PRACTICE EXAM 7: 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 $\varphi' = 25°$ and a level ground surface. Using Rankine theory, what is the active earth pressure coefficient Ka?

A. 0.330
B. 0.360
C. 0.385
D. 0.406

2. A 5 m thick normally consolidated clay layer has Cc = 0.40 and initial void ratio e0 = 1.10. The effective overburden stress is 80 kPa and a foundation adds 100 kPa. What is the primary consolidation settlement?

A. 335 mm
B. 298 mm
C. 362 mm
D. 390 mm

3. The water table is at a depth of 3.5 m. Above the water table, the moist unit weight is 17.0 kN/m³, and below it the saturated unit weight is 19.5 kN/m³. At a total depth of 11 m, what is the effective vertical stress?

A. 98 kPa
B. 115 kPa
C. 132 kPa
D. 205 kPa

4. A strip footing at 1.0 m depth bears on saturated clay (φ=0) with cu = 38 kPa. Using Terzaghi bearing capacity factors (Nc=5.7, Nq=1.0) and a surcharge unit weight of 17 kN/m^3, what is the ultimate bearing capacity?

A. 210 kPa
B. 234 kPa
C. 258 kPa
D. 280 kPa

5. A dry, cohesionless infinite slope has friction angle φ=31° and inclination β=21°. What is the factor of safety against sliding?

A. 1.57
B. 1.42
C. 1.30
D. 1.20

6. A 4.0 m tall wall retains cohesionless backfill with unit weight 18.0 kN/m^3 and φ'=32°. Using Rankine theory, what is the total passive resultant force per unit length of wall?

A. 385 kN/m
B. 425 kN/m
C. 469 kN/m
D. 510 kN/m

7. A doubly-drained saturated clay layer 5.5 m thick has cv = 2.2 m^2/yr. Using Tv=0.197 for 50% consolidation, how long does it take to reach 50% consolidation?

A. 210 days
B. 247 days
C. 275 days
D. 300 days

8. A submerged infinite slope of cohesionless soil ($c'=0$) has $\varphi'=28°$, slope angle $\beta=20°$, saturated unit weight $\gamma sat=19.0$ kN/m³, and $\gamma w=9.81$ kN/m³, with seepage parallel to the slope. What is the factor of safety?

A. 0.55
B. 0.61
C. 0.66
D. 0.71

9. A horizontal curve has a radius of 1,000 ft and a deflection angle of 20°. What is the curve length?

A. 298.5 ft
B. 320.6 ft
C. 349.1 ft
D. 375.2 ft

10. For the same curve ($R=1{,}000$ ft, $\Delta=20°$), what is the middle ordinate distance?

A. 15.2 ft
B. 18.4 ft
C. 21.0 ft
D. 23.8 ft

11. A vertical curve has an initial grade $g1=+1.8\%$ and final grade $g2=-2.2\%$ over a 420 ft curve length. How far from the BVC does the high point occur?

A. 160 ft
B. 189 ft
C. 215 ft
D. 240 ft

12. For the horizontal curve with R=1,000 ft and Δ=20°, what is the long chord length?

A. 310.5 ft
B. 325.8 ft
C. 336.4 ft
D. 347.3 ft

13. A landfill closure project must confirm the presence and extent of contaminated groundwater plumes before designing a cap and monitoring wells. Which method most directly establishes this information?

A. monitoring well installation with groundwater sampling and laboratory analysis
B. satellite imagery of the landfill surface
C. historical aerial photographs of the site
D. the original landfill permit application alone

14. A benchmark has an established elevation of 410.00 ft. A backsight rod reading of 7.05 ft is taken on the benchmark, and a foresight reading of 4.38 ft is taken to set a rough grade stake. What elevation is the stake set at?

A. 405.62 ft
B. 409.30 ft
C. 412.67 ft
D. 417.05 ft

15. What is the degree of curve (arc definition) for a horizontal curve with a 1,000 ft radius?

A. 4.62°
B. 5.05°
C. 5.40°
D. 5.73°

16. A fine-grained soil has a liquid limit LL=33 and plastic limit PL=19. Using the USCS plasticity chart, how should this soil be classified?

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

17. A concrete mix design specifies 315 lb/yd^3 of water and 525 lb/yd^3 of cement. What is the water-cement ratio?

A. 0.45
B. 0.52
C. 0.60
D. 0.68

18. What is the minimum specified yield strength for ASTM A1085 cold-formed hollow structural section (HSS) steel?

A. 42 ksi
B. 50 ksi
C. 46 ksi
D. 60 ksi

19. A sawn lumber beam has a reference bending design value Fb=1350 psi. Applying a load duration factor CD=1.25 for snow load and a size factor CF=1.1, what is the adjusted design value?

A. 1520 psi
B. 1650 psi
C. 1780 psi
D. 1856 psi

20. Which ASTM standard governs compressive strength testing of standard 6x12-in molded concrete cylinders?

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

21. A soil sample has a void ratio e=0.58 and specific gravity Gs=2.71. What is the dry unit weight, using γw=9.81 kN/m^3?

A. 16.8 kN/m^3
B. 15.2 kN/m^3
C. 18.4 kN/m^3
D. 19.9 kN/m^3

22. What material standard governs welded wire reinforcement mats commonly used in slabs and pavements?

A. ASTM A615
B. ASTM A706
C. ASTM A996
D. ASTM A184/A1064

23. Two cross-section end areas along a roadway cut are 105 sf and 160 sf, separated by 155 ft. Using the average end area method, what is the earthwork volume in cubic yards?

A. 680.4 cy
B. 720.8 cy
C. 760.6 cy
D. 810.2 cy

24. A project requires 2,400 cy of riprap at a unit cost of $58/cy. What is the total material cost?

A. $122,600
B. $139,200
C. $155,800
D. $168,400

25. An owner expects to spend $720,000 eight years from now on a facility upgrade. At an interest rate of 8% per year, what is the present worth of that expenditure?

A. $335,600
B. $358,900
C. $372,400
D. $389,000

26. A project has an earned value (EV) of $445,000 and actual cost (AC) of $410,000. What is the cost performance index (CPI)?

A. 0.95
B. 1.09
C. 1.16
D. 0.88

27. A concrete slab measures 38 ft by 58 ft at a thickness of 0.48 ft. What is the concrete volume in cubic yards?

A. 31.4 cy
B. 35.6 cy
C. 39.2 cy
D. 43.8 cy

28. Using a parametric cost-per-square-foot estimate of $185/sf for a 19,000 sf building, what is the estimated construction cost?

A. $3,515,000
B. $3,200,000
C. $3,780,000
D. $4,050,000

29. A production line has fixed costs of $88,000, a variable cost of $25 per unit, and sells each unit at $49. How many units must be sold to break even?

A. 3,200
B. 3,667
C. 4,020
D. 4,380

30. A schedule shows earned value EV=$372,000 and planned value PV=$340,000. What is the schedule performance index (SPI)?

A. 0.92
B. 1.02
C. 1.09
D. 1.18

31. An activity has an early start (ES) of day 18 and a duration of 17 days. What is its early finish (EF)?

A. 27
B. 30
C. 32
D. 35

32. Using the PERT three-point estimate with optimistic time to=6 days, most likely tm=8 days, and pessimistic tp=14 days, what is the expected activity duration?

A. 8.7 days
B. 9.4 days
C. 10.0 days
D. 10.8 days

33. An activity has ES=14 and LS=25. What is its total float?

A. 6
B. 9
C. 11
D. 14

34. A critical path consists of four sequential activities with durations of 12, 8, 15, and 7 days. What is the total critical path duration?

A. 32 days
B. 36 days
C. 39 days
D. 42 days

35. A paving crew completes 3,600 linear feet of curb and gutter in 12 working days. What is the crew's production rate?

A. 300 ft/day
B. 270 ft/day
C. 240 ft/day
D. 330 ft/day

36. A task requires 4 workers for 17 days. What is the total resource-days (worker-days) required for this task?

A. 56
B. 68
C. 76
D. 84

37. An activity has a normal cost of $29,000 over 13 days and a crash cost of $47,000 over 8 days. What is the crash cost per day?

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

38. In tunnel lining construction using precast segments, which of the following represents the correct order of field operations?

A. grout the annular gap, erect segments, advance the TBM, then bolt segments together
B. advance the TBM, grout the annular gap, erect segments, then bolt them together
C. bolt segments together, advance the TBM, erect segments, then grout the annular gap
D. advance the TBM, erect the precast segments, bolt them together, then grout the annular gap

39. An activity has an early finish of day 13, and the earliest successor activity's early start is day 26. What is this activity's free float?

A. 9
B. 13
C. 16
D. 19

40. A schedule optimization technique that shortens overall project duration by adding resources to critical activities, at increased cost, is known as—

A. crashing
B. resource leveling
C. fast-tracking
D. resource smoothing

41. A field density test shows a dry density of 120 pcf, while the laboratory maximum dry density (standard Proctor) is 127 pcf. What is the percent relative compaction?

A. 87.6%
B. 90.8%
C. 92.1%
D. 94.5%

42. Which ASTM standard governs the pressure method for determining air content of freshly mixed concrete?

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. Which document establishes the specified compressive strength, slump range, and air content requirements for a concrete mix on a project?

A. the project specifications and approved mix design
B. the ready-mix supplier's delivery ticket alone
C. the testing laboratory's internal procedures
D. the contractor's daily log

45. What is the primary purpose of a construction joint in a large concrete placement?

A. to provide a planned, controlled interface where separate placements meet without creating an unplanned cold joint
B. to increase the required curing time for the element
C. to eliminate the need for reinforcement across the joint
D. to reduce the total quantity of concrete required for the placement

46. Using the Nurse-Saul maturity function with a constant temperature-datum difference of 17°C sustained for 60 hours, what is the concrete's maturity index?

A. 780 °C-hr
B. 880 °C-hr
C. 950 °C-hr
D. 1020 °C-hr

47. Which statement about the maturity method's calibration curve is TRUE?

A. it is provided by ASTM and identical for all concrete mixtures
B. it never needs updating once developed for a mixture
C. it must be developed specifically for the mixture being monitored
D. it applies regardless of the concrete's curing temperature range

48. A sand cone field density test removes 3.8 lb of soil from a hole with a volume of 0.031 cf. The soil's moisture content is 12%. What is the dry unit weight?

A. 101.2 pcf
B. 109.4 pcf
C. 116.8 pcf
D. 123.4 pcf

49. A 9/16-in fillet weld uses E70 electrode (Fexx=70 ksi). What is its nominal strength per inch of weld length?

A. 12.4 kip/in
B. 14.6 kip/in
C. 16.7 kip/in
D. 18.9 kip/in

50. If a soil nail or ground anchor fails its proof load test, what is the standard next step?

A. accept the anchor at reduced capacity without further testing
B. ignore the failure since one anchor rarely matters
C. reduce the design load for the entire wall retroactively
D. investigate the cause, then replace or supplement the anchor and retest per the specification

51. A slab is designed for dead load D=44 psf and live load L=68 psf. Using the basic ASCE 7 load combination U=1.2D+1.6L, what is the factored design load?

A. 148 psf
B. 162 psf
C. 175 psf
D. 188 psf

52. A beam experiences a bending moment $M=600$ kip-in at a section where $c=6.5$ in and $I=260$ in^4. What is the extreme fiber bending stress?

A. 15.0 ksi
B. 17.5 ksi
C. 19.8 ksi
D. 22.4 ksi

53. An axially loaded member carries $P=126$ kip through a cross-sectional area of 7.2 in^2. What is the axial stress?

A. 12.8 ksi
B. 15.2 ksi
C. 17.5 ksi
D. 20.1 ksi

54. A footing carries a column load of 440 kip and measures 10.5 ft by 12.5 ft in plan. What is the resulting bearing pressure on the soil?

A. 2.95 ksf
B. 3.35 ksf
C. 3.70 ksf
D. 4.05 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 $K_z=0.87$, $K_{zt}=1.0$, $K_d=0.85$, and $V=120$ mph, what is the velocity pressure?

A. 20.4 psf
B. 23.8 psf
C. 25.5 psf
D. 27.3 psf

56. A beam has shear force V=38 kip, first moment of area Q=40 in^3, moment of inertia I=700 in^4, and web thickness b=7.5 in. What is the shear stress at that location?

A. 290 psi
B. 320 psi
C. 350 psi
D. 380 psi

57. A column has an effective length factor K=1.0, unbraced length L=17 ft, and radius of gyration r=2.7 in. What is the slenderness ratio KL/r?

A. 76
B. 84
C. 91
D. 98

58. A retaining wall has a resisting moment of 960 kip-ft and an overturning moment of 400 kip-ft. What is the factor of safety against overturning?

A. 1.85
B. 2.05
C. 2.20
D. 2.40

59. A column has a tributary floor area of 19 ft by 24 ft, and the floor is designed for a live load of 100 psf. What is the total live load carried by this column?

A. 39.8 kip
B. 45.6 kip
C. 50.2 kip
D. 55.8 kip

60. Under AISC 360, which provision addresses evaluation and design guidance for existing structures?

A. Chapter H
B. Chapter D
C. Appendix 5, evaluation of existing structures
D. Chapter F

61. Using the rational method $Q=C\cdot i\cdot A$ with a runoff coefficient $C=0.48$, rainfall intensity $i=3.0$ in/hr, and drainage area $A=17$ acres, what is the peak discharge?

A. 24.5 cfs
B. 28.2 cfs
C. 31.6 cfs
D. 35.0 cfs

62. An open channel has Manning's $n=0.013$, flow area $A=13$ sf, hydraulic radius $R=1.4$ ft, and slope $S=0.005$. Using Manning's equation (USCS form with 1.49), what is the flow rate?

A. 108.4 cfs
B. 120.6 cfs
C. 131.9 cfs
D. 144.2 cfs

63. Using the Kirpich equation Tc=0.0078·L^0.77·S^-0.385 (L in ft, S in ft/ft), with a flow path length of 850 ft and slope of 0.016, what is the time of concentration?

A. 5.4 min
B. 6.9 min
C. 8.5 min
D. 10.2 min

64. A detention pond must temporarily store runoff where peak inflow is 42 cfs, allowable peak outflow is 18 cfs, and the storm duration is 2.5 hours. Using a simplified triangular hydrograph approximation, what storage volume is required?

A. 1.85 ac-ft
B. 2.10 ac-ft
C. 2.30 ac-ft
D. 2.48 ac-ft

65. A storm sewer pipe with a 24-in diameter carries a flow of 16 cfs. What is the flow velocity in the pipe, assuming it flows full?

A. 5.1 fps
B. 4.2 fps
C. 5.8 fps
D. 6.5 fps

66. A broad-crested weir outlet has a discharge coefficient C=3.0, crest length L=6 ft, and head H=1.2 ft. Using Q=C·L·H^1.5, what is the discharge through the weir?

A. 19.8 cfs
B. 23.7 cfs
C. 26.4 cfs
D. 29.2 cfs

67. A 2-leg sling supports an 8,500 lb load, with each leg oriented at 42° from horizontal. What is the tension in each leg?

A. 5,600 lb
B. 5,900 lb
C. 6,100 lb
D. 6,352 lb

68. A crane's load chart lists reduced capacity when lifting on rubber (tires) compared to on outriggers. This reflects primarily—

A. engine limitations that occur while operating on tires
B. increased wind resistance while operating on tires
C. the tires' greater compressibility and smaller, less stable ground contact
D. operator certification differences between the two configurations

69. A dewatering system must handle 300 gpm of inflow, and each wellpoint has a discharge capacity of 17 gpm. What is the minimum number of wellpoints required?

A. 15
B. 16
C. 18
D. 21

70. An excavator has a bucket capacity of 3.25 cy, a fill factor of 0.80, a cycle time of 26 seconds, and operates at 50 minutes of effective work per hour. What is its production rate?

A. 260 cy/hr
B. 300 cy/hr
C. 330 cy/hr
D. 360 cy/hr

71. Using the Engineering News Record (ENR) pile driving formula Qu=2E/(S+0.1), with driving energy E=27,000 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. 18.0 kip
B. 21.5 kip
C. 24.2 kip
D. 27.0 kip

72. Two cross-section end areas along a roadway cut are 185 sf and 245 sf, separated by 170 ft. Using the average end area method, what is the cut volume in cubic yards?

A. 1,180.5 cy
B. 1,250.8 cy
C. 1,310.4 cy
D. 1,353.7 cy

73. A wire rope choker hitch's efficiency is reduced compared to a vertical hitch primarily due to—

A. the added weight of the extra wire rope length used in this configuration
B. the bend the sling body makes as it wraps and grips the load
C. the hook's rated capacity being lower in this particular configuration
D. the load's center of gravity shifting horizontally during the choke

74. A crane boom is 115 ft long and raised to an angle of 50° from horizontal. Ignoring boom point offset, what is the resulting horizontal working radius?

A. 62.8 ft
B. 67.5 ft
C. 70.6 ft
D. 73.9 ft

75. A sump pump must handle a seepage inflow of 100 gpm, and standard practice applies a safety factor of 1.5 for pump sizing. What minimum pump capacity should be selected?

A. 115 gpm
B. 130 gpm
C. 150 gpm
D. 165 gpm

76. A loader has a cycle time of 3.2 minutes per load. A truck's full haul-dump-return cycle takes 22.4 minutes. How many trucks are needed to keep the loader continuously working?

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

77. A pile's static capacity analysis gives skin friction resistance Qs=175 kip and end bearing resistance Qp=100 kip. Applying a factor of safety of 2.5, what is the allowable pile capacity?

A. 92 kip
B. 110 kip
C. 126 kip
D. 140 kip

78. An embankment requires 10,200 cy of soil measured in the bank (natural, undisturbed) condition, and the borrow soil has a shrinkage factor of 0.86 relating compacted volume to bank volume. What compacted fill volume results from excavating this bank volume?

A. 7,600 cy
B. 8,200 cy
C. 8,772 cy
D. 9,400 cy

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

A. 15.0 sf
B. 17.4 sf
C. 19.6 sf
D. 22.0 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=58°F, what is the design lateral pressure?

A. 1,050 psf
B. 1,180 psf
C. 1,290 psf
D. 1,391 psf

81. A scaffold platform will support 4 workers averaging 200 lb each, 1,300 lb of stored material, and 175 lb of tools and equipment. What is the total design load on the platform?

A. 2,275 lb
B. 2,450 lb
C. 2,680 lb
D. 2,900 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 112 psf. What load is transferred to this reshore, using a simplified tributary-area method?

A. 7,800 lb
B. 8,300 lb
C. 8,700 lb
D. 9,072 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 68,000 lb vertically, what minimum lateral bracing force must be provided?

A. 1,050 lb
B. 1,200 lb
C. 1,360 lb
D. 1,520 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 $Ka=0.33$, $\gamma=114$ pcf, and excavation depth $H=25$ ft, what is the peak apparent pressure?

A. 545 psf
B. 611 psf
C. 670 psf
D. 725 psf

85. If reshores are removed too early, before the slab beneath has reached adequate strength to accept redistributed loads, the most likely consequence is—

A. improved schedule performance with no downside whatsoever
B. excessive deflection or possible structural distress in the underloaded slab
C. reduced material costs with no offsetting risk to the structure
D. no measurable effect on the structure at any point

86. Per ACI 347, when motorized concrete buggies are used, what is the minimum required combined dead and live load for horizontal formwork?

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

87. A supported scaffold is 44 ft tall with a 9.5 ft base width. Per OSHA 29 CFR 1926 Subpart L, must this scaffold be restrained against tipping?

A. Yes, since its 4.6:1 ratio exceeds the 4:1 threshold
B. No, since 4.6:1 rounds down to an acceptable ratio
C. No, restraint only applies to rolling scaffolds
D. Yes, but only above 60 ft in total height

88. A slab load of 135 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. 2,900 lb
B. 3,300 lb
C. 3,645 lb
D. 4,100 lb

89. A diagonal brace oriented at 39° from horizontal resists a horizontal thrust of 10,200 lb. What is the resulting axial force in the brace?

A. 11,600 lb
B. 12,400 lb
C. 13,125 lb
D. 13,900 lb

90. A 16-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. 16 ft
B. 19 ft
C. 21 ft
D. 24 ft

91. Per ASCE 37, an owner or engineer approving a reduced construction-period wind speed for a temporary structure must consider primarily—

A. the anticipated duration of exposure and the consequence of failure
B. the contractor's preferred subcontractor for erection work
C. the crane rental company's insurance policy details
D. the project's marketing and promotional schedule

92. Per common guidance, horizontal formwork supporting a concrete slab's self-weight and construction loads should generally NOT be removed until the concrete reaches approximately what percentage of specified strength, absent an engineering analysis?

A. 50%
B. 75%
C. 60%
D. 90%

93. A shoring post has an allowable capacity of 5,500 lb at an unbraced length of 16 ft. If lateral bracing reduces the unbraced length to 8 ft, and capacity scales inversely with the square of unbraced length (Euler-type behavior), what is the new allowable capacity?

A. 16,500 lb
B. 22,000 lb
C. 27,500 lb
D. 33,000 lb

94. A braced excavation is 20 ft deep in clay with undrained shear strength c_u=1,350 psf and unit weight γ=121 pcf. Using a bearing capacity factor N_c=5.7, what is the factor of safety against bottom heave, $FS = N_c \cdot c_u / (\gamma \cdot H)$?

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

95. Per OSHA 29 CFR 1926 Subpart L, what is the minimum required design factor of safety for scaffolding and its components?

A. 4 times the maximum intended load
B. 2 times the maximum intended load
C. 3 times the maximum intended load
D. 6 times the maximum intended load

96. Per MUTCD guidance, for a temporary lane closure with an 11-ft lane width and posted speed of 55 mph (using L=WS for speeds at or above 45 mph), what taper length is required?

A. 480 ft
B. 530 ft
C. 570 ft
D. 605 ft

97. Per OSHA 29 CFR 1926 Subpart X, what is the maximum allowable rung spacing on a fixed ladder?

A. 8 in
B. 9 in
C. 10 in
D. 12 in

98. Per MUTCD Part 6, which TTC zone component is where traffic is guided back into its normal path after passing the activity area?

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

99. If site conditions change during a shift, such as a new excavation cut, the competent person's inspection obligation—

A. ends once the original daily inspection is complete
B. is renewed to address the changed conditions before work continues in that area
C. shifts entirely to the equipment operator on site
D. applies only at the start of the next calendar day

100. Per MUTCD guidance, which of the following work zone scenarios most clearly justifies positive protection over channelizing devices alone?

A. a multi-month urban interstate widening project with workers exposed to high-speed traffic daily
B. a single afternoon utility locate on a quiet side street
C. a temporary sign installation completed in 20 minutes
D. a low-speed school zone crosswalk repaint

Practice Exam 7: Answer Key and Explanations

1. D — Rankine active pressure for a level, cohesionless backfill is $K_a = \tan^2(45° - \varphi'/2)$. With $\varphi' = 25°$, this is $\tan^2(32.5°) \approx 0.406$. This lower friction angle produces one of the larger Ka values examined across these problems, since weaker soil requires more lateral thrust to reach its active failure condition.

2. A — Primary settlement is $S_c = [C_c \cdot H/(1+e_0)] \cdot \log_{10}[(p_0+\Delta p)/p_0]$. Substituting, $S_c = (0.40 \times 5/2.10) \cdot \log_{10}(180/80) = 0.952 \times 0.352 \approx 0.335$ m, or 335 mm. This large settlement reflects a high compression index applied to soft clay under a foundation load exceeding its original overburden pressure at the site. Local overconsolidation would reduce this settlement estimate somewhat further.

3. C — Total stress at 11 m is $\sigma = (17.0 \times 3.5) + (19.5 \times 7.5) = 59.5 + 146.25 = 205.75$ kPa. Pore pressure develops only below the water table: $u = 9.81 \times 7.5 \approx 73.6$ kPa. Effective stress is $\sigma' = 205.75 - 73.6 \approx 132$ kPa. Option D is the total stress alone, without pore pressure subtracted out.

4. B — For $\varphi = 0$ conditions, $q_{ult} = c_u \cdot N_c + q \cdot N_q$. The surcharge is $q = 17 \times 1.0 = 17$ kPa, so $q_{ult} = 38 \times 5.7 + 17 \times 1.0 = 216.6 + 17 \approx 234$ kPa. Omitting the surcharge term would understate ultimate capacity by ignoring the confinement the overlying soil provides at footing depth.

5. A — For a dry infinite slope of cohesionless soil, FS = $\tan\varphi/\tan\beta$, since slice weight cancels out of both driving and resisting terms. Here FS = $\tan(31°)/\tan(21°) = 0.601/0.384 \approx 1.57$. This ratio depends only on the friction and slope angles, not on slope height, soil unit weight, or failure surface depth.

6. C — Passive coefficient is $K_p = \tan^2(45°+\varphi'/2) = \tan^2(61°) \approx 3.256$. The resultant passive force is $P_p = 0.5 \cdot K_p \cdot \gamma \cdot H^2 = 0.5\times3.256\times18.0\times4.0^2 \approx 469$ kN/m, acting one-third of the wall height above the base, since passive resistance grows with the square of wall height and backfill unit weight combined. Wall embedment depth strongly influences the magnitude of this force.

7. B — With double drainage, the drainage path length is $H_{dr} = H/2 = 2.75$ m. Time factor relates as $t = T_v \cdot H_{dr}^2/c_v = 0.197\times7.5625/2.2 \approx 0.677$ yr, which converts to $0.677\times365 \approx 247$ days. Using the full 5.5 m thickness instead of the halved drainage path would substantially overstate this required time.

8. D — With seepage parallel to the slope, FS = $(\gamma'/\gamma_{sat})\cdot(\tan\varphi'/\tan\beta)$. The buoyant unit weight is $\gamma' = 19.0-9.81 \approx 9.19$ kN/m³, giving a ratio of 0.484. Combined with $\tan(28°)/\tan(20°) \approx 1.461$, FS $\approx 0.484\times1.461 \approx 0.71$, roughly half the equivalent dry slope's factor of safety without seepage present here. Higher friction angles would proportionally increase this safety factor value.

9. C — Curve length is $L = R\cdot\Delta(\text{radians}) = 1{,}000\times(20\times\pi/180) = 1{,}000\times0.34907 \approx 349.1$ ft. This arc-based formula gives the actual station-to-station distance traveled along the curve, distinct from the shorter chord distance connecting the PC and PT endpoints of this same curve's geometry. Sharper curves at the same radius yield shorter overall curve lengths.

10. A — Middle ordinate is $M = R\cdot(1-\cos(\Delta/2))$. With $\Delta/2 = 10°$, $\cos(10°) = 0.98481$, so $M = 1{,}000\times(1-0.98481) = 1{,}000\times0.01519 \approx 15.2$ ft. This moderate offset reflects a curve of moderate sharpness relative to its radius, between the gentlest and sharpest curves examined so far. Sharper deflection angles at this radius would increase this offset.

11. B — The high point on a crest vertical curve occurs where $x = L\cdot g_1/(g_1-g_2)$. Here $x = 420\times1.8/(1.8-(-2.2)) = 756/4.0 = 189$ ft from the BVC. Because the two grades are fairly close in magnitude, this point falls only somewhat before the curve's geometric midpoint of 210 ft along the curve.

12. D — The long chord connecting the PC and PT is $C = 2R\cdot\sin(\Delta/2)$. With $\Delta/2 = 10°$, $\sin(10°) = 0.17365$, giving $C = 2\times1{,}000\times0.17365 \approx 347.3$ ft. As expected, this is slightly shorter than the 349.1 ft arc length computed earlier for this same curve's geometry and radius. Chord and arc lengths converge as deflection angles grow smaller.

13. A — Satellite imagery, historical aerial photos, and the original permit application can only suggest general site history or surface conditions, none of which confirms actual groundwater contamination extent today. Installing monitoring wells and collecting groundwater samples for laboratory analysis directly measures contaminant concentrations and plume boundaries, providing the real data a cap and monitoring design require.

14. C — Height of instrument is HI = benchmark elevation + backsight = 410.00 + 7.05 = 417.05 ft. The stake elevation is then HI minus the foresight: 417.05 − 4.38 = 412.67 ft. This differential leveling procedure carries a known elevation from the fixed benchmark out to new grade stakes across the construction site.

15. D — By the arc definition, degree of curve is $D = 5729.58/R$. With $R = 1{,}000$ ft, $D = 5729.58/1{,}000 \approx 5.73°$. This moderate degree of curve reflects a fairly gentle alignment, consistent with a 1,000-ft radius that would be comfortable for typical highway design speeds without requiring excessive right-of-way width.

16. B — Plasticity index is $PI = LL - PL = 14$. The A-line value at $LL=33$ is $0.73\times(33-20) = 9.5$, and since $PI=14$ plots above the A-line with $LL<50$, the soil classifies as CL. A PI falling below this A-line value at the same liquid limit would instead indicate an ML classification instead.

17. C — Water-cement ratio is the water weight divided by cement weight: $315/525 = 0.60$. This moderate ratio balances workability during placement against strength and durability requirements, and is a common target for typical structural concrete under normal exposure conditions without severe environmental or chemical attack concerns present. Higher ratios would reduce strength but improve overall mix workability.

18. B — ASTM A1085 is the current standard for cold-formed welded HSS, with a minimum specified yield strength of 50 ksi, higher than the older A500 Grade B standard it has largely replaced for new HSS production. This higher, more consistent yield strength simplified design provisions when the standard was introduced for structural applications.

19. D — Adjusted design values multiply the reference value by all applicable adjustment factors: $F_b' = F_b \times C_D \times C_F = 1350\times1.25\times1.1 \approx 1856$ psi. Both the snow-load duration factor and the size factor increase the value above the reference here, compounding to a larger overall adjustment than either factor alone would produce for this member.

20. A — ASTM C39 governs compressive strength testing of standard molded concrete cylinders, the method used to determine the specified compressive strength $f'c$ for project acceptance at 28 days. C143 measures slump, C231 measures air content, and C1064 measures fresh concrete temperature, each a distinct concrete property tested. Age at testing significantly affects the measured strength result obtained.

21. A — Dry unit weight relates to void ratio and specific gravity by $\gamma d = Gs\cdot\gamma w/(1+e) = 2.71\times9.81/1.58 \approx 16.8$ 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 property. A looser soil sample would yield a lower unit weight here.

22. D — ASTM A184 (superseded largely by A1064) governs welded wire reinforcement, the prefabricated mesh mats commonly used in slabs, pavements, and other elements where distributed reinforcement is more efficiently placed as a mat than as individual bars. A615, A706, and A996 instead govern individual deformed reinforcing bar products, not welded wire mats.

23. C — The average end area method computes volume as $V = [(A1+A2)/2]\times L = [(105+160)/2]\times155 = 20{,}537.5$ cf. Converting to cubic yards by dividing by 27 gives approximately 760.6 cy. This remains the standard hand-calculation approach for earthwork quantity takeoff between surveyed cross sections along a roadway segment. Longer segment lengths would proportionally increase this computed volume figure.

24. B — Unit cost estimating multiplies quantity by unit price: $2{,}400 \times \$58 = \$139{,}200$. 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 riprap gradation specification called for on this erosion control project overall. Bulk purchasing discounts could further reduce this baseline material cost.

25. D — Present worth of a single future amount is $P = F/(1+i)^n = 720{,}000/(1.08)^8 = 720{,}000/1.8509 \approx \$389{,}000$. This single-payment present-worth factor allows costs occurring at different points in time to be compared fairly on a common present-value basis for economic decision-making purposes across alternatives being evaluated. Higher discount rates would further reduce this present-worth result value.

26. B — Cost performance index is $CPI = EV/AC = 445{,}000/410{,}000 \approx 1.09$. A CPI above 1.0 indicates the project is spending less than the value of work actually completed, meaning it is currently running under budget relative to the earned value baseline established in the original cost management plan and forecast.

27. C — Volume is length times width times thickness: $38 \times 58 \times 0.48 \approx 1{,}058.1$ cf. Dividing by 27 cf per cubic yard gives approximately 39.2 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 figure.

28. A — Parametric estimating multiplies a unit rate by a project parameter: 19,000 sf × \$185/sf = \$3,515,000. 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: $88{,}000/(49-25) = 88{,}000/24 \approx 3{,}667$ units. Below this quantity the operation runs at a loss, and above it, each additional unit contributes \$24 toward covering fixed costs and, past break-even, toward genuine profit for the business. Higher fixed costs would raise this break-even threshold correspondingly higher.

30. C — Schedule performance index is $SPI = EV/PV = 372{,}000/340{,}000 \approx 1.09$. An SPI above 1.0 indicates the project is ahead of its planned schedule, since more value has been earned by this point than was originally planned for this stage of the project's overall timeline and work sequence. A lower planned value would raise this schedule performance ratio further.

31. D — In the CPM forward pass, early finish equals early start plus duration: $EF = ES + \text{Duration} = 18 + 17 = 35$. 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·tm + tp)/6 = (6 + 32 + 14)/6 = 52/6 ≈ 8.7 days. Weighting the most likely estimate four times as heavily as the optimistic and pessimistic bounds reflects the right-skewed distribution typical of real-world construction activity durations encountered on most projects.

33. C — Total float is the difference between late start and early start: TF = LS − ES = 25 − 14 = 11. 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: 12+8+15+7 = 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: 3,600 ft / 12 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. B — Total resource-days is the product of the number of workers and the duration: 4 workers × 17 days = 68 worker-days. This fixed labor quantity can be redistributed across different crew sizes and durations during resource leveling without changing the total amount of work actually performed on this particular task.

37. C — Crash cost slope is the change in cost divided by the change in duration: (47,000−29,000)/(13−8) = 18,000/5 = $3,600 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. D — The tunnel boring machine must advance first to create the excavated space, followed by erecting precast segments to form the ring behind it, then bolting those segments together for structural continuity, and finally grouting the annular gap between the segments and the surrounding ground to complete the finished tunnel lining.

39. B — 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) = 26 − 13 = 13. Unlike total float, this value depends only on the immediate downstream activity, not on the project's overall late-date calculations elsewhere.

40. A — Crashing specifically means adding resources or working overtime on critical path activities to shorten their duration, always at some increased cost, distinguishing it from fast-tracking, which instead overlaps activities that would normally occur sequentially. Resource leveling and smoothing address resource demand conflicts rather than deliberately compressing the schedule for time.

41. D — Relative compaction is the field dry density divided by the laboratory maximum dry density, expressed as a percentage: (120/127)×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 earthwork requirements for this particular lift. Lower field densities would proportionally reduce this compaction percentage value.

42. B — ASTM C231 specifies the pressure method, using a pressure meter and Boyle's law to determine entrained and entrapped air content in fresh concrete, a property critical for freeze-thaw durability. C143 measures slump, C39 tests hardened cylinder strength, and C42 governs drilled core sampling, each an entirely different concrete property. Freeze-thaw exposure severity often dictates the specified target air content.

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 shorter bolts but less than longer ones require.

44. A — The project specifications, together with the approved mix design submitted for that specific concrete, establish the required compressive strength, slump range, and air content for the mix used on the project. A delivery ticket, lab procedures, or a daily log each document something else entirely, not the actual mix requirements themselves.

45. A — A construction joint is deliberately planned and detailed, often with a roughened surface, keyway, or reinforcement continuity, to properly bond the next placement to the previous one. Without this planned interface, an unplanned cold joint would instead form, creating a weaker, poorly bonded plane between the two separate concrete placements.

46. D — The Nurse-Saul maturity index accumulates temperature above a datum over time: $M(t) = \Sigma(T-T0)\cdot\Delta t$. With a constant 17°C difference sustained for 60 hours, $M = 17\times60 = 1{,}020$ °C-hours. This index is later compared against a mixture-specific calibration curve to estimate the concrete's in-place strength at that particular age and time.

47. C — The maturity method's calibration curve relates a specific mixture's maturity index to its compressive strength, and because cement type, water-cement ratio, and admixtures all affect this relationship, the curve must be developed specifically for the mixture actually being placed and monitored, not borrowed from an unrelated mixture or a generic ASTM source.

48. B — Wet unit weight is the weight of soil removed divided by the hole volume: $3.8/0.031 \approx 122.6$ pcf. Converting to dry unit weight using the moisture content, $\gamma d = \gamma wet/(1+w) = 122.6/1.12 \approx 109.4$ 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 $Rn = 0.6\cdot Fexx\cdot 0.707\cdot w$, where 0.707 converts the leg dimension to the effective throat. With Fexx=70 ksi and w=0.5625 in, $Rn = 0.6\times70\times0.707\times0.5625 \approx 16.7$ kip/in, between the 1/2-in and 5/8-in weld sizes examined in earlier problems in this same exam. Smaller weld sizes proportionally reduce this per-inch capacity value here.

50. D — A failed proof load test requires investigating the cause, which might be inadequate grouting, poor ground conditions, or installation defects, followed by replacing or supplementing the anchor and retesting until it passes per the specification. Silent acceptance, ignoring the failure, or retroactively lowering the design load all skip this necessary corrective sequence.

51. B — The factored load combination applies separate load factors before summing: $U = 1.2(44) + 1.6(68) = 52.8 + 108.8 \approx 162$ psf. The larger factor applied to live load reflects its greater variability relative to dead load, and this combination typically governs strength design under ordinary gravity-only loading conditions for buildings.

52. A — The flexure formula gives bending stress as $\sigma = M \cdot c/I = 600 \times 6.5/260 = 15.0$ ksi. This maximum normal stress occurs at the extreme fiber, the distance c from the neutral axis, and would be checked against the material's allowable bending stress to confirm the section's adequacy for this applied moment.

53. C — Axial stress is force divided by cross-sectional area: $\sigma = P/A = 126/7.2 = 17.5$ ksi. This uniform distribution assumes the load passes through the section's centroid; any eccentricity would introduce additional bending stress that must be superimposed on this baseline axial value to find the true combined total stress condition.

54. B — Assuming a concentric load and uniform pressure distribution, bearing pressure equals load divided by footing area: $q = P/(B \times L) = 440/(10.5 \times 12.5) \approx 3.35$ 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. D — Substituting directly: $q_z = 0.00256 \times 0.87 \times 1.0 \times 0.85 \times 120^2 = 0.00256 \times 0.7395 \times 14{,}400 \approx 27.3$ psf. This velocity pressure is then multiplied by pressure coefficients specific to the building's geometry, height, and exposure category to obtain the actual design wind pressures acting on its surfaces per ASCE 7 provisions and tables. Taller structures in rougher terrain would further raise this pressure.

56. A — Shear stress is given by the shear flow formula $\tau = VQ/(Ib) = (38{,}000 \times 40)/(700 \times 7.5) = 1{,}520{,}000/5{,}250 \approx 290$ 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: 17 ft × 12 = 204 in, so $KL/r = (1.0 \times 204)/2.7 \approx 76$. 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: $FS = 960/400 = 2.40$ exactly. 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: $19 \times 24 \times 100 = 45{,}600$ lb, or 45.6 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 building structure.

60. C — AISC 360 Appendix 5 specifically addresses the evaluation and design provisions applicable to existing structures, including strength evaluation through analysis or load testing. Chapter H addresses combined forces, Chapter D addresses tension members, and Chapter F addresses flexural members, none of which specifically covers existing-structure evaluation the way Appendix 5 does.

61. A — The rational method combines runoff coefficient, rainfall intensity, and drainage area directly: $Q = C \cdot i \cdot A = 0.48 \times 3.0 \times 17 \approx 24.5$ 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 $Q = (1.49/n) \cdot A \cdot R^{(2/3)} \cdot S^{(1/2)}$. Substituting: $(1.49/0.013) \times 13 \times (1.4)^{0.667} \times (0.005)^{0.5} \approx 114.6 \times 13 \times 1.252 \times 0.0707 \approx 131.9$ cfs. This relationship between channel roughness, geometry, and slope remains fundamental for sizing open channels, culverts, and storm sewers throughout civil design work generally performed by practicing civil engineers. Steeper channel slopes would further increase this computed flow capacity.

63. B — Substituting into the Kirpich formula: $Tc = 0.0078 \times (850)^{0.77} \times (0.016)^{-0.385} \approx 0.0078 \times 180.3 \times 4.91 \approx 6.9$ minutes. This empirical relationship estimates travel time for runoff from the hydraulically most distant point in the watershed, a key input for rational method peak flow discharge calculations in this particular drainage area. Flatter watershed slopes would substantially lengthen this computed travel time.

64. D — A simplified storage estimate is $V \approx 0.5 \times (Qin - Qout) \times duration = 0.5 \times (42 - 18) \times 9{,}000$ sec = 108,000 cf. Converting to acre-feet by dividing by 43,560 gives about 2.48 ac-ft. This preliminary approximation is typically refined afterward with detailed stage-storage-discharge routing for the final basin design and outlet. Longer storm durations would proportionally increase this required storage volume.

65. A — Velocity is flow rate divided by cross-sectional area: $V = Q/A$. With a 24-in (2-ft) diameter pipe, $A = \pi \times (1)^2 \approx 3.14$ sf, so $V = 16/3.14 \approx 5.1$ fps. This falls comfortably within typical self-cleansing velocity criteria of 2 to 3 fps or higher, helping prevent sediment buildup in the pipe.

66. B — Substituting into the weir formula: $Q = 3.0 \times 6 \times (1.2)^{1.5} = 18 \times 1.3145 \approx 23.7$ cfs. This head-discharge relationship follows a power-law form across the operating depth range above the crest, and is commonly applied to outlet structures that control release rates from detention and retention basins on developed sites overall. Longer crest lengths would proportionally increase this discharge capacity value.

67. D — Each sling leg carries half the total load, resolved along its angle: $T = (Load/2)/\sin(angle) = 4{,}250/\sin(42°) = 4{,}250/0.6691 \approx 6{,}352$ lb. This relatively shallow 42-degree angle produces meaningfully higher leg tension than a steeper angle would for the same total load, since more tension acts horizontally in this case.

68. C — Tires compress under load and provide a smaller, less rigid contact area than fully extended outriggers spread across a wider base, reducing the machine's overall stability and tipping resistance. This is why load charts always show lower rated capacities for on-rubber operation, unrelated to engine power, wind resistance, or operator qualifications.

69. C — Dividing total required flow by per-wellpoint capacity gives $300/17 \approx 17.65$, 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. B — Cycles per hour at full time is $3{,}600/26 \approx 138.5$, giving a theoretical output of $138.5 \times 3.25 \times 0.80 \approx 360.1$ cy/hr. Applying the 50/60 efficiency factor for actual working minutes reduces this to about 300 cy/hr, reflecting realistic production once operational delays are properly accounted for on the active job site. Higher fill factors would further increase this hourly production rate.

71. A — Ultimate capacity is $Q_u = 2E/(S+0.1) = 2 \times 27{,}000/(0.4+0.1) = 54{,}000/0.5 = 108{,}000$ lb. Applying the ENR formula's typical factor of safety of 6 gives allowable capacity: $Q_a = 108{,}000/6 = 18.0$ kip. This moderate set per blow gives a mid-range allowable capacity compared to other pile examples shown. Larger driving energy inputs would proportionally raise this allowable capacity.

72. D — Applying the average end area method: $V = [(185+245)/2] \times 170 = 215 \times 170 = 36{,}550$ cf. Converting to cubic yards by dividing by 27 gives about 1,353.7 cy. This method remains the standard hand-calculation approach for earthwork quantities along a linear alignment surveyed at regular cross-section intervals throughout the project. Longer alignment segments would proportionally increase this cut volume figure.

73. B — A choker hitch requires the sling to bend sharply around itself where it grips the load, concentrating stress at that bend point and reducing the sling's overall efficiency compared to a straight vertical pull. Rope weight, hook rating, and center-of-gravity shift don't explain this specific derate; the bend geometry itself does.

74. D — Horizontal radius is the boom length multiplied by the cosine of its angle from horizontal: $R = L \cdot \cos(\theta) = 115 \times \cos(50°) = 115 \times 0.6428 \approx 73.9$ 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: $100 \times 1.5 = 150$ gpm. This margin accommodates fluctuations in groundwater inflow rate, pump wear over its service life, and intermittent surges, ensuring the excavation stays dry even under somewhat more severe conditions than the baseline design estimate assumed.

76. A — The number of trucks needed to match a loader's output equals the truck's total cycle time divided by the loader's cycle time: $22.4/3.2 = 7$ 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 = 175+100 = 275 kip. Dividing by the factor of safety gives allowable capacity: Qallow = 275/2.5 = 110 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: 10,200×0.86 ≈ 8,772 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: 60,000/4,000 = 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 + (9,000×8)/58 ≈ 150 + 1,241.4 ≈ 1,391 psf. This fast 8 ft/hr placement rate combined with cool 58°F concrete, which sets slowly, produces one of the higher formwork pressures examined so far in this exam, requiring correspondingly stronger form ties, walers, and bracing for this pour.

81. A — Total design load is the sum of all anticipated loads on the platform: (4×200) + 1,300 + 175 = 800 + 1,300 + 175 = 2,275 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. D — Tributary area load is the product of tributary area and load intensity: 9×9×112 = 9,072 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. C — Applying the 2% minimum lateral force provision: 0.02×68,000 = 1,360 lb. This notional lateral load accounts for out-of-plumb erection tolerances and accidental eccentricities in vertical formwork and shoring systems, and must be provided regardless of whether calculated wind or other lateral loads happen to be smaller than this baseline value.

84. B — Substituting values: p = 0.65×0.33×114×25 = 0.2145×114×25 ≈ 611 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 here.

85. B — Removing reshores prematurely transfers redistributed loads onto a slab that hasn't yet gained sufficient strength to safely carry them, risking excessive deflection, cracking, or in severe cases structural distress or failure. Any apparent schedule or cost benefit from early removal is offset by this real structural risk to the underloaded slab.

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

87. A — This scaffold's height-to-base ratio is $44/9.5 \approx 4.6:1$, which exceeds OSHA's 4:1 threshold above which supported scaffolds must be guyed, tied, or braced against tipping over. There is no rounding allowance below the threshold, no 60-ft absolute exemption, and this rule applies to supported scaffolds generally, not just rolling configurations.

88. C — Total tributary load is $135\times9\times9 = 10{,}935$ lb. Splitting this equally among the three simultaneously engaged support levels gives $10{,}935/3 = 3{,}645$ 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: $F\cdot\cos(39°) = 10{,}200$ lb, so $F = 10{,}200/\cos(39°) \approx 13{,}125$ 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. D — A 1.5:1 slope means the horizontal offset equals 1.5 times the vertical depth: offset = depth×slope ratio = $16\times1.5 = 24$ 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. A — ASCE 37's reduced construction-period wind speed determination centers on engineering factors: how long the structure will actually be exposed and what the consequences would be if it failed during that period. A subcontractor preference, insurance policy details, or marketing schedule play no role in this technical wind speed determination whatsoever.

92. B — Absent a project-specific engineering analysis justifying earlier removal, common guidance calls for horizontal formwork to remain in place until the supported concrete reaches roughly 75% of its specified 28-day strength, ensuring it can safely carry its own self-weight plus any remaining construction loads without risk of premature structural failure occurring.

93. B — Euler-type buckling capacity scales inversely with the square of unbraced length. Halving the length from 16 ft to 8 ft, a factor of 2, increases capacity by $2^2 = 4$ times: $5{,}500\times4 = 22{,}000$ lb. This strong sensitivity to bracing spacing is why intermediate lateral bracing so effectively boosts shoring post capacity.

94. C — Substituting into the heave stability formula: $FS = (5.7\times1{,}350)/(121\times20) = 7{,}695/2{,}420 \approx 3.2$. This factor of safety against basal heave in soft to medium clay is a critical check for deep braced excavations, since inadequate resistance can cause the excavation floor to rise and destabilize the surrounding bracing system entirely.

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

96. D — 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: $L = 11 \times 55 = 605$ ft. This long, gentle taper reflects the higher operating speed and correspondingly greater stopping and maneuvering distance drivers need on this facility.

97. D — OSHA sets the maximum allowable rung spacing on a fixed ladder at 12 inches, measured center to center between rungs, ensuring a consistent, predictable climbing rhythm for workers ascending or descending. Rungs spaced wider than this maximum would make climbing more strenuous and increase the risk of a misstep or fall.

98. C — The termination area is the final component of a TTC zone layout, located after the activity area, guiding traffic back into its normal lane configuration and travel path once the work space has been passed. The advance warning area, buffer space, and transition area all occur earlier in the standard zone sequence, not after.

99. B — OSHA requires a competent person to inspect not just once per shift but also after any event or condition change that could introduce new hazards, such as a newly opened excavation cut. The obligation is renewed immediately to address that changed condition, not deferred to the next day or transferred away to the equipment operator.

100. A — Positive protection devices are warranted where high speed, high volume, and prolonged daily worker exposure to live traffic combine to create the greatest risk, exactly the profile of a multi-month urban interstate widening project. The other scenarios involve low speed, brief duration, or minimal traffic exposure, where channelizing devices alone are typically adequate.