PRACTICE EXAM 19: 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 $\varphi' = 33°$ and a level ground surface. Using Rankine theory, what is the active earth pressure coefficient Ka?

A. 0.260
B. 0.295
C. 0.325
D. 0.360

2. A 5.5 m thick normally consolidated clay layer has Cc = 0.22 and initial void ratio e0 = 0.75. The effective overburden stress is 130 kPa and a foundation adds 95 kPa. What is the primary consolidation settlement?

A. 165 mm
B. 188 mm
C. 210 mm
D. 232 mm

3. The water table is at a depth of 5 m. Above the water table, the moist unit weight is 16.8 kN/m³, and below it the saturated unit weight is 19.0 kN/m³. At a total depth of 12 m, what is the effective vertical stress?

A. 108 kPa
B. 128 kPa
C. 138 kPa
D. 148 kPa

4. A strip footing at 1.6 m depth bears on saturated clay ($\varphi=0$) with cu = 48 kPa. Using Terzaghi bearing capacity factors ($N_c=5.7$, $N_q=1.0$) and a surcharge unit weight of 19 kN/m^3, what is the ultimate bearing capacity?

A. 260 kPa
B. 282 kPa
C. 304 kPa
D. 326 kPa

5. A dry, cohesionless infinite slope has friction angle $\varphi=34°$ and inclination $\beta=23°$. What is the factor of safety against sliding?

A. 1.24
B. 1.38
C. 1.46
D. 1.59

6. A 3.8 m tall wall retains cohesionless backfill with unit weight 18.2 kN/m^3 and $\varphi'=29°$. Using Rankine theory, what is the total passive resultant force per unit length of wall?

A. 379 kN/m
B. 420 kN/m
C. 458 kN/m
D. 495 kN/m

7. A doubly-drained saturated clay layer 8 m thick has cv = 4 m^2/yr. Using $T_v=0.197$ for 50% consolidation, how long does it take to reach 50% consolidation?

A. 245 days
B. 288 days
C. 320 days
D. 350 days

8. A submerged infinite slope of cohesionless soil ($c'=0$) has $\varphi'=31°$, slope angle $\beta=21°$, saturated unit weight $\gamma sat=19.8$ kN/m³, and $\gamma w=9.81$ kN/m³, with seepage parallel to the slope. What is the factor of safety?

A. 0.60
B. 0.71
C. 0.79
D. 0.87

9. A horizontal curve has a radius of 1,250 ft and a deflection angle of 12°. What is the curve length?

A. 210.5 ft
B. 235.6 ft
C. 261.8 ft
D. 285.4 ft

10. For the same curve ($R=1,250$ ft, $\Delta=12°$), what is the middle ordinate distance?

A. 6.8 ft
B. 8.4 ft
C. 9.8 ft
D. 11.2 ft

11. A vertical curve has an initial grade $g1=+1.2\%$ and final grade $g2=-2.8\%$ over a 400 ft curve length. How far from the BVC does the high point occur?

A. 95 ft
B. 120 ft
C. 145 ft
D. 170 ft

12. For the horizontal curve with R=1,250 ft and Δ=12°, what is the long chord length?

A. 235.6 ft
B. 248.2 ft
C. 254.9 ft
D. 261.3 ft

13. A pipeline replacement project along an active roadway must verify the depth of an existing gas main before trenching begins. Which method provides the most direct, physical confirmation?

A. a review of the gas utility's GIS mapping alone
B. hand-digging (hydro-vac or vacuum excavation) at the marked utility location
C. an aerial LiDAR survey of the roadway surface
D. interviewing nearby residents about past excavation work

14. A benchmark has an established elevation of 220.00 ft. A backsight rod reading of 2.95 ft is taken on the benchmark, and a foresight reading of 8.40 ft is taken to set a rough grade stake. What elevation is the stake set at?

A. 214.55 ft
B. 218.20 ft
C. 225.60 ft
D. 231.35 ft

15. What is the degree of curve (arc definition) for a horizontal curve with a 1,250 ft radius?

A. 3.65°
B. 4.12°
C. 4.58°
D. 5.05°

16. A fine-grained soil has a liquid limit LL=52 and plastic limit PL=24. Using the USCS plasticity chart, how should this soil be classified?

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

17. A concrete mix design specifies 270 lb/yd^3 of water and 600 lb/yd^3 of cement. What is the water-cement ratio?

A. 0.45
B. 0.53
C. 0.61
D. 0.69

18. What is the minimum specified yield strength for ASTM A53 Grade B steel pipe, commonly used for pipe piles?

A. 42 ksi
B. 46 ksi
C. 50 ksi
D. 35 ksi

19. A sawn lumber beam has a reference bending design value Fb=1450 psi. Applying a load duration factor CD=1.25 for snow load and a size factor CF=0.98, what is the adjusted design value?

A. 1610 psi
B. 1776 psi
C. 1920 psi
D. 2050 psi

20. Which ASTM standard uses a pressure meter and Boyle's law to determine the air content of freshly mixed concrete?

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

21. A soil sample has a void ratio $e=0.60$ and specific gravity $G_s=2.66$. What is the dry unit weight, using $\gamma_w=9.81$ kN/m³?

A. 13.2 kN/m³
B. 14.6 kN/m³
C. 15.5 kN/m³
D. 16.3 kN/m³

22. What is the minimum specified yield strength for ASTM A615 Grade 40 reinforcing steel?

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

23. Two cross-section end areas along a roadway cut are 130 sf and 190 sf, separated by 145 ft. Using the average end area method, what is the earthwork volume in cubic yards?

A. 725.6 cy
B. 859.3 cy
C. 920.4 cy
D. 985.1 cy

24. A project requires 1,650 cy of asphalt at a unit cost of $88/cy. What is the total material cost?

A. $145,200
B. $128,600
C. $158,900
D. $172,400

25. An owner expects to spend $820,000 seven years from now on a facility upgrade. At an interest rate of 9% per year, what is the present worth of that expenditure?

A. $385,200
B. $418,600
C. $448,600
D. $478,900

26. A project has an earned value (EV) of $362,000 and actual cost (AC) of $395,000. What is the cost performance index (CPI)?

A. 0.82
B. 0.92
C. 1.01
D. 1.10

27. A concrete slab measures 36 ft by 54 ft at a thickness of 0.45 ft. What is the concrete volume in cubic yards?

A. 24.6 cy
B. 27.8 cy
C. 30.1 cy
D. 32.4 cy

28. Using a parametric cost-per-square-foot estimate of $145/sf for a 30,000 sf building, what is the estimated construction cost?

A. $4,350,000
B. $3,900,000
C. $4,650,000
D. $4,950,000

29. A production line has fixed costs of $70,000, a variable cost of $19 per unit, and sells each unit at $43. How many units must be sold to break even?

A. 2,560
B. 2,917
C. 3,280
D. 3,650

30. A schedule shows earned value EV=$298,000 and planned value PV=$340,000. What is the schedule performance index (SPI)?

A. 1.05
B. 0.98
C. 0.91
D. 0.88

31. An activity has an early start (ES) of day 22 and a duration of 9 days. What is its early finish (EF)?

A. 25
B. 28
C. 31
D. 34

32. Using the PERT three-point estimate with optimistic time to=4 days, most likely tm=7 days, and pessimistic tp=16 days, what is the expected activity duration?

A. 8.0 days
B. 8.8 days
C. 9.4 days
D. 10.0 days

33. An activity has ES=18 and LS=27. What is its total float?

A. 5
B. 9
C. 12
D. 15

34. A critical path consists of four sequential activities with durations of 9, 12, 7, and 14 days. What is the total critical path duration?

A. 30 days
B. 34 days
C. 38 days
D. 42 days

35. A paving crew completes 4,800 linear feet of curb and gutter in 16 working days. What is the crew's production rate?

A. 300 ft/day
B. 260 ft/day
C. 230 ft/day
D. 340 ft/day

36. A task requires 6 workers for 14 days. What is the total resource-days (worker-days) required for this task?

A. 60
B. 72
C. 84
D. 96

37. An activity has a normal cost of $28,000 over 12 days and a crash cost of $44,000 over 8 days. What is the crash cost per day?

A. $2,800
B. $3,200
C. $3,600
D. $4,000

38. In loadbearing masonry wall construction, which of the following represents the correct sequence of field operations?

A. place grout, lay units, tie reinforcement, then inspect
B. lay units and tie vertical reinforcement in place, place grout, then inspect
C. inspect, lay units, place grout, then tie reinforcement
D. place grout, tie reinforcement, lay units, then inspect

39. An activity has an early finish of day 20, and the earliest successor activity's early start is day 32. What is this activity's free float?

A. 12
B. 15
C. 18
D. 21

40. Extending a non-critical activity's duration to reduce its daily resource demand, without affecting the project finish date, is only possible if the activity's original float exceeds—

A. its predecessor's total duration measured in working days
B. the project's total schedule contingency reserve amount available
C. the number of additional days added to its duration
D. the crew's approved overtime allowance for that week

41. A field density test shows a dry density of 115 pcf, while the laboratory maximum dry density (standard Proctor) is 122 pcf. What is the percent relative compaction?

A. 90.6%
B. 94.3%
C. 97.1%
D. 100.4%

42. Which ASTM standard measures fresh concrete's slump to evaluate consistency and workability?

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

43. For an ASTM A325 high-strength bolt installed by the turn-of-nut method, with a bolt length between 4 and 8 diameters and both connected surfaces normal to the bolt axis, what nut rotation from snug-tight is required?

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

44. When a contractor's proposed substitute material differs from what is specified, who has final authority to approve or reject the substitution?

A. the independent testing laboratory
B. the material supplier
C. the project scheduler
D. the design engineer of record

45. What is the primary purpose of curing compound or moist curing applied to freshly finished concrete?

A. to accelerate the concrete's initial set time
B. to increase the water-cement ratio at the exposed surface
C. to eliminate the need for a vibrator during placement
D. to retain moisture so cement hydration can continue and strength can develop properly

46. Using the Nurse-Saul maturity function with a constant temperature-datum difference of 16°C sustained for 70 hours, what is the concrete's maturity index?

A. 1120 °C-hr
B. 980 °C-hr
C. 1250 °C-hr
D. 1380 °C-hr

47. The maturity method estimates strength based on temperature history, but it cannot account for which of the following factors affecting actual in-place strength?

A. the accumulated temperature-time history of the concrete
B. the mixture's cement content
C. inadequate consolidation or poor curing practices in the field
D. the calibration curve developed for that mixture

48. A sand cone field density test removes 3.4 lb of soil from a hole with a volume of 0.028 cf. The soil's moisture content is 9%. What is the dry unit weight?

A. 103.8 pcf
B. 111.4 pcf
C. 118.6 pcf
D. 124.9 pcf

49. A 3/8-in fillet weld uses E80 electrode (Fexx=80 ksi). What is its nominal strength per inch of weld length?

A. 9.6 kip/in
B. 11.2 kip/in
C. 12.7 kip/in
D. 14.5 kip/in

50. If soil compaction testing reveals a failed lift beneath an already-placed subsequent lift, what is the standard corrective approach?

A. remove the overlying lift(s) as needed, rework and retest the failed lift, then replace the removed material
B. leave both lifts in place since removal is impractical at this stage
C. reduce the compaction specification for that area retroactively
D. accept the lift based on passing tests from adjacent areas alone

51. A slab is designed for dead load D=38 psf and live load L=72 psf. Using the basic ASCE 7 load combination U=1.2D+1.6L, what is the factored design load?

A. 128 psf
B. 142 psf
C. 152 psf
D. 161 psf

52. A beam experiences a bending moment $M=675$ kip-in at a section where $c=6$ in and $I=245$ in^4. What is the extreme fiber bending stress?

A. 13.8 ksi
B. 16.5 ksi
C. 19.2 ksi
D. 21.6 ksi

53. An axially loaded member carries $P=132$ kip through a cross-sectional area of 8.8 in^2. What is the axial stress?

A. 12.6 ksi
B. 15.0 ksi
C. 17.4 ksi
D. 19.8 ksi

54. A footing carries a column load of 460 kip and measures 11 ft by 13 ft in plan. What is the resulting bearing pressure on the soil?

A. 2.60 ksf
B. 2.85 ksf
C. 3.05 ksf
D. 3.22 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 $K_z=0.83$, $K_{zt}=1.0$, $K_d=0.85$, and $V=105$ mph, what is the velocity pressure?

A. 14.2 psf
B. 17.5 psf
C. 19.9 psf
D. 23.1 psf

56. A beam has shear force V=36 kip, first moment of area Q=38 in^3, moment of inertia I=680 in^4, and web thickness b=7 in. What is the shear stress at that location?

A. 287 psi
B. 320 psi
C. 350 psi
D. 385 psi

57. A column has an effective length factor K=1.0, unbraced length L=22 ft, and radius of gyration r=3.4 in. What is the slenderness ratio KL/r?

A. 78
B. 86
C. 93
D. 100

58. A retaining wall has a resisting moment of 1,150 kip-ft and an overturning moment of 470 kip-ft. What is the factor of safety against overturning?

A. 1.85
B. 2.05
C. 2.24
D. 2.45

59. A column has a tributary floor area of 18 ft by 22 ft, and the floor is designed for a live load of 110 psf. What is the total live load carried by this column?

A. 38.2 kip
B. 43.6 kip
C. 48.5 kip
D. 52.9 kip

60. Under AISC 360, which chapter covers stability design, including the direct analysis method for accounting for second-order effects?

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

61. Using the rational method $Q=C \cdot i \cdot A$ with a runoff coefficient $C=0.38$, rainfall intensity $i=4.0$ in/hr, and drainage area $A=14$ acres, what is the peak discharge?

A. 21.3 cfs
B. 24.6 cfs
C. 27.9 cfs
D. 31.2 cfs

62. An open channel has Manning's $n=0.014$, flow area $A=14$ sf, hydraulic radius $R=1.6$ ft, and slope $S=0.0045$. Using Manning's equation (USCS form with 1.49), what is the flow rate?

A. 108.2 cfs
B. 122.5 cfs
C. 136.7 cfs
D. 150.9 cfs

63. Using the Kirpich equation Tc=0.0078·L^0.77·S^-0.385 (L in ft, S in ft/ft), with a flow path length of 500 ft and slope of 0.03, what is the time of concentration?

A. 2.8 min
B. 3.6 min
C. 4.5 min
D. 5.3 min

64. A detention pond must temporarily store runoff where peak inflow is 38 cfs, allowable peak outflow is 15 cfs, and the storm duration is 3 hours. Using a simplified triangular hydrograph approximation, what storage volume is required?

A. 2.15 ac-ft
B. 2.48 ac-ft
C. 2.68 ac-ft
D. 2.85 ac-ft

65. A storm sewer pipe with a 15-in diameter carries a flow of 8 cfs. What is the flow velocity in the pipe, assuming it flows full?

A. 6.5 fps
B. 5.2 fps
C. 7.4 fps
D. 8.1 fps

66. A broad-crested weir outlet has a discharge coefficient C=3.3, crest length L=3.5 ft, and head H=1.3 ft. Using Q=C·L·H^1.5, what is the discharge through the weir?

A. 11.4 cfs
B. 13.2 cfs
C. 15.1 cfs
D. 17.1 cfs

67. A 2-leg sling supports a 7,500 lb load, with each leg oriented at 45° from horizontal. What is the tension in each leg?

A. 4,800 lb
B. 5,303 lb
C. 5,800 lb
D. 6,200 lb

68. A load chart specifies capacity 'on outriggers, fully extended.' If a crane operator sets up with outriggers only partially extended, the applicable rated capacity is—

A. the same as fully extended, since outriggers are always rigid once deployed
B. always higher, since less ground area is occupied by the setup
C. significantly lower, per the load chart's reduced-outrigger-extension capacity table
D. governed solely by the boom angle, with no effect from outrigger position

69. A dewatering system must handle 340 gpm of inflow, and each wellpoint has a discharge capacity of 19 gpm. What is the minimum number of wellpoints required?

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

70. An excavator has a bucket capacity of 1.75 cy, a fill factor of 0.95, a cycle time of 18 seconds, and operates at 52 minutes of effective work per hour. What is its production rate?

A. 230 cy/hr
B. 255 cy/hr
C. 270 cy/hr
D. 288 cy/hr

71. Using the Engineering News Record (ENR) pile driving formula Qu=2E/(S+0.1), with driving energy E=26,000 ft-lb and set S=0.45 in per blow, and applying a factor of safety of 6, what is the allowable pile capacity?

A. 11.2 kip
B. 13.6 kip
C. 15.8 kip
D. 18.4 kip

72. Two cross-section end areas along a roadway cut are 145 sf and 205 sf, separated by 155 ft. Using the average end area method, what is the cut volume in cubic yards?

A. 1,004.6 cy
B. 1,150.8 cy
C. 1,280.4 cy
D. 1,395.2 cy

73. As the choke angle in a wire rope choker hitch decreases below 120 degrees, the sling's rated capacity—

A. must be further reduced beyond the standard choker derate
B. increases due to added friction between the sling and the load
C. remains constant regardless of the choke angle involved
D. applies only to synthetic web slings, not wire rope slings

74. A crane boom is 95 ft long and raised to an angle of 52° from horizontal. Ignoring boom point offset, what is the resulting horizontal working radius?

A. 48.2 ft
B. 52.6 ft
C. 55.1 ft
D. 58.5 ft

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

A. 90 gpm
B. 100 gpm
C. 112.5 gpm
D. 125 gpm

76. A loader has a cycle time of 2.8 minutes per load. A truck's full haul-dump-return cycle takes 19.6 minutes. How many trucks are needed to keep the loader continuously working?

A. 5
B. 7
C. 9
D. 11

77. A pile's static capacity analysis gives skin friction resistance Qs=165 kip and end bearing resistance Qp=95 kip. Applying a factor of safety of 2.5, what is the allowable pile capacity?

A. 88 kip
B. 104 kip
C. 118 kip
D. 132 kip

78. An embankment requires 8,200 cy of soil measured in the bank (natural, undisturbed) condition, and the borrow soil has a shrinkage factor of 0.87 relating compacted volume to bank volume. What compacted fill volume results from excavating this bank volume?

A. 6,200 cy
B. 6,650 cy
C. 7,134 cy
D. 7,600 cy

79. A crane outrigger imposes a load of 54,000 lb on the ground, and the allowable soil bearing pressure is 3,600 psf. What minimum outrigger pad area is required?

A. 15.0 sf
B. 17.2 sf
C. 19.6 sf
D. 21.8 sf

80. Using the ACI 347 formwork lateral pressure formula for columns, Cw=150+9000R/T, with a placement rate R=7 ft/hr and concrete temperature T=55°F, what is the design lateral pressure?

A. 950 psf
B. 1,080 psf
C. 1,180 psf
D. 1,295 psf

81. A scaffold platform will support 4 workers averaging 200 lb each, 1,400 lb of stored material, and 220 lb of tools and equipment. What is the total design load on the platform?

A. 1,980 lb
B. 2,150 lb
C. 2,300 lb
D. 2,420 lb

82. A reshore below a freshly poured slab has a tributary area of 7.5 ft by 7.5 ft, and the slab's dead load is 100 psf. What load is transferred to this reshore, using a simplified tributary-area method?

A. 4,800 lb
B. 5,625 lb
C. 6,300 lb
D. 6,900 lb

83. A minimum lateral bracing design provision requires lateral bracing force equal to 2% of the supported vertical load. For a formwork system supporting 55,000 lb vertically, what minimum lateral bracing force must be provided?

A. 1,100 lb
B. 1,250 lb
C. 1,400 lb
D. 1,550 lb

84. For a braced excavation in sand with an apparent earth pressure diagram per Terzaghi-Peck, $p=0.65 \cdot Ka \cdot \gamma \cdot H$, with $Ka=0.32$, $\gamma=112$ pcf, and excavation depth $H=20$ ft, what is the peak apparent pressure?

A. 380 psf
B. 425 psf
C. 466 psf
D. 505 psf

85. A construction sequence plan that removes all shoring from a level immediately after the concrete reaches its 7-day strength, without further analysis, risks—

A. no risk, since 7-day strength always exceeds design requirements
B. an improved schedule with no offsetting structural consequence
C. reduced material costs with no offsetting risk to the structure
D. overloading the slab before it has gained adequate strength to safely carry loads from levels above

86. Per ACI 347, absent motorized concrete buggies, formwork must be designed for a minimum combined dead and live load of at least—

A. 75 psf
B. 100 psf
C. 110 psf
D. 90 psf

87. A supported scaffold is 24 ft tall with a 7 ft base width. Per OSHA 29 CFR 1926 Subpart L, is guying, tying, or bracing automatically required based on the height-to-base ratio alone?

A. No, since 3.4:1 is below the 4:1 threshold
B. Yes, since all scaffolds over 20 ft require restraint
C. Yes, since the ratio exceeds 3:1
D. No, since only rolling scaffolds require restraint

88. A slab load of 130 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. 3,510 lb
B. 4,200 lb
C. 4,800 lb
D. 5,400 lb

89. A diagonal brace oriented at 44° from horizontal resists a horizontal thrust of 6,500 lb. What is the resulting axial force in the brace?

A. 7,800 lb
B. 8,400 lb
C. 9,036 lb
D. 9,700 lb

90. An 8-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. 8 ft
B. 12 ft
C. 16 ft
D. 20 ft

91. Per ASCE 37, the design wind speed used for a temporary structure with a planned exposure period of only a few weeks may be reduced relative to the permanent structure's design wind speed, based primarily on—

A. the contractor's preference for a lighter bracing system
B. the owner's budget constraints alone, without any technical justification
C. the specific crane model being used on site
D. the reduced statistical probability of the full-service design wind event occurring

92. Vertical formwork that carries no load other than the fresh concrete's own lateral pressure may generally be stripped once the concrete reaches sufficient strength to resist surface damage, without needing to reach the higher strength threshold required for—

A. completing the finishing operations on the surface
B. achieving final color uniformity across the element
C. load-bearing horizontal shoring supporting other loads
D. passing the standard 28-day cylinder break

93. A shoring post has an allowable capacity of 9,000 lb at an unbraced length of 18 ft. If lateral bracing reduces the unbraced length to 9 ft, and capacity scales inversely with the square of unbraced length (Euler-type behavior), what is the new allowable capacity?

A. 27,000 lb
B. 31,500 lb
C. 33,000 lb
D. 36,000 lb

94. A braced excavation is 22 ft deep in clay with undrained shear strength $cu=1{,}500$ psf and unit weight $\gamma=128$ pcf. Using a bearing capacity factor $Nc=5.7$, what is the factor of safety against bottom heave, $FS=Nc\cdot cu/(\gamma\cdot H)$?

A. 2.6

B. 3.0
C. 3.5
D. 3.9

95. Per OSHA 29 CFR 1926 Subpart L, what is the maximum permissible distance between a scaffold platform and the face of the work, absent an approved alternative, to minimize fall hazards?

A. 10 in
B. 12 in
C. 14 in
D. 18 in

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

A. 660 ft
B. 590 ft
C. 720 ft
D. 780 ft

97. Per OSHA 29 CFR 1926 Subpart X, what is the maximum recommended pitch, or angle from horizontal, for a non-self-supporting portable ladder?

A. 60 degrees
B. 68 degrees
C. 75.5 degrees
D. 82 degrees

98. Per MUTCD Part 6, which TTC zone component provides the transition, using tapers, from the normal travel lane alignment into the reduced or shifted alignment required by the work zone?

A. the activity area
B. the transition area
C. the advance warning area
D. the termination area

99. A competent person's determination that a protective system is unnecessary for a shallow excavation must be based primarily on—

A. the contractor's production schedule for the week
B. the availability of trench boxes on the project site
C. the owner's preference to avoid the extra cost of shoring
D. an evaluation of soil classification, groundwater conditions, and other site-specific hazard factors

100. Per MUTCD guidance, positive protection devices are generally LEAST likely to be warranted in which of the following work zone conditions?

A. a low-speed, low-volume residential street closure
B. a high-speed interstate shoulder closure
C. an extended-duration urban freeway project
D. a work zone with high traffic exposure near workers

Practice Exam 19: Answer Key and Explanations

1. B — Rankine active pressure for a level, cohesionless backfill is $K_a = \tan^2(45° - \varphi'/2)$. With $\varphi' = 33°$, this is $\tan^2(28.5°) \approx 0.295$. This value continues the trend of decreasing Ka as friction angle increases, since a stronger soil skeleton needs less lateral thrust to reach its active failure state.

2. A — Primary consolidation settlement is $S_c = [C_c \cdot H/(1+e_0)] \cdot \log_{10}[(p_0+\Delta p)/p_0]$. Substituting, $S_c = (0.22 \times 5.5/1.75) \cdot \log_{10}(225/130) = 0.691 \times 0.238 \approx 0.165$ m, or 165 mm. This reflects a fairly low compression index applied over a thick clay layer under a substantial added stress relative to the existing overburden pressure at this particular site. Softer clay compressibility would further increase this settlement estimate.

3. D — Total stress at 12 m is $\sigma = (16.8\times5) + (19.0\times7) = 84 + 133 = 217$ kPa. Pore pressure develops only below the water table: $u = 9.81\times7 \approx 68.7$ kPa. Effective stress is $\sigma' = 217 - 68.7 \approx 148$ kPa. Options A through C understate the value by mishandling either the total stress or pore pressure term.

4. C — For $\varphi = 0$ conditions, $q_{ult} = c_u\cdot N_c + q\cdot N_q$. The surcharge is $q = 19\times1.6 = 30.4$ kPa, so $q_{ult} = 48\times5.7 + 30.4\times1.0 = 273.6 + 30.4 \approx 304$ kPa. Omitting the surcharge term, as in option B, understates ultimate capacity by ignoring the confinement the overlying soil provides at footing level.

5. D — For a dry infinite slope of cohesionless soil, $FS = \tan\varphi/\tan\beta$, since slice weight cancels out of both driving and resisting terms. Here $FS = \tan(34°)/\tan(23°) = 0.675/0.424 \approx 1.59$. This ratio depends only on the friction and slope angles, not on slope height, soil unit weight, or the depth of any failure surface.

6. A — Passive coefficient is $K_p = \tan^2(45°+\varphi'/2) = \tan^2(59.5°) \approx 2.943$. The resultant passive force is $P_p = 0.5\cdot K_p\cdot\gamma\cdot H^2 = 0.5\times2.943\times18.2\times3.8^2 \approx 379$ kN/m, acting one-third of the wall height above the base, since passive resistance grows with the square of wall height and embedment depth combined here. Wall embedment depth strongly influences the magnitude of this force.

7. B — With double drainage, the drainage path length is $H_{dr} = H/2 = 4$ m. Time factor relates as $t = T_v\cdot H_{dr}^2/c_v = 0.197\times16/4 = 0.788$ yr, which converts to $0.788\times365 \approx 288$ days. Using the full 8 m thickness instead of the halved drainage path would substantially overstate this required consolidation time.

8. C — With seepage parallel to the slope, $FS = (\gamma'/\gamma_{sat})\cdot(\tan\varphi'/\tan\beta)$. The buoyant unit weight is $\gamma' = 19.8-9.81 \approx 9.99$ kN/m³, giving a ratio of 0.505. Combined with $\tan(31°)/\tan(21°) \approx 1.565$, $FS \approx 0.505\times1.565 \approx 0.79$, roughly half the equivalent dry slope's factor of safety without seepage present here. Higher friction angles would proportionally increase this safety factor.

9. C — Curve length is $L = R\cdot\Delta(\text{radians}) = 1{,}250\times(12\times\pi/180) = 1{,}250\times0.20944 \approx 261.8$ ft. This arc-based formula gives the actual station-to-station distance traveled along the curve, distinct from the shorter chord distance connecting the PC and PT endpoints of this curve. Sharper curves at the same radius yield shorter overall lengths here.

10. A — Middle ordinate is $M = R\cdot(1-\cos(\Delta/2))$. With $\Delta/2 = 6°$, $\cos(6°) = 0.99452$, so $M = 1{,}250\times(1-0.99452) = 1{,}250\times0.00548 \approx 6.8$ ft. This small offset reflects a gentle curve relative to its large radius, since sharper curves at the same radius produce larger middle ordinates. Sharper deflection angles at this radius increase this offset value.

11. B — The high point on a crest vertical curve occurs where $x = L\cdot g_1/(g_1-g_2)$. Here $x = 400\times1.2/(1.2-(-2.8)) = 480/4.0 = 120$ ft from the BVC. Because the outgoing grade is much steeper than the incoming grade, this point falls well before the curve's geometric midpoint of 200 ft. Symmetric grades would instead place the high point at midpoint.

12. D — The long chord connecting the PC and PT is $C = 2R\cdot\sin(\Delta/2)$. With $\Delta/2 = 6°$, $\sin(6°) = 0.10453$, giving $C = 2\times1{,}250\times0.10453 \approx 261.3$ ft. As expected, this is only slightly shorter than the

261.8 ft arc length computed earlier for this same gentle curve's geometry and radius. Chord and arc lengths converge as deflection angles grow smaller.

13. B — GIS mapping, aerial surveys, and resident recollections all provide indirect or approximate information at best, none of which reliably confirms an underground gas main's actual depth. Hand-digging or vacuum excavation at the marked location physically exposes the main without the risk of striking it, providing the only truly direct depth confirmation before trenching.

14. A — Height of instrument is HI = benchmark elevation + backsight = 220.00 + 2.95 = 222.95 ft. The stake elevation is then HI minus the foresight: 222.95 − 8.40 = 214.55 ft. This differential leveling procedure carries a known elevation from the fixed benchmark out to new grade stakes across the construction site.

15. C — By the arc definition, degree of curve is $D = 5729.58/R$. With $R = 1{,}250$ ft, $D = 5729.58/1{,}250 \approx 4.58°$. This small degree of curve reflects a very gentle, wide-radius alignment, typical of higher-speed roadway design where sharper curvature would be uncomfortable or unsafe for the design vehicle at speed.

16. D — Plasticity index is PI = LL−PL = 28. The A-line value at LL=52 is $0.73\times(52-20) = 23.4$, and since PI=28 plots above the A-line with LL≥50, the soil classifies as CH. A PI falling below this A-line value at the same liquid limit would instead point toward an MH classification.

17. A — Water-cement ratio is the water weight divided by cement weight: 270/600 = 0.45. This relatively low ratio typically produces higher strength and better durability than the moderate ratios examined earlier, though it demands careful attention to workability, often requiring water-reducing admixtures to maintain placeability without adding extra mixing water to the batch.

18. D — ASTM A53 Grade B pipe has a minimum specified yield strength of 35 ksi, lower than typical structural wide-flange steel, reflecting its origin as a general-purpose pipe specification rather than a dedicated structural shape standard. It remains widely used for pipe piles, casings, and miscellaneous structural pipe applications in construction.

19. B — Adjusted design values multiply the reference value by all applicable adjustment factors: $F_b' = F_b \times C_D \times C_F = 1450\times1.25\times0.98 \approx 1776$ psi. A size factor slightly below 1.0 modestly reduces capacity for this particular member size, but the larger snow-load duration factor still yields a net increase over the unadjusted reference value.

20. C — ASTM C231 specifies the pressure method, applying Boyle's law to relate an observed pressure change to the air content of a fresh concrete sample. C39 tests hardened cylinder strength, C143 measures slump, and C1064 measures fresh concrete temperature, each capturing an entirely different property of the concrete being tested at that time.

21. D — Dry unit weight relates to void ratio and specific gravity by $\gamma_d = G_s \cdot \gamma_w/(1+e) = 2.66\times9.81/1.60 \approx 16.3$ kN/m³. This moderate void ratio produces a dry unit weight between the denser and looser samples examined in earlier problems, illustrating how compaction effort directly shifts this fundamental soil index property. A looser soil sample would yield a lower unit weight.

22. C — ASTM A615 Grade 40 reinforcing bars have a minimum specified yield strength of 40 ksi, the lowest common grade in the A615 family. It remains available primarily for smaller-diameter bars and applications like stirrups and ties where the ductility and bendability of lower-strength steel is preferred over the higher-strength Grade 60 bar.

23. B — The average end area method computes volume as $V = [(A1+A2)/2]\times L = [(130+190)/2]\times 145 = 23{,}200$ cf. Converting to cubic yards by dividing by 27 gives approximately 859.3 cy. This remains the standard hand-calculation approach for earthwork quantity takeoff between surveyed cross sections along a roadway alignment segment. Longer segment lengths would proportionally increase this computed volume.

24. A — Unit cost estimating multiplies quantity by unit price: 1,650×$88 = $145,200. This calculation is only as reliable as the underlying quantity takeoff and unit price data, both of which should reflect current market conditions and the specific asphalt mix design called for on this particular paving project and specification. Bulk purchasing discounts could further reduce this baseline cost.

25. C — Present worth of a single future amount is $P = F/(1+i)^n = 820{,}000/(1.09)^7 = 820{,}000/1.8280 \approx \$448{,}600$. This single-payment present-worth factor allows costs occurring at different points in time to be compared fairly on a common present-value basis for economic decision-making purposes across project alternatives being evaluated. Higher discount rates would further reduce this present-worth result.

26. B — Cost performance index is $CPI = EV/AC = 362{,}000/395{,}000 \approx 0.92$. A CPI below 1.0 indicates the project is spending more than the value of work actually completed, signaling a cost overrun trend that warrants management attention before it grows further as remaining work is performed and eventually billed. A higher actual cost would further reduce this performance index.

27. D — Volume is length times width times thickness: $36\times54\times0.45 = 874.8$ cf. Dividing by 27 cf per cubic yard gives approximately 32.4 cy. This slab-on-grade takeoff is routinely used to order the correct number of ready-mix truck loads and plan crew workload for the day of the scheduled concrete pour. Thicker slab sections would proportionally increase this computed volume.

28. A — Parametric estimating multiplies a unit rate by a project parameter: 30,000 sf × $145/sf = $4,350,000. This method is useful in early conceptual design before detailed quantities exist, trading precision for speed, with reliability depending heavily on how well the historical rate matches this project's scope and finish level overall.

29. B — Break-even quantity equals fixed cost divided by the contribution margin per unit: $70{,}000/(43-19) = 70{,}000/24 \approx 2{,}917$ units. Below this quantity the operation runs at a loss, and above it, each additional unit contributes $24 toward covering fixed costs and, past break-even, toward genuine profit for the business overall. Higher fixed costs would raise this break-even threshold correspondingly.

30. D — Schedule performance index is $SPI = EV/PV = 298{,}000/340{,}000 \approx 0.88$. An SPI below 1.0 indicates the project is behind its planned schedule, since less value has been earned by this point than was originally planned for this stage, signaling that schedule recovery measures may soon become necessary going forward.

31. C — In the CPM forward pass, early finish equals early start plus duration: EF = ES + Duration = 22 + 9 = 31. This value becomes the early start for any successor activity that depends solely on this one, propagating forward through the network toward the earliest possible project completion date achievable.

32. A — PERT expected time is $te = (to + 4 \cdot tm + tp)/6 = (4 + 28 + 16)/6 = 48/6 = 8.0$ days. Weighting the most likely estimate four times as heavily as the optimistic and pessimistic bounds reflects the right-skewed distribution typical of real construction activity durations encountered on most projects.

33. B — Total float is the difference between late start and early start: TF = LS − ES = 27 − 18 = 9. This represents how many days the activity's start can slip without delaying the overall project completion date, assuming the float isn't shared with or consumed by other activities on its path.

34. D — Since these activities occur sequentially with no overlap along the critical path, total duration is simply their sum: 9+12+7+14 = 42 days. The critical path is the longest chain of dependent activities through the network, and it alone sets the shortest possible achievable project completion date given these four durations.

35. A — Production rate for a linear (line-of-balance) schedule is distance divided by time: 4,800 ft / 16 days = 300 ft/day. This rate defines the slope of the crew's line on a time-distance diagram, used to sequence multiple crews so faster crews don't overtake slower ones working ahead of them on the alignment.

36. C — Total resource-days is the product of the number of workers and the duration: 6 workers × 14 days = 84 worker-days. This fixed labor quantity can be redistributed across different crew sizes and durations during resource leveling without changing the total amount of work actually performed on this particular task.

37. D — Crash cost slope is the change in cost divided by the change in duration: (44,000−28,000)/(12−8) = 16,000/4 = $4,000 per day. This slope tells the scheduler how much it costs to compress each day out of this activity, guiding which activities to crash first when accelerating an overall project schedule.

38. B — Masonry units must first be laid up with vertical reinforcing steel positioned in the cells as the wall rises, since the units themselves form the formwork for the grout. Grout is then placed to fill the reinforced cells, and the completed lift is inspected afterward to confirm proper consolidation and reinforcement placement.

39. A — 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) = 32 − 20 = 12. Unlike total float, this value depends only on the immediate downstream activity, not on the project's overall late-date calculations elsewhere.

40. C — Stretching an activity out over more days lowers its daily resource demand but consumes float equal to the additional days added, since the activity now finishes later than its original early finish. This is only safe if the activity's available float exceeds that added duration, or the schedule's finish date will be pushed back.

41. B — Relative compaction is the field dry density divided by the laboratory maximum dry density, expressed as a percentage: $(115/122)\times100 \approx 94.3\%$. This result would typically satisfy a specification requiring 90 to 95% relative compaction, confirming the field placement and compaction effort met the earthwork requirements for this particular lift. Lower field densities would proportionally reduce this compaction percentage.

42. A — ASTM C143 defines the slump test, in which a cone-shaped mold of fresh concrete is filled, rodded in layers, and then lifted, with the resulting settlement measured as the slump value. C231 measures air content, C39 tests hardened cylinder strength, and C42 governs drilled core sampling, each addressing an entirely different property.

43. C — The RCSC Specification's turn-of-nut method scales required nut rotation with bolt length. For bolt lengths between 4 and 8 diameters, with both connected surfaces normal to the bolt axis, the required rotation beyond snug-tight is 1/2 turn, more than the 1/3 turn used for the shortest bolts but less than longer ones require.

44. D — Substitution requests must be evaluated against the original design intent, a judgment that belongs to the design engineer of record who authored the specifications and understands the performance requirements behind them. The testing laboratory verifies physical properties, the supplier has an obvious commercial interest, and the scheduler manages timeline, not design conformance.

45. D — Curing compounds and moist curing methods work by retaining the moisture already present in the fresh concrete, allowing cement hydration to continue over the following days and weeks so the concrete can develop its intended strength and durability. Without adequate curing, surface moisture evaporates too quickly, weakening the near-surface concrete significantly.

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 16°C difference sustained for 70 hours, $M = 16\times70 = 1{,}120$ °C-hours. This index is later compared against a mixture-specific calibration curve to estimate the concrete's in-place strength at that particular age. Higher sustained temperatures would proportionally increase this maturity value.

47. C — The maturity method assumes the concrete was properly consolidated and cured, since its calibration curve was developed under those same properly executed conditions. If field consolidation is inadequate or curing is neglected, the actual in-place strength can fall well below what the maturity index alone predicts, since the method cannot detect these workmanship defects.

48. B — Wet unit weight is the weight of soil removed divided by the hole volume: $3.4/0.028 \approx 121.4$ pcf. Converting to dry unit weight using the moisture content, $\gamma d = \gamma wet/(1+w) = 121.4/1.09 \approx 111.4$

pcf. This field value is compared against the laboratory Proctor curve to check the relative compaction achieved.

49. C — Nominal fillet weld strength per unit length is $R_n = 0.6 \cdot F_{exx} \cdot 0.707 \cdot w$, where 0.707 converts the leg dimension to the effective throat. With F_{exx}=80 ksi and w=0.375 in, $R_n = 0.6 \times 80 \times 0.707 \times 0.375 \approx 12.7$ kip/in, higher than an equivalent E70 weld of the same size due to the stronger electrode grade used.

50. A — A failed lift buried beneath a subsequent placement must still be exposed, reworked, and retested to confirm it meets specification, even though this requires removing the overlying material first. Leaving a known deficient lift in place, retroactively lowering the specification, or relying on unrelated adjacent test results all skip this necessary corrective sequence.

51. D — The factored load combination applies separate load factors before summing: $U = 1.2(38) + 1.6(72) = 45.6 + 115.2 \approx 161$ psf. The larger factor applied to live load reflects its greater variability relative to dead load, and this combination typically governs strength design under ordinary gravity-only loading conditions for most buildings.

52. B — The flexure formula gives bending stress as $\sigma = M \cdot c/I = 675 \times 6/245 \approx 16.5$ ksi. This maximum normal stress occurs at the extreme fiber, the distance c from the neutral axis, and would be checked against the material's allowable bending stress to confirm the section's adequacy for this applied moment.

53. B — Axial stress is force divided by cross-sectional area: $\sigma = P/A = 132/8.8 = 15.0$ ksi. This uniform distribution assumes the load passes through the section's centroid; any eccentricity would introduce additional bending stress that must be superimposed on this baseline axial value to find the true combined total stress.

54. D — Assuming a concentric load and uniform pressure distribution, bearing pressure equals load divided by footing area: $q = P/(B \times L) = 460/(11 \times 13) \approx 3.22$ 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 column load.

55. C — Substituting directly: $q_z = 0.00256 \times 0.83 \times 1.0 \times 0.85 \times 105^2 = 0.00256 \times 0.7055 \times 11{,}025 \approx 19.9$ psf. This velocity pressure is then multiplied by pressure coefficients specific to the building's geometry, height, and exposure category to obtain the actual design wind pressures acting on its surfaces per ASCE 7 tables. Taller structures in rougher terrain would further raise this pressure.

56. A — Shear stress is given by the shear flow formula $\tau = VQ/(Ib) = (36{,}000 \times 38)/(680 \times 7) = 1{,}368{,}000/4{,}760 \approx 287$ psi. This formula gives shear stress at a horizontal plane within the section, generally maximum at the neutral axis where Q is largest, and vanishing at the section's extreme top and bottom fibers.

57. A — Slenderness ratio is KL/r, using consistent units for length. Converting L to inches: 22 ft × 12 = 264 in, so $KL/r = (1.0 \times 264)/3.4 \approx 78$. This ratio helps determine whether the column's compressive strength is governed by inelastic or elastic Euler buckling behavior under AISC Chapter E design provisions.

58. D — Factor of safety against overturning is the ratio of resisting moment to overturning moment: FS = 1,150/470 ≈ 2.45. This comfortably exceeds the commonly required minimum of roughly 1.5 to 2.0, confirming the wall's weight and geometry provide ample resistance to the lateral earth pressure driving rotation about the toe.

59. B — Tributary area load is the product of tributary area and design load intensity: 18×22×110 = 43,560 lb, or about 43.6 kip. This tributary area approach assumes the column collects load from half the distance to each adjacent column line, a standard simplification for gravity load distribution in a framed structure.

60. C — AISC 360 Chapter C covers stability design requirements, including the direct analysis method used to account for second-order (P-delta) effects, initial imperfections, and stiffness reduction in frame analysis. Chapter H addresses combined forces, Chapter F addresses flexural members, and Chapter J addresses connections, each a separate design topic entirely handled elsewhere.

61. A — The rational method combines runoff coefficient, rainfall intensity, and drainage area directly: Q = C·i·A = 0.38×4.0×14 ≈ 21.3 cfs, with units already arranged to give cfs directly without conversion. This remains the standard peak-flow method for small drainage areas typically under a few hundred acres in storm sewer design.

62. C — Manning's equation is Q = (1.49/n)·A·R^(2/3)·S^(1/2). Substituting: (1.49/0.014)×14×(1.6)^0.667×(0.0045)^0.5 ≈ 106.4×14×1.368×0.0671 ≈ 136.7 cfs. This relationship between channel roughness, geometry, and slope remains fundamental for sizing open channels, culverts, and storm sewers throughout civil site design and roadway drainage work overall. Steeper channel slopes would further increase this computed flow capacity.

63. B — Substituting into the Kirpich formula: Tc = 0.0078×(500)^0.77×(0.03)^-0.385 ≈ 0.0078×119.7×3.86 ≈ 3.6 minutes. This empirical relationship estimates travel time for runoff from the hydraulically most distant point in the watershed, a key input for rational method peak flow discharge calculations in small, steep drainage basins. Flatter watershed slopes would substantially lengthen this computed travel time.

64. D — A simplified storage estimate is V ≈ 0.5×(Qin−Qout)×duration = 0.5×(38−15)×10,800 sec = 124,200 cf. Converting to acre-feet by dividing by 43,560 gives about 2.85 ac-ft. This preliminary approximation is typically refined afterward with detailed stage-storage-discharge routing for the final detention basin design and outlet structure. Longer storm durations would proportionally increase this required volume.

65. A — Velocity is flow rate divided by cross-sectional area: V = Q/A. With a 15-in (1.25-ft) diameter pipe, A = π×$(0.625)^2$ ≈ 1.23 sf, so V = 8/1.23 ≈ 6.5 fps. This exceeds typical minimum self-cleansing velocity criteria of 2 to 3 fps, helping prevent sediment deposition in this smaller-diameter line.

66. D — Substituting into the weir formula: Q = 3.3×3.5×(1.3)^1.5 = 11.55×1.482 ≈ 17.1 cfs. This head-discharge relationship follows a power-law form across the operating depth range above the crest, and is commonly applied to outlet structures that control release rates from detention and retention basins on developed construction sites. Longer crest lengths would proportionally increase this discharge capacity.

67. B — Each leg carries half the total load, resolved along its angle: T = (Load/2)/sin(angle) = 3,750/sin(45°) = 3,750/0.7071 ≈ 5,303 lb. Since 45 degrees is often cited as a practical minimum working angle in rigging references, tension here is already noticeably higher than it would be at steeper leg angles for the same load.

68. C — Load charts publish separate capacity tables for different outrigger extension configurations, since a narrower outrigger base provides a smaller, less stable tipping line than a fully extended base does. Operating with partially extended outriggers requires consulting the reduced-capacity table for that specific configuration, which yields significantly lower rated capacities at every radius.

69. B — Dividing total required flow by per-wellpoint capacity gives 340/19 ≈ 17.89, which must be rounded up to 18 wellpoints since a fractional wellpoint cannot be installed on site. Rounding up rather than down ensures the system has adequate capacity for the full anticipated groundwater inflow with a reasonable working margin.

70. D — Cycles per hour at full time is 3,600/18 = 200, giving a theoretical output of 200×1.75×0.95 ≈ 332.5 cy/hr. Applying the 52/60 efficiency factor for actual working minutes reduces this to about 288 cy/hr, reflecting realistic production once operational delays are properly accounted for on an active job site and schedule.

71. C — Ultimate capacity is Qu = 2E/(S+0.1) = 2×26,000/(0.45+0.1) = 52,000/0.55 ≈ 94,545 lb. Applying the ENR formula's typical factor of safety of 6 gives allowable capacity: Qa = 94,545/6 ≈ 15.8 kip. This moderate set per blow indicates driving resistance between the harder and softer cases examined earlier in this section.

72. A — Applying the average end area method: V = [(145+205)/2]×155 = 175×155 = 27,125 cf. Converting to cubic yards by dividing by 27 gives about 1,004.6 cy. This method remains the standard hand-calculation approach for earthwork quantities along a linear alignment surveyed at regular cross-section intervals throughout the roadway project. Longer alignment segments would proportionally increase this cut volume.

73. A — The standard 75 to 80% choker derate assumes a reasonably open choke angle, and as that angle tightens below 120 degrees, the sling body bends more sharply around itself, concentrating additional stress that further reduces the sling's safe rated capacity beyond the baseline choker derate already applied to a straight choke configuration.

74. D — Horizontal radius is the boom length multiplied by the cosine of its angle from horizontal: R = L·cos(θ) = 95×cos(52°) = 95×0.6157 ≈ 58.5 ft. This moderate boom angle produces a working radius that falls between the shallower and steeper angle examples examined in earlier crane geometry problems shown previously.

75. C — Required pump capacity is the anticipated inflow multiplied by the safety factor: 75×1.5 = 112.5 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: 19.6/2.8 = 7 trucks. This ensures a truck is arriving to load just as the previous one departs full, keeping the loader continuously productive rather than sitting idle between successive hauling cycles.

77. B — Ultimate capacity is the sum of skin friction and end bearing: Qult = Qs+Qp = 165+95 = 260 kip. Dividing by the factor of safety gives allowable capacity: Qallow = 260/2.5 = 104 kip. This static computation is typically confirmed in the field with a load test or a dynamic pile driving formula check afterward.

78. C — With the shrinkage factor defined as compacted volume divided by bank volume, the resulting compacted volume is bank volume multiplied by that factor: 8,200×0.87 ≈ 7,134 cy. Soil always occupies less volume compacted into an embankment than in its natural bank state, which is why this factor stays below one.

79. A — Required pad area is the outrigger load divided by the allowable bearing pressure: 54,000/3,600 = 15.0 sf. Undersized outrigger pads risk punching into soft ground or causing excessive differential settlement under one outrigger, which can destabilize the crane during a lift, making this bearing check routine in crane setup planning.

80. D — Substituting directly: Cw = 150 + (9,000×7)/55 ≈ 150 + 1,145.5 ≈ 1,295 psf. This 7 ft/hr placement rate combined with cool 55°F concrete, which sets slowly, produces a substantial formwork pressure, requiring correspondingly stronger form ties, walers, and bracing to safely resist the fresh concrete's lateral thrust on the forms.

81. D — Total design load is the sum of all anticipated loads on the platform: (4×200) + 1,400 + 220 = 800 + 1,400 + 220 = 2,420 lb. This total must be checked against the scaffold's rated capacity for its assigned duty classification before workers and materials occupy the platform simultaneously during construction operations.

82. B — Tributary area load is the product of tributary area and load intensity: 7.5×7.5×100 = 5,625 lb. This simplified single-level tributary method estimates the axial load carried by an individual reshore post, though detailed multi-level shoring analysis accounts for load sharing across several connected floor levels beneath the fresh pour above.

83. A — Applying the 2% minimum lateral force provision: 0.02×55,000 = 1,100 lb. This notional lateral load accounts for out-of-plumb erection tolerances and accidental eccentricities in vertical formwork and shoring systems, and must be provided regardless of whether calculated wind or other lateral loads happen to be smaller than this baseline value.

84. C — Substituting values: $p = 0.65 \times 0.32 \times 112 \times 20 = 0.208 \times 112 \times 20 \approx 466$ psf. The Terzaghi-Peck apparent pressure diagram is an empirical envelope rather than an actual triangular distribution, developed specifically for designing the struts and wales in braced excavation systems based on observed field pressures at similar sites and depths. Deeper excavations proportionally increase this peak apparent pressure value.

85. D — Seven-day strength is typically well below the concrete's eventual 28-day design strength, so removing shoring at that early age without a supporting engineering analysis risks transferring loads from fresh pours above onto a slab that hasn't yet gained enough strength to safely carry them, potentially causing excessive deflection or structural failure.

86. B — ACI 347 establishes a floor value for formwork design loads independent of 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 operations.

87. A — This scaffold's height-to-base ratio is $24/7 \approx 3.4:1$, which stays below OSHA's 4:1 threshold that triggers a mandatory guying, tying, or bracing requirement for supported scaffolds. There is no separate absolute height trigger at 20 ft, and this rule applies to supported scaffolds generally, not exclusively to rolling scaffold configurations.

88. A — Total tributary load is $130 \times 9 \times 9 = 10{,}530$ lb. Splitting this equally among the three simultaneously engaged support levels gives $10{,}530/3 = 3{,}510$ 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: $F \cdot \cos(44°) = 6{,}500$ lb, so $F = 6{,}500/\cos(44°) \approx 9{,}036$ lb. As the brace angle becomes shallower relative to horizontal, the axial force required to resist a given horizontal thrust increases correspondingly and noticeably in magnitude.

90. B — A 1.5:1 slope means the horizontal offset equals 1.5 times the vertical depth: offset = depth×slope ratio = $8 \times 1.5 = 12$ ft. OSHA 29 CFR 1926 Subpart P assigns this flatter slope to the less stable Type C soil, requiring more excavated width than the steeper slopes permitted for Type A or Type B soil.

91. D — ASCE 37's reduced construction-period wind speeds are grounded in probability: a structure exposed for only a few weeks has a much lower chance of experiencing the rare, full-service design wind event than a permanent structure exposed for its entire service life. This statistical basis, not budget or equipment choices, justifies the reduction.

92. C — Vertical elements like wall and column forms only resist lateral pressure from the fresh concrete itself, so they can strip much earlier once the surface can resist minor damage. Horizontal shoring, by contrast, must actually carry the slab's self-weight and construction loads, requiring a much higher strength threshold before it can safely be removed.

93. D — Euler-type buckling capacity scales inversely with the square of unbraced length. Halving the length from 18 ft to 9 ft, a factor of 2, increases capacity by $2^2 = 4$ times: $9{,}000 \times 4 = 36{,}000$ lb. This strong sensitivity to bracing spacing is why intermediate lateral bracing so effectively boosts shoring post capacity.

94. B — Substituting into the heave stability formula: $FS = (5.7 \times 1{,}500)/(128 \times 22) = 8{,}550/2{,}816 \approx 3.0$. This factor of safety against basal heave in soft to medium clay is a critical check for deep braced excavations, since inadequate resistance can cause the excavation floor to rise and destabilize the surrounding bracing system entirely.

95. C — OSHA generally limits the gap between a scaffold platform and the face of the work to 14 inches, since a wider gap increases the risk of a worker falling through the opening while reaching to perform work. Where a 14-inch gap isn't practical, an approved alternative fall protection measure must be used instead.

96. A — 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: $L = 11 \times 60 = 660$ ft. This long, gentle taper reflects the higher operating speed and correspondingly greater stopping and maneuvering distance drivers need on this facility.

97. C — OSHA's guidance for non-self-supporting portable ladders follows the 4:1 rule of thumb, placing the base one foot away from the support for every four feet of working ladder length, which corresponds to a pitch of roughly 75.5 degrees from horizontal. A steeper or shallower angle than this increases the risk of the ladder sliding or tipping.

98. B — The transition area uses tapers to physically move traffic from its normal lane alignment into the reduced or shifted path required around the work space, following the advance warning area that alerts drivers beforehand. The activity area contains the actual work, and the termination area guides traffic back afterward, at the very end.

99. D — OSHA requires a competent person's protective-system determination to rest on an actual engineering and site evaluation, including soil classification, groundwater conditions, surcharge loads, and other hazard-relevant factors specific to that excavation. Schedule pressure, equipment availability, or cost preference are never acceptable substitutes for this required hazard-based technical evaluation and judgment.

100. A — Positive protection devices are reserved for conditions combining high speed, high volume, extended exposure duration, and close worker proximity to live traffic, since that combination creates the greatest risk of a vehicle intrusion. A low-speed, low-volume residential street closure lacks essentially all of these risk factors, making channelizing devices generally sufficient there instead.