PRACTICE EXAM 12: 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 10 ft high retains a cohesionless backfill with unit weight $\gamma = 125$ 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. 2.083 kip/ft
B. 3.125 kip/ft
C. 1.563 kip/ft
D. 4.167 kip/ft

2. A normally consolidated clay layer 12 ft thick has an initial void ratio $e0 = 0.80$ and compression index $Cc = 0.28$. The effective overburden stress at mid-height is 1,800 psf, and a footing load increases the effective stress at mid-height by 1,200 psf. What is the primary consolidation settlement of the layer?

A. 3.10 in
B. 6.20 in
C. 4.97 in
D. 2.45 in

3. A soil profile consists of 9 ft of sand (moist unit weight 120 pcf) above the water table, underlain by 10 ft of saturated sand (saturated unit weight 130 pcf) below the water table. What is the effective vertical stress at a depth of 19 ft (bottom of the saturated layer)?

A. 2,380 psf
B. 1,080 psf
C. 1,300 psf
D. 1,756 psf

4. A strip footing 3.5 ft wide is founded at a depth of 4.5 ft in a cohesionless soil with unit weight 115 pcf. At this friction angle, Terzaghi's bearing capacity factors are $N_q = 16$ and $N_\gamma = 11$. What is the ultimate bearing capacity of the footing, neglecting the cohesion term?

A. 8,280 psf
B. 10,494 psf
C. 2,214 psf
D. 12,000 psf

5. An infinite slope in cohesionless sand is inclined at 22° to the horizontal. The sand has an effective friction angle of 34° and no cohesion, with the slope fully drained. What is the factor of safety against sliding along a plane parallel to the slope surface?

A. 1.20
B. 1.68
C. 1.80
D. 2.50

6. What condition must be satisfied for full active earth pressure to develop behind a retaining wall?

A. The wall must yield away from the backfill enough to mobilize the soil's shear strength
B. The wall must be perfectly rigid and completely immovable
C. The retained backfill must be fully saturated with groundwater

D. The wall must move toward the retained backfill instead

7. Immediately after a rapid drawdown of water on the downstream side of an embankment dam, why does the effective stress within the embankment temporarily decrease compared to steady-state seepage conditions?

A. Because total stress in the embankment increases suddenly after drawdown

B. Because the soil's unit weight decreases suddenly after drawdown

C. Because pore pressure has not yet dissipated to match the new lower water level

D. Because seepage forces within the embankment permanently reverse direction

8. A footing is subjected to an eccentric vertical load, in addition to the usual concentric load, causing a non-uniform pressure distribution beneath it. Using Meyerhof's effective width method, how is this eccentricity typically addressed when computing ultimate bearing capacity?

A. Eccentricity is ignored entirely if it is less than 10% of the footing width

B. An effective width $B' = B + 2e$ is used, which increases the calculated bearing capacity

C. Eccentricity is assumed to affect settlement only, never bearing capacity

D. An effective footing width $B' = B - 2e$ is used in place of the actual width, and bearing capacity is calculated based on this reduced area

9. A horizontal curve has a radius of 900 ft and a deflection angle (Δ) of 50°. What is the length of the curve?

A. 628.3 ft

B. 706.9 ft

C. 550.0 ft

D. 785.4 ft

10. For a horizontal curve with radius 1,500 ft and a deflection angle of 20°, what is the middle ordinate (M) of the curve?

A. 22.9 ft
B. 33.2 ft
C. 48.7 ft
D. 40.9 ft

11. What is the primary purpose of establishing a closed control traverse with known coordinates around a project site before construction layout begins?

A. To satisfy a purely administrative permitting requirement with no technical function
B. To provide a checkable network of points for verifying layout and catching survey errors through traverse closure
C. To mark the final property boundary for legal recording purposes
D. To eliminate the need for a licensed surveyor on the project

12. A grade stake is set where the existing ground elevation is 310.20 ft and the design subgrade elevation is 307.85 ft, requiring a cut. What is the magnitude of the cut, in feet, to be noted on the stake?

A. 1.35 ft
B. 3.35 ft
C. 2.35 ft
D. 0.35 ft

13. A crest vertical curve connects a +3.5% grade to a −2.5% grade, is 600 ft long, and begins (PVC) at station 15+00 with an elevation of 180.00 ft. What is the elevation of the highest point on the curve?

A. 183.25 ft
B. 189.00 ft
C. 186.125 ft
D. 192.25 ft

14. Why do survey crews on a large site often tie into more than one established control monument rather than relying on just one, when establishing new control points?

A. Because a single monument is not legally recognized under state survey law

B. Because GPS receivers require at least two named points to power on and operate

C. Because local ordinances mandate a minimum monument count regardless of project size

D. To detect errors through cross-checking (closure) between independent ties, rather than blindly trusting a single, possibly disturbed monument

15. During staged construction of an embankment over soft clay, what is the primary purpose of installing piezometers within the clay layer?

A. To monitor pore pressure dissipation over time, verifying consolidation and strength gain before adding the next fill stage

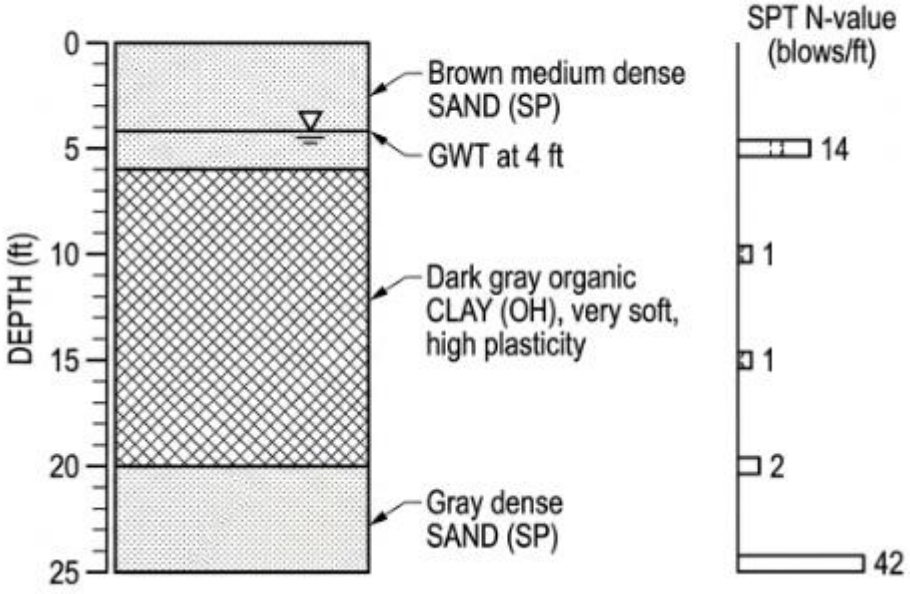
B. To measure the horizontal alignment of the embankment crest as it is built

C. To measure ambient air temperature for the project's weather records

D. To determine the final elevation of the finished embankment surface

16. Based on the boring log figure shown, at what depth range does the soil profile transition from a condition suitable for conventional shallow spread footings to one likely requiring deep foundations or ground improvement?

Figure PQ-1: Vertical boring log profile diagram



A. The transition occurs at 8 ft, where dense sand begins

B. The transition occurs at 6 ft, where very soft organic clay (OL/OH) begins and continues to 20 ft

C. The transition occurs at 20 ft, where dense sand resumes

D. There is no such transition; the entire profile is suitable for shallow footings

17. A concrete mix uses 480 lb of cement and 216 lb of water per cubic yard. What is the water-cement ratio (w/c) of this mix?

A. 0.45

B. 0.55

C. 0.40

D. 0.60

18. What is the primary purpose of moist curing concrete for an extended period after placement?

A. To accelerate the concrete's initial setting time

B. To reduce the amount of cement needed in future batches of the same mix

C. To maintain adequate moisture so cement hydration can continue, allowing the concrete to develop its full design strength and reduce permeability

D. To eliminate the need for air-entraining admixture in freeze-thaw exposures

19. Which engineered wood product is manufactured by bonding together individual dimension lumber laminations along their length and depth under controlled conditions, commonly used for large structural beams and arches with long spans?

A. Laminated veneer lumber (LVL)

B. Glued laminated timber (glulam)

C. Cross-laminated timber (CLT)

D. Oriented strand board (OSB)

20. A sieve analysis of a coarse aggregate sample shows 540 g retained cumulative on the No. 4 sieve out of a total sample mass of 900 g. What percent of the sample passes the No. 4 sieve?

A. 60%
B. 46%
C. 54%
D. 40%

21. Why is calcium chloride generally avoided as an accelerating admixture in reinforced concrete, despite its effectiveness at speeding strength gain?

A. It significantly increases the risk of long-term corrosion of embedded reinforcing steel
B. It decreases the concrete's compressive strength immediately upon addition
C. It prevents the concrete from achieving a workable slump at any dosage
D. It is prohibited only in precast concrete production, never in cast-in-place work

22. A steel tension member has a cross-sectional area of 3.6 in^2 and is subjected to an axial tensile force of 126 kips. What is the axial stress in the member?

A. 28 ksi
B. 40 ksi
C. 30 ksi
D. 35 ksi

23. A rectangular concrete footing measures 6 ft by 6 ft by 1.5 ft thick. How many cubic yards of concrete are required for one footing, ignoring waste?

A. 1.50 cy
B. 2.50 cy
C. 2.00 cy
D. 1.75 cy

24. A contractor estimates that placing structural concrete costs $195 per cubic yard for materials and $105 per cubic yard for labor and equipment. What is the total estimated cost to place 220 cubic yards of concrete?

A. $42,900
B. $66,000
C. $50,600
D. $59,400

25. A contractor is deciding between purchasing equipment for $72,000 with annual operating savings of $12,000, 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. 4 years
B. 5 years
C. 7 years
D. 6 years

26. A project has a Budgeted Cost of Work Performed (earned value) of $420,000 and an Actual Cost of Work Performed of $480,000. What is the Cost Performance Index (CPI) for the project?

A. 1.14
B. 0.875
C. 0.80
D. 1.20

27. Two adjacent cross-sections along a roadway alignment, spaced 120 ft apart, have cut areas of 240 ft^2 and 280 ft^2, respectively. Using the average end area method, what is the cut volume, in cubic yards, between the two sections?

A. 1,155.6 cy
B. 924.4 cy
C. 1,386.7 cy
D. 693.3 cy

28. A contractor's direct cost estimate for a project totals $1,100,000. If the contractor applies a combined markup of 10% for overhead and profit, what is the total bid price?

A. $1,100,000
B. $1,155,000
C. $1,210,000
D. $1,265,000

29. A footing requires 50 pieces of No. 4 reinforcing bar, each 8 ft long. The unit weight of No. 4 rebar is 0.668 lb/ft. What is the total weight of reinforcing steel required, rounded to the nearest pound?

A. 234 lb
B. 267 lb
C. 301 lb
D. 199 lb

30. In a life-cycle cost comparison, how does a higher assumed salvage value at the end of an alternative's service life affect that alternative's net present-worth cost?

A. It increases net present worth, since salvage value is always treated as an added future cost
B. It has no effect on present worth calculations
C. It reduces the alternative's net present-worth cost, since salvage value is treated as a future cost credit discounted back to present terms
D. It only affects the initial cost estimate, not any future cost comparisons

31. In typical commercial interior build-out sequencing, which activity must be substantially complete before wall drywall (gypsum board) installation begins?

A. Final paint of the completed walls
B. Ceiling tile installation in the finished space
C. Carpet or floor finish installation
D. MEP (mechanical, electrical, plumbing) rough-in within the wall cavities

32. An activity's duration estimates using PERT are: optimistic (a) = 5 days, most likely (m) = 8 days, pessimistic (b) = 17 days. What is the PERT expected duration (te) for this activity?

A. 9 days
B. 10 days
C. 8 days
D. 11 days

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

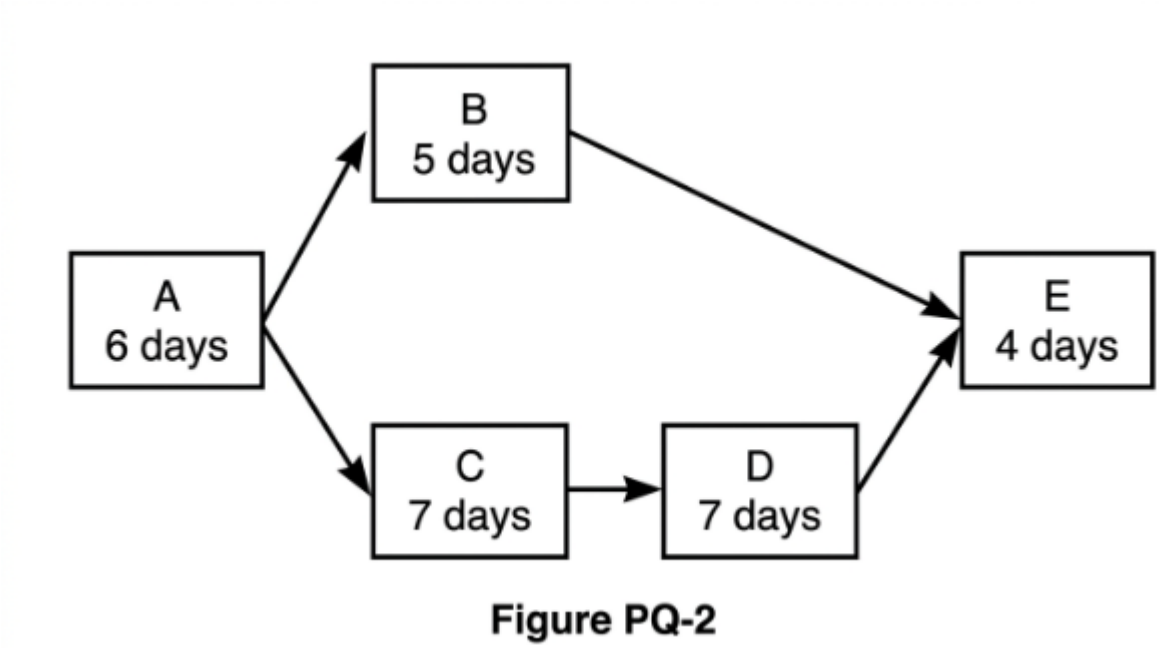


Figure PQ-2

A. 17 days
B. 21 days
C. 24 days
D. 20 days

34. An activity has an Early Start of day 10, an Early Finish of day 18, and a Late Finish of day 22. What is the total float for this activity?

A. 4 days
B. 8 days
C. 10 days
D. 12 days

35. Between crashing and fast-tracking as schedule compression techniques, which one necessarily adds direct cost to achieve its schedule compression?

A. Fast-tracking, since it requires additional supervision staff
B. Crashing, since it adds resources such as labor or overtime, which increases direct cost
C. Neither technique adds any cost under any circumstances
D. Both techniques always add exactly equal amounts of cost

36. An activity has a normal duration of 14 days at a normal cost of $9,000, and a crash duration of 9 days at a crash cost of $16,500. What is the cost slope (cost per day) to crash this activity?

A. $1,000/day
B. $1,875/day
C. $2,500/day
D. $1,500/day

37. A residential subdivision project with 60 nearly identical homes under construction on a staggered schedule would most benefit from which scheduling technique to track and balance crew production across units?

A. PERT with three-point estimates alone
B. Linear scheduling method (line-of-balance)
C. A simple, unlinked bar chart with no logic ties
D. A milestone-only schedule with no intermediate detail

38. A project's critical path must be shortened by 6 days to meet a contractual deadline. The only critical activity available to crash has a cost slope of $1,100 per day, with enough crash days available. What is the minimum additional direct cost to achieve the required 6-day reduction?

A. $5,500
B. $4,400
C. $7,700
D. $6,600

39. Three activities are scheduled to run concurrently on a given day, each requiring one crew of ironworkers: Activity X needs 6 ironworkers, Activity Y needs 4 ironworkers, and Activity Z needs 7 ironworkers. If only 13 ironworkers are available that day, what is the resource shortfall?

A. 4 ironworkers
B. 2 ironworkers
C. 6 ironworkers
D. 17 ironworkers

40. What distinguishes a schedule 'milestone' from a normal schedule activity in a CPM network?

A. A milestone always has the longest duration of any item in the schedule
B. A milestone can only occur at the very end of a project's schedule
C. A milestone has zero duration and marks a significant point in time, such as a start or completion
D. A milestone requires its own dedicated resource assignment separate from any activity

41. A 6-in. diameter concrete test cylinder fails in compression at a load of 127,234 lb. What is the measured compressive strength of the cylinder, in psi?

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

42. In the calibrated wrench tensioning method for high-strength bolts, what must be periodically verified to ensure the torque wrench is still producing the correct bolt tension?

A. The bolt's mill material certification paperwork alone
B. The wrench's calibration, checked against a bolt tension calibrator device
C. Only the bolt's physical length before installation begins
D. Nothing; once initially set, calibrated wrenches never require rechecking

43. On a project where the owner retains an independent QA consultant to audit the contractor's quality control program and procedures, what best describes this consultant's role?

A. Quality control, since it involves reviewing test results directly
B. Project management, entirely unrelated to quality functions
C. Quality assurance, since auditing overall program adequacy is a prevention-level function
D. Safety management, unrelated to quality

44. What is a primary concern during hot-weather concreting that requires special mix design or placement precautions?

A. Rapid moisture loss and accelerated setting can cause plastic shrinkage cracking and reduced final strength if not mitigated
B. The concrete will not set at all above 90°F ambient temperature
C. Hot weather always increases the required air content dramatically beyond normal specifications
D. Hot weather eliminates the need for any curing after placement

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 68°F for 48 hours accumulates how much maturity (temperature-time factor), in °F-hours?

A. 1,728 °F-hr
B. 1,296 °F-hr
C. 2,160 °F-hr

D. 864 °F-hr

46. A field density test on a compacted embankment fill shows a dry unit weight of 115 pcf. The laboratory maximum dry unit weight from a standard Proctor test is 125 pcf. What is the percent (relative) compaction achieved in the field?

A. 88.0%
B. 92.0%
C. 95.0%
D. 85.0%

47. Beyond simply exceeding a specification limit, what quality concern arises when concrete slump is excessively high due to added water at the jobsite?

A. Excessively high slump has no quality concerns beyond the specification limit itself
B. It only affects the concrete's surface color, not its structural properties
C. Increased risk of segregation and bleeding, along with reduced strength and increased permeability from the higher water-cement ratio
D. It only matters for concrete being placed in cold-weather conditions

48. A fillet weld connecting two steel plates has a leg size of 1/2 in. What is the effective throat thickness of this fillet weld?

A. 0.250 in
B. 0.500 in
C. 0.442 in
D. 0.354 in

49. Which two general methods are commonly used to verify in-place density of compacted hot-mix asphalt pavement?

A. Visual inspection and thermal imaging alone
B. Nuclear density gauge testing and extracted core sample testing

C. Slump testing and air content testing

D. Sieve analysis and Atterberg limits testing

50. What is a key limitation of the maturity method, even when properly calibrated for the project's specific concrete mix?

A. It estimates strength from temperature history alone, not direct in-place strength; periodic correlation testing is still needed

B. It can only be legally used for concrete placed after dark

C. It eliminates the need for any cylinder testing on the entire project

D. It works only for concrete mixes containing no chemical admixtures whatsoever

51. A structural member for a construction-stage condition is subjected to a dead load of 720 lb/ft and a construction live load of 380 lb/ft. Using an unfactored D + Lc service-level combination, what is the total line load on the member?

A. 720 lb/ft

B. 950 lb/ft

C. 1,000 lb/ft

D. 1,100 lb/ft

52. A rectangular timber beam is 7 in. wide by 16 in. deep and carries a maximum bending moment of 18 kip-ft. What is the maximum bending stress in the beam?

A. 890 psi

B. 650 psi

C. 723 psi

D. 965 psi

53. A short steel column with a cross-sectional area of 7.2 in^2 has an allowable compressive stress of 22 ksi. What is the allowable axial load capacity of the column, neglecting buckling effects?

A. 130 kips
B. 158.4 kips
C. 180 kips
D. 144 kips

54. A simply supported steel beam spans 22 ft and carries a concentrated load of 9 kips at midspan. The beam has a moment of inertia $I = 900\ in^4$ and modulus of elasticity $E = 29{,}000$ ksi. Using $\Delta = PL^3/48EI$, what is the maximum deflection at midspan?

A. 0.132 in
B. 0.113 in
C. 0.089 in
D. 0.156 in

55. Based on the triangular active earth pressure distribution shown in the figure, acting over a wall stem height of 14 ft, at what height above the base of the wall (Point O) does the resultant active earth pressure force act?

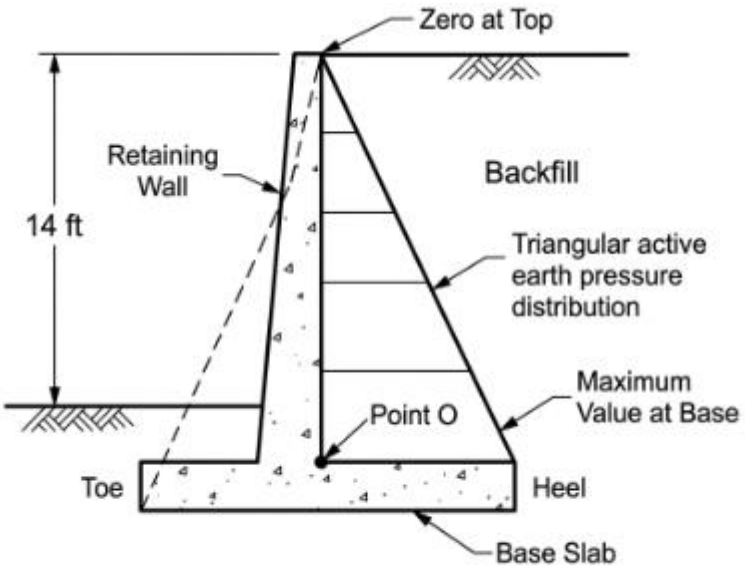


Figure PQ-3: Cross-section of Cantilever Retaining Wall

A. 7.00 ft
B. 3.50 ft
C. 9.33 ft

D. 4.67 ft

56. A roof purlin has a tributary width of 7 ft and carries a uniform roof live load of 22 psf. What is the total uniform line load on the purlin from this live load?

A. 110 lb/ft
B. 130 lb/ft
C. 175 lb/ft
D. 154 lb/ft

57. A concrete slab several years old exhibits a widespread pattern of fine, interconnected 'map cracking' across its surface, with no vertical offset, accompanied by slight surface expansion. What deterioration mechanism is most consistent with this pattern?

A. Plastic shrinkage cracking from placement-day moisture loss
B. Differential settlement of the underlying subgrade
C. Alkali-silica reaction (ASR) between reactive aggregate and cement paste alkalis
D. Overloading from repeated vehicular traffic

58. A rectangular beam 9 in. wide by 16 in. deep carries a maximum shear force of 13 kips. Using Vmax = 1.5V/(bd) for a rectangular section, what is the maximum shear stress in the beam?

A. 108 psi
B. 120 psi
C. 135 psi
D. 150 psi

59. In a two-way reinforced concrete slab already reinforced for flexure in both principal directions, is separate temperature and shrinkage reinforcement typically still required?

A. No, the flexural steel in both directions already serves the crack-control role dedicated shrinkage steel provides

B. Yes, a third layer of steel at 45 degrees is always required in addition

C. Yes, but only in slabs thicker than 12 inches

D. No, because two-way slabs are exempt from all crack control requirements entirely

60. A column carries an axial load producing a uniform stress of 12 ksi and a bending moment producing an extreme fiber bending stress of 8 ksi in the same direction. What is the maximum combined compressive stress at the extreme fiber?

A. 12 ksi

B. 20 ksi

C. 16 ksi

D. 8 ksi

61. A circular storm sewer pipe with a diameter of 36 in. flows full at a slope of 0.006 ft/ft. Using Manning's equation with n = 0.014 and R = D/4 for a full circular pipe, what is the approximate full-flow capacity of the pipe, in cfs?

A. 25.4 cfs

B. 35.9 cfs

C. 45.2 cfs

D. 55.7 cfs

62. Using the Rational Method (Q = CiA), a drainage area of 18 acres has a runoff coefficient C = 0.45 and a design rainfall intensity of 3.2 in/hr. What is the peak runoff rate?

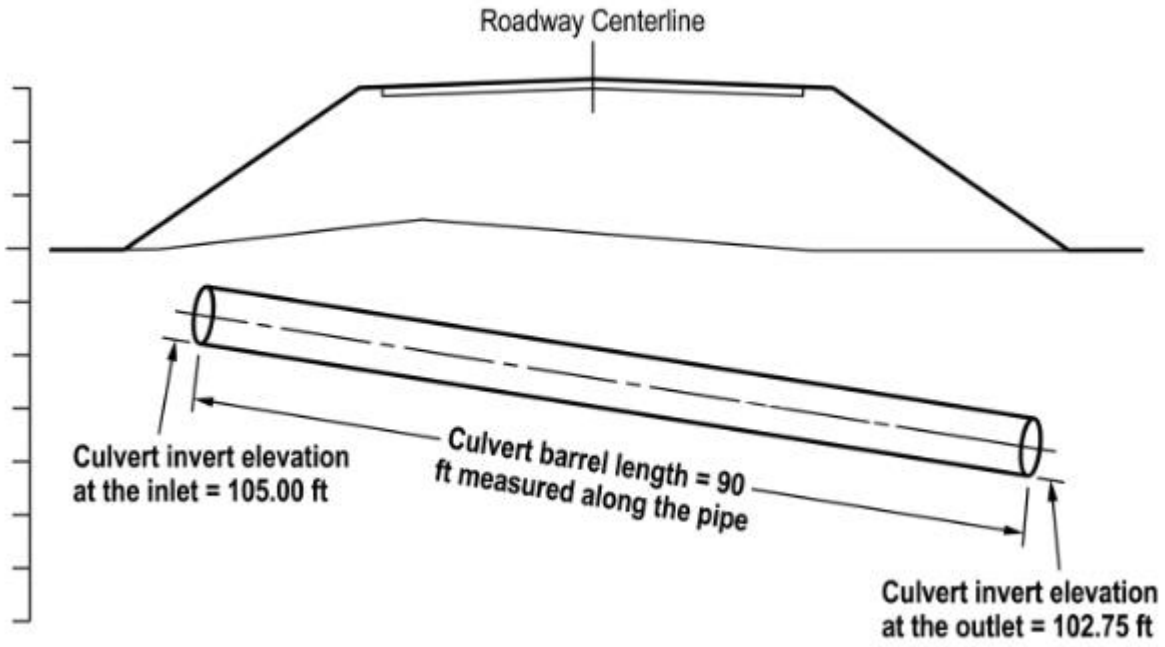
A. 20.60 cfs

B. 30.24 cfs

C. 18.36 cfs

D. 25.92 cfs

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



A. 1.5%

B. 2.0%

C. 2.5%

D. 3.5%

64. A proposed detention pond has a bottom area of 7,000 ft², a top area at the design water surface 4.5 ft above the bottom of 11,000 ft², and a mid-height area of 8,900 ft². Using the prismoidal formula $V = (h/6)(A_{bottom}+4\times A_{mid}+A_{top})$, what is the storage volume of the pond?

A. 40,200 ft³

B. 36,000 ft³

C. 45,000 ft³

D. 50,300 ft³

65. Once storm runoff has concentrated into a well-defined ditch, swale, or open channel with measurable cross-sectional flow, which time-of-concentration segment governs travel time from that point onward, before entering any enclosed pipe?

A. Sheet flow
B. Channel (open channel) flow
C. Shallow concentrated flow
D. Pipe flow

66. An open channel flow condition where the Froude number is less than 1.0 is classified as what type of flow?

A. Subcritical (tranquil) flow
B. Supercritical (rapid) flow
C. Critical flow
D. Laminar flow

67. A load of 12,000 lb is lifted using a two-leg sling with each leg inclined at 50° from the horizontal. What is the tension in each sling leg, assuming the load is shared equally?

A. 6,000 lb
B. 7,834 lb
C. 7,835 lb
D. 9,193 lb

68. A mobile crane's load chart lists a maximum capacity of 20,000 lb at a 30-ft operating radius. The rigging weighs 700 lb, and the load to be lifted weighs 17,500 lb. What is the remaining capacity margin at this radius after accounting for rigging weight?

A. 2,300 lb
B. 2,500 lb
C. 1,500 lb
D. 1,800 lb

69. An excavation requires dewatering at a rate of 420 gallons per minute (gpm) to maintain a dry work area. A pump is rated at 700 gpm capacity. What percentage of the pump's rated capacity is being utilized?

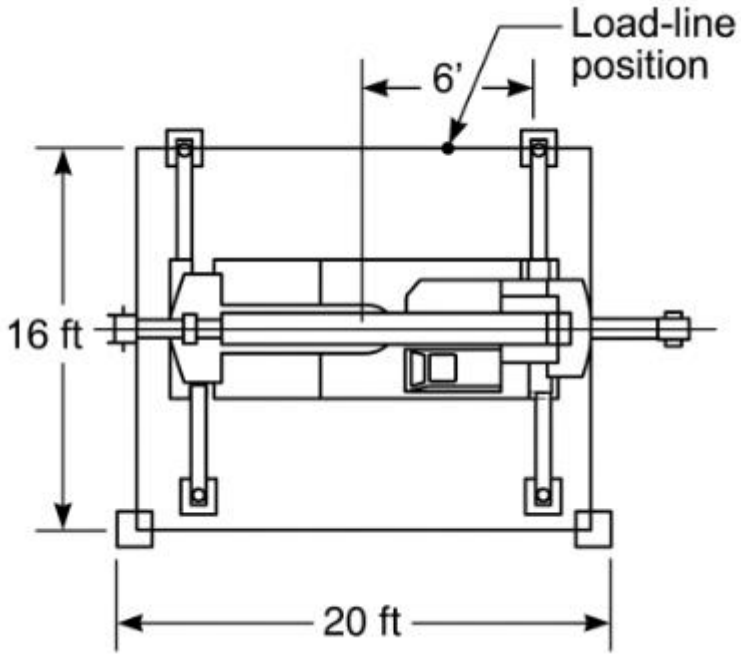
A. 50%

B. 60%

C. 70%

D. 80%

70. Based on the crane outrigger footprint shown, why must the outrigger pad nearest an offset load line be individually checked against soil bearing capacity, rather than assuming all four pads share the crane's total reaction equally?



A. Because equal sharing is always a safe, conservative assumption in every case

B. Because the crane's load chart directly reports each individual pad's reaction

C. Because outrigger pad loads are entirely independent of the boom's position

D. Because the offset concentrates a larger share of the reaction onto the nearest pad, which could exceed bearing pressure

71. For moving material across a site with soft, saturated, low-bearing-capacity soil where standard rubber-tired equipment would become mired, which type of equipment is generally most appropriate?

A. Standard highway dump trucks operating at full load

B. Rubber-tired scrapers loaded to full capacity

C. Low-ground-pressure tracked equipment that distributes load over a larger footprint

D. Any wheeled equipment, provided tire pressure is increased beforehand

72. A borrow pit excavation removes soil with an in-situ (bank) volume of 18,000 cy. If the soil has a shrinkage factor of 0.90 when placed and compacted as fill, what compacted fill volume will this borrow material yield?

A. 16,200 cy

B. 20,000 cy

C. 14,400 cy

D. 18,000 cy

73. A driven pile is being installed using a hammer with a rated energy of 28,000 ft-lb per blow, and the pile advances 0.24 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. 28,000 lb

B. 56,000 lb

C. 45,161 lb

D. 22,581 lb

74. A dump truck hauls fill material a one-way distance of 2.0 miles at an average haul speed of 18 mph, and returns empty at an average speed of 28 mph over the same distance. Ignoring loading and dumping time, what is the total round-trip travel time for one cycle?

A. 8.5 min

B. 9.5 min

C. 12.0 min

D. 10.95 min

75. What is the primary safety function of a crane's load moment indicator (LMI) system during a lift?

A. It records fuel consumption for the crane's maintenance scheduling program
B. It monitors actual load, radius, and boom angle, warning if the load approaches rated capacity
C. It controls only the crane's swing speed during rotation
D. It is required only on cranes with a capacity over 200 tons

76. An excavator has a bucket capacity of 2.2 cy, a fill factor of 0.88, a cycle time of 20 seconds, and an efficiency (working-time) factor of 0.85. What is the estimated production rate in cy per hour?

A. 296.2 cy/hr
B. 348.5 cy/hr
C. 260.7 cy/hr
D. 310.0 cy/hr

77. For dewatering a deep excavation, greater than about 20 ft, in a highly permeable, coarse-grained soil where a single-stage wellpoint system cannot achieve the needed drawdown, which dewatering method is typically preferred?

A. Deep wells with submersible pumps, not limited by atmospheric vacuum lift like surface wellpoints
B. A single shallow wellpoint stage, regardless of the required depth
C. No dewatering method exists for this depth and soil combination
D. Sump pumping alone, without any wells or wellpoints installed

78. A cut excavation removes 9,000 cy of soil measured in its in-situ (bank) state. The soil has a swell factor of 1.22 when excavated and loaded loose into trucks. What is the loose (hauled) volume of this excavated material?

A. 7,377 cy
B. 9,000 cy
C. 9,900 cy
D. 10,980 cy

79. For a mid-rise building project on a tightly constrained urban lot with no room for a large mobile crane's outriggers or ground-level travel path, which crane type is typically necessary despite its higher setup cost?

A. A rough-terrain crane requiring open ground travel
B. A tower crane, needing only a small ground footprint that can climb or stay fixed
C. A telehandler with limited lift height
D. A truck-mounted boom crane requiring roadway access and setup space

80. Concrete is placed in a wall form at a rate of 6.5 ft/hr, with a concrete temperature of 68°F. 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. 900 psf
B. 870 psf
C. 1,010 psf
D. 1,150 psf

81. A scaffold frame leg has an allowable capacity of 4,000 lb. If four legs support a uniformly distributed platform load, and the total load on the scaffold bay is 14,000 lb, what is the utilization ratio of each leg, assuming equal load distribution?

A. 80.0%
B. 87.5%
C. 92.0%
D. 95.0%

82. A newly placed concrete slab imposes a construction load of 200 psf, distributed among three levels of shores and reshores of similar stiffness below it. Assuming the load is shared equally among all three levels, what load does each level carry?

A. 200 psf

B. 100 psf
C. 66.7 psf
D. 50 psf

83. A temporary sign or windscreen attached to a construction hoist tower has an exposed area of 280 ft² and experiences a design wind pressure of 16 psf. What is the total design wind force acting on this exposed area?

A. 4,480 lb
B. 3,920 lb
C. 5,040 lb
D. 4,200 lb

84. A braced excavation in sand, 22 ft deep, uses an apparent earth pressure diagram per Peck's method with a maximum ordinate pa = 0.65·Ka·γ·H. Given Ka = 0.31, γ = 118 pcf, and H = 22 ft, what is the value of the maximum apparent pressure ordinate, pa?

A. 420 psf
B. 480 psf
C. 500 psf
D. 554 psf

85. Based on the wall formwork cross-section shown, if the maximum lateral concrete pressure on the form is 750 psf and the tie spacing is 3 ft vertical by 2 ft horizontal, what is the design tension load on each individual form tie?

FIGURE PQ-6: CROSS-SECTION DIAGRAM OF A WALL FORMWORK SYSTEM

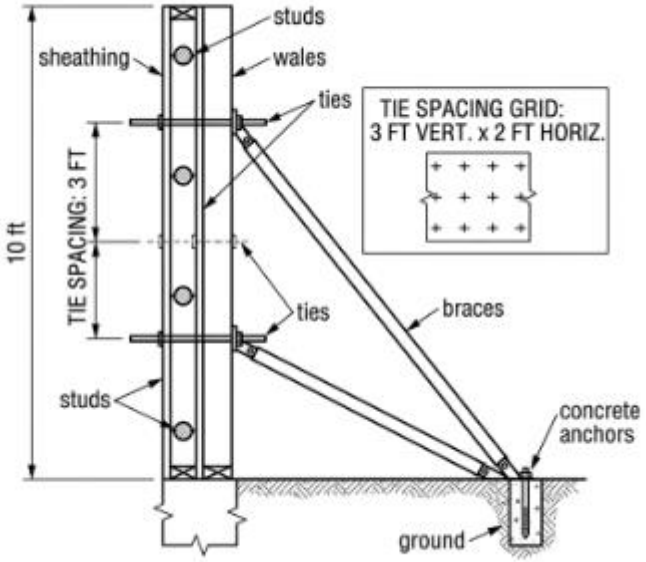


FIGURE PQ-6: CROSS-SECTION DIAGRAM OF A WALL FORMWORK SYSTEM

A. 3,750 lb

B. 3,000 lb

C. 5,250 lb

D. 4,500 lb

86. A guy wire bracing a temporary mast is anchored 10 ft horizontally from the base of the mast and attaches to the mast at a height of 24 ft, giving a wire length of 26 ft. If the horizontal force to be resisted at the attachment point is 1,400 lb, what tension in the guy wire is required to provide this horizontal resistance?

A. 1,400 lb

B. 3,000 lb

C. 3,640 lb

D. 3,360 lb

87. During steel erection, why are bolted connections generally preferred over field welding for the initial temporary connections made before final alignment and permanent connection?

A. Bolted connections allow quick installation and adjustment before final permanent connections are made

B. Bolted connections are always structurally stronger than any welded connection

C. Welding is entirely prohibited by OSHA during steel erection operations

D. Bolted connections eliminate the need for any temporary guying of the structure

88. A structure's typical floor construction load capacity (allowable) is 95 psf once the concrete reaches adequate strength, and each freshly poured slab imposes a construction load of 225 psf that must be distributed among the shore/reshore levels below it. Assuming the load distributes equally among 3 supporting levels, what is the load imposed on each level, in psf?

A. 112.5 psf

B. 75 psf

C. 56.25 psf

D. 225 psf

89. A horizontal strut in a braced excavation supports a tributary height of 9 ft and a tributary width of 14 ft along the wall, with an apparent lateral earth pressure of 480 psf acting uniformly over the tributary height. What is the total axial load in the strut?

A. 50,400 lb

B. 60,480 lb

C. 43,200 lb

D. 67,200 lb

90. A contractor widens a supported scaffold's base so that its height-to-base-width ratio no longer exceeds 4:1. What is the effect on the OSHA restraint requirement for guying, tying, or bracing?

A. The mandatory restraint requirement no longer applies, since it is specifically triggered only when the 4:1 ratio is exceeded

B. The restraint requirement still applies regardless of the ratio achieved

C. Widening the base has no effect on any OSHA scaffold requirement whatsoever

D. Restraint is instead required only above a 6:1 ratio after widening the base

91. A partially cured elevated slab has a current allowable load capacity of 100 psf. A piece of construction equipment imposes an equivalent distributed load of 145 psf on the slab during a planned operation. By how much does the equipment load exceed the slab's current allowable capacity?

A. 35 psf
B. 25 psf
C. 55 psf
D. 45 psf

92. Why must soldier piles in a soldier pile and lagging system be embedded to a depth below the bottom of the planned excavation, rather than terminating right at subgrade?

A. Embedment below subgrade is purely a cosmetic requirement with no structural function
B. Embedment increases the lagging boards' span capacity between piles
C. The embedded portion provides passive soil resistance and fixity to resist bending and prevent kick-out
D. Embedment is only needed to support the excavation's dewatering system piping

93. A form tie rod has an ultimate tensile capacity of 20,000 lb, and the project specifies a safety factor of 2.5 for formwork ties. What is the maximum allowable working load for this tie?

A. 8,000 lb
B. 10,000 lb
C. 9,000 lb
D. 12,000 lb

94. What must be confirmed before falsework and formwork supporting a cast-in-place concrete bridge girder can be removed?

A. Only that the specified curing time in days has elapsed, regardless of measured strength
B. Only that the concrete surface appears dry and hard to the touch

C. That the concrete has achieved the minimum specified strength, verified by cylinder breaks, cores, or an approved test method

D. Only that the project schedule requires the falsework removed by that date

95. Per OSHA excavation standards, spoil piles, stored materials, and equipment must be kept at what minimum distance from the edge of an excavation, unless retaining devices are used instead?

A. 1 ft

B. 3 ft

C. 4 ft

D. 2 ft

96. Per OSHA's guardrail system criteria, the top edge height of a guardrail's top rail must fall within what range above the walking/working surface?

A. 36 to 42 inches

B. 39 to 45 inches

C. 42 to 48 inches

D. 30 to 36 inches

97. Per MUTCD guidance, which category of devices, such as cones, drums, or vertical panels, is used to channelize traffic and provide a visual guide through a temporary traffic control zone, distinct from positive physical barriers?

A. Channelizing devices

B. Positive protection barriers

C. Regulatory signs

D. Pavement markings

98. Under OSHA construction standards, which party bears the ultimate legal responsibility for ensuring workers have received adequate training for a hazardous task, even when a qualified or competent person is designated to conduct that training?

A. The individual worker performing the task
B. The employer
C. The equipment manufacturer supplying the tools used
D. The project's general liability insurance carrier

99. In the standard MUTCD temporary traffic control zone layout, which zone segment comes last, after the activity area, and reintroduces traffic to its normal path and speed?

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

100. Under the OSH Act's General Duty Clause, does an employer's obligation to address a recognized workplace hazard depend on the size of the employer's workforce?

A. Yes, it applies only to employers with fewer than 10 employees
B. Yes, it applies only to employers with more than 50 employees
C. Yes, it applies only to employers in designated high-hazard industries
D. No, it applies regardless of size if a hazard likely causes death or serious harm

Practice Exam 12: Answer Key and Explanations

1. A — The Rankine active coefficient is Ka = (1-sin30°)/(1+sin30°) = 0.333. The total active force per foot is the triangular pressure diagram's area: $0.5 \times Ka \times \gamma \times H^2 = 0.5 \times 0.333 \times 125 \times 10^2 \approx 2{,}083$ lb/ft, or 2.083 kip/ft. This resultant governs the design of the wall stem and base. The other options use the wrong coefficient or omit the 0.5 area factor.

2. C — Primary settlement uses $Sc = [Cc \cdot H/(1+e0)] \cdot \log10[(p0+\Delta p)/p0]$. With H = 144 in, $Sc = (0.28 \times 144/1.80) \times \log10(1.6667) \approx 22.4 \times 0.222 \approx 4.97$ in. This settlement develops gradually over time as excess pore pressure in the clay layer slowly dissipates through drainage. The distractors misapply the void-ratio term or the logarithmic stress ratio in the formula.

3. D — Total stress at 19 ft is 9×120 + 10×130 = 2,380 psf. Pore pressure from the water table 10 ft above is 10×62.4 = 624 psf. Effective stress is total stress minus pore pressure: 2,380 − 624 ≈ 1,756 psf. Option A wrongly reports total stress without deducting any pore pressure contribution at all.

4. B — Terzaghi's equation gives qu = q·Nq + 0.5·γ·B·Nγ, with q = γ·Df = 115×4.5 = 517.5 psf. This gives qu = 517.5×16 + 0.5×115×3.5×11 ≈ 8,280 + 2,214 = 10,494 psf. The distractors isolate only one of the two additive terms, the surcharge term or the width term, instead of correctly summing both contributions together.

5. B — For a dry, cohesionless infinite slope, FS = tanφ/tanβ. With φ = 34° and β = 22°, FS = tan34°/tan22° ≈ 0.675/0.404 ≈ 1.68. Since FS exceeds 1.0, the slope is stable under fully drained conditions; the other values come from swapping or mis-ratioing the two given angles in the formula.

6. A — Active pressure only fully develops once a wall yields, translating or rotating away from the retained soil enough for its shear strength to mobilize along a failure wedge. A rigid, immovable wall instead experiences at-rest pressure, and movement into the soil, not away, would mobilize passive pressure, which is a substantially higher value than either active or at-rest.

7. C — Rapid drawdown lowers the external water level faster than pore water within the embankment can drain out to match it, so elevated pore pressure temporarily persists inside the embankment. Since effective stress equals total stress minus pore pressure, this lingering excess pore pressure temporarily reduces effective stress and, with it, the embankment's shear strength, until drainage catches up.

8. D — Meyerhof's method reduces the footing to an effective width B' = B - 2e, centered on the load's point of application, and computes bearing capacity using this smaller effective area. This directly accounts for the reduced effective bearing area an eccentric load produces, rather than ignoring the effect or increasing the assumed width.

9. D — Curve length is L = R·Δ with Δ in radians: Δ = 50×π/180 ≈ 0.8727 rad. Multiplying by R = 900 ft gives L ≈ 900×0.8727 ≈ 785.4 ft. This arc-length relationship only holds once the deflection angle is converted from degrees, which is where the other, incorrect choices go wrong.

10. A — The middle ordinate is M = R(1−cos(Δ/2)). With Δ/2 = 10°, cos10° ≈ 0.9848, so M = 1,500×(1−0.9848) ≈ 22.9 ft. This is distinct from the external distance, which offsets from the PI rather than the long chord. Using the full deflection angle instead of half of it produces the other values.

11. B — A closed traverse allows the surveyor to compute a closure error by returning to the starting point through a loop of measured angles and distances, revealing whether measurement errors exceed an acceptable tolerance before any layout work relies on those points. This internally checkable network then serves as the trusted basis for all subsequent construction layout across the site.

12. C — Cut is the difference between the higher existing ground elevation and the lower design subgrade elevation: 310.20 − 307.85 = 2.35 ft. Since existing ground sits above the design grade here, material must be removed rather than added, and the stake is marked with this cut amount so the grading crew knows how much to excavate at that point.

13. C — The high point on a crest curve is at $x = g1L/(g1-g2) = 0.035\times600/0.06 \approx 350$ ft from the PVC. Its elevation is $elevPVC + g1x - [(g1-g2)/2L]x^2 = 180 + 12.25 - 6.125 \approx 186.125$ ft. Option D (192.25 ft) is the common error of omitting the parabolic curve correction term entirely.

14. D — Tying into two or more independent control monuments allows the new work to be checked for internal consistency, or closure, between the two ties. If a single relied-upon monument has been disturbed, damaged, or recorded incorrectly, that error would otherwise propagate undetected into all new points established from it, which redundancy is specifically meant to catch early.

15. A — Piezometers directly measure pore water pressure within the clay, letting engineers track how quickly excess pore pressure generated by each fill stage dissipates through consolidation. This verifies that the clay is gaining the strength assumed in the staged construction plan before the next lift of fill is placed, helping avoid a stability failure from adding load too quickly.

16. B — The dense sand from 0 to 6 ft could support shallow footings, but N-values of only 1 to 2 blows/ft from 6 to 20 ft indicate a thick, very soft, compressible organic clay unsuitable for shallow foundations. This layer would typically require deep foundations bearing in the sand below 20 ft, or ground improvement, instead of a spread footing.

17. A — Water-cement ratio is the weight of water divided by the weight of cement: 216 lb / 480 lb = 0.45. This ratio strongly influences both strength and permeability, with lower w/c ratios generally producing stronger, more durable concrete. The other options would require different water or cement quantities than the ones actually stated in this problem.

18. C — Cement hydration, the chemical reaction that develops concrete's strength, requires sustained moisture to continue progressing after placement. Moist curing keeps the surface wet long enough for hydration to continue well beyond the first day, developing more of the concrete's full design strength and reducing its long-term permeability, rather than affecting setting time, cement quantity, or air entrainment needs.

19. B — Glued laminated timber, or glulam, is built by gluing individual dimension lumber boards together along their length and stacking them in depth, producing large, deep structural members suited to long-span beams and arches. This differs from LVL, which laminates thin veneers rather than full lumber sections, and from CLT, which cross-orients layers for two-directional panel strength instead.

20. B — Percent passing is the complement of percent retained: 900 − 540 = 360 g passing, or $360/900\times100 = 40\%$. Option A (60%) is simply the percent retained value, mistakenly reported directly as percent passing instead of first subtracting the retained mass from the total sample mass before dividing to get the true passing percentage.

21. A — Calcium chloride introduces chloride ions into the concrete, and chlorides are well known to promote corrosion of embedded steel reinforcement over time by breaking down its protective passive oxide layer. This long-term durability risk is why non-chloride accelerating admixtures are generally specified instead for reinforced concrete, despite calcium chloride's effectiveness and low cost as an accelerator.

22. D — Axial stress equals force divided by area: $\sigma = P/A = 126$ kips / 3.6 in² = 35 ksi. This stress is then compared against the steel's allowable or yield stress to check whether the member is adequate. The other values would only result from using a different area or force than the ones actually given in this problem.

23. C — Footing volume is 6×6×1.5 = 54 ft³. Converting to cubic yards by dividing by 27 ft³ per cy gives 54/27 = 2.00 cy exactly. This same volume-to-cy conversion applies to any rectangular concrete element and is the standard basis for estimating concrete quantities directly from a footing's plan dimensions and thickness.

24. B — The combined unit cost is \$195 + \$105 = \$300 per cy. Multiplying by the 220 cy quantity gives \$300×220 = \$66,000. This is the standard method of summing all applicable unit-cost components together before multiplying by total quantity, rather than using only one component in isolation as several of the other choices reflect.

25. D — Simple break-even analysis divides the purchase price by the annual savings: \$72,000/\$12,000 per year = 6 years. After this period, cumulative savings equal the initial purchase price, making continued use net-favorable versus renting from that point forward; this simplified approach ignores the time value of money that a full economic analysis would apply.

26. B — CPI equals earned value divided by actual cost: \$420,000/\$480,000 = 0.875. A CPI below 1.0 indicates the project has spent more than the value of work actually accomplished so far, signaling a cost overrun relative to the progress achieved. Option A inverts this ratio, producing a misleadingly favorable index reading for the project.

27. A — The average end area method gives volume as [(240+280)/2]×120 = 260×120 = 31,200 ft³, or 31,200/27 ≈ 1,155.6 cy after converting to cubic yards. The distractors result from using only one section's area alone, or from omitting the ft³-to-cy unit conversion step entirely at the very end of the calculation.

28. C — Applying a 10% markup multiplies the direct cost by 1.10: \$1,100,000×1.10 = \$1,210,000. This single multiplication correctly combines overhead and profit as one percentage applied to the direct cost base. Option A omits markup entirely, while B and D reflect different, incorrect markup percentages applied to that same direct cost base.

29. B — Total steel length is 50 bars × 8 ft each = 400 ft. Multiplying by the unit weight of 0.668 lb/ft gives 400×0.668 = 267.2 lb, which rounds to 267 lb. This length-times-unit-weight approach is the standard quantity takeoff method for estimating reinforcing steel tonnage directly from a bar schedule listing.

30. C — Salvage value represents a future cash inflow, or cost credit, recovered at the end of an asset's service life, and it is discounted back to present terms like any other future cash flow. A higher assumed salvage value reduces the alternative's net present-worth cost, since more value is expected to be recovered at the end of its useful life.

31. D — Drywall installation encloses the wall cavities, so all mechanical, electrical, and plumbing rough-in work that must run through those cavities needs to be substantially complete and inspected first. Paint, ceiling tiles, and floor finishes are all later activities that occur after the walls are closed up and finished, not activities that need to precede drywall installation.

32. A — PERT expected duration weights the most likely estimate four times as heavily as the optimistic and pessimistic estimates: te = (a+4m+b)/6 = (5+32+17)/6 = 54/6 = 9 days. This weighting better reflects the skewed beta-distribution shape typically assumed for activity durations than a simple average of the three raw estimates would produce.

33. C — Two paths run from A to E: A-B-E totals 6+5+4 = 15 days, and A-C-D-E totals 6+7+7+4 = 24 days. The critical path is the longer of the two, since it determines the minimum project duration: 24 days. Path A-B-E carries substantial float relative to this longer, governing path through the network.

34. A — Total float equals late finish minus early finish (equivalently, late start minus early start): 22 − 18 = 4 days. This represents the amount of slack the activity can absorb without delaying the overall project completion date. The other choices would require different combinations of the given early and late dates than what was actually provided.

35. B — Crashing compresses an activity's duration specifically by adding resources, extra crews, equipment, or overtime hours, which directly increases the project's direct cost in proportion to the compression achieved. Fast-tracking instead compresses duration by overlapping activities that would normally run sequentially, adding coordination risk rather than a guaranteed direct cost increase like crashing does.

36. D — Cost slope is (crash cost − normal cost)/(normal duration − crash duration) = ($16,500−$9,000)/(14−9) = $7,500/5 = $1,500 per day. This marginal cost figure lets a scheduler compare which activities are cheapest to compress when the overall project duration needs shortening by some given number of days on the critical path.

37. B — The linear scheduling method, or line-of-balance, plots each trade's production against unit number and time, making the repetitive, staggered construction cycle across all 60 homes directly visible in one view. This reveals whether a faster crew on one home might catch up to and interfere with a slower crew working the home ahead of it in the sequence.

38. B — The minimum added cost to crash an activity is its cost slope multiplied by the number of days shortened: $1,100/day × 6 days = $6,600. Since this is the only available critical activity, all 6 days of compression must come from it alone, leaving no cheaper combination of activities to achieve the required deadline reduction.

39. A — Total demand for that day is 6+4+7 = 17 ironworkers, while only 13 are available, leaving a shortfall of 17−13 = 4 ironworkers. This over-allocation must be resolved by delaying one activity within its available float, bringing in additional crew capacity, or extending the schedule before all three activities can proceed as originally planned that day.

40. C — A milestone is a zero-duration point in the schedule marking a significant event, such as the start or completion of a project phase, contract execution, or a permit approval, rather than representing actual work being performed over time. Unlike a normal activity, it consumes no duration or resources itself; it simply flags when a defined point has been reached.

41. D — For a 6-in. diameter cylinder, area = $\pi \times 3^2 \approx 28.27$ in². Compressive strength is failure load divided by area: 127,234/28.27 ≈ 4,500 psi. This standard cylinder-break calculation confirms whether delivered concrete achieves its specified design strength, and here the result closely matches a 4,500 psi mix requirement, confirming the load's acceptance.

42. B — The torque-tension relationship depends on friction conditions at the threads and bearing surfaces, which can drift due to wear, lubrication changes, or weather, so a calibrated wrench's actual output must be periodically re-verified against a bolt tension calibrator device. Skipping this recheck risks the wrench under- or over-tensioning bolts despite an initial correct calibration setting.

43. C — Auditing a contractor's quality control program and procedures for adequacy, rather than performing the hands-on tests and inspections themselves, is a planning and prevention-focused activity, which is precisely the definition of quality assurance. Quality control, by contrast, is the hands-on testing and inspection of the actual completed work, a distinct and more direct verification function performed elsewhere on the project.

44. A — High ambient and concrete temperatures accelerate hydration and increase surface moisture evaporation, both of which can cause plastic shrinkage cracking before the concrete gains strength and can also reduce the ultimate strength achieved if not properly mitigated. Precautions like cooling materials, adjusting placement timing, and prompt curing are used specifically to counteract these hot-weather effects on fresh concrete.

45. A — The Nurse-Saul maturity factor is $M = \Sigma(T - T0) \cdot \Delta t = (68 - 32) \times 48 = 36 \times 48 = 1{,}728$ °F-hours. This accumulated value is compared against a project-specific calibration curve relating maturity to compressive strength, giving an early strength estimate long before a companion cylinder break could even be cured, tested, and reported back to the field.

46. B — Percent compaction compares field dry unit weight to the laboratory maximum: 115/125×100 = 92.0% exactly. Specifications commonly require 95% or greater relative compaction for structural fill, so this result would fall short of a typical 95% minimum requirement and should be checked carefully against the project's actual compaction specification value before acceptance.

47. C — Adding water at the jobsite raises the actual water-cement ratio above the approved mix design, reducing strength and increasing permeability, while the resulting watery slump also raises the risk of aggregate segregation and surface bleeding during placement. These durability and structural concerns exist regardless of season, contradicting the idea that only a specification limit is at stake.

48. D — The effective throat of an equal-leg fillet weld equals the leg size times 0.707 (cos45°), the shortest distance through the weld's triangular cross-section: 0.5 in × 0.707 ≈ 0.354 in. This throat

dimension, rather than the leg size directly, is what governs the weld's effective strength in structural design calculations for the connection.

49. B — Nuclear density gauges provide rapid, non-destructive density readings directly on the mat during or shortly after compaction, while extracted core samples provide a physical specimen that can be measured in the lab for a more definitive density check. Slump, air content, sieve analysis, and Atterberg limits are all concrete or soil test methods, not asphalt density verification methods.

50. A — Even a properly calibrated maturity method only estimates strength indirectly, from a temperature-time history correlated to strength on companion specimens, rather than directly measuring the actual concrete's in-place condition. Periodic verification testing, such as breaking cured cylinders or extracting cores, is still needed to confirm the calibration remains valid throughout the project and hasn't drifted from actual field conditions.

51. D — An unfactored service-level combination sums the applicable loads directly: D + Lc = 720 + 380 = 1,100 lb/ft. This combined demand is what the member must be checked against for the temporary construction-stage condition, which can differ meaningfully from whatever load combinations govern the structure's later, final permanent-service condition.

52. A — Section modulus for a rectangular section is $S = bd^2/6 = 7\times256/6 \approx 298.7$ in³. Converting the moment, M = 18 kip-ft × 12 in/ft × 1,000 = 216,000 lb-in. Bending stress is $\sigma = M/S = 216{,}000/298.7 \approx 723$ psi, the maximum fiber stress at the top and bottom of the beam's cross-section.

53. B — For a short column not governed by buckling, allowable capacity is the allowable stress multiplied by the cross-sectional area: 22 ksi × 7.2 in² = 158.4 kips. A longer, more slender column carrying this same load would instead need a reduced allowable stress to account for buckling, which is not a governing concern in this short-column scenario.

54. C — Converting the 22-ft span to 264 in, $\Delta = PL^3/48EI = (9\times264^3)/(48\times29{,}000\times900) \approx 0.132$ in. This is the standard midspan deflection formula for a simply supported beam under a central point load, used to check serviceability against an allowable limit such as span/360, a common criterion for many floor framing members.

55. D — For a triangular pressure distribution, the resultant force acts at the centroid of the triangle, one-third of the height up from the base: 14 ft/3 ≈ 4.67 ft above Point O. This one-third rule is a standard statics result for any triangular loading, distinct from a uniform (rectangular) distribution, whose resultant instead acts at mid-height above the base.

56. D — A uniform area load converts to a line load by multiplying by the tributary width the member collects: 22 psf × 7 ft = 154 lb/ft. The purlin's span length does not enter into this unit conversion; it instead determines the total load and bending moment the member must resist along its full length once this line load is established.

57. C — Alkali-silica reaction produces an expansive gel as reactive aggregate reacts with alkalis in the cement paste over years, causing the characteristic slow, widespread map-cracking pattern along with slight overall surface expansion. Plastic shrinkage cracking occurs within hours of placement, while

differential settlement and traffic overload would each tend to produce localized or offset cracking rather than this diffuse expansive pattern.

58. C — For a rectangular section, maximum shear stress occurs at the neutral axis and equals 1.5 times the average shear stress: $\tau_{max} = 1.5V/(bd) = 1.5\times13{,}000/(9\times16) = 19{,}500/144 \approx 135$ psi. The 1.5 factor reflects the parabolic shear stress distribution that develops across the depth of a rectangular cross-section under this loading.

59. A — A two-way slab already carries flexural reinforcement in both principal directions, and this steel also serves the crack-control function dedicated temperature and shrinkage reinforcement provides in a one-way slab's non-flexural direction. Since no direction lacks flexural steel, a separate temperature and shrinkage layer is typically unnecessary, though minimum reinforcement ratios still apply.

60. B — When axial and bending stresses act in the same sense at an extreme fiber, they superimpose directly: combined stress = axial + bending = 12 + 8 = 20 ksi. This combined-stress check at the governing fiber is central to designing members subject to both axial compression and bending, such as beam-columns in a braced or unbraced building frame.

61. B — For a 3-ft diameter pipe, area = $\pi r^2 \approx 7.07$ ft² and hydraulic radius R = D/4 = 0.75 ft. Manning's equation gives Q = (1.486/n)AR^(2/3)S^(1/2) ≈ (1.486/0.014)×7.07×0.75^0.667×0.006^0.5 ≈ 35.9 cfs. This full-flow capacity check confirms whether the pipe size can convey the design peak flow it is required to carry.

62. D — The Rational Method computes peak runoff as Q = CiA = 0.45×3.2×18 = 25.92 cfs, with drainage area in acres and rainfall intensity in in/hr conveniently combining to give cfs directly. This simplified method remains widely used for preliminary sizing of storm drainage systems on relatively small drainage areas such as this one.

63. C — Culvert slope equals the drop in invert elevation divided by the barrel length: (105.00−102.75)/90×100 = 2.25/90×100 = 2.5% exactly. Maintaining adequate barrel slope helps sustain self-cleansing velocity through the culvert, preventing sediment accumulation, and this value would be checked against a minimum design velocity or slope criterion for the project.

64. A — The prismoidal formula gives V = (h/6)(Abottom+4Amid+Atop) = (4.5/6)×(7,000+4×8,900+11,000) = 0.75×53,600 = 40,200 ft³ exactly. This method accounts for the changing cross-sectional area with depth in a sloped-side pond, weighting the mid-height area to more accurately reflect the pond's actual sloped-wall geometry throughout its full depth, unlike a simple average.

65. B — Time of concentration typically progresses through sheet flow, then shallow concentrated flow, and finally channel or pipe flow once runoff reaches a defined conveyance. Once water flows in a measurable, well-defined ditch or channel, the channel flow segment governs travel time from that point forward, until reaching a pipe or other enclosed conveyance.

66. A — The Froude number compares inertial to gravitational forces in open channel flow; a value less than 1.0 indicates subcritical, or tranquil, flow, where disturbances can propagate upstream. A Froude

number greater than 1.0 indicates supercritical flow instead, and exactly 1.0 marks the critical condition; laminar versus turbulent is an entirely separate flow classification unrelated to the Froude number.

67. C — Each leg supports half the vertical load, but because the leg is inclined, its tension exceeds that vertical component: T = (load/2)/sin50° = 6,000/0.766 ≈ 7,835 lb. Sling leg tension increases sharply as the angle from horizontal decreases, which is why shallow sling angles are avoided in rigging practice to limit excessive leg tension on the sling.

68. B — The total weight the crane must support at this radius is the load plus all rigging: 17,500+700 = 18,200 lb. Subtracting this from the rated capacity of 20,000 lb gives a margin of 20,000−18,200 = 1,800 lb. Rigging weight must always be included in this check; the chart's rated capacity is not the payload weight alone.

69. B — Percent utilization compares the required flow rate to the pump's rated capacity: 420/700×100 = 60% exactly. Operating at 60% of rated capacity leaves meaningful reserve margin for surges in inflow or performance degradation over time, which is generally preferable to selecting a pump expected to run continuously near its maximum rated capacity.

70. D — When the load line and boom shift off the crane's geometric center, the reaction each outrigger pad carries redistributes unevenly, with the pad nearest the offset carrying more than an even one-quarter share. Checking only the average reaction across all four pads could miss a localized overload at that one pad, even when the overall average appears acceptable.

71. C — Low-ground-pressure tracked equipment, using wide steel or rubber tracks, spreads the machine's weight over a much larger contact area than tires would, substantially reducing the bearing pressure applied to soft, saturated soil. Standard highway trucks, loaded scrapers, and increasing tire pressure would all concentrate load over a smaller area, making them prone to becoming mired in this soil condition.

72. A — Shrinkage factor accounts for the volume reduction when loose, excavated soil is recompacted into denser fill: compacted fill volume = bank volume × shrinkage factor = 18,000×0.90 = 16,200 cy exactly. Ignoring this shrinkage and simply using the bank volume, as in option D, would overstate the actual compacted fill volume this borrow source can produce for the project.

73. C — Substituting into the Engineering News formula gives Ru = 2×28,000/(0.24+1.0) = 56,000/1.24 ≈ 45,161 lb. This dynamic formula relates hammer energy and pile penetration per blow to an estimated ultimate capacity, offering a quick field check during driving, though it is generally considered less reliable than a wave-equation analysis or a static load test on the pile.

74. C — Loaded travel time is 2.0 mi/18 mph ≈ 0.1111 hr, and empty return time is 2.0 mi/28 mph ≈ 0.0714 hr, for a combined travel time of about 0.1825 hr, or roughly 10.95 minutes. This travel-time component is then added to loading and dumping time, excluded here, to build the truck's complete production cycle time estimate.

75. B — A load moment indicator continuously calculates the crane's actual loading condition, combining measured load weight, boom radius, and boom angle, comparing this against the rated

capacity for that configuration. If the load approaches or exceeds that capacity, the LMI provides warnings, and on many cranes can automatically inhibit further hazardous motion.

76. A — Cycles per hour equal 3,600 seconds divided by the 20-second cycle time, or 180 cycles/hr. Each cycle effectively moves 2.2×0.88 = 1.936 cy, giving 180×1.936 ≈ 348.5 cy/hr before accounting for downtime. Applying the 0.85 efficiency factor for non-productive time reduces this to 348.5×0.85 ≈ 296.2 cy/hr, the realistic estimated rate.

77. A — Deep wells use submersible pumps placed down within the well itself, pushing water rather than relying on suction lift from the surface, avoiding the roughly 15 to 18 ft atmospheric vacuum limit constraining surface-mounted wellpoint systems. This makes deep wells preferred once drawdown depth exceeds what a single wellpoint stage can achieve.

78. D — Swell factor accounts for the volume increase when compact, in-situ soil is excavated and loosened: loose volume = bank volume × swell factor = 9,000×1.22 = 10,980 cy exactly. This loose, not bank, volume is what actually determines how many truckloads are required to haul the excavated material off the site once it has been loosened by excavation.

79. B — A tower crane occupies only a small ground footprint at its base while reaching over the entire site and surrounding property from height, well suited to a tightly constrained urban lot where a mobile crane's outriggers and travel path would not fit. Its higher setup cost is justified as the only practical option here.

80. B — Substituting the given values: Pmax = 150 + 9,000×(6.5/68) ≈ 150 + 860 ≈ 1,010 psf. Placement rate and concrete temperature are the two dominant variables in this simplified formula, since a faster placement rate or colder concrete both increase the hydrostatic-like pressure buildup before the concrete gains enough strength to become self-supporting in the form.

81. B — With four legs sharing the load equally, each leg carries 14,000/4 = 3,500 lb. Comparing this to the leg's allowable capacity of 4,000 lb gives a utilization ratio of 3,500/4,000×100 = 87.5% exactly. Since this is below 100%, the legs have adequate capacity, provided load distribution in the field is reasonably even.

82. C — Multi-level shoring analysis typically assumes the total construction load distributes among all supporting levels roughly in proportion to their relative stiffness. With three levels of comparable stiffness sharing the load equally, each carries one-third of the 200 psf total: 200/3 ≈ 66.7 psf, a value each supported level below must be checked against for adequacy.

83. A — Total wind force equals design wind pressure multiplied by the exposed area subject to it: F = 16 psf × 280 ft² = 4,480 lb. This resultant force is then resisted by the hoist tower's bracing and anchorage system, along with wind acting on the tower and hoist structure itself, not the windscreen area alone.

84. D — Substituting into Peck's apparent pressure formula: pa = 0.65×0.31×118×22 ≈ 554 psf. This apparent pressure envelope, rather than a simple triangular active pressure diagram, is used specifically

for designing struts and walers in braced excavations, since it better reflects redistributed pressures observed in staged, braced excavation construction over the full depth.

85. D — Each tie's tributary area is its vertical spacing times its horizontal spacing: 3 ft × 2 ft = 6 ft². Multiplying by the maximum lateral pressure gives the design tension load on each tie: 750 psf × 6 ft² = 4,500 lb exactly. This tributary-area method is standard for distributing lateral pressure to form ties.

86. C — The 10-24-26 geometry is a 5-12-13 right triangle scaled up, where horizontal force = tension × (horizontal leg / hypotenuse). Solving for tension: tension = 1,400×(26/10) = 3,640 lb exactly, the wire force needed to provide the required 1,400-lb horizontal resistance at the mast's attachment point on the structure above the anchor.

87. A — Bolted temporary connections can be installed quickly and adjusted, loosened, or repositioned as needed while a steel frame is being plumbed and aligned, before final permanent connections are made. Field welding is comparatively slow and effectively permanent once made, making it poorly suited to a connection that may still need adjustment during alignment.

88. B — Distributing the 225 psf construction load equally across 3 supporting levels gives 225/3 = 75 psf per level exactly. Since this is below the 95 psf allowable floor capacity per level, the 3-level shoring and reshoring scheme is adequate for this load; fewer levels would concentrate more load onto each remaining level and could exceed that allowable capacity.

89. B — The strut's tributary area is its tributary height times tributary width: 9 ft × 14 ft = 126 ft². Multiplying by the uniform apparent pressure of 480 psf gives the total axial strut load: 480×126 = 60,480 lb exactly. This tributary-area method converts the wall's distributed earth pressure into a discrete design load for the individual strut member.

90. A — OSHA's scaffold standard specifically triggers the mandatory guying, tying, or bracing requirement only once a supported scaffold's height-to-base-width ratio exceeds 4:1. If widening the base brings that ratio back within the 4:1 limit, the mandatory restraint requirement specifically tied to exceeding that ratio no longer applies, though other general scaffold stability and safety requirements continue to apply regardless.

91. B — The excess load is the imposed equipment load minus the slab's current allowable capacity: 145−100 = 45 psf exactly. This overload indicates the planned operation should not proceed on the slab in its current condition without allowing further curing and strength gain, adding temporary shoring beneath, or reducing the equipment loading before the work proceeds as planned.

92. C — The portion of the soldier pile embedded below the excavation's subgrade mobilizes passive soil resistance in front of the pile, providing the fixity needed to resist bending from lateral earth pressure above and preventing the base from kicking out. Without adequate embedment, the pile could rotate or translate at its base, compromising system stability.

93. A — Allowable working load is the ultimate tensile capacity divided by the specified safety factor: 20,000/2.5 = 8,000 lb exactly. This safety factor provides margin against uncertainties in material

variability, installation quality, and unanticipated load increases, so the tie is never designed to operate close to its actual breaking capacity during normal formwork use on the project.

94. C — Falsework removal must be based on verified, measured concrete strength, through standard cylinder breaks, extracted cores, or an approved in-place method like the maturity technique, confirming the concrete can safely support its own weight and other loads. Elapsed curing days, surface appearance, and schedule pressure alone are not reliable substitutes for this verification.

95. D — OSHA's excavation standard requires that spoil piles, stored materials, and equipment be kept at least 2 ft back from the edge of an excavation, or that retaining devices sufficient to prevent falling or rolling in be used instead. This setback protects workers below from loose material being dislodged or rolling in on them.

96. B — OSHA specifies a top rail height of 42 inches, plus or minus 3 inches, above the walking/working surface, giving an acceptable range of 39 to 45 inches. This tolerance accommodates real-world variation in installation and surface conditions while still keeping the rail high enough to reliably prevent an employee from falling over the top edge of the guardrail system.

97. A — Channelizing devices, such as cones, drums, tubular markers, and vertical panels, provide a visual guide directing traffic along a desired path through or around a work zone, but they don't physically stop an errant vehicle the way a positive protection barrier does. Regulatory signs and pavement markings serve separate roles conveying rules and lane guidance instead.

98. B — While OSHA standards often specify that training be conducted or overseen by a qualified or competent person, the employer bears the ultimate legal responsibility under the OSH Act for ensuring workers actually receive adequate training before hazardous work. Designating a qualified or competent person to conduct training does not shift this responsibility away from the employer.

99. C — The termination area is the final segment of a temporary traffic control zone, positioned after the activity area, where traffic is guided back to its normal travel path and released from the reduced-speed conditions of the work zone. The advance warning area, transition area, and buffer space all precede or bound the activity area earlier in the sequence.

100. D — The General Duty Clause requires any employer covered by the OSH Act to keep its workplace free of recognized hazards likely to cause death or serious harm, filling gaps where no specific OSHA standard addresses that hazard. This obligation does not hinge on employee count or a high-hazard industry classification; it applies broadly regardless of size.