PRACTICE EXAM 16: 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 $\varphi' = 34°$ and a level ground surface. Using Rankine theory, what is the active earth pressure coefficient Ka?

A. 0.246
B. 0.283
C. 0.321
D. 0.360

2. A 5 m thick normally consolidated clay layer has Cc = 0.25 and initial void ratio e0 = 0.80. The effective overburden stress is 120 kPa and a foundation adds 80 kPa. What is the primary consolidation settlement?

A. 120 mm
B. 138 mm
C. 154 mm
D. 172 mm

3. The water table is at a depth of 3 m. Above the water table, the moist unit weight is 17 kN/m³, and below it the saturated unit weight is 19 kN/m³. At a total depth of 8 m, what is the effective vertical stress?

A. 97 kPa
B. 105 kPa
C. 88 kPa
D. 146 kPa

4. A strip footing at 1.2 m depth bears on saturated clay (φ=0) with cu = 60 kPa. Using Terzaghi bearing capacity factors (Nc=5.7, Nq=1.0) and a surcharge unit weight of 20 kN/m^3, what is the ultimate bearing capacity?

A. 300 kPa
B. 330 kPa
C. 342 kPa
D. 366 kPa

5. A dry, cohesionless infinite slope has friction angle φ=28° and inclination β=18°. What is the factor of safety against sliding?

A. 1.28
B. 1.45
C. 1.64
D. 1.82

6. A 4 m tall wall retains cohesionless backfill with unit weight 19 kN/m^3 and φ'=32°. Using Rankine theory, what is the total passive resultant force per unit length of wall?

A. 495 kN/m
B. 412 kN/m
C. 560 kN/m
D. 630 kN/m

7. A doubly-drained saturated clay layer 6 m thick has cv = 3 m^2/yr. Using Tv=0.197 for 50% consolidation, how long does it take to reach 50% consolidation?

A. 178 days
B. 216 days
C. 254 days
D. 288 days

8. A submerged infinite slope of cohesionless soil ($c'=0$) has $\varphi'=28°$, slope angle $\beta=16°$, saturated unit weight $\gamma sat=19$ kN/m³, and $\gamma w=9.81$ kN/m³, with seepage parallel to the slope. What is the factor of safety?

A. 0.62
B. 0.71
C. 0.80
D. 0.90

9. A horizontal curve has a radius of 950 ft and a deflection angle of 18°. What is the curve length?

A. 245.6 ft
B. 267.3 ft
C. 281.9 ft
D. 298.5 ft

10. For the same curve ($R=950$ ft, $\Delta=18°$), what is the middle ordinate distance?

A. 11.7 ft
B. 14.2 ft
C. 16.8 ft
D. 19.5 ft

11. A vertical curve has an initial grade $g1=+1.5\%$ and final grade $g2=-2.5\%$ over a 500 ft curve length. How far from the BVC does the high point occur?

A. 125 ft
B. 156 ft
C. 187.5 ft
D. 220 ft

12. For the horizontal curve with R=950 ft and Δ=18°, what is the long chord length?

A. 271.4 ft
B. 297.2 ft
C. 312.6 ft
D. 328.9 ft

13. A geotechnical investigation adjacent to a historic masonry building must assess potential construction-induced settlement risk before excavation begins. Which approach is most appropriate to establish a pre-construction monitoring baseline?

A. soil boring logs from the original geotechnical report alone
B. the contractor's daily field reports without any survey baseline
C. as-built drawings from the building's original construction only
D. a pre-construction condition survey with optical or laser monitoring points and crack gauges

14. A benchmark has an established elevation of 250.00 ft. A backsight rod reading of 4.28 ft is taken on the benchmark, and a foresight reading of 6.75 ft is taken to set a rough grade stake. What elevation is the stake set at?

A. 247.53 ft
B. 252.72 ft
C. 241.03 ft
D. 250.00 ft

15. What is the degree of curve (arc definition) for a horizontal curve with a 950 ft radius?

A. 4.85°
B. 5.44°
C. 6.03°
D. 6.72°

16. A fine-grained soil has a liquid limit LL=62 and plastic limit PL=28. 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 310 lb/yd^3 of water and 517 lb/yd^3 of cement. What is the water-cement ratio?

A. 0.45
B. 0.60
C. 0.72
D. 0.85

18. What is the minimum specified yield strength Fy for ASTM A572 Grade 50 structural steel plate?

A. 50 ksi
B. 42 ksi
C. 60 ksi
D. 65 ksi

19. A sawn lumber beam has a reference bending design value Fb=1400 psi. Applying a load duration factor CD=1.15 for a 7-day construction load and a size factor CF=1.0, what is the adjusted design value?

A. 1400 psi
B. 1470 psi
C. 1540 psi
D. 1610 psi

20. Which test method uses the pressure method to determine the air content of freshly mixed concrete?

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

21. A soil sample has a void ratio e=0.55 and specific gravity Gs=2.70. What is the dry unit weight, using $\gamma w=9.81\ kN/m^3$?

A. $14.8\ kN/m^3$
B. $17.1\ kN/m^3$
C. $19.4\ kN/m^3$
D. $21.6\ kN/m^3$

22. A structural drawing specifies Grade 80 reinforcing steel per ASTM A615. What is the minimum specified yield strength?

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

23. Two cross-section end areas along a roadway cut are 150 sf and 210 sf, separated by 120 ft. Using the average end area method, what is the earthwork volume in cubic yards?

A. 620.0 cy
B. 705.0 cy
C. 750.0 cy
D. 800.0 cy

24. A project requires 1,800 cy of asphalt at a unit cost of $95/cy. What is the total material cost?

A. $171,000
B. $152,000
C. $189,000
D. $205,000

25. An owner expects to spend $750,000 eight years from now on a facility upgrade. At an interest rate of 6% per year, what is the present worth of that expenditure?

A. $470,560
B. $495,200
C. $512,800
D. $540,100

26. A project has an earned value (EV) of $475,000 and actual cost (AC) of $440,000. What is the cost performance index (CPI)?

A. 0.93
B. 1.00
C. 1.08
D. 1.15

27. A concrete slab measures 55 ft by 35 ft at a thickness of 0.5 ft. What is the concrete volume in cubic yards?

A. 22.4 cy
B. 28.7 cy
C. 31.9 cy
D. 35.6 cy

28. Using a parametric cost-per-square-foot estimate of $210/sf for a 15,000 sf building, what is the estimated construction cost?

A. $2,850,000
B. $3,150,000
C. $3,450,000
D. $3,700,000

29. A production line has fixed costs of $65,000, a variable cost of $18 per unit, and sells each unit at $40. How many units must be sold to break even?

A. 2,955
B. 3,250
C. 3,610
D. 4,060

30. A schedule shows earned value EV=$410,000 and planned value PV=$380,000. What is the schedule performance index (SPI)?

A. 0.94
B. 1.08
C. 1.16
D. 1.24

31. An activity has an early start (ES) of day 14 and a duration of 9 days. What is its early finish (EF)?

A. 19
B. 21
C. 23
D. 25

32. Using the PERT three-point estimate with optimistic time to=3 days, most likely tm=5 days, and pessimistic tp=13 days, what is the expected activity duration?

A. 5.0 days
B. 5.5 days
C. 5.8 days
D. 6.0 days

33. An activity has ES=8 and LS=19. What is its total float?

A. 5
B. 8
C. 11
D. 14

34. A critical path consists of four sequential activities with durations of 6, 9, 7, and 10 days. What is the total critical path duration?

A. 32 days
B. 38 days
C. 44 days
D. 50 days

35. A paving crew completes 3,600 linear feet of curb and gutter in 15 working days. What is the crew's production rate?

A. 180 ft/day
B. 200 ft/day
C. 220 ft/day
D. 240 ft/day

36. A task requires 6 workers for 9 days. What is the total resource-days (worker-days) required for this task?

A. 42
B. 54
C. 63
D. 72

37. An activity has a normal cost of $25,000 over 12 days and a crash cost of $41,000 over 7 days. What is the crash cost per day?

A. $2,400
B. $2,800
C. $3,000
D. $3,200

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

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

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

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

40. Shifting an activity's start date later within a resource leveling exercise, without delaying the project's overall finish date, requires that the activity—

A. be on the critical path
B. retain unused float at that point in the schedule
C. have unlimited resources available
D. use a fixed-duration constraint

41. A field density test shows a dry density of 121 pcf, while the laboratory maximum dry density (standard Proctor) is 128 pcf. What is the percent relative compaction?

A. 86.2%
B. 89.7%
C. 91.8%
D. 94.5%

42. Which test method uses the pressure method to determine the air content of freshly mixed concrete?

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

43. For an ASTM A325 high-strength bolt installed by the turn-of-nut method in a slip-critical connection, 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. 1/2 turn
B. 1/3 turn
C. 2/3 turn
D. 5/6 turn

44. Which party typically reviews and approves contractor submittals for conformance with the design intent established in the contract documents?

A. the independent testing laboratory
B. the project's design engineer of record
C. the project scheduler
D. the owner's surety company

45. When placing concrete underwater or into deep, congested formwork, which method is used specifically to control the concrete's fall and prevent segregation during placement?

A. a vibrating screed
B. a bull float
C. a broom finish tool
D. a tremie pipe

46. Using the Nurse-Saul maturity function with a constant temperature-datum difference of 25°C sustained for 40 hours, what is the concrete's maturity index?

A. 1000 °C-hr
B. 800 °C-hr
C. 1200 °C-hr
D. 1400 °C-hr

47. Before the maturity method can be used to predict in-place concrete strength, what must first be established for that specific concrete mixture?

A. a minimum 90-day cylinder break
B. a strength-maturity calibration curve
C. a rebound hammer reading
D. a slump test result

48. A sand cone field density test removes 3.6 lb of soil from a hole with a volume of 0.030 cf. The soil's moisture content is 10%. What is the dry unit weight?

A. 98.4 pcf
B. 104.7 pcf
C. 109.1 pcf
D. 115.6 pcf

49. A 3/8-in fillet weld uses E70 electrode (Fexx=70 ksi). What is its nominal strength per inch of weld length?

A. 8.4 kip/in
B. 11.1 kip/in
C. 13.6 kip/in
D. 15.9 kip/in

50. If a structural steel connection's bolt torque values fail inspection, what is the standard next step before acceptance or rejection is decided?

A. automatically reject the connection without any further inspection
B. ignore the failure since torque wrench readings always vary somewhat
C. re-torque and re-inspect the bolts using a calibrated inspection tool per the specified procedure
D. reduce the connection's design load rating retroactively without re-inspection

51. A slab is designed for dead load D=35 psf and live load L=70 psf. Using the basic ASCE 7 load combination U=1.2D+1.6L, what is the factored design load?

A. 154 psf
B. 168 psf
C. 182 psf
D. 196 psf

52. A beam experiences a bending moment $M=720$ kip-in at a section where $c=7$ in and $I=250$ in^4. What is the extreme fiber bending stress?

A. 14.2 ksi
B. 16.8 ksi
C. 18.5 ksi
D. 20.2 ksi

53. An axially loaded member carries $P=120$ kip through a cross-sectional area of 8 in^2. What is the axial stress?

A. 12.5 ksi
B. 15.0 ksi
C. 17.5 ksi
D. 20.0 ksi

54. A footing carries a column load of 380 kip and measures 9 ft by 11 ft in plan. What is the resulting bearing pressure on the soil?

A. 2.95 ksf
B. 3.35 ksf
C. 3.60 ksf
D. 3.84 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 $V=120$ mph, what is the velocity pressure?

A. 28.2 psf
B. 24.6 psf
C. 31.8 psf
D. 35.4 psf

56. A beam has shear force V=48 kip, first moment of area $Q=52\ in^3$, moment of inertia $I=900\ in^4$, and web thickness b=9 in. What is the shear stress at that location?

A. 220 psi
B. 265 psi
C. 308 psi
D. 345 psi

57. A column has an effective length factor K=1.0, unbraced length L=18 ft, and radius of gyration r=2.8 in. What is the slenderness ratio KL/r?

A. 77
B. 89
C. 96
D. 104

58. A retaining wall has a resisting moment of 920 kip-ft and an overturning moment of 430 kip-ft. What is the factor of safety against overturning?

A. 1.78
B. 2.14
C. 2.46
D. 2.80

59. A column has a tributary floor area of 22 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. 38.2 kip
B. 44.6 kip
C. 51.5 kip
D. 58.3 kip

60. For a compact wide-flange beam-column subject to combined axial compression and flexure under AISC Chapter H, when $P_r/P_c < 0.2$, which interaction equation governs, and how does it treat the axial term?

A. H1-2, treats the axial term with full weight
B. H1-3, ignores the bending term entirely
C. H1-1a, identical to the high-axial-ratio case
D. H1-1b, which reduces the axial term's contribution relative to bending

61. Using the rational method $Q=C\cdot i\cdot A$ with a runoff coefficient $C=0.40$, rainfall intensity $i=2.8$ in/hr, and drainage area $A=22$ acres, what is the peak discharge?

A. 16.8 cfs
B. 20.5 cfs
C. 24.6 cfs
D. 28.9 cfs

62. An open channel has Manning's $n=0.015$, flow area $A=15$ sf, hydraulic radius $R=1.8$ ft, and slope $S=0.004$. Using Manning's equation (USCS form with 1.49), what is the flow rate?

A. 139.4 cfs
B. 158.2 cfs
C. 172.6 cfs
D. 186.9 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 1,000 ft and slope of 0.015, what is the time of concentration?

A. 6.1 min
B. 8.0 min
C. 9.8 min
D. 11.4 min

64. A detention pond must temporarily store runoff where peak inflow is 60 cfs, allowable peak outflow is 25 cfs, and the storm duration is 1.5 hours. Using a simplified triangular hydrograph approximation, what storage volume is required?

A. 1.45 ac-ft
B. 1.78 ac-ft
C. 1.95 ac-ft
D. 2.17 ac-ft

65. A storm sewer pipe with a 30-in diameter carries a flow of 20 cfs. What is the flow velocity in the pipe, assuming it flows full?

A. 3.1 fps
B. 4.1 fps
C. 5.4 fps
D. 6.8 fps

66. A broad-crested weir outlet has a discharge coefficient C=3.0, crest length L=5 ft, and head H=1.4 ft. Using $Q=C \cdot L \cdot H^{1.5}$, what is the discharge through the weir?

A. 17.2 cfs
B. 20.6 cfs
C. 22.8 cfs
D. 24.8 cfs

67. A 2-leg sling supports a 10,000 lb load, with each leg oriented at 50° from horizontal. What is the tension in each leg?

A. 6,527 lb
B. 5,800 lb
C. 7,100 lb
D. 7,650 lb

68. A crawler crane's load chart shows a 60,000 lb capacity at a 25-ft working radius. If the operator must reach a 35-ft radius for the same lift, what must occur to remain within safe limits?

A. no change is needed, since capacity is independent of radius
B. capacity increases as radius grows, since the boom moment arm lengthens favorably
C. the load must be reduced to match the lower rated capacity listed at 35 ft
D. only the boom angle needs adjustment, with no effect on rated capacity

69. A dewatering system must handle 320 gpm of inflow, and each wellpoint has a discharge capacity of 18 gpm. What is the minimum number of wellpoints required?

A. 18
B. 15
C. 21
D. 24

70. An excavator has a bucket capacity of 3.0 cy, a fill factor of 0.80, a cycle time of 22 seconds, and operates at 48 minutes of effective work per hour. What is its production rate?

A. 265 cy/hr
B. 314 cy/hr
C. 348 cy/hr
D. 380 cy/hr

71. Using the Engineering News Record (ENR) pile driving formula Qu=2E/(S+0.1), with driving energy E=30,000 ft-lb and set S=0.4 in per blow, and applying a factor of safety of 6, what is the allowable pile capacity?

A. 13.3 kip
B. 16.7 kip
C. 18.2 kip
D. 20.0 kip

72. Two cross-section end areas along a roadway cut are 180 sf and 240 sf, separated by 200 ft. Using the average end area method, what is the cut volume in cubic yards?

A. 1,240.5 cy
B. 1,385.2 cy
C. 1,555.6 cy
D. 1,720.8 cy

73. Compared to a straight vertical hitch, a wire rope sling rigged as a choker hitch has its rated capacity—

A. unchanged from the vertical rating
B. increased due to the wraparound grip on the load
C. reduced to roughly 75–80% of the vertical rating
D. reduced to about 25% regardless of the choke angle

74. A crane boom is 120 ft long and raised to an angle of 65° from horizontal. Ignoring boom point offset, what is the resulting horizontal working radius?

A. 50.7 ft
B. 58.4 ft
C. 64.2 ft
D. 71.6 ft

75. A sump pump must handle a seepage inflow of 95 gpm, and standard practice applies a safety factor of 1.5 for pump sizing. What minimum pump capacity should be selected?

A. 105 gpm

B. 118 gpm
C. 130 gpm
D. 142.5 gpm

76. A loader has a cycle time of 2.5 minutes per load. A truck's full haul-dump-return cycle takes 20 minutes. How many trucks are needed to keep the loader continuously working?

A. 5
B. 8
C. 6
D. 10

77. A pile's static capacity analysis gives skin friction resistance Qs=180 kip and end bearing resistance Qp=110 kip. Applying a factor of safety of 2.5, what is the allowable pile capacity?

A. 92 kip
B. 104 kip
C. 110 kip
D. 116 kip

78. An embankment requires 12,000 cy of soil measured in the bank (natural, undisturbed) condition, and the borrow soil has a shrinkage factor of 0.82 relating compacted volume to bank volume. What compacted fill volume results from excavating this bank volume?

A. 8,200 cy
B. 9,100 cy
C. 9,840 cy
D. 10,600 cy

79. A crane outrigger imposes a load of 75,000 lb on the ground, and the allowable soil bearing pressure is 3,500 psf. What minimum outrigger pad area is required?

A. 21.4 sf
B. 18.2 sf
C. 24.8 sf
D. 27.6 sf

80. Using the ACI 347 formwork lateral pressure formula for columns, Cw=150+9000R/T, with a placement rate R=8 ft/hr and concrete temperature T=60°F, what is the design lateral pressure?

A. 980 psf
B. 1,350 psf
C. 1,620 psf
D. 1,840 psf

81. A scaffold platform will support 4 workers averaging 200 lb each, 1,500 lb of stored material, and 200 lb of tools and equipment. What is the total design load on the platform?

A. 2,500 lb
B. 2,150 lb
C. 2,800 lb
D. 3,100 lb

82. A reshore below a freshly poured slab has a tributary area of 9 ft by 9 ft, and the slab's dead load is 110 psf. What load is transferred to this reshore, using a simplified tributary-area method?

A. 7,600 lb
B. 8,910 lb
C. 10,100 lb
D. 11,400 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 65,000 lb vertically, what minimum lateral bracing force must be provided?

A. 950 lb
B. 1,120 lb
C. 1,300 lb
D. 1,480 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 $K_a=0.30$, $\gamma=120$ pcf, and excavation depth $H=28$ ft, what is the peak apparent pressure?

A. 480 psf
B. 545 psf
C. 600 psf
D. 655 psf

85. When determining whether a lower slab can safely carry redistributed reshore loads from a fresh concrete pour above, what is the controlling factor?

A. the shore manufacturer's catalog rating only
B. the slab's eventual specified 28-day strength
C. the slab's actual in-place strength at the time of loading
D. the formwork contractor's assumed factor of safety only

86. Per ACI 347 guidance, what is the minimum required design value for the combined dead and live load on horizontal formwork when motorized buggies ARE used?

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

87. Per OSHA 29 CFR 1926 Subpart L, at what height-to-base-width ratio must guying, tying, or bracing generally be provided for a supported scaffold?

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

88. A slab load of 175 psf acts on a 9 ft by 9 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. 3,850 lb
B. 4,725 lb
C. 5,600 lb
D. 6,300 lb

89. A diagonal brace oriented at 35° from horizontal resists a horizontal thrust of 9,500 lb. What is the resulting axial force in the brace?

A. 10,200 lb
B. 10,900 lb
C. 11,597 lb
D. 12,400 lb

90. A 15-ft-deep trench is excavated in Type C soil at OSHA's maximum allowable slope of 1.5:1 (horizontal:vertical). What is the horizontal offset at the top of the excavation, measured from the trench bottom edge?

A. 15 ft
B. 18 ft
C. 20 ft
D. 22.5 ft

91. Per ASCE 37, temporary bracing during steel erection must account for which loading condition not captured by the permanent structure's in-service design loads?

A. construction-stage loads such as wind, erection equipment reactions, and out-of-plumb tolerances
B. only the building's final seismic design load
C. the dead load of the completed structure only
D. occupant live load at full building occupancy

92. Absent a specific engineering analysis, common guidance calls for concrete supporting its own weight plus construction loads to reach approximately what percentage of specified 28-day strength before shoring is removed?

A. 50%
B. 60%
C. 65%
D. 75%

93. A shoring post has an allowable capacity of 6,000 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. 18,000 lb
B. 24,000 lb
C. 30,000 lb
D. 36,000 lb

94. A braced excavation is 18 ft deep in clay with undrained shear strength cu=1,400 psf and unit weight γ=125 pcf. Using a bearing capacity factor Nc=5.7, what is the factor of safety against bottom heave, $FS=Nc \cdot cu/(\gamma \cdot H)$?

A. 2.6
B. 3.1
C. 3.5
D. 4.0

95. Per OSHA 29 CFR 1926 Subpart L, what is the standard required height range for a scaffold guardrail's top rail above the platform surface?

A. 30 to 37 inches
B. 38 to 45 inches
C. 46 to 52 inches
D. 24 to 30 inches

96. Per MUTCD guidance, for a temporary lane closure with an 11-ft lane width and posted speed of 40 mph (using $L=WS^2/60$ for speeds under 45 mph), what taper length is required?

A. 293 ft
B. 340 ft
C. 385 ft
D. 420 ft

97. Per OSHA 29 CFR 1926 Subpart L, at what height above a lower level must fall protection generally be provided for workers on a scaffold platform?

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

98. Per MUTCD Part 6, which temporary traffic control (TTC) zone component immediately precedes the activity area and provides a buffer between traffic and the work space?

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

99. Under OSHA 29 CFR 1926 Subpart P, which individual must be capable of identifying excavation hazards and has the authority to require prompt corrective measures?

A. the site's general safety consultant
B. the excavation equipment operator
C. a designated competent person
D. the project's insurance adjuster

100. Per MUTCD guidance, in which work zone condition are positive protection devices, such as concrete barrier, generally warranted over channelizing devices alone?

A. low-volume residential streets with minimal traffic exposure
B. short-duration daytime closures with flaggers present at all times
C. bicycle lane closures exclusively, separate from vehicle travel lanes
D. high-speed, high-volume conditions with significant exposure to workers and errant vehicles

Practice Exam 16: Answer Key and Explanations

1. B — Rankine active pressure for a level, cohesionless backfill is $Ka = \tan^2(45° - \varphi'/2)$. With $\varphi' = 34°$, this is $\tan^2(28°) \approx 0.283$. Larger friction angles produce smaller Ka values, since a stronger soil skeleton needs less lateral thrust to reach its active failure state, reducing the wall's design pressure.

2. C — Primary consolidation settlement is $Sc = [Cc \cdot H/(1+e0)] \cdot \log10[(p0+\Delta p)/p0]$. Substituting, $Sc = (0.25\times5/1.80) \cdot \log10(200/120) = 0.694\times0.222 \approx 0.154$ m, or 154 mm. This formula assumes one-dimensional consolidation with no lateral strain, the standard simplifying assumption used for settlement estimates beneath wide foundations on soft, normally consolidated clay deposits over time, without further adjustment.

3. A — Total stress at 8 m is $\sigma = (17\times3) + (19\times5) = 51 + 95 = 146$ kPa. Pore pressure develops only below the water table: $u = 9.81\times5 = 49.05$ kPa. Effective stress is $\sigma' = 146 - 49.05 \approx 97$ kPa. Option D is the total stress alone, without subtracting pore pressure.

4. D — For $\varphi = 0$ conditions, $qult = cu \cdot Nc + q \cdot Nq$. The surcharge is $q = 20\times1.2 = 24$ kPa, so $qult = 60\times5.7 + 24\times1.0 = 342 + 24 = 366$ kPa. Ignoring the surcharge term, as in option C, understates ultimate capacity by neglecting the confinement the overlying soil provides at footing level.

5. C — For a dry infinite slope of cohesionless soil, FS = $\tan\varphi/\tan\beta$, since slice weight cancels out of both the driving and resisting force terms entirely. Here FS = $\tan(28°)/\tan(18°) = 0.532/0.325 \approx 1.64$. This ratio depends only on the two angles, not on slope height, soil unit weight, or the depth of any potential failure surface.

6. A — Passive coefficient is $K_p = \tan^2(45°+\varphi'/2) = \tan^2(61°) \approx 3.256$. The resultant passive force is $P_p = 0.5 \cdot K_p \cdot \gamma \cdot H^2 = 0.5 \times 3.256 \times 19 \times 4^2 \approx 495$ kN/m, acting one-third of the wall height above the base. Passive resistance grows with the square of wall height, making it very sensitive to embedment depth and backfill unit weight.

7. B — With double drainage, the drainage path length is $H_{dr} = H/2 = 3$ m. Time factor relates as $t = T_v \cdot H_{dr}^2/c_v = 0.197 \times 9/3 = 0.591$ yr, which converts to $0.591 \times 365 \approx 216$ days. Using the full 6 m thickness instead of the halved drainage path would substantially overstate the required time.

8. D — With seepage parallel to the slope, FS = $(\gamma'/\gamma_{sat}) \cdot (\tan\varphi'/\tan\beta)$. The buoyant unit weight is $\gamma' = 19-9.81 = 9.19$ kN/m^3, giving a ratio of 0.484. Combined with $\tan(28°)/\tan(16°) \approx 1.855$, FS $\approx 0.484 \times 1.855 \approx 0.90$. Submergence again roughly halves the safety factor compared to the equivalent dry slope case examined without seepage.

9. D — Curve length is $L = R \cdot \Delta(\text{radians}) = 950 \times (18 \times \pi/180) = 950 \times 0.31416 \approx 298.5$ ft. This arc-based formula gives the actual station-to-station distance traveled along the curve, distinct from the shorter chord distance, and is the value used to set the PT station once the PC station has been established in the field.

10. A — Middle ordinate is $M = R \cdot (1-\cos(\Delta/2))$. With $\Delta/2 = 9°$, $\cos(9°) = 0.9877$, so $M = 950 \times (1-0.9877) = 950 \times 0.0123 \approx 11.7$ ft. This small offset reflects how gentle a curve this is relative to its radius, since larger deflection angles produce proportionally larger middle ordinates for a given radius value.

11. C — The high point on a crest vertical curve occurs where $x = L \cdot g_1/(g_1-g_2)$. Here $x = 500 \times 1.5/(1.5-(-2.5)) = 750/4 = 187.5$ ft from the BVC. Because the incoming and outgoing grades are unequal, this point falls off-center, shifted toward the flatter of the two approach grades, rather than sitting at the curve's true midpoint.

12. B — The long chord connecting the PC and PT is $C = 2R \cdot \sin(\Delta/2)$. With $\Delta/2 = 9°$, $\sin(9°) = 0.15643$, giving $C = 2 \times 950 \times 0.15643 \approx 297.2$ ft. As expected, this chord distance is slightly shorter than the 298.5 ft arc length found earlier, since a chord cuts directly across rather than following the curved path.

13. D — Boring logs describe subsurface conditions but say nothing about the existing structure's present condition, and daily reports or as-builts don't establish a quantitative baseline either. A pre-construction condition survey combined with monitoring points and crack gauges provides the documented reference needed to detect and attribute any settlement or movement that occurs once excavation begins.

14. A — Height of instrument is HI = benchmark elevation + backsight = 250.00 + 4.28 = 254.28 ft. The stake elevation is then HI minus the foresight: 254.28 − 6.75 = 247.53 ft. This differential leveling procedure is repeated at successive setups to carry a known elevation across a construction site to new grade stakes.

15. C — By the arc definition, degree of curve is $D = 5729.58/R$. With $R = 950$ ft, $D = 5729.58/950 \approx 6.03°$. This inverse relationship means larger radius curves have smaller degrees of curve, since a gentler curve subtends a smaller central angle for the same 100-ft arc length used in the definition.

16. C — Plasticity index is $PI = LL-PL = 34$. The A-line value at LL=62 is $0.73\times(62-20) = 30.7$, and since PI=34 plots above the A-line with $LL\geq50$, the soil classifies as CH. Falling below the A-line at this same liquid limit would instead indicate an MH high-plasticity silt classification rather than a clay.

17. B — Water-cement ratio is the water weight divided by cement weight: $310/517 \approx 0.60$. This is a moderate ratio suitable for typical structural concrete, balancing adequate workability during placement with reasonable strength and durability, whereas a lower ratio like 0.45 would require admixtures to maintain workability without adding extra mixing water.

18. A — ASTM A572 Grade 50 specifies a minimum yield strength of 50 ksi, and this grade is commonly used for plate material in built-up sections, connection plates, and base plates. The designation number directly indicates the grade's minimum yield strength in ksi, distinguishing it from lower Grade 42 or higher Grade 65 plate.

19. D — Adjusted design values are found by multiplying the reference value by all applicable adjustment factors: $Fb' = Fb\times CD\times CF = 1400\times1.15\times1.0 = 1610$ psi. Applying only a partial adjustment, or omitting the load duration factor entirely as in the smallest option, would understate the member's true adjusted bending capacity under this loading.

20. B — ASTM C231 uses a pressure meter and Boyle's law to determine entrained and entrapped air content in fresh concrete, a property critical for freeze-thaw durability in exterior exposures. C143 measures slump, C39 tests hardened cylinder strength, and C1064 measures fresh concrete temperature, each capturing an entirely different fresh or hardened property.

21. B — Dry unit weight relates to void ratio and specific gravity by $\gamma d = Gs\cdot\gamma w/(1+e) = 2.70\times9.81/1.55 \approx 17.1$ kN/m³. A lower void ratio than in a looser sample produces a denser soil skeleton and correspondingly higher dry unit weight, illustrating how compaction directly increases this fundamental index property in the field.

22. C — ASTM A615 Grade 80 reinforcing bars have a minimum specified yield strength of 80 ksi, a newer high-strength grade introduced to reduce bar congestion in heavily reinforced elements. Because its yield strength is higher than the common Grade 60, design provisions place additional restrictions on how it may be used and detailed.

23. D — The average end area method computes volume as $V = [(A1+A2)/2]\times L = [(150+210)/2]\times120 = 21{,}600$ cf. Converting to cubic yards by dividing by 27 gives exactly 800.0 cy. This clean result occurs whenever the end areas and length happen to divide evenly, which is not always the case in practice.

24. A — Unit cost estimating multiplies quantity by unit price: 1,800×$95 = $171,000. This straightforward 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 mix design or specification called for on this particular paving project's scope.

25. A — Present worth of a single future amount is $P = F/(1+i)^n = 750{,}000/(1.06)^8 = 750{,}000/1.5938 \approx \$470{,}560$. This single-payment present-worth factor lets costs occurring at different points in time be compared on a common present-value basis, a foundational concept in engineering economic analysis and the comparison of competing alternatives over a project's full life.

26. C — Cost performance index is $CPI = EV/AC = 475{,}000/440{,}000 \approx 1.08$. A CPI above 1.0 indicates the project is spending less than the value of work actually completed, meaning it is currently running under budget relative to the earned value baseline established in the project's original cost management plan and forecast.

27. D — Volume is length times width times thickness: 55×35×0.5 = 962.5 cf. Dividing by 27 cf per cubic yard gives approximately 35.6 cy. This slab-on-grade quantity takeoff is routinely used to order the correct number of ready-mix truck loads and plan the placement crew's workload for the day of the pour.

28. B — Parametric estimating multiplies a unit rate by a project parameter: 15,000 sf × $210/sf = $3,150,000. This approach is useful in early conceptual design before detailed quantities are available, trading precision for speed, and its accuracy depends heavily on how closely the historical rate matches this project's scope and finish level.

29. A — Break-even quantity equals fixed cost divided by the contribution margin per unit: $65{,}000/(40-18) = 65{,}000/22 \approx 2{,}955$ units. Below this quantity the operation runs at a loss, and above it, each additional unit contributes $22 toward covering fixed costs and, beyond break-even, toward genuine profit for the operation as sales continue to grow.

30. B — Schedule performance index is $SPI = EV/PV = 410{,}000/380{,}000 \approx 1.08$. 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. This earned-value metric is tracked alongside CPI to monitor overall project health and trends.

31. C — In the CPM forward pass, early finish equals early start plus duration: $EF = ES + Duration = 14 + 9 = 23$. This value becomes the early start for any successor activity that depends solely on this one finishing, propagating forward through the network toward the project's overall early completion date.

32. D — PERT expected time is $t_e = (t_o + 4 \cdot t_m + t_p)/6 = (3 + 20 + 13)/6 = 36/6 = 6.0$ days. Weighting the most likely estimate four times as heavily as the optimistic and pessimistic bounds reflects the typically right-skewed distribution of real-world activity durations encountered in construction scheduling practice.

33. C — Total float is the difference between late start and early start: TF = LS − ES = 19 − 8 = 11. This represents how many days the activity's start can slip without delaying the overall project completion date, assuming no other activities along its path also consume their available float.

34. A — Since these activities occur sequentially with no overlap along the critical path, total duration is simply their sum: 6+9+7+10 = 32 days. The critical path is the longest chain of dependent activities through the network, and it alone determines the shortest possible overall project completion date achievable given these durations.

35. D — Production rate for a linear (line-of-balance) schedule is distance divided by time: 3,600 ft / 15 days = 240 ft/day. This rate defines the slope of the crew's line on a time-distance diagram, and is used to sequence multiple crews so that faster-moving crews don't overtake slower ones ahead of them.

36. B — Total resource-days is the product of the number of workers and the duration: 6 workers × 9 days = 54 worker-days. This fixed labor quantity is a key input for resource leveling, since it can be redistributed across different crew sizes and durations without changing the total amount of work performed.

37. D — Crash cost slope is the change in cost divided by the change in duration: (41,000−25,000)/(12−7) = 16,000/5 = $3,200 per day. This slope tells the scheduler how much it costs to compress each day out of this particular activity, information used to identify the cheapest activities to crash first when accelerating.

38. A — Columns must be erected first to provide vertical support points, followed by setting beams between them to form the frame, then plumbing and aligning the assembly to correct tolerances before final bolt-up and welding lock the connections permanently in place. Welding or bolting before plumbing would make later alignment corrections physically impossible.

39. C — Free float is the amount an activity can be delayed without affecting the early start of any successor: FF = (successor ES) − (this activity's EF) = 30 − 17 = 13. Unlike total float, this value depends only on the immediate downstream activity, not on the project's overall late-date calculations.

40. B — Resource leveling works by shifting activities inside their existing slack; critical path activities have zero float by definition, so shifting them would delay the project finish. Only an activity that still has unused float remaining can absorb a later start date without pushing back the overall project completion date and deadline.

41. D — Relative compaction is the field dry density divided by the laboratory maximum dry density, expressed as a percentage: (121/128)×100 ≈ 94.5%. This result would typically satisfy a specification requiring 90 to 95% relative compaction, confirming the field placement and compaction effort met the project's earthwork quality requirements for this lift.

42. C — ASTM C231 uses a pressure meter and Boyle's law to determine entrained and entrapped air content in fresh concrete, a property critical for freeze-thaw durability in exterior exposures. C143 measures slump, C39 tests hardened strength, and C1064 measures fresh concrete temperature, each capturing a distinct fresh or hardened concrete property.

43. A — The RCSC Specification's turn-of-nut method scales required rotation with bolt length, since longer bolts need more elongation to reach the specified pretension. For bolts between 8 and 12 diameters long with both surfaces normal to the axis, the required rotation beyond snug-tight is 1/2 turn, more than the 1/3 turn used for shorter bolts.

44. B — Submittal review verifies that proposed materials, shop drawings, and methods conform to the design intent, a judgment that belongs to the design engineer of record who authored that intent. The testing laboratory instead verifies physical material properties, the scheduler manages timeline, and the surety addresses financial and performance guarantees, not design conformance.

45. D — A tremie pipe extends down into the formwork or below the water surface, allowing concrete to be placed from the bottom up without free-falling through water or air, which would otherwise wash out cement paste and cause segregation of the mix. Screeds, bull floats, and broom finishes are surface tools, not placement-control methods.

46. A — The Nurse-Saul maturity index accumulates temperature above a datum over time: $M(t) = \Sigma(T-T0)\cdot\Delta t$. With a constant 25°C difference sustained for 40 hours, $M = 25\times40 = 1{,}000$ °C-hours. This index is later compared to a mixture-specific calibration curve to estimate the concrete's in-place compressive strength at a given time.

47. B — The maturity method only converts a measured temperature history into an estimated strength once a calibration curve relating maturity index to compressive strength has been developed specifically for that mixture. Without this mixture-specific curve established beforehand, the raw maturity index number carries no direct predictive value for actual in-place concrete strength.

48. C — Wet unit weight is the weight of soil removed divided by the hole volume: $3.6/0.030 = 120.0$ pcf. Converting to dry unit weight using the moisture content, $\gamma d = \gamma wet/(1+w) = 120.0/1.10 \approx 109.1$ pcf. This field value is then compared against the laboratory Proctor curve to check relative compaction achieved.

49. B — Nominal fillet weld strength per unit length is $Rn = 0.6\cdot Fexx\cdot 0.707\cdot w$, where 0.707 converts the leg dimension to the effective throat. With Fexx=70 ksi and w=0.375 in, $Rn = 0.6\times70\times0.707\times0.375 \approx 11.1$ kip/in, larger than a 5/16-in weld since capacity scales directly with leg size and the resulting effective throat dimension.

50. C — A failed torque check first prompts re-torquing and re-inspection using a properly calibrated tool following the specified inspection procedure, since torque readings can be affected by tool calibration, thread condition, or technique. Immediate rejection or ignoring the failure both skip this essential verification step required by standard quality control practice.

51. A — The factored load combination applies separate load factors before summing: $U = 1.2(35) + 1.6(70) = 42 + 112 = 154$ psf. The larger factor on live load reflects its greater variability compared to dead load, and this combination typically governs strength design for ordinary gravity-only loading scenarios in buildings.

52. D — The flexure formula gives bending stress as $\sigma = M \cdot c/I = 720 \times 7/250 \approx 20.2$ ksi. This maximum normal stress occurs at the extreme fiber, the distance c from the neutral axis, and would be compared against the material's allowable or design bending stress to check whether the section is adequate.

53. B — Axial stress is force divided by cross-sectional area: $\sigma = P/A = 120/8 = 15.0$ ksi. This uniform distribution assumes the load passes through the section's centroid; any eccentric application of the load would introduce additional bending stress that must be superimposed on this baseline axial stress value to find the total.

54. D — Assuming a concentric load and uniform pressure distribution, bearing pressure equals load divided by footing area: $q = P/(B \times L) = 380/(9 \times 11) \approx 3.84$ 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. A — Substituting directly: $qz = 0.00256 \times 0.90 \times 1.0 \times 0.85 \times 120^2 = 0.00256 \times 0.765 \times 14{,}400 \approx 28.2$ 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 walls, roof, and any openings per ASCE 7 provisions and the applicable exposure category tables.

56. C — Shear stress is given by the shear flow formula $\tau = VQ/(Ib) = (48{,}000 \times 52)/(900 \times 9) = 2{,}496{,}000/8{,}100 \approx 308$ psi. This formula gives shear stress at a horizontal plane within the cross-section, generally maximum at the neutral axis where Q is largest, and vanishing at the extreme top and bottom fibers.

57. A — Slenderness ratio is KL/r, using consistent units for length. Converting L to inches: 18 ft × 12 = 216 in, so $KL/r = (1.0 \times 216)/2.8 \approx 77$. This ratio helps determine whether the column's compressive strength is governed by inelastic or elastic Euler buckling behavior under AISC Chapter E design provisions.

58. B — Factor of safety against overturning is the ratio of resisting moment to overturning moment: $FS = 920/430 \approx 2.14$. This exceeds the commonly required minimum of roughly 1.5 to 2.0, confirming the wall's weight and geometry provide adequate resistance to the lateral earth pressure driving rotation about the toe of the footing.

59. C — Tributary area load is the product of tributary area and design load intensity: $22 \times 26 \times 90 = 51{,}480$ lb, or about 51.5 kip. This tributary area approach assumes the column collects load from half the distance to each adjacent column line, a standard simplification for distributing gravity loads through a framed structure.

60. D — AISC 360 Chapter H splits its interaction check by axial load ratio: H1-1a governs at $Pr/Pc \geq 0.2$, while H1-1b applies below that threshold and reduces the weight given to the axial term relative to bending, since bending dominates the failure interaction when axial load is comparatively small on the member.

61. C — The rational method combines runoff coefficient, rainfall intensity, and drainage area directly: $Q = C \cdot i \cdot A = 0.40 \times 2.8 \times 22 \approx 24.6$ 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: $(1.49/0.015) \times 15 \times (1.8)^{0.667} \times (0.004)^{0.5} \approx 99.3 \times 15 \times 1.480 \times 0.0632 \approx 139.4$ cfs. This empirical relationship between channel roughness, geometry, and slope remains fundamental for sizing open channels, culverts, and storm sewers throughout civil site development and roadway drainage design work generally performed by practicing civil engineers on active projects.

63. B — Substituting into the Kirpich formula: $Tc = 0.0078 \times (1{,}000)^{0.77} \times (0.015)^{-0.385} \approx 0.0078 \times 204.2 \times 5.04 \approx 8.0$ minutes. This empirical relationship estimates the travel time for runoff from the hydraulically most distant point in the watershed, a key input for rational method peak discharge calculations in small-watershed drainage design work performed throughout the developed site.

64. D — A simplified storage estimate is $V \approx 0.5 \times (Qin-Qout) \times duration = 0.5 \times (60-25) \times 5{,}400$ sec = 94,500 cf. Converting to acre-feet by dividing by 43,560 gives about 2.17 ac-ft. This preliminary approximation is typically refined afterward using detailed stage-storage-discharge routing for the final detention basin outlet design and the overall site grading and drainage plan.

65. B — Velocity is flow rate divided by cross-sectional area: $V = Q/A$. With a 30-in (2.5-ft) diameter pipe, $A = \pi \times (1.25)^2 \approx 4.91$ sf, so $V = 20/4.91 \approx 4.1$ fps. This should be checked against minimum self-cleansing velocity criteria, typically 2 to 3 fps, to prevent sediment buildup in the sewer line.

66. D — Substituting into the weir formula: $Q = 3.0 \times 5 \times (1.4)^{1.5} = 15 \times 1.656 \approx 24.8$ cfs. This head-discharge relationship follows a power-law form across the operating depth range above the crest, and is commonly applied to outlet structures that control release rates from detention and retention basins on a developed construction site over time.

67. A — Each leg carries half the total load, resolved along its angle: $T = (Load/2)/\sin(angle) = 5{,}000/\sin(50°) = 5{,}000/0.766 \approx 6{,}527$ lb. Compared to a steeper 60° leg angle, this shallower 50° angle increases individual leg tension for the same total load, since more of the tension acts horizontally rather than vertically.

68. C — Crane capacity is set by the overturning moment the machine can safely resist, and that moment grows directly with lift radius for a given load. Because the load chart's rated capacity always decreases as radius increases, the operator must either reduce the load or select a different chart configuration to safely reach 35 ft.

69. A — Dividing total required flow by per-wellpoint capacity gives $320/18 \approx 17.78$, which must be rounded up to 18 wellpoints since a fractional wellpoint cannot be installed. Rounding up rather than down ensures the system has adequate capacity to handle the full anticipated groundwater inflow with a reasonable working margin for variability.

70. B — Cycles per hour at full time is $3{,}600/22 \approx 163.6$, giving a theoretical output of $163.6 \times 3.0 \times 0.80 \approx 392.7$ cy/hr. Applying the 48/60 efficiency factor for actual working minutes reduces this to about 314 cy/hr, reflecting realistic productivity once operational delays and minor interruptions are properly accounted for on an active job site.

71. D — Ultimate capacity is $Qu = 2E/(S+0.1) = 2\times30{,}000/(0.4+0.1) = 60{,}000/0.5 = 120{,}000$ lb. Applying the ENR formula's typical factor of safety of 6 gives allowable capacity: $Qa = 120{,}000/6 = 20.0$ kip. A smaller set per blow indicates harder driving resistance and a correspondingly higher allowable pile capacity at that depth.

72. C — Applying the average end area method: $V = [(180+240)/2]\times200 = 210\times200 = 42{,}000$ cf. Converting to cubic yards by dividing by 27 gives about 1,555.6 cy. This method remains the standard hand-calculation approach for earthwork quantities along a linear roadway alignment surveyed at regular cross-section intervals throughout the length of the roadway project.

73. C — The sharp bend a choker hitch creates in the sling body where it wraps the load concentrates stress and reduces the sling's efficiency relative to a straight vertical pull. Rigging references typically derate the choker configuration to roughly 75 to 80% of the sling's vertical rated capacity, decreasing further as the choke angle tightens.

74. A — Horizontal radius is the boom length multiplied by the cosine of its angle from horizontal: $R = L\cdot\cos(\theta) = 120\times\cos(65°) = 120\times0.4226 \approx 50.7$ ft. Raising the boom angle from 60° to 65° shrinks the working radius further, which is why load charts pair boom angle directly with radius values.

75. D — Required pump capacity is the anticipated inflow multiplied by the safety factor: $95\times1.5 = 142.5$ 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. B — The number of trucks needed to match a loader's output equals the truck's total cycle time divided by the loader's cycle time: $20/2.5 = 8$ trucks. This ensures a truck is arriving to load just as the previous one departs full, keeping the loader continuously productive rather than sitting idle between hauling cycles.

77. D — Ultimate capacity is the sum of skin friction and end bearing: $Qult = Qs+Qp = 180+110 = 290$ kip. Dividing by the factor of safety gives allowable capacity: $Qallow = 290/2.5 = 116$ kip. This static computation is typically confirmed in the field with a load test or a dynamic driving formula check.

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: $12{,}000\times0.82 = 9{,}840$ cy. Soil always occupies less volume once compacted into an embankment than it did in its natural bank state, which is why this factor stays below one.

79. A — Required pad area is the outrigger load divided by the allowable bearing pressure: $75{,}000/3{,}500 \approx 21.4$ 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 check a routine part of crane setup planning.

80. B — Substituting directly: Cw = 150 + (9,000×8)/60 = 150 + 1,200 = 1,350 psf. Cooler concrete at 60°F sets more slowly than the 70°F case examined previously, and combined with a faster 8 ft/hr placement rate, this produces significantly higher formwork pressure requiring stronger ties and bracing to resist safely.

81. A — Total design load is the sum of all anticipated loads on the platform: (4×200) + 1,500 + 200 = 800 + 1,500 + 200 = 2,500 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.

82. B — Tributary area load is the product of tributary area and load intensity: 9×9×110 = 8,910 lb. This simplified single-level tributary method estimates the axial load carried by an individual reshore post, though detailed multi-level shoring analysis accounts for load sharing across several connected floor levels engaged beneath the fresh pour.

83. C — Applying the 2% minimum lateral force provision: 0.02×65,000 = 1,300 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 requirement.

84. D — Substituting values: p = 0.65×0.30×120×28 = 0.195×120×28 ≈ 655 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 rather than on classical earth pressure theory alone in isolation.

85. C — Because concrete gains strength progressively rather than all at once, a lower slab may already be carrying reshore loads well before it reaches its eventual 28-day specified strength. The controlling factor is therefore the slab's actual in-place strength at the time it is loaded, not its future strength or the shore rating alone.

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

87. A — OSHA requires supported scaffolds to be restrained by guying, tying, or bracing once their height-to-base-width ratio exceeds 4:1, since taller, narrower scaffolds become increasingly prone to tipping under lateral loads and eccentric loading. Restraints must then be installed at specified vertical and horizontal intervals for the remaining height above that ratio.

88. B — Total tributary load is 175×9×9 = 14,175 lb. Splitting this equally among the three simultaneously engaged support levels gives 14,175/3 = 4,725 lb per level. Actual shoring analysis typically uses stiffness-based distribution rather than an equal split, but this simplified method gives a reasonable preliminary estimate for design review purposes.

89. C — The brace's axial force must have a horizontal component equal to the thrust it resists: $F \cdot \cos(35°) = 9{,}500$ lb, so $F = 9{,}500/\cos(35°) \approx 11{,}597$ lb. Because this brace is shallower than a 40° brace resisting the same thrust, it must carry a larger axial force to provide the same horizontal resistance.

90. D — A 1.5:1 slope means the horizontal offset equals 1.5 times the vertical depth: offset = depth×slope ratio = 15×1.5 = 22.5 ft. OSHA 29 CFR 1926 Subpart P assigns this flatter slope to the less stable Type C soil, requiring considerably more excavated width than the steeper 1:1 slope permitted for Type B soil.

91. A — ASCE 37 addresses design loads specific to the construction phase, before the permanent lateral force-resisting system is complete. Temporary bracing during erection must account for construction-stage wind, erection equipment reactions, and out-of-plumb tolerances, none of which are represented by the in-service dead, live, or seismic loads used for the completed structure.

92. D — Common guidance calls for concrete to reach roughly 75% of its specified 28-day strength, along with sufficient strength to carry its own weight and any remaining construction loads, before shoring is removed absent a project-specific engineering analysis justifying earlier removal. This threshold reduces the risk of premature structural failure during construction.

93. B — 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: 6,000×4 = 24,000 lb. This strong sensitivity to bracing spacing is why adding intermediate lateral bracing so effectively boosts shoring capacity.

94. C — Substituting into the heave stability formula: $FS = (5.7 \times 1{,}400)/(125 \times 18) = 7{,}980/2{,}250 \approx 3.5$. 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 ground and bracing.

95. B — OSHA requires a scaffold guardrail's top rail to be installed between 38 and 45 inches above the platform surface, a range chosen to provide effective fall protection for workers of varying height without creating a tripping or climbing hazard. Rails installed outside this range, whether too low or too high, don't satisfy the standard.

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: $L = 11 \times 1{,}600/60 \approx 293$ ft. This formula produces a shorter taper than the $L=WS$ formula used at highway speeds of 45 mph and above.

97. B — OSHA's scaffold-specific standard sets a fall protection trigger height of 10 ft for workers on scaffold platforms, distinct from the general construction trigger height of 6 ft that applies to most other walking and working surfaces under Subpart M. Scaffold builders and users must apply this higher, scaffold-specific threshold instead.

98. A — The buffer space sits between the transition area and the activity area, providing a recovery zone for errant vehicles and a margin of safety for workers before traffic reaches the actual work space.

The advance warning and transition areas come earlier in the sequence, and the termination area comes afterward, past the activity area entirely.

99. C — OSHA requires a designated competent person, one capable of identifying existing and predictable excavation hazards, to be present with authority to require prompt corrective measures whenever unsafe conditions are found. This authority to halt or correct work immediately distinguishes the competent person's role from an equipment operator, consultant, or insurance representative.

100. D — Positive protection devices provide physical containment against errant vehicles, unlike channelizing devices such as cones or drums, which merely delineate the travel path without stopping an out-of-control vehicle. MUTCD guidance directs their use specifically where high speed, high traffic volume, and worker exposure combine to create the greatest risk of a vehicle intrusion.