 40 worker-days. This quantity is a key input to resource leveling analysis, since it represents fixed labor demand that can be redistributed across the available float without changing total required effort.

37. A — Crash cost slope is the change in cost divided by the change in duration: (32,000−20,000)/(10−6) = 12,000/4 = $3,000 per day. This slope identifies the cheapest activities to compress first when performing time-cost trade-off analysis to shorten a project's overall duration at the minimum added cost, which is central to schedule acceleration decisions.

38. C — Formwork must be erected first to contain the concrete, followed by placing reinforcing steel inside the formed cavity, then pouring concrete against the rebar and forms, and finally stripping the formwork once the concrete has gained adequate strength. Any other order is not physically constructible in the field and would compromise the finished structural element.

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) = 25 − 13 = 12. Unlike total float, free float doesn't depend on the project's overall late dates, only on the immediate downstream activity.

40. B — Resource leveling relies on shifting activities inside their existing slack; critical path activities have zero float by definition and can't absorb a shift without delaying the finish date. Only activities that still retain unused float can be moved earlier or later within that window, smoothing peak resource demand without extending the overall project completion date.

41. C — Relative compaction is the field dry density divided by the laboratory maximum dry density, expressed as a percentage: $(118/124)\times100 = 95.2\%$. Most earthwork specifications require a minimum of 90 to 95% relative compaction depending on the application, making this comparison a routine field acceptance check during embankment or backfill placement.

42. A — ASTM C143 defines the slump test, which measures the consistency and workability of freshly mixed concrete by observing how far a molded cone of concrete settles after the mold is removed. C39 tests hardened cylinder strength, C231 measures entrained air content, and C1064 measures fresh concrete temperature, each a different property.

43. D — The RCSC Specification's turn-of-nut method requires 1/3 turn beyond snug-tight for bolts of this length range when both faces are normal to the bolt axis. Required rotation increases with bolt length or when surfaces are sloped, since more elongation is needed to develop the specified pretension across a longer bolt.

44. B — Independence from the installing contractor is central to credible quality assurance, so accredited independent testing laboratories are typically retained to sample and test materials like concrete, soil, and steel. The superintendent manages field operations, the engineer of record reviews design conformance, and the insurance carrier plays no direct testing role.

45. B — Common industry guidance limits unassisted free-fall of fresh concrete to about 5 ft, beyond which the coarse aggregate tends to separate from the mortar, producing segregation and honeycombing in the finished element. Greater drop heights require a tremie, elephant trunk, or pump line to control the concrete's fall and preserve mix uniformity throughout the placement.

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 20°C difference sustained for 48 hours, $M = 20\times48 = 960$ °C-hours. This index is then compared against a strength-maturity calibration curve for the specific mixture to estimate in-place concrete strength at any given time during curing.

47. A — The maturity method only converts a measured temperature history into an estimated strength if a calibration curve relating maturity index to compressive strength has first been developed for that specific concrete mixture. Without this mixture-specific curve, the maturity index alone carries no predictive strength value, regardless of how it is measured.

48. C — Wet unit weight is the weight of soil removed divided by the hole volume: $3.2/0.026 = 123.1$ pcf. Converting to dry unit weight using the moisture content, $\gamma d = \gamma wet/(1+w) = 123.1/1.12 = 109.9$ pcf. This field result is then compared against the laboratory Proctor curve to check relative compaction.

49. B — Nominal fillet weld strength per unit length is $Rn = 0.6\cdot Fexx\cdot0.707\cdot w$, where 0.707 converts the leg size to the effective throat dimension. With $Fexx=70$ ksi and $w=5/16$ in, $Rn = 0.6\times70\times0.707\times0.3125 = 9.28$ kip/in. This is the base metal-independent capacity used in AISC weld design before applying the specified resistance factors and load combinations.

50. A — Cylinder breaks are an indirect proxy for in-place strength, so a low result triggers core extraction and testing per ASTM C42 to directly evaluate the actual concrete in the structure before any acceptance or rejection decision. Immediate demolition or blanket acceptance both skip this essential verification step required by practice.

51. C — The factored load combination applies separate load factors to each load type before summing: $U = 1.2(40) + 1.6(60) = 48 + 96 = 144$ psf. This combination reflects the greater variability typically associated with live loads compared to dead loads, and governs strength design under most gravity-only loading scenarios.

52. D — The flexure formula gives bending stress as $\sigma = M \cdot c/I = 600 \times 6/200 = 18$ ksi. This stress occurs at the extreme fiber, the distance c from the neutral axis, and represents the maximum normal stress in the cross-section due to bending, before any adjustment for shear or combined loading effects.

53. A — Axial stress is simply force divided by cross-sectional area: $\sigma = P/A = 90/6 = 15.0$ ksi. This uniform stress distribution assumes the load is applied concentrically 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 stress state.

54. B — Assuming a concentric load with uniform pressure distribution, bearing pressure equals load divided by footing area: $q = P/(B \times L) = 300/(8 \times 10) = 3.75$ ksf. This value must be checked against the soil's allowable bearing capacity, obtained from geotechnical testing, to confirm the footing is adequately sized for the applied column load without excessive settlement.

55. D — Substituting directly into the formula: $q_z = 0.00256 \times 0.85 \times 1.0 \times 0.85 \times 115^2 = 0.00256 \times 0.7225 \times 13{,}225 \approx 24.5$ psf. This velocity pressure is then multiplied by pressure coefficients specific to the building's geometry, height, and exposure category to determine actual design wind pressures acting on each surface of the structure, including walls, roof, and openings, per ASCE 7 provisions.

56. C — Shear stress is given by the shear flow formula $\tau = VQ/(Ib) = (40{,}000 \times 45)/(800 \times 8) = 1{,}800{,}000/6{,}400 = 281$ psi. This formula gives the shear stress at a horizontal plane within the section, which is generally maximum at the neutral axis where Q is largest, and drops to zero at the extreme fibers.

57. A — Slenderness ratio is KL/r, using consistent units for length. Converting L to inches: 15 ft × 12 = 180 in, so $KL/r = (1.0 \times 180)/2.5 = 72$. This ratio governs whether a column's strength is controlled by inelastic buckling (lower slenderness) or elastic Euler buckling (higher slenderness) under AISC Chapter E.

58. C — Factor of safety against overturning is the ratio of resisting moment to overturning moment: $FS = 850/380 = 2.24$. This exceeds the commonly required minimum of about 1.5 to 2.0 for overturning stability, confirming the wall's geometry and self-weight provide adequate resistance to the lateral pressure driving rotation about the toe.

59. D — Tributary area load is the product of tributary area and design load intensity: $20 \times 24 \times 100 = 48{,}000$ lb, or 48 kip. This tributary area approach assumes the column collects load from half the distance to each adjacent column line in both directions, a standard simplification for distributing gravity loads across a framed building's structural system.

60. B — AISC 360 Chapter H uses two interaction equations depending on the axial load ratio: H1-1a governs when $P_r/P_c \geq 0.2$, giving full weight to both axial and bending terms, while H1-1b applies at lower axial ratios and reduces the axial term's influence. This distinction reflects how axial load dominance affects failure.

61. D — The rational method combines runoff coefficient, rainfall intensity, and drainage area directly: $Q = C \cdot i \cdot A = 0.35 \times 3.2 \times 15 = 16.8$ cfs, with units arranged so that acres and in/hr combine to give cfs directly without additional conversion factors. This method remains the standard peak-flow estimate used for small drainage areas in storm sewer and culvert design.

62. C — Manning's equation is $Q = (1.49/n) \cdot A \cdot R^{(2/3)} \cdot S^{(1/2)}$. Substituting the given values: $(1.49/0.013) \times 12 \times (1.5)^{0.667} \times (0.005)^{0.5} = 114.6 \times 12 \times 1.310 \times 0.0707 \approx 127.4$ cfs. This empirical formula relates channel geometry, roughness, and slope to open-channel flow capacity, and is fundamental to storm sewer, culvert, and open-channel sizing calculations throughout civil design practice for drainage systems and roadside ditches.

63. B — Substituting into the Kirpich formula: $T_c = 0.0078 \times (800)^{0.77} \times (0.02)^{-0.385} = 0.0078 \times 172.1 \times 4.51 \approx 6.0$ minutes. This empirical relationship estimates the time for runoff to travel from the hydraulically most distant point in the watershed to the point of interest, a key input required for rational method peak flow discharge calculations in small-watershed design.

64. A — A simplified storage estimate is $V \approx 0.5 \times (Q_{in} - Q_{out}) \times \text{duration} = 0.5 \times (45 - 20) \times 7{,}200 \text{ sec} = 90{,}000$ cf. Converting to acre-feet by dividing by 43,560 gives 2.07 ac-ft. This approximation serves as a preliminary sizing check, with detailed stage-storage-discharge routing typically used afterward to refine the final detention basin design, outlet structure, and emergency spillway sizing.

65. B — Velocity is flow rate divided by cross-sectional area: $V = Q/A$. With a 24-in (2-ft) diameter pipe, $A = \pi \times (1)^2 = 3.14$ sf, so $V = 15/3.14 \approx 4.8$ fps. This velocity should be checked against minimum self-cleansing velocity criteria, typically 2 to 3 fps, to prevent sediment deposition in the pipe.

66. C — Substituting into the weir formula: $Q = 3.1 \times 4 \times (1.2)^{1.5} = 12.4 \times 1.3145 \approx 16.3$ cfs. Weir outlet structures like this are commonly used to control discharge from detention and retention ponds, with the head-discharge relationship following this power-law form across a defined range of flow depths above the crest elevation of the structure.

67. A — Each sling leg carries half the total load, resolved along its angle: $T = (\text{Load}/2)/\sin(\text{angle}) = 4{,}000/\sin(45°) = 4{,}000/0.7071 = 5{,}657$ lb. As sling angle from horizontal decreases, leg tension increases sharply for the same vertical load, which is why rigging references generally require staying above roughly 45 degrees whenever practical for a lift.

68. D — Crane capacity is governed by the overturning moment the machine and its outriggers can resist, and moment increases directly with radius for a given load. As radius grows, rated capacity must drop to keep the resulting tipping moment within stability limits, which is why load charts always show declining capacity with radius.

69. C — Dividing total required flow by per-wellpoint capacity gives $250/15 = 16.67$, which must be rounded up to 17 wellpoints since a fractional wellpoint cannot be installed, and the system must have adequate capacity to handle the full anticipated inflow with reasonable margin for variability in the surrounding soil and groundwater conditions encountered.

70. D — Cycles per hour at full time is $3{,}600/25 = 144$, giving a theoretical output of $144 \times 2.5 \times 0.85 = 306$ cy/hr. Applying the 50/60 efficiency factor for actual working minutes per hour reduces this to $306 \times (50/60) \approx 255$ cy/hr, reflecting realistic production accounting for operational delays, minor stoppages, and interruptions during the shift.

71. A — Ultimate capacity is $Qu = 2E/(S+0.1) = 2 \times 24{,}000/(0.5+0.1) = 48{,}000/0.6 = 80{,}000$ lb. Applying the ENR formula's typical factor of safety of 6 gives the allowable capacity: $Qa = 80{,}000/6 \approx 13.3$ kip. Dynamic formulas like ENR provide a quick field check, though static analysis or load testing is more reliable.

72. B — Applying the average end area method: $V = [(200+260)/2] \times 150 = 230 \times 150 = 34{,}500$ cf. Converting to cubic yards by dividing by 27 gives 1,277.8 cy. This same method used earlier for cut volumes applies equally to fill quantities, forming the basis for mass-haul diagram development during earthwork balancing and haul route planning.

73. B — A choker hitch bends the sling body sharply around itself where it grips the load, concentrating stress and reducing efficiency compared to a straight vertical pull. Rigging references typically derate a choker hitch to roughly 75 to 80% of the sling's vertical rated capacity, with further reduction as the choke angle sharpens.

74. C — Horizontal radius is the boom length multiplied by the cosine of the angle from horizontal: $R = L \cdot \cos(\theta) = 100 \times \cos(60°) = 100 \times 0.5 = 50$ ft. As the boom angle increases toward vertical, the working radius shrinks, which is why load charts pair boom angle with radius when specifying safe lift capacities.

75. A — Required pump capacity is the anticipated inflow multiplied by the safety factor: $80 \times 1.5 = 120$ gpm. This margin accounts for fluctuations in groundwater inflow, pump wear over time, and intermittent surges, ensuring the dewatering system maintains a dry excavation even under conditions somewhat more severe than the baseline design estimate assumed at the outset.

76. D — The number of trucks needed to match a loader's output equals the truck's total cycle time divided by the loader's cycle time: $18/3 = 6$ trucks. This ensures a truck is always arriving at the loading point as the previous one departs, keeping the loader continuously productive rather than idling while waiting.

77. A — Ultimate capacity is the sum of skin friction and end bearing: Qult = Qs+Qp = 150+90 = 240 kip. Dividing by the factor of safety gives the allowable capacity: Qallow = 240/2.5 = 96 kip. Static analysis methods like this are typically verified in the field with load tests or dynamic pile driving formulas.

78. C — With the shrinkage factor defined as compacted volume divided by bank volume, the resulting compacted volume is bank volume multiplied by the shrinkage factor: 10,000×0.85 = 8,500 cy. Soil compacted in an embankment occupies less volume than it did in its natural bank state, which is why this factor is always less than one.

79. B — Required pad area is the outrigger load divided by the allowable bearing pressure: 60,000/4,000 = 15 sf. Undersized outrigger pads risk punching through soft ground or causing excessive differential settlement under one outrigger, which can destabilize the crane during a lift, so this bearing check is a standard part of crane setup planning on site.

80. D — Substituting directly: Cw = 150 + (9,000×6)/70 = 150 + 771.4 = 921.4 psf. This formula reflects that faster placement rates and cooler concrete, which sets more slowly, both increase the lateral pressure fresh concrete exerts on column formwork, requiring stronger form ties and bracing to resist that pressure safely.

81. D — Total design load is the sum of all anticipated loads on the platform: (3×200) + 1,200 + 150 = 600 + 1,200 + 150 = 1,950 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: 8×8×100 = 6,400 lb. This simplified single-level tributary method estimates the axial load carried by an individual shore or reshore post, though detailed multi-level shoring analysis accounts for load redistribution across several connected floor levels engaged simultaneously beneath the fresh pour.

83. C — Applying the 2% minimum lateral force provision: 0.02×50,000 = 1,000 lb. This minimum notional lateral load accounts for out-of-plumb erection tolerances and accidental eccentricities in vertical formwork and shoring systems, and must be provided even where calculated wind or other lateral loads are smaller than this required baseline value for the system.

84. B — Substituting values: p = 0.65×0.33×115×24 = 0.2145×115×24 ≈ 592 psf. The Terzaghi-Peck apparent pressure diagram is an empirical envelope, not an actual triangular distribution, used specifically for designing bracing systems such as struts and wales in braced cuts, since it better represents observed field pressures than classical earth pressure theory alone.

85. A — Because concrete gains strength progressively, a lower slab may be carrying reshore loads from newly poured floors above well before it reaches its 28-day design strength. The shoring analysis must therefore verify against the slab's actual strength at the time of loading, not its eventual specified strength, to prevent premature overload.

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

87. C — OSHA requires supported scaffolds to be guyed, tied, or braced once the height-to-base ratio exceeds 4:1. Here, the ratio is $32/6 \approx 5.33:1$, exceeding the threshold, so this scaffold would require restraint at specified vertical and horizontal intervals to prevent it from tipping over under lateral loads or eccentric loading during use.

88. B — Total tributary load is $150 \times 10 \times 10 = 15{,}000$ lb. Splitting this equally among the three simultaneously engaged support levels gives $15{,}000/3 = 5{,}000$ lb per level. Actual shoring analysis typically uses stiffness-based load distribution rather than an equal split, but this simplified method provides a reasonable preliminary estimate for reshore design and review.

89. A — The brace's axial force must have a horizontal component equal to the thrust it resists: $F \cdot \cos(40°) = 8{,}000$ lb, so $F = 8{,}000/\cos(40°) = 8{,}000/0.766 \approx 10{,}443$ lb. As the brace angle becomes shallower relative to horizontal, the axial force required to resist the same horizontal thrust increases correspondingly and significantly.

90. B — A 1:1 slope means the horizontal offset equals the vertical depth: offset = depth×slope ratio = $12 \times 1 = 12$ ft. OSHA 29 CFR 1926 Subpart P assigns this maximum slope to Type B soil, while the less stable Type C soil requires a flatter 1.5:1 slope for the same depth.

91. C — ASCE 37 specifically addresses design loads during the construction phase, when the permanent lateral force-resisting system may not yet be complete. Temporary bracing must account for construction-stage wind, erection equipment reactions, and out-of-plumb tolerances, none of which are captured by the in-service dead, live, or seismic loads used for the final structure.

92. D — Absent a project-specific engineering analysis justifying an earlier removal, common guidance calls for concrete to reach roughly 75% of its specified strength, along with adequate strength to safely carry its own weight plus any construction loads still applied, before shoring supporting that slab's self-weight is removed, reducing the risk of premature structural failure.

93. A — Euler-type buckling capacity scales inversely with the square of the unbraced length. Halving the length from 10 ft to 5 ft, a factor of 2, increases capacity by $2^2 = 4$ times: $8{,}000 \times 4 = 32{,}000$ lb. This strong sensitivity to bracing spacing is why intermediate lateral bracing effectively increases shoring capacity.

94. B — Substituting into the heave stability formula: $FS = (5.7 \times 1{,}200)/(120 \times 15) = 6{,}840/1{,}800 = 3.8$. 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 bottom to rise and destabilize the surrounding ground and bracing system entirely.

95. D — OSHA's excavation standard requires a protective system for trenches 5 ft deep or greater, unless the excavation is made entirely in stable rock. Below this threshold, a competent person may still determine that a protective system is warranted based on soil classification and site conditions, but 5 ft is the general trigger depth.

96. C — For speeds at or above 45 mph, MUTCD taper length is $L = W \times S$, where W is the offset width in feet and S is the posted speed in mph: $L = 12 \times 55 = 660$ ft. This formula produces a longer, gentler taper at highway speeds than the $L=WS^2/60$ formula used for lower-speed roadways.

97. D — OSHA's construction fall protection standard sets the general trigger height at 6 ft above a lower level, requiring guardrails, safety nets, or personal fall arrest systems above that threshold. This differs from the general industry standard, which uses a 4-ft trigger height, so construction sites must apply the more protective 6-ft rule.

98. B — The termination area is the final component of a TTC zone layout, located after the activity area, and its function is to guide traffic back to its normal lane configuration and travel path safely. It typically includes an end-of-work-zone sign and downstream taper, distinct from the buffer and activity areas preceding it.

99. C — OSHA requires a designated competent person, someone capable of identifying existing and predictable excavation hazards and authorized to take prompt corrective action, to inspect excavations daily and after events like rainstorms that could increase hazards. This role carries authority to halt work immediately if unsafe conditions are observed, regardless of schedule pressure.

100. A — Positive protection devices provide physical containment against errant vehicles, unlike channelizing devices such as cones or drums, which only delineate the intended travel path. MUTCD guidance directs their use where traffic speed, volume, and worker exposure combine to create significant risk, since channelizing devices alone offer no meaningful crash protection in higher-risk conditions.