PRACTICE EXAM 10: PE CIVIL–CONSTRUCTION DEPTH SIMULATION (100 QUESTIONS)

This practice exam contains 100 questions modeled on the NCEES Principles and Practice of Engineering (PE) Civil–Construction depth exam. The actual NCEES exam contains 80 questions and allows 9 hours to complete, including a tutorial and an optional scheduled break; examinees must answer every question. The exam is computer-based, closed-book, with electronic references (the NCEES PE Civil Reference Handbook and listed design standards) provided on-screen. NCEES does not publish a fixed passing percentage; results are scaled for form difficulty. Select the best answer for each question.

1. A retaining wall 12 ft high retains a cohesionless backfill with unit weight $\gamma = 120$ pcf and angle of internal friction $\varphi = 30°$, with a level backfill surface and no surcharge. Using Rankine theory, what is the total active lateral force per foot of wall length acting on the wall?

A. 2.88 kip/ft
B. 4.32 kip/ft
C. 1.92 kip/ft
D. 5.76 kip/ft

2. A normally consolidated clay layer 10 ft thick has an initial void ratio $e0 = 0.85$ and compression index $Cc = 0.30$. The effective overburden stress at mid-height is 2,000 psf, and a footing load increases the effective stress at mid-height by 1,000 psf. What is the primary consolidation settlement of the layer?

A. 2.1 in
B. 3.4 in
C. 4.8 in
D. 1.7 in

3. A soil profile consists of 8 ft of sand (moist unit weight 115 pcf) above the water table, underlain by 12 ft of saturated sand (saturated unit weight 125 pcf) below the water table. What is the effective vertical stress at a depth of 20 ft (bottom of the saturated layer)?

A. 2,420 psf
B. 920 psf
C. 1,671 psf
D. 1,500 psf

4. A strip footing 3 ft wide is founded at a depth of 4 ft in a cohesionless soil with unit weight 110 pcf. At this friction angle, Terzaghi's bearing capacity factors are $N_q = 20$ and $N_\gamma = 15$. What is the ultimate bearing capacity of the footing, neglecting the cohesion term?

A. 8,800 psf
B. 2,475 psf
C. 6,600 psf
D. 11,275 psf

5. An infinite slope in cohesionless sand is inclined at 20° to the horizontal. The sand has an effective friction angle of 32° and no cohesion, with the slope fully drained and no seepage. What is the factor of safety against sliding along a plane parallel to the slope surface?

A. 1.72
B. 1.40
C. 0.95
D. 2.05

6. For a basement wall that is perfectly rigid and prevented from any lateral translation or rotation by floor diaphragms, which earth pressure condition governs the design lateral pressure on the wall?

A. Active condition
B. At-rest condition
C. Passive condition
D. Rankine minimum condition

7. According to Terzaghi's principle of effective stress, which statement correctly describes how total stress, pore water pressure, and effective stress relate in a saturated soil?

A. Effective stress equals pore pressure minus total stress
B. Total stress equals effective stress minus pore pressure
C. Effective stress equals total stress minus pore water pressure
D. Effective stress and pore pressure are independent and unrelated

8. A shallow foundation's bearing capacity is being evaluated for a site where groundwater is anticipated to rise from well below the footing to the base of the footing after construction. Compared to bearing capacity computed using the dry unit weight, how does the ultimate bearing capacity change once the water table rises to the footing base?

A. It increases, because rising water raises the total overburden stress
B. It does not change; the water table has no effect
C. It decreases, because effective unit weight below the water table becomes buoyant
D. It decreases, because submergence reduces the soil's friction angle

9. A horizontal curve has a radius of 800 ft and a deflection angle (Δ) of 36°. What is the length of the curve?

A. 402.1 ft
B. 453.6 ft
C. 550.0 ft
D. 502.7 ft

10. For a horizontal curve with radius 1,000 ft and a deflection angle of 24°, what is the middle ordinate (M) of the curve?

A. 15.4 ft
B. 21.9 ft
C. 28.6 ft

D. 34.2 ft

11. Prior to excavation adjacent to an existing building on a shared property line, what is the primary purpose of conducting a pre-construction survey of the adjacent structure?

A. To design the new adjacent foundation system
B. To satisfy building permit application requirements
C. To help schedule the construction sequencing
D. To document existing conditions as a baseline for comparison

12. A grade stake is set where the existing ground elevation is 452.35 ft and the design subgrade elevation is 448.90 ft, requiring a cut. What is the magnitude of the cut, in feet, to be noted on the stake?

A. 3.45 ft
B. 1.45 ft
C. 4.45 ft
D. 2.45 ft

13. A crest vertical curve connects a +2.5% grade to a −1.5% grade, is 400 ft long, and begins (PVC) at station 10+00 with an elevation of 100.00 ft. What is the elevation of the highest point on the curve?

A. 101.56 ft
B. 103.13 ft
C. 104.69 ft
D. 106.25 ft

14. During construction layout, what is the primary function of a benchmark established near the project site?

A. To serve as a fixed reference point for deriving elevations
B. To mark the exact property boundary corner location

C. To establish only the horizontal coordinate system origin

D. To identify the precise location of underground utilities

15. Which method is most appropriate for accurately locating the horizontal and vertical position of an unknown underground utility line before excavation begins, when existing utility records are unreliable?

A. Reviewing as-built utility record drawings only

B. Ground-penetrating radar alone, with no verification

C. Vacuum excavation (potholing) to physically expose the line

D. Relying on the 811 utility locate paint marks alone

16. Based on the boring log figure shown, which soil layer is most likely to raise a bearing capacity concern due to low shear strength and also be subject to significant consolidation settlement under sustained foundation loads?

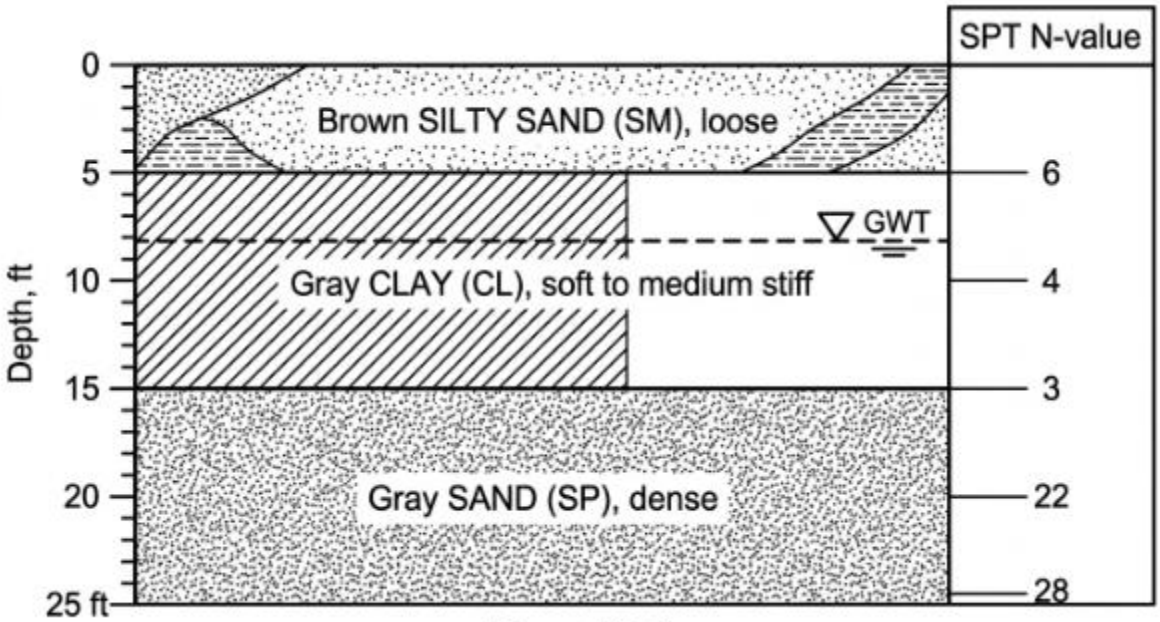


Figure PQ-1

A. The brown SILTY SAND (SM) layer from 0 to 5 ft

B. The gray SAND (SP) layer from 15 to 25 ft

C. The groundwater table zone specifically at 8 ft depth

D. The gray CLAY (CL) layer from 5 to 15 ft

17. A concrete mix uses 470 lb of cement and 235 lb of water per cubic yard. What is the water-cement ratio (w/c) of this mix?

A. 0.50
B. 0.65
C. 0.40
D. 0.75

18. In a pretensioned prestressed concrete member, which phenomenon describes the gradual loss of stress in the prestressing strand over time while held at constant length after tensioning, prior to release?

A. Elastic shortening
B. Creep of concrete
C. Relaxation of the prestressing steel
D. Shrinkage of concrete

19. Which engineered wood product is manufactured by bonding thin wood veneers with their grain oriented primarily parallel to the member's length, producing a structural panel product with high strength along that length, commonly used for I-joist flanges and headers?

A. Oriented strand board (OSB)
B. Plywood
C. Glued laminated timber (glulam)
D. Laminated veneer lumber (LVL)

20. A sieve analysis of a coarse aggregate sample shows 850 g retained cumulative on the No. 4 sieve out of a total sample mass of 1,000 g. What percent of the sample passes the No. 4 sieve?

A. 85%
B. 15%
C. 8.5%
D. 42.5%

21. Which concrete admixture is added primarily to entrain microscopic air bubbles in the mix to improve resistance to freeze-thaw damage?

A. Water-reducing admixture
B. Accelerating admixture
C. Retarding admixture
D. Air-entraining admixture

22. A steel tension member has a cross-sectional area of 4.0 in^2 and is subjected to an axial tensile force of 100 kips. What is the axial stress in the member?

A. 15 ksi
B. 25 ksi
C. 35 ksi
D. 40 ksi

23. A rectangular concrete footing measures 4 ft by 4 ft by 1.5 ft thick. How many cubic yards of concrete are required for one footing (ignoring waste)?

A. 0.60 cy
B. 1.33 cy
C. 0.89 cy
D. 2.00 cy

24. A contractor estimates that placing structural concrete costs $185 per cubic yard for materials and $95 per cubic yard for labor and equipment. What is the total estimated cost to place 240 cubic yards of concrete?

A. $67,200
B. $44,400
C. $84,000
D. $52,800

25. A contractor is deciding between purchasing a piece of equipment for $50,000 with annual operating savings of $12,500, versus continuing to rent. Ignoring the time value of money, how many years of use are required for the purchase to break even against the savings?

A. 2 years
B. 3 years
C. 4 years
D. 5 years

26. A project has a Budgeted Cost of Work Performed (earned value) of $450,000 and an Actual Cost of Work Performed of $500,000. What is the Cost Performance Index (CPI) for the project?

A. 0.90
B. 1.11
C. 0.75
D. 1.25

27. Two adjacent cross-sections along a roadway alignment, spaced 100 ft apart, have cut areas of 220 ft^2 and 180 ft^2, respectively. Using the average end area method, what is the cut volume, in cubic yards, between the two sections?

A. 370.4 cy
B. 555.6 cy
C. 666.7 cy
D. 740.7 cy

28. A contractor's direct cost estimate for a project totals $1,200,000. If the contractor applies a combined markup of 12% for overhead and profit, what is the total bid price?

A. $1,200,000
B. $1,344,000
C. $1,368,000

D. $1,296,000

29. A footing requires 40 pieces of No. 6 reinforcing bar, each 12 ft long. The unit weight of No. 6 rebar is 1.502 lb/ft. What is the total weight of reinforcing steel required, rounded to the nearest pound?

A. 577 lb
B. 649 lb
C. 721 lb
D. 793 lb

30. In a life-cycle cost analysis comparing two paving alternatives with different service lives, which cost category must be converted to a common time basis (e.g., present worth or equivalent uniform annual cost) before the alternatives can be validly compared?

A. Future costs occurring at different times, such as rehabilitation and salvage value
B. Only the initial construction cost
C. Only costs incurred in year one
D. Costs are never adjusted for timing in life-cycle analysis

31. In a typical building construction sequence, which activity must logically precede the installation of interior wall framing on a concrete slab-on-grade structure?

A. Installation of roofing
B. Interior painting
C. Installation of finish flooring
D. Placement and curing of the concrete slab-on-grade

32. An activity's duration estimates using PERT are: optimistic (a) = 6 days, most likely (m) = 9 days, pessimistic (b) = 18 days. What is the PERT expected duration (te) for this activity?

A. 9 days

B. 11 days

C. 8 days

D. 10 days

33. Based on the CPM network diagram shown, what is the length of the critical path through the project, in days?

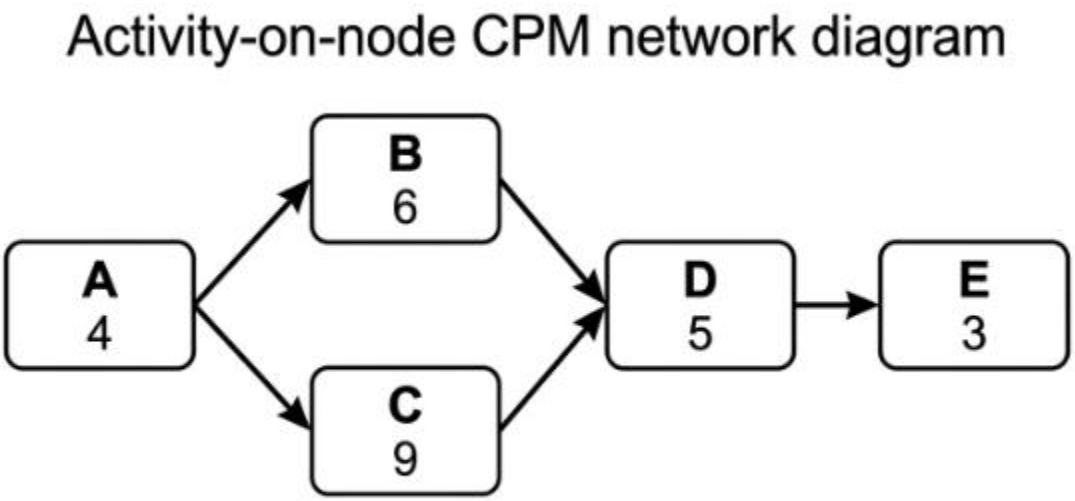


Figure PQ-2: Activity-on-node CPM network diagram with five nodes labeled A through E, connected left to right by arrows: A→B, A→C, B→D, C→D, D→E. Duration in days shown inside each node: A=4, B=6, C=9, D=5, E=3. Simple black-and-white box-and-arrow precedediagram.

A. 18 days

B. 21 days

C. 15 days

D. 24 days

34. An activity has an Early Start of day 12, an Early Finish of day 18, and a Late Finish of day 24. What is the total float for this activity?

A. 12 days

B. 6 days

C. 4 days

D. 8 days

35. Which resource management technique adjusts activity start and finish dates within their available float to smooth out peaks and valleys in resource demand, without changing the project's overall completion date?

A. Leveling that extends the critical path
B. Crashing the schedule with added resources
C. Resource leveling/smoothing within available float
D. Fast-tracking overlapping activities

36. An activity has a normal duration of 10 days at a normal cost of $8,000, and a crash duration of 6 days at a crash cost of $12,000. What is the cost slope (cost per day) to crash this activity?

A. $1,000/day
B. $2,000/day
C. $800/day
D. $1,333/day

37. A linear (repetitive) construction schedule, such as one used for a highway paving project with multiple similar segments, is best represented and analyzed using which scheduling technique?

A. Linear scheduling method (line-of-balance)
B. Precedence diagramming with only finish-to-start relationships
C. Bar chart with no logic ties
D. Program Evaluation and Review Technique (PERT) exclusively

38. A project's critical path must be shortened by 4 days to meet a contractual deadline. The only critical activity available to crash has a cost slope of $1,500 per day, with enough crash days available. What is the minimum additional direct cost to achieve the required 4-day reduction?

A. $1,500
B. $3,000
C. $4,500

D. $6,000

39. Three activities are scheduled to run concurrently on day 15 of a project, each requiring one crew of carpenters: Activity X needs 4 carpenters, Activity Y needs 3 carpenters, and Activity Z needs 5 carpenters. If only 9 carpenters are available on that day, what is the resource shortfall on day 15?

A. 1 carpenter
B. 3 carpenters
C. 5 carpenters
D. 12 carpenters

40. What is the definition of free float for an activity in a CPM schedule?

A. The amount of time an activity can be delayed without delaying the project completion date
B. The difference between an activity's duration and its crash duration
C. The time an activity can be delayed without delaying the early start of its immediate successor
D. The total float of the entire project

41. A 6-in. diameter concrete test cylinder fails in compression at a load of 141,372 lb. What is the measured compressive strength of the cylinder, in psi?

A. 3,750 psi
B. 4,000 psi
C. 4,500 psi
D. 5,000 psi

42. In a slip-critical high-strength bolted connection using the turn-of-nut method, why is a specified minimum number of nut rotations past snug-tight required rather than relying on torque alone?

A. Because torque wrenches typically cannot reach the required preload level
B. Because friction variability makes torque unreliable, while rotation reliably indicates pretension

C. Because building codes generally prohibit torque-based bolt installation entirely

D. Because bolt rotation directly increases its ultimate tensile strength

43. Which statement correctly distinguishes quality assurance (QA) from quality control (QC) on a construction project?

A. QA prevents defects through planned procedures; QC inspects and tests completed work for conformance

B. QA and QC are interchangeable terms with no meaningful distinction

C. QC is management-level oversight while QA is field-level inspection only

D. QA applies only to materials while QC applies only to labor

44. Concrete has an initial setting time of approximately 4.5 hours based on field testing. To avoid a cold joint, what is the maximum acceptable elapsed time between placing one lift of concrete and placing the next lift directly on top of it?

A. Any time within 24 hours is acceptable

B. Exactly 6 hours, per standard practice

C. Less than 4.5 hours, before the previous lift reaches initial set

D. Time is not a factor if the mix contains fly ash

45. Using the Nurse-Saul maturity method with a datum temperature of 32°F (0°C), a concrete cylinder cured at an average temperature of 70°F for 24 hours accumulates how much maturity (temperature-time factor), in °F-hours?

A. 456 °F-hr

B. 684 °F-hr

C. 912 °F-hr

D. 1,140 °F-hr

46. A field density test on a compacted embankment fill shows a dry unit weight of 118 pcf. The laboratory maximum dry unit weight from a standard Proctor test is 124 pcf. What is the percent (relative) compaction achieved in the field?

A. 95.2%
B. 90.0%
C. 98.5%
D. 105.1%

47. A concrete delivery arrives at the site with a specified slump of 4 in. ± 1 in. A slump test performed upon arrival measures 6.5 in. What action should be taken regarding this load?

A. Accept the load, since higher slump improves workability
B. Reject the load; it exceeds the upper tolerance limit of 5 in.
C. Accept the load but reduce the water-cement ratio afterward
D. Accept the load and add retarder to compensate

48. A fillet weld connecting two steel plates has a leg size of 5/16 in. What is the effective throat thickness of this fillet weld?

A. 0.156 in
B. 0.313 in
C. 0.442 in
D. 0.221 in

49. During hot-mix asphalt paving, compaction rollers must complete their passes before the mat cools below which approximate critical temperature threshold, beyond which further densification becomes largely ineffective?

A. 300°F
B. 250°F
C. 175°F

D. 100°F

50. A maturity method calibration curve predicts an in-place concrete strength of 3,200 psi at the time formwork removal is being considered, with a required minimum strength of 3,000 psi specified for form removal. Companion field-cured cylinders broken at the same time confirm a compressive strength of 2,850 psi. Which value should govern the decision to remove formwork?

A. The maturity-predicted 3,200 psi value, since it exceeds the requirement
B. The field-cured cylinder result of 2,850 psi; formwork should not be removed yet
C. The average of the two values, 3,025 psi, which satisfies the requirement
D. Neither value is valid until standard 28-day cylinders are broken

51. A structural member for a construction-stage condition is subjected to a dead load of 500 lb/ft and a construction live load of 300 lb/ft. Using an unfactored D + Lc service-level combination for temporary construction loading, what is the total line load on the member?

A. 800 lb/ft
B. 650 lb/ft
C. 950 lb/ft
D. 1,100 lb/ft

52. A rectangular timber beam is 6 in. wide by 12 in. deep and carries a maximum bending moment of 15 kip-ft. What is the maximum bending stress in the beam?

A. 625 psi
B. 833 psi
C. 1,000 psi
D. 1,250 psi

53. A short steel column with a cross-sectional area of 8.0 in^2 has an allowable compressive stress of 18 ksi. What is the allowable axial load capacity of the column, neglecting buckling effects?

A. 144 kips
B. 120 kips
C. 160 kips
D. 100 kips

54. A simply supported steel beam spans 20 ft and carries a concentrated load of 10 kips at midspan. The beam has a moment of inertia $I = 800\ in^4$ and modulus of elasticity $E = 29{,}000\ ksi$. Using $\Delta = PL^3/48EI$, what is the maximum deflection at midspan?

A. 0.086 in
B. 0.124 in
C. 0.158 in
D. 0.201 in

55. Based on the triangular active earth pressure distribution shown in the figure, acting over a wall stem height of 10 ft, at what height above the base of the wall (Point O) does the resultant active earth pressure force act?

Figure PQ-3: Cantilever Retaining Wall & Active Pressure

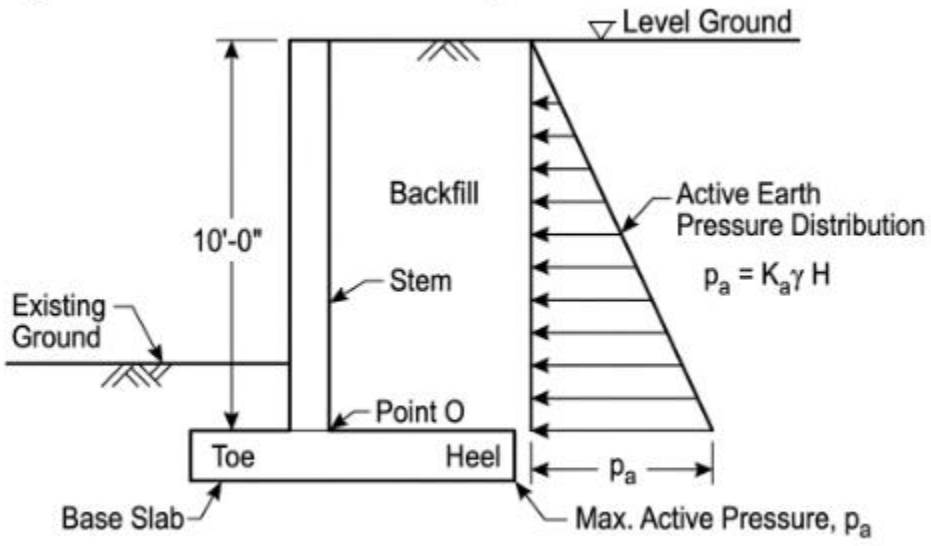


Figure PQ-3: Cantilever Retaining Wall & Active Pressure

A. 5.00 ft
B. 6.67 ft
C. 2.50 ft

D. 3.33 ft

56. A roof purlin spans 8 ft on center and supports a tributary width of 8 ft over a simply supported span of 20 ft, carrying a uniform roof live load of 20 psf. What is the total uniform line load on the purlin from this live load?

A. 100 lb/ft
B. 125 lb/ft
C. 160 lb/ft
D. 200 lb/ft

57. A slab-on-grade floor slab experiences random, irregular surface cracking shortly after placement, occurring before the concrete has gained significant strength, in a pattern not aligned with any control joints. What is the most likely cause of this cracking?

A. Long-term drying shrinkage after 28 days
B. Overloading from construction traffic
C. Differential settlement of the subgrade
D. Plastic shrinkage cracking from rapid early moisture loss

58. A rectangular beam 8 in. wide by 16 in. deep carries a maximum shear force of 12 kips. Using Vmax = 1.5V/(bd) for a rectangular section, what is the maximum shear stress in the beam?

A. 93.8 psi
B. 117.2 psi
C. 140.6 psi
D. 187.5 psi

59. In a one-way reinforced concrete slab, why is temperature and shrinkage reinforcement placed perpendicular to the main flexural reinforcement?

A. To control cracking caused by concrete shrinkage and thermal movement in the direction carrying no significant flexural stress

B. To resist the primary bending moment in the slab

C. To support the main reinforcement during placement only

D. Because building code requires it only in slabs over 12 in. thick

60. A column carries an axial load producing a uniform stress of 8 ksi and a bending moment producing an extreme fiber bending stress of 6 ksi in the same direction. What is the maximum combined compressive stress at the extreme fiber?

A. 8 ksi

B. 14 ksi

C. 10 ksi

D. 17 ksi

61. A circular storm sewer pipe with a diameter of 24 in. flows full at a slope of 0.005 ft/ft. Using Manning's equation with n = 0.013 and R = D/4 for a full circular pipe, what is the approximate full-flow capacity of the pipe, in cfs?

A. 8.0 cfs

B. 12.0 cfs

C. 16.0 cfs

D. 20.0 cfs

62. Using the Rational Method (Q = CiA), a drainage area of 15 acres has a runoff coefficient C = 0.40 and a design rainfall intensity of 3.0 in/hr. What is the peak runoff rate?

A. 18 cfs

B. 24 cfs

C. 12 cfs

D. 30 cfs

63. Based on the culvert profile shown, what is the slope of the culvert barrel, expressed as a percentage?

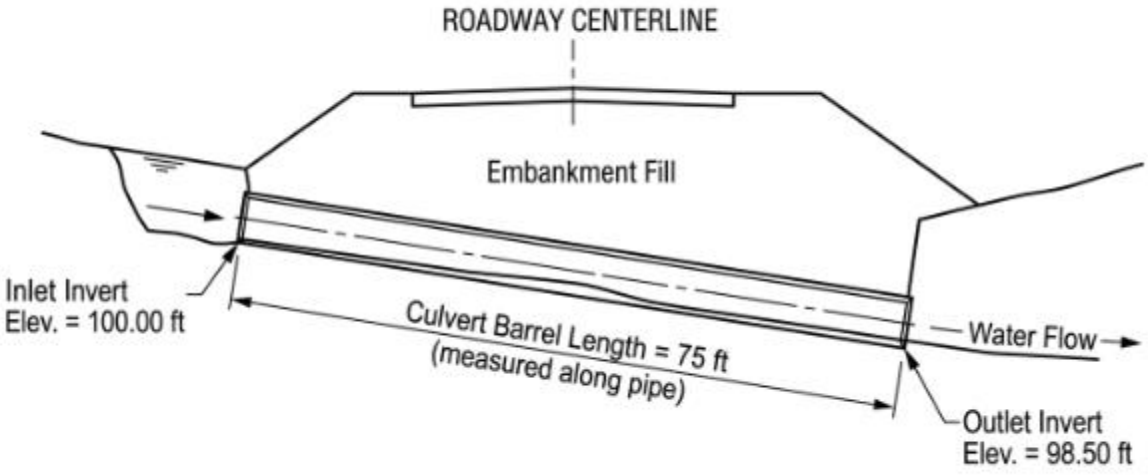


Figure PQ-4: Culvert Longitudinal Profile

A. 0.5%

B. 1.0%

C. 1.5%

D. 2.0%

64. A proposed detention pond has a bottom area of 8,000 ft², a top area at the design water surface 4 ft above the bottom of 12,000 ft², and a mid-height area of 9,900 ft². Using the prismoidal formula V = (h/6)(Abottom + 4×Amid + Atop), what is the storage volume of the pond?

A. 32,000 ft³

B. 39,733 ft³

C. 48,000 ft³

D. 59,600 ft³

65. Which component of a watershed's time of concentration typically represents the travel time for the initial, shallow, unchanneled overland sheet flow segment before runoff enters a defined channel or pipe?

A. Shallow concentrated flow time

B. Channel flow time

C. Sheet flow travel time

D. Pipe flow travel time

66. In open-channel flow, at what flow condition does the specific energy for a given discharge reach its minimum value?

A. At normal depth

B. At critical depth, where the Froude number equals 1

C. At the maximum channel depth

D. Only when the channel slope is zero

67. A load of 8,000 lb is lifted using a two-leg sling with each leg inclined at 60° from the horizontal. What is the tension in each sling leg, assuming the load is shared equally?

A. 4,619 lb

B. 4,000 lb

C. 5,333 lb

D. 6,928 lb

68. A mobile crane's load chart lists a maximum capacity of 22,000 lb at a 40-ft operating radius. The rigging (sling, shackles, and spreader bar) weighs 800 lb, and the load to be lifted weighs 19,500 lb. What is the remaining capacity margin at this radius after accounting for rigging weight?

A. 2,500 lb

B. 2,000 lb

C. 800 lb

D. 1,700 lb

69. An excavation requires dewatering at a rate of 450 gallons per minute (gpm) to maintain a dry work area. A pump is rated at 750 gpm capacity. What percentage of the pump's rated capacity is being utilized?

A. 60%

B. 75%

C. 50%

D. 90%

70. Based on the crane outrigger footprint shown in the figure, why is it important for the crane operator to verify that ground bearing pressure beneath each outrigger pad does not exceed the allowable soil bearing capacity before making the lift?

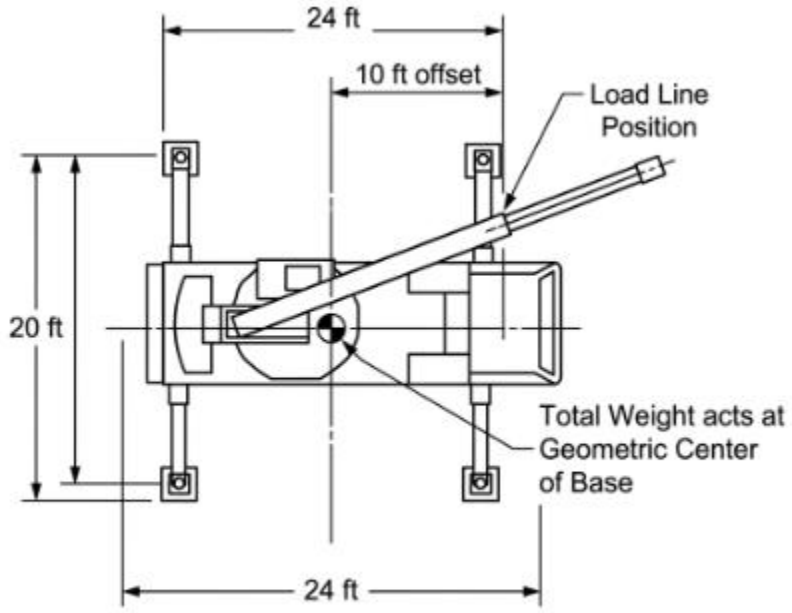


Figure PQ-5

A. Because all four outriggers always carry exactly equal load regardless of boom position

B. Because outrigger reactions redistribute as the boom position changes, and the most heavily loaded pad can exceed soil bearing capacity

C. Because ground bearing pressure only matters for tracked cranes, not outrigger-mounted cranes

D. Because the crane's load chart already accounts for soil bearing capacity at every jobsite

71. For excavating a deep, narrow trench in soft, saturated soil where a stable vertical trench wall cannot be maintained, which excavation equipment configuration is generally most appropriate?

A. A scraper working in continuous push-pull operation

B. A dragline excavator without shoring

C. An excavator or trencher combined with trench shielding for worker protection

D. A bulldozer with a ripper attachment

72. A borrow pit excavation removes soil with an in-situ (bank) volume of 12,000 cy. If the soil has a shrinkage factor of 0.85 when placed and compacted as fill, what compacted fill volume will this borrow material yield?

A. 14,118 cy
B. 12,000 cy
C. 9,000 cy
D. 10,200 cy

73. A driven pile is being installed using a hammer with a rated energy of 30,000 ft-lb per blow, and the pile advances 0.25 in. per blow at final set. Using the simplified Engineering News formula, Ru = 2E/(s+1.0), with E in ft-lb and s in inches, what is the estimated ultimate pile capacity?

A. 30,000 lb
B. 60,000 lb
C. 48,000 lb
D. 24,000 lb

74. A dump truck hauls fill material a one-way distance of 2.5 miles at an average haul speed of 25 mph, and returns empty at an average speed of 35 mph over the same distance. Ignoring loading and dumping time, what is the total round-trip travel time for one cycle?

A. 6.0 min
B. 10.3 min
C. 15.0 min
D. 8.6 min

75. A crawler crane begins to tip about its front idler, the point of rotation nearest the load, while lifting a load at maximum radius. What is this condition called, and what factor primarily governs the crane's resistance to it?

A. This is a structural boom failure, resisted by the boom's steel yield strength

B. This is a foundation bearing failure, resisted by soil bearing capacity alone

C. This is a wire rope failure, resisted by the rope's breaking strength

D. This is a tipping/stability failure, resisted by the crane's stabilizing moment (weight) about the tipping axis

76. An excavator has a bucket capacity of 2.5 cy, a fill factor of 0.90, a cycle time of 25 seconds, and an efficiency (working-time) factor of 0.83. What is the estimated production rate in cy per hour?

A. 268.9 cy/hr

B. 324.0 cy/hr

C. 224.1 cy/hr

D. 291.6 cy/hr

77. A wellpoint dewatering system is most appropriate for lowering groundwater in which type of soil condition?

A. Relatively permeable, fine to medium sands suited to vacuum wellpoint drawdown

B. Dense, low-permeability clay with negligible groundwater seepage rate

C. Solid rock formations with no groundwater present at all

D. Only in soils below the maximum practical wellpoint lift regardless of permeability

78. A cut excavation removes 10,000 cy of soil measured in its in-situ (bank) state. The soil has a swell factor of 1.25 when excavated and loaded loose into trucks. What is the loose (hauled) volume of this excavated material?

A. 8,000 cy

B. 10,000 cy

C. 11,250 cy

D. 12,500 cy

79. For a high-rise building project requiring frequent lifts of materials to increasing heights over a long construction duration, with a relatively confined site footprint, which crane type is typically most suitable?

A. A rough-terrain crane
B. A tower crane (fixed or climbing)
C. A truck-mounted crane
D. A floating (barge-mounted) crane

80. Concrete is placed in a wall form at a rate of 6 ft/hr, with a concrete temperature of 70°F and a unit weight of 150 pcf. Using a simplified maximum lateral pressure formula for walls, Pmax = 150 + 9,000(R/T), where R is placement rate in ft/hr and T is temperature in °F, what is the maximum lateral pressure on the formwork?

A. 650 psf
B. 785 psf
C. 921 psf
D. 1,050 psf

81. A scaffold frame leg has an allowable capacity of 4,200 lb. If four legs support a uniformly distributed platform load, and the total load on the scaffold bay (including materials and workers) is 15,000 lb, what is the utilization ratio of each leg, assuming equal load distribution?

A. 71.4%
B. 80.0%
C. 89.3%
D. 95.0%

82. A newly placed concrete slab imposes a construction load of 150 psf. Immediately below it, one level of shores is installed, and below that, one level of reshores supports a slab that has already gained significant strength. Assuming the load is shared equally between the shore level and the reshore level due to their similar stiffness, what load does each level carry?

A. 150 psf
B. 75 psf
C. 50 psf
D. 100 psf

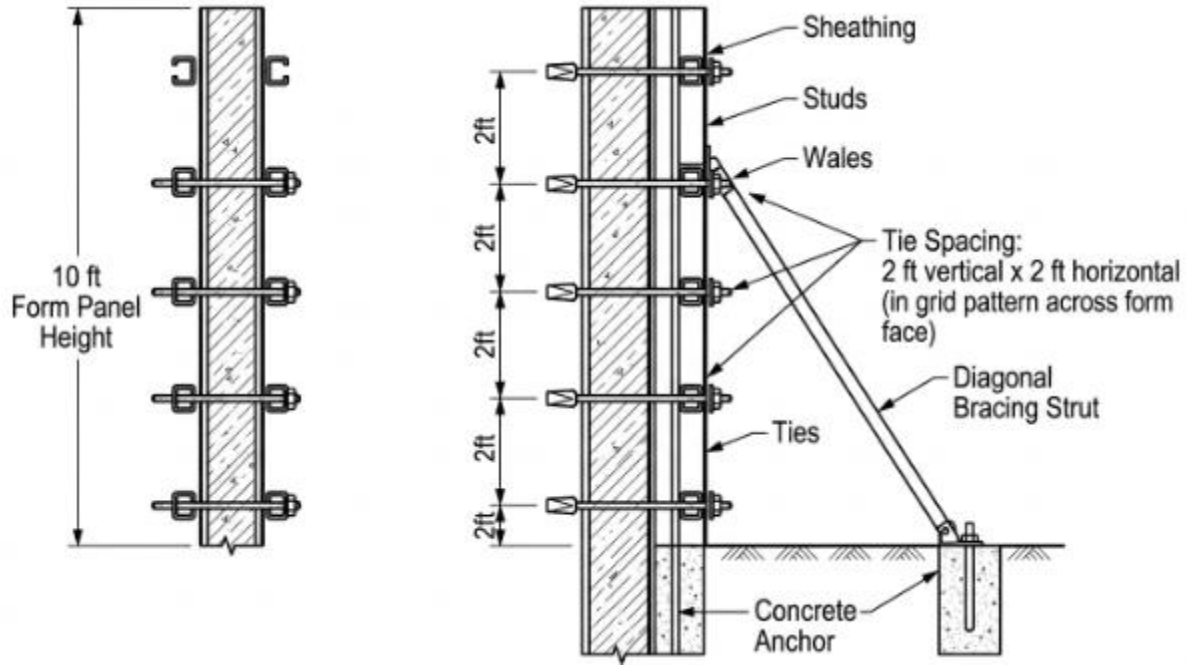
83. A temporary sign or windscreen attached to a construction hoist tower has an exposed area of 200 ft² and experiences a design wind pressure of 20 psf. What is the total design wind force acting on this exposed area?

A. 4,000 lb
B. 3,000 lb
C. 5,000 lb
D. 6,000 lb

84. A braced excavation in sand, 24 ft deep, uses an apparent earth pressure diagram per Peck's method with a maximum ordinate pa = 0.65·Ka·γ·H. Given Ka = 0.30, γ = 115 pcf, and H = 24 ft, what is the value of the maximum apparent pressure ordinate, pa?

A. 345 psf
B. 414 psf
C. 460 psf
D. 538 psf

85. Based on the wall formwork cross-section shown, if the maximum lateral concrete pressure on the form is 800 psf and the tie spacing is 2 ft vertical by 2 ft horizontal, what is the design tension load on each individual form tie?



A. 1,600 lb

B. 3,200 lb

C. 4,800 lb

D. 6,400 lb

86. A guy wire bracing a temporary mast is anchored 12 ft horizontally from the base of the mast and attaches to the mast at a height of 16 ft, giving a wire length of 20 ft. If the horizontal force to be resisted at the attachment point is 1,500 lb, what tension in the guy wire is required to provide this horizontal resistance?

A. 1,500 lb

B. 1,800 lb

C. 2,000 lb

D. 2,500 lb

87. During steel erection, a partially connected multi-story steel frame is most vulnerable to which failure mode before all permanent bracing, decking, and connections are complete?

A. Lateral/overall frame instability (progressive collapse or racking) due to incomplete lateral bracing

B. Excessive vertical deflection of fully braced floor beams

C. Long-term fatigue failure of bolted connections

D. Corrosion of exposed steel surfaces

88. A structure's typical floor construction load capacity (allowable) is 100 psf once the concrete reaches adequate strength, and each freshly poured slab imposes a construction load of 175 psf that must be distributed among the shore/reshore levels below it. If the load is assumed to distribute equally among 3 supporting levels, what is the load imposed on each level, in psf?

A. 87.5 psf

B. 175.0 psf

C. 58.3 psf

D. 100.0 psf

89. A horizontal strut in a braced excavation supports a tributary height of 8 ft and a tributary width of 15 ft along the wall, with an apparent lateral earth pressure of 450 psf acting uniformly over the tributary height. What is the total axial load in the strut?

A. 54,000 lb

B. 40,500 lb

C. 67,500 lb

D. 48,000 lb

90. OSHA construction standards generally require that supported scaffolds be restrained from tipping by guying, tying, or bracing when the scaffold height exceeds what multiple of its minimum base dimension, absent an engineered design for a taller freestanding configuration?

A. Two times (2:1)

B. Four times (4:1)

C. Six times (6:1)

D. Eight times (8:1)

91. A partially cured elevated slab has a current allowable load capacity of 80 psf. A piece of construction equipment imposes an equivalent distributed load of 110 psf on the slab during a planned operation. By how much does the equipment load exceed the slab's current allowable capacity?

A. 10 psf
B. 20 psf
C. 40 psf
D. 30 psf

92. In a soldier pile and lagging excavation support system, what is the primary structural function of the horizontal lagging boards installed between the vertical soldier piles?

A. To carry the vertical dead load of the excavation
B. To provide the primary resistance to overall wall bending
C. To retain soil between the piles and transfer the lateral earth pressure to the piles
D. To serve only as a walking surface for workers

93. A form tie rod has an ultimate tensile capacity of 15,000 lb, and the project specifies a safety factor of 2.0 for formwork ties. What is the maximum allowable working load for this tie?

A. 7,500 lb
B. 10,000 lb
C. 6,000 lb
D. 5,000 lb

94. When designing falsework to support a concrete bridge girder during construction, which load combination typically governs the design of the falsework system?

A. Only the dead load of the finished, cured structure
B. The wet concrete weight, formwork self-weight, plus applicable construction live loads
C. Only wind load acting alone
D. The seismic load combination used for the permanent structure

95. Per OSHA excavation standards (29 CFR 1926 Subpart P), at what minimum depth does an excavation generally require a protective system (shoring, shielding, or sloping), absent specific soil and stability exceptions?

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

96. Under OSHA 29 CFR 1926 Subpart M, at what height above a lower level does fall protection generally become required for most construction work, with certain exceptions such as steel erection?

A. 4 ft
B. 8 ft
C. 10 ft
D. 6 ft

97. Per the Manual on Uniform Traffic Control Devices (MUTCD), Part 6, what is the primary purpose of a temporary traffic control (TTC) plan for a highway work zone?

A. To safely and efficiently move traffic through the work zone while protecting workers and the public
B. To eliminate the need for any warning signs during short-duration work zones
C. To permit contractors to close all travel lanes without prior notice
D. To replace the need for flaggers on all highway projects

98. An OSHA competent person is required to conduct which type of inspection at excavation sites?

A. Only annual inspections of the excavation site
B. Inspections conducted only after a cave-in occurs
C. Inspections performed exclusively by a licensed engineer
D. Daily inspections for hazards before work begins and as conditions change

99. In a temporary traffic control zone, what is the primary function of the buffer space located between the last transition taper and the actual work area?

A. To store construction materials and equipment

B. To provide additional parking for workers

C. To provide a recovery/protective space between traffic and the work area

D. To serve as the location where flaggers are required to stand

100. Per OSHA construction standards, a competent person is defined as an individual who is capable of identifying existing and predictable hazards in the surroundings and who has what additional authority?

A. A professional engineering license in the relevant discipline

B. Authorization to take prompt corrective measures to eliminate the hazards

C. At least 10 years of field experience

D. Certification from a nationally accredited safety organization

Practice Exam 10: Answer Key and Explanations

1. A — The Rankine active coefficient is Ka = (1-sin30°)/(1+sin30°) = 0.333. The total active force per foot equals the area of the triangular pressure diagram: $0.5 \times Ka \times \gamma \times H^2 = 0.5 \times 0.333 \times 120 \times 12^2 = 2{,}880$ lb/ft, or 2.88 kip/ft. This resultant is what the wall stem and base must resist. The other options use the wrong coefficient or omit the 0.5 triangular-area factor.

2. B — Primary consolidation settlement for a normally consolidated clay uses $Sc = [Cc \cdot H/(1+e0)] \cdot \log10[(p0+\Delta p)/p0]$. With H = 120 in, $Sc = (0.30 \times 120/1.85) \times \log10(1.5) = 19.46 \times 0.176 = 3.43$ in, rounding to 3.4 in. This settlement develops gradually as excess pore pressure dissipates over time. The distractors result from misapplying the void-ratio term or omitting the logarithmic stress ratio.

3. C — Total vertical stress at 20 ft is $8 \times 115 + 12 \times 125 = 2{,}420$ psf. Pore water pressure at that depth, measured from the water table 12 ft above, is $12 \times 62.4 = 748.8$ psf. Effective stress equals total stress minus pore pressure: $2{,}420 - 749 \approx 1{,}671$ psf. Option A wrongly reports total stress with no pore-pressure deduction.

4. D — Terzaghi's bearing capacity for a cohesionless soil is $qu = q \cdot Nq + 0.5 \cdot \gamma \cdot B \cdot N\gamma$, with $q = \gamma \cdot Df = 110 \times 4 = 440$ psf. This gives $qu = 440 \times 20 + 0.5 \times 110 \times 3 \times 15 = 8{,}800 + 2{,}475 = 11{,}275$ psf. The wrong answers isolate only one of the two additive terms instead of summing both.

5. A — For a dry, cohesionless infinite slope, the factor of safety against planar sliding is FS = tanφ/tanβ. With φ = 32° and β = 20°, FS = tan32°/tan20° = 0.625/0.364 ≈ 1.72. Since FS exceeds 1.0, the slope is stable under drained conditions; the other values come from swapping or mis-ratioing the two angles.

6. B — Active and passive pressures are limit states that only develop after the wall moves away from or into the soil, respectively. A perfectly rigid wall restrained against any translation or rotation never mobilizes either limit state, so the soil remains at its in-situ lateral stress, governed by the at-rest coefficient K0, which lies between the active and passive values.

7. C — Terzaghi's principle states that the effective stress, which controls soil strength and volume-change behavior, equals the total stress minus the pore water pressure acting in the void spaces (σ' = σ − u). This relationship is fundamental to bearing capacity, settlement, and slope stability analysis. The other options reverse or sever this required subtraction relationship.

8. C — When groundwater rises to the footing base, soil below the water table becomes buoyant, reducing its effective unit weight to roughly half the dry value. Since both the surcharge (q) and the Nγ term depend on effective unit weight, ultimate bearing capacity decreases substantially. Friction angle is not reduced by submergence, ruling out option D.

9. D — Curve length is L = R·Δ, with Δ expressed in radians: Δ = 36×π/180 = 0.6283 rad. Multiplying by R = 800 ft gives L = 800×0.6283 = 502.7 ft. This arc-length relationship only applies once the deflection angle is converted from degrees. The other choices result from using degrees directly or an incorrect radius-to-arc conversion.

10. B — The middle ordinate is the offset from the long chord to the curve midpoint, M = R(1−cos(Δ/2)). With Δ/2 = 12°, cos12° = 0.9781, so M = 1,000×(1−0.9781) = 21.9 ft. This is a distinct geometric quantity from the external distance, which offsets from the PI instead. Errors using the full deflection angle instead of half produce the other values.

11. D — A pre-construction condition survey photographs and records existing cracks, settlement, and other defects in an adjacent structure before nearby excavation or construction begins. This baseline record protects both parties by distinguishing pre-existing conditions from any new damage that might occur during construction, and it supports resolution of disputes over responsibility for claimed damage.

12. A — Cut is the difference between the existing ground elevation and the lower design subgrade elevation: 452.35 − 448.90 = 3.45 ft. Since the existing ground is higher than the design grade, material must be removed (cut) rather than added, and the stake is marked accordingly. The other values reflect simple subtraction or transcription errors in the elevations given.

13. B — The high point on a crest curve is located at x = g1L/(g1−g2) = 0.025×400/0.04 = 250 ft from the PVC. Its elevation is elevPVC + g1x − [(g1−g2)/2L]x² = 100 + 6.25 − 3.125 = 103.13 ft. Option D (106.25 ft) is the common error of omitting the parabolic curve correction term entirely.

14. A — A benchmark is a permanently monumented point of known, verified elevation. Surveyors use it as the vertical control reference for transferring elevations throughout the site via differential leveling,

and it allows elevations set at different times or by different crews to be checked against a common, stable datum, preventing accumulated vertical error.

15. C — Vacuum excavation, or potholing, uses a high-velocity air or water jet with vacuum extraction to safely expose a buried utility without damaging it, giving a direct, verified horizontal and vertical position. Record drawings, radar, and paint marks are useful screening tools but each carries significant location uncertainty and cannot substitute for physical confirmation before excavation.

16. D — The CL clay layer from 5 to 15 ft has low N-values of 4 and 3 blows/ft, indicating soft to medium-stiff clay with low undrained shear strength, which governs shallow foundation bearing capacity in that zone. This clay is also compressible and normally consolidated, so it undergoes significant time-dependent settlement, unlike the denser, higher N-value sands above and below it.

17. A — Water-cement ratio is simply the weight of water divided by the weight of cement in the mix: 235 lb / 470 lb = 0.50. This ratio is a key durability and strength parameter; lower w/c ratios generally produce higher strength and lower permeability concrete. The other values would require different water or cement quantities than those given in the problem.

18. C — Relaxation is a property of the prestressing steel itself: when held at essentially constant strain, the internal stress in the strand gradually decreases over time. Elastic shortening and shrinkage/creep are losses associated with the concrete's response to the applied prestress, and they occur mainly at and after release, not while the strand is tensioned and anchored beforehand.

19. D — Laminated veneer lumber is produced by gluing thin wood veneers together with the grain of every layer oriented parallel to the member's length, maximizing strength and stiffness along that axis. This distinguishes it from plywood, which alternates veneer grain direction for panel strength in two directions, and from OSB, which uses oriented wood strands rather than continuous veneers.

20. B — Percent passing is the complement of percent retained: with 850 g retained out of 1,000 g total, the mass passing is $1{,}000 - 850 = 150$ g, or $150/1{,}000 \times 100 = 15\%$. Option A (85%) is the percent retained value itself, mistakenly reported as percent passing rather than being subtracted from the total sample mass.

21. D — Air-entraining admixtures deliberately introduce a stable system of microscopic, uniformly distributed air bubbles into the concrete matrix. These voids relieve internal hydraulic pressure generated when pore water freezes and expands, greatly improving the concrete's durability and resistance to freeze-thaw cycling. Water-reducing, accelerating, and retarding admixtures instead target workability or setting-time characteristics, not air content.

22. B — Axial stress equals the applied force divided by the cross-sectional area: $\sigma = P/A = 100$ kips / 4.0 in^2 = 25 ksi. This straightforward calculation is the basis for checking a tension member against its material's allowable or yield stress. The other options would only result from using an incorrect area or force value.

23. C — The footing volume is $4 \times 4 \times 1.5 = 24$ ft^3. Converting to cubic yards by dividing by 27 ft^3 per cy gives 24/27 = 0.89 cy. This conversion is the standard method for estimating concrete quantities from

linear dimensions. The other answers stem from arithmetic errors in the volume calculation or the ft³-to-cy conversion.

24. A — The combined unit cost per cubic yard is $185 + $95 = $280. Multiplying by the total quantity of 240 cy gives a total estimated cost of $280×240 = $67,200. The other totals result from using only one of the two unit-cost components rather than summing materials and labor/equipment together before multiplying by quantity.

25. C — Simple break-even analysis divides the initial investment by the annual savings it generates: $50,000 / $12,500 per year = 4 years. After this period, the cumulative operating savings equal the purchase price, and continued use becomes net-favorable compared to renting. This simplified method ignores discounting, which a full economic analysis would otherwise incorporate.

26. A — CPI is defined as earned value divided by actual cost: CPI = BCWP/ACWP = $450,000/$500,000 = 0.90. A CPI below 1.0 indicates the project is over budget relative to the work actually accomplished, since more has been spent than the value of work performed. Option B inverts the ratio, giving a misleadingly favorable result.

27. D — The average end area method computes volume as the average of the two end areas times the distance between them: [(220+180)/2]×100 = 200×100 = 20,000 ft³. Dividing by 27 ft³ per cy converts this to 20,000/27 = 740.7 cy. The distractors result from using only one section's area or omitting the unit conversion.

28. B — Applying a 12% markup means multiplying the direct cost by 1.12: $1,200,000×1.12 = $1,344,000. This single multiplication correctly adds overhead and profit as one combined percentage of the direct cost base. Option A omits the markup entirely, while C and D reflect slightly different, incorrect markup percentages applied to the base cost.

29. C — Total steel length is 40 bars × 12 ft each = 480 ft. Multiplying by the unit weight of 1.502 lb/ft gives 480×1.502 = 720.96 lb, which rounds to 721 lb. This quantity takeoff approach, length times unit weight per foot, is the standard method for estimating reinforcing steel tonnage from bar schedules.

30. A — Because alternatives may have different service lives and different timing of rehabilitation, maintenance, and salvage value, these future cash flows must be converted to a common time basis, such as present worth, so they can be fairly compared alongside the initial cost. Comparing only initial costs, as in option B, ignores these significant time-distributed differences between alternatives.

31. D — Interior wall framing on a slab-on-grade building is typically anchored directly to the finished slab, so the slab must be placed and cured to adequate strength before framing layout and anchor bolts can be installed. Roofing, finish flooring, and painting are all downstream activities that occur after the structural frame, including interior walls, is largely complete.

32. D — The PERT expected duration weights the most likely estimate four times more heavily than the optimistic and pessimistic estimates: te = (a+4m+b)/6 = (6+36+18)/6 = 60/6 = 10 days. This beta-distribution approximation accounts for uncertainty and skew in activity duration estimates better than simply averaging the three values or using the most likely value alone.

33. B — Two paths run from A to E: A-B-D-E totals 4+6+5+3 = 18 days, and A-C-D-E totals 4+9+5+3 = 21 days. The critical path is the longest path through the network, since it determines the minimum project duration, so A-C-D-E at 21 days governs. Path A-B-D-E has 3 days of float relative to the critical path.

34. B — Total float is the difference between an activity's late finish and its early finish (equivalently, late start minus early start): 24 − 18 = 6 days. This represents how much the activity can slip without delaying the overall project completion date. The other values would require different combinations of the given early and late dates.

35. C — Resource smoothing shifts non-critical activities within their existing total float to reduce sharp peaks and valleys in resource demand, deliberately preserving the project's original completion date. This differs from crashing, which shortens durations by adding resources at extra cost, and from fast-tracking, which overlaps sequential activities, both of which can change project duration or risk.

36. A — Cost slope is the additional cost per day of duration reduction: (crash cost − normal cost) / (normal duration − crash duration) = ($12,000 − $8,000)/(10 − 6) = $4,000/4 = $1,000 per day. This slope tells the scheduler the marginal cost of shortening this specific activity and is compared against other activities' slopes when choosing what to crash.

37. A — The linear scheduling method, also called line-of-balance, plots production against location and time, making it well suited to repetitive, linear work such as highway paving or pipeline installation. It visualizes crew production rates and identifies where one crew might catch up to and interfere with another, something a standard CPM bar chart does not show.

38. D — The minimum added cost to crash an activity is simply its cost slope multiplied by the number of days reduced: $1,500/day × 4 days = $6,000. Because this is the only available critical activity, all four days of reduction must come from it, so no cheaper combination of activities exists to achieve the required schedule compression.

39. B — The total carpenter demand on day 15 is 4+3+5 = 12, while only 9 are available, leaving a shortfall of 12−9 = 3 carpenters. This over-allocation signals that the scheduler must either delay one activity within its available float, add crew capacity, or extend the schedule to resolve the resource conflict before day 15 arrives.

40. C — Free float is the amount an activity can slip without pushing back the early start of its immediately following activity, a narrower measure than total float. Total float, by contrast, is the delay an activity can absorb without affecting overall project completion, the distinct project-level metric described in option A.

41. D — Compressive strength is the failure load divided by the cylinder's cross-sectional area. For a 6-in. diameter cylinder, area = $\pi \times 3^2 = 28.27$ in², so f'c = 141,372/28.27 ≈ 5,000 psi. This standard cylinder-break calculation verifies whether delivered concrete meets its specified 28-day design strength, here confirming a 5,000 psi mix.

42. B — Torque-tension relationships are highly sensitive to variables like thread lubrication, surface condition, and friction, making torque alone an unreliable predictor of the actual bolt tension achieved. The turn-of-nut method instead measures rotation past a snug-tight condition, which correlates more directly and consistently with elongation and, therefore, achieved pretension, regardless of friction variability between bolts.

43. A — Quality assurance is proactive: it is the overarching system of planning, procedures, and audits designed to prevent defects before they occur. Quality control is reactive and specific: the actual inspection, sampling, and testing performed on completed work to confirm it conforms to project specifications. Treating these as identical, as in option B, obscures this important planning-versus-verification distinction.

44. C — A cold joint forms when a new lift of concrete is placed after the previous lift has already begun to set, preventing proper bonding and monolithic behavior between lifts. To avoid this, the next lift must be placed and consolidated before the underlying concrete reaches its initial set, here approximately 4.5 hours, regardless of mix additions such as fly ash.

45. C — The Nurse-Saul maturity factor accumulates the product of temperature above the datum and elapsed time: $M = \Sigma(T - T0)\cdot\Delta t = (70-32)\times 24 = 38\times 24 = 912$ °F-hours. This maturity value is then compared against a calibration curve relating maturity to compressive strength, allowing an estimate of in-place strength without waiting for a companion cylinder break.

46. A — Percent compaction compares the field dry unit weight achieved to the laboratory maximum dry unit weight from the Proctor test: 118/124×100 = 95.2%. Specifications commonly require 95% or greater relative compaction for structural fill, so this result would typically meet a 95% minimum requirement, though it should be checked against the specific project specification value.

47. B — The specified slump tolerance is 4 in. ± 1 in., meaning the acceptable range is 3 to 5 in. A measured slump of 6.5 in. exceeds the upper limit, typically indicating excess water was added, which reduces strength and durability. Such a load should be rejected rather than accepted, since the water-cement ratio cannot be corrected after the fact.

48. D — The effective throat of an equal-leg fillet weld is the leg size multiplied by 0.707 (cos45°), reflecting the shortest distance through the weld's triangular cross-section: 0.3125 in × 0.707 = 0.221 in. This throat dimension, not the leg size itself, is used to compute the weld's effective area and strength in design calculations.

49. C — As hot-mix asphalt cools, the binder stiffens and the mat becomes progressively more resistant to further densification. Once the mat temperature drops to roughly 175°F, rolling can no longer meaningfully increase density regardless of additional passes, so all required breakdown, intermediate, and finish rolling must be completed before the mat reaches this threshold.

50. B — The maturity method is an estimating tool that must be verified against actual tested strength; when a direct, companion-cylinder break contradicts the maturity prediction, the tested result governs.

Here the field-cured cylinders show only 2,850 psi, below the 3,000 psi requirement, so formwork removal should be delayed regardless of the higher maturity-based estimate.

51. A — An unfactored service-level combination simply sums the applicable loads: D + Lc = 500 + 300 = 800 lb/ft. This combined line load represents the demand the member must be checked against during the temporary construction stage, distinct from the load combinations, and load magnitudes, that would apply once the structure reaches its final, permanent condition.

52. D — Section modulus for a rectangular section is $S = bd^2/6 = 6\times144/6 = 144$ in³. Converting the moment to consistent units, M = 15 kip-ft × 12 in/ft × 1,000 = 180,000 lb-in. Bending stress is $\sigma = M/S = 180{,}000/144 = 1{,}250$ psi, the maximum fiber stress at the top and bottom of the beam.

53. A — For a short column where buckling is not a governing concern, allowable axial capacity is simply the allowable stress multiplied by the cross-sectional area: 18 ksi × 8.0 in² = 144 kips. For a longer, more slender column, this capacity would need to be further reduced to account for buckling, which is not applicable in this short-column scenario.

54. B — Converting the 20-ft span to 240 in for unit consistency, $\Delta = PL^3/48EI = (10\times240^3)/(48\times29{,}000\times800) = 138{,}240{,}000/1{,}113{,}600{,}000 \approx 0.124$ in. This standard midspan deflection formula for a simply supported beam under a central point load is used to check serviceability against allowable deflection limits such as span/360, a common criterion.

55. D — For a triangular pressure distribution, the resultant force acts at the centroid of the triangle, located at one-third of the height from the base: 10 ft/3 = 3.33 ft above Point O. This is a standard result from statics for any triangular loading, distinguishing it from a rectangular (uniform) pressure distribution, whose resultant would act at the mid-height instead.

56. C — A uniformly distributed area load is converted to a line load by multiplying by the tributary width the member collects: 20 psf × 8 ft tributary width = 160 lb/ft. The purlin's span length of 20 ft does not affect this unit line-load conversion; it instead determines the total load and moment the purlin must resist along its length.

57. D — Plastic shrinkage cracking occurs while concrete is still plastic, when surface moisture evaporates faster than bleed water can replace it, typically under hot, dry, or windy conditions. This produces random, irregular cracks shortly after placement, unrelated to joint layout. Long-term drying shrinkage, subgrade settlement, and traffic overload instead develop later, after the concrete has hardened and gained strength.

58. C — For a rectangular cross-section, maximum shear stress occurs at the neutral axis and equals 1.5 times the average shear stress: $\tau_{max} = 1.5V/(bd) = 1.5\times12{,}000/(8\times16) = 18{,}000/128 \approx 140.6$ psi. This factor of 1.5 reflects the parabolic shear stress distribution across a rectangular section, higher than the simple average V/(bd) would suggest.

59. A — A one-way slab's main flexural steel resists bending in the span direction, but the perpendicular direction carries no significant flexural demand and remains vulnerable to shrinkage and thermal cracking. Temperature and shrinkage reinforcement is placed in that transverse direction specifically to distribute and limit such cracking, not to serve a structural bending role or merely support the main bars.

60. B — When axial and bending stresses act in the same sense at an extreme fiber, they are superimposed directly: combined stress = axial stress + bending stress = 8 + 6 = 14 ksi. This combined-stress check at the critical fiber governs the design of members subject to both axial compression and bending, such as beam-columns.

61. C — For a 2-ft diameter pipe, area = πr^2 = 3.14 ft² and hydraulic radius R = D/4 = 0.5 ft. Manning's equation gives Q = (1.486/n)AR^(2/3)S^(1/2) = (1.486/0.013)×3.14×0.5^0.667×0.005^0.5 ≈ 16.0 cfs. This full-flow capacity check confirms whether the pipe size is adequate for the design peak flow it must convey.

62. A — The Rational Method computes peak runoff as the product of runoff coefficient, rainfall intensity, and drainage area: Q = CiA = 0.40×3.0×15 = 18 cfs, with the area in acres and intensity in in/hr conveniently yielding cfs directly. This simplified method is widely used for preliminary sizing of storm drainage systems on small drainage areas.

63. D — Culvert slope is the drop in invert elevation from inlet to outlet divided by the barrel length: (100.00−98.50)/75×100 = 1.50/75×100 = 2.0%. Adequate barrel slope helps maintain self-cleansing velocity through the culvert and prevents sediment accumulation, so this slope value would be checked against a minimum velocity or slope criterion during design.

64. B — The prismoidal formula gives V = (h/6)(Abottom+4Amid+Atop) = (4/6)×(8,000+4×9,900+12,000) = 0.667×59,600 ≈ 39,733 ft³. This method accounts for the changing cross-sectional area with depth in a sloped-side pond, since it explicitly weights the mid-height area, giving a more accurate volume estimate than simply averaging only the top and bottom surface areas.

65. C — Time of concentration is typically computed as the sum of several flow segments: sheet flow across the initial unchanneled portion of the watershed, followed by shallow concentrated flow, and finally channel or pipe flow once runoff reaches a defined conveyance. Sheet flow is specifically the shallow, unchanneled segment occurring at the very start of the flow path.

66. B — For a fixed discharge, specific energy plotted against depth has a minimum at critical depth, where the Froude number equals 1.0. This condition marks the transition between subcritical (tranquil) and supercritical (rapid) flow regimes and is independent of the channel's actual slope or the normal depth, which depends instead on the channel's roughness and slope.

67. A — Each leg carries half the load vertically, but because the leg is inclined, its tension exceeds the vertical component it supports: T = (load/2)/sin60° = 4,000/0.866 = 4,619 lb. Sling tension always increases as the leg angle from horizontal decreases, which is why shallow sling angles are avoided in rigging to prevent excessive leg tension.

68. D — The total weight to be supported by the crane at this radius is the load plus all rigging: 19,500+800 = 20,300 lb. Subtracting this from the chart's rated capacity of 22,000 lb gives a remaining margin of 22,000−20,300 = 1,700 lb. Rigging weight must always be included in this check; the load chart capacity is not the load's weight alone.

69. A — Percent utilization compares the actual required flow rate to the pump's rated capacity: 450/750×100 = 60%. Operating at 60% of rated capacity leaves meaningful reserve margin for surges in inflow or pump performance degradation over time, which is generally preferable to selecting a pump that would run near its rated maximum continuously.

70. B — As the boom slews or the load moves off the crane's centerline, the reaction carried by each outrigger pad changes, with the pad nearest the load typically carrying more than an even one-quarter share. If that concentrated reaction exceeds the soil's allowable bearing capacity, localized pad punch-through or tipping instability can result.

71. C — Soft, saturated soil that cannot maintain a stable vertical face requires a protective system for any worker entry, most commonly a trench shield (box) used in combination with an excavator or trenching machine to dig the trench and place or advance the shield. Scrapers, draglines without shoring, and dozers with rippers are not suited to this narrow, deep trench condition.

72. D — Shrinkage factor accounts for the volume reduction that occurs when loose, excavated soil is recompacted into a denser fill condition: compacted fill volume = bank volume × shrinkage factor = 12,000×0.85 = 10,200 cy. This shrinkage must be factored into borrow-source quantity calculations, since bank volume alone would overstate the usable compacted fill volume produced.

73. C — Substituting the given values into the Engineering News formula gives Ru = 2×30,000/(0.25+1.0) = 60,000/1.25 = 48,000 lb. This dynamic formula relates hammer energy and pile set (penetration per blow) to an estimated ultimate capacity, providing a quick field check during driving, though it is generally considered less reliable than a wave-equation analysis or static load test.

74. B — Loaded travel time is 2.5 mi/25 mph = 0.10 hr, and empty return time is 2.5 mi/35 mph = 0.0714 hr, giving a combined travel time of 0.1714 hr, or 0.1714×60 ≈ 10.3 minutes. This travel-time component is then added to loading and dumping time (excluded here) to estimate the truck's full production cycle time.

75. D — A crane rotating about its front idler or tipping fulcrum under an excessive load-induced overturning moment is exhibiting a stability, not a strength, failure. Resistance to tipping comes primarily from the stabilizing moment created by the crane's own weight, carbody, and counterweight acting about that same tipping axis, not from boom material strength, rope capacity, or soil bearing alone.

76. A — Cycles per hour equal 3,600 seconds divided by the 25-second cycle time, or 144 cycles/hr. Each cycle effectively moves 2.5×0.90 = 2.25 cy, giving 144×2.25 = 324 cy/hr at full efficiency. Applying the 0.83 efficiency factor for non-productive time reduces this to 324×0.83 ≈ 268.9 cy/hr, the realistic estimated production rate.

77. A — Wellpoint systems apply a vacuum to a header pipe connected to closely spaced small-diameter points, which works in soils permeable enough, fine to medium sands, for groundwater to flow to the points under vacuum within a practical lift. Low-permeability clay yields water too slowly for this method, and rock has essentially no groundwater to remove.

78. D — Swell factor accounts for the volume increase when compact, in-situ soil is excavated and loosened, since loosened material occupies more space than in its natural bank state: loose volume = bank volume × swell factor = 10,000×1.25 = 12,500 cy. This loose volume, not the bank volume, determines the truckloads required for hauling.

79. B — Tower cranes, whether fixed to a foundation or climbing internally within the building core, are specifically designed for the sustained, repetitive high-reach lifting demands of high-rise construction over a long duration, while occupying a minimal site footprint. Mobile options like rough-terrain, truck-mounted, or floating cranes are generally better suited to shorter-duration or lower-height lifting tasks.

80. C — Substituting into the simplified wall pressure formula: Pmax = 150 + 9,000×(6/70) = 150+9,000×0.0857 = 150+771.4 ≈ 921 psf. Placement rate and concrete temperature are the two dominant variables in this formula, since faster placement or colder concrete both slow the rate of strength gain relative to the rate of hydrostatic head buildup in the form.

81. C — With four legs sharing the load equally, each leg carries 15,000/4 = 3,750 lb. Comparing this to the leg's allowable capacity of 4,200 lb gives a utilization ratio of 3,750/4,200×100 = 89.3%. Because this is below 100%, the scaffold legs have adequate capacity for the stated load, though load distribution may not be perfectly equal in the field.

82. B — Multi-level shoring analysis typically assumes the total construction load is distributed among all supporting levels approximately in proportion to their relative stiffness. With two levels of comparable stiffness sharing the load equally, each carries half of the 150 psf total: 150/2 = 75 psf, a load each supported level and slab below must be checked against.

83. A — Total wind force is simply the design wind pressure multiplied by the exposed area subject to that pressure: F = 20 psf × 200 ft² = 4,000 lb. This resultant force must then be resisted by the hoist tower's bracing and anchorage system, in combination with wind acting on the tower and hoist structure itself, not just the screen alone.

84. D — Substituting the given values into Peck's apparent pressure formula: pa = 0.65×0.30×115×24 = 538.2 psf. This apparent pressure envelope, rather than a simple triangular active pressure diagram, is specifically used for designing struts and walers in braced excavations, since it better represents the redistributed pressures observed in staged, braced excavation construction.

85. B — Each tie's tributary area is its vertical spacing times its horizontal spacing: 2 ft × 2 ft = 4 ft². Multiplying by the maximum lateral concrete pressure gives the design tension load: 800 psf × 4 ft² = 3,200 lb. This tributary-area approach is standard for distributing lateral pressure to discrete form ties.

86. D — The 12-16-20 geometry forms a 3-4-5 right triangle, where the horizontal component of the wire tension relates to the total tension by the ratio of the horizontal leg to the hypotenuse. Since horizontal force = tension × (12/20), tension = 1,500×(20/12) = 2,500 lb, the wire force needed to produce the required 1,500-lb horizontal resistance.

87. A — A partially erected steel frame, before permanent bracing, decking, and all connections are in place, lacks the full lateral stability system the completed structure will ultimately have. This makes the

frame particularly susceptible to racking or overall instability under wind, seismic, or construction loads, which is why temporary guying and bracing plans are a critical part of the erection sequence.

88. C — Distributing the 175 psf construction load equally across 3 supporting levels gives 175/3 ≈ 58.3 psf per level. Since this is well below the 100 psf allowable floor capacity per level, the shoring and reshoring scheme with 3 levels is adequate for this load; fewer levels would concentrate more load onto each remaining level and could exceed capacity.

89. A — The strut's tributary area is the tributary height times tributary width: 8 ft × 15 ft = 120 ft². Multiplying this by the uniform apparent pressure of 450 psf gives the total axial strut load: 450×120 = 54,000 lb. This tributary-area method converts the wall's distributed earth pressure into a discrete design load carried by each individual strut.

90. B — OSHA's scaffold standard generally requires restraint against tipping, through guying, tying, or bracing, once a supported scaffold's height exceeds four times its minimum base dimension (a 4:1 height-to-base ratio), unless the scaffold has been specifically designed and configured by a qualified person to be safe without such restraint at a greater height.

91. D — The excess load is found by subtracting the slab's current allowable capacity from the imposed equipment load: 110−80 = 30 psf. This overload indicates the planned equipment operation should not proceed on the slab in its current condition without either allowing further curing and strength gain, adding temporary shoring, or reducing the equipment loading before the operation.

92. C — Lagging boards span horizontally between adjacent soldier piles, retaining the exposed soil face and transferring the lateral earth pressure they receive to the piles as simply supported horizontal spans. The soldier piles, driven or drilled vertically, provide the primary structural bending resistance and transfer loads down to a stable bearing stratum.

93. A — Allowable working load is found by dividing the ultimate tensile capacity by the specified safety factor: 15,000/2.0 = 7,500 lb. This safety factor provides a margin against uncertainties in material variability, installation quality, and unanticipated load increases, ensuring the tie is never designed to operate near its actual breaking capacity during normal formwork use.

94. B — Falsework must be designed for the actual loading condition it experiences during construction: the full weight of the wet, uncured concrete (which is heavier than the cured structure per ASCE 37 hydrostatic considerations for formwork), the self-weight of the formwork and falsework itself, and applicable construction live loads such as workers, equipment, and impact, not the finished structure's service loads.

95. C — OSHA's excavation standard generally requires a protective system, sloping, benching, shoring, or shielding, for excavations 5 ft or deeper, unless the excavation is entirely in stable rock or a competent person determines no protective system is needed for a shallower excavation based on specific soil and site conditions documented at the time.

96. D — OSHA's general construction fall protection standard sets the trigger height at 6 ft above a lower level for most construction work, requiring guardrails, safety nets, or personal fall arrest systems at or

above that height. Certain specialized activities, such as steel erection, have their own distinct trigger heights and requirements under separate subparts of the standard.

97. A — A temporary traffic control plan under MUTCD Part 6 is developed to guide road users safely and efficiently through or around a work zone while protecting both the traveling public and workers performing the work. It does not eliminate the need for warning devices or flaggers, both of which remain integral components that a TTC plan specifies where appropriate.

98. D — OSHA requires a competent person to inspect excavations, adjacent areas, and protective systems daily, before work begins, and as needed throughout the shift as conditions change, looking for evidence of possible cave-ins, water accumulation, or other hazardous conditions. This role does not require a professional engineering license; it requires specific training and authority to identify and correct hazards.

99. C — The buffer space is an open, unobstructed area between the end of the taper and the start of the actual work activity area, intended to give errant vehicles room to recover or stop before reaching workers or equipment. It should be kept clear of stored materials, parked vehicles, or other obstructions, since its protective function depends entirely on remaining open.

100. B — OSHA defines a competent person as someone capable of identifying existing and predictable hazards, whether in the surroundings or working conditions, and who additionally has management authorization to take prompt corrective action to eliminate those hazards. This authority to act, not a specific license, years of experience, or third-party certification, is the defining regulatory requirement for the role.