PRACTICE EXAM 13: 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 11 ft high retains a cohesionless backfill with unit weight $\gamma = 118$ pcf and angle of internal friction $\varphi = 28°$, 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. 3.87 kip/ft
B. 1.93 kip/ft
C. 5.16 kip/ft
D. 2.58 kip/ft

2. A normally consolidated clay layer 14 ft thick has an initial void ratio $e0 = 0.75$ and compression index $Cc = 0.32$. The effective overburden stress at mid-height is 2,200 psf, and a footing load increases the effective stress at mid-height by 1,400 psf. What is the primary consolidation settlement of the layer?

A. 6.57 in
B. 4.20 in
C. 8.10 in
D. 3.35 in

3. A soil profile consists of 7 ft of sand (moist unit weight 112 pcf) above the water table, underlain by 13 ft of saturated sand (saturated unit weight 124 pcf) below the water table. What is the effective vertical stress at a depth of 20 ft (bottom of the saturated layer)?

A. 2,396 psf
B. 784 psf
C. 1,585 psf
D. 1,612 psf

4. A strip footing 4 ft wide is founded at a depth of 5 ft in a cohesionless soil with unit weight 110 pcf. At this friction angle, Terzaghi's bearing capacity factors are $N_q = 14$ and $N_\gamma = 10$. What is the ultimate bearing capacity of the footing, neglecting the cohesion term?

A. 7,700 psf
B. 9,900 psf
C. 2,200 psf
D. 11,500 psf

5. An infinite slope in cohesionless sand is inclined at 25° to the horizontal. The sand has an effective friction angle of 36° 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. 1.10
B. 1.30
C. 1.90
D. 1.56

6. Jaky's empirical equation, $K_0 \approx 1 - \sin\varphi'$, is commonly used to estimate which lateral earth pressure coefficient for a normally consolidated soil?

A. The at-rest earth pressure coefficient
B. The Rankine active earth pressure coefficient

C. The Rankine passive earth pressure coefficient

D. The coefficient of consolidation

7. In a 'quicksand' condition, upward seepage forces in a cohesionless soil become large enough to produce what specific effect on effective stress?

A. Effective stress rises to a maximum, causing over-consolidation of the soil mass

B. Effective stress drops to zero, so the soil loses its shear strength and behaves as a heavy liquid

C. Total stress drops to zero while effective stress stays unchanged throughout

D. Pore pressure becomes negative, which then increases the effective stress

8. Two shallow footings are spaced closely enough that their pressure bulbs beneath the ground overlap significantly. Compared to an isolated footing of the same size and load, how is settlement typically affected?

A. Settlement decreases, since the two footings brace each other structurally

B. Settlement is unaffected, since each footing responds fully independently

C. Settlement increases, since the overlapping stress zones add together beneath and between the footings

D. Settlement only affects bearing capacity, never total settlement magnitude

9. A horizontal curve has a radius of 750 ft and a deflection angle (Δ) of 45°. What is the length of the curve?

A. 589.0 ft

B. 471.2 ft

C. 648.3 ft

D. 706.9 ft

10. For a horizontal curve with radius 1,100 ft and a deflection angle of 28°, what is the middle ordinate (M) of the curve?

A. 24.1 ft
B. 40.5 ft
C. 32.7 ft
D. 48.2 ft

11. On a project site far from the nearest permanent USGS or municipal benchmark, why would a survey crew establish and reference a temporary benchmark (TBM) at the site?

A. Because temporary benchmarks are legally required on every construction project
B. Because TBMs are inherently more accurate than any permanent benchmark
C. Because GPS receivers cannot establish elevation on remote project sites
D. To provide a convenient, site-local elevation reference, avoiding repeated long leveling back to the permanent point

12. A grade stake is set where the existing ground elevation is 402.60 ft and the design subgrade elevation is 405.10 ft, requiring a fill. What is the magnitude of the fill, in feet, to be noted on the stake?

A. 1.50 ft
B. 2.50 ft
C. 3.50 ft
D. 0.50 ft

13. A sag vertical curve connects a −3.0% grade to a +2.0% grade, is 400 ft long, and begins (PVC) at station 8+00 with an elevation of 95.00 ft. What is the elevation of the lowest point on the curve?

A. 89.00 ft
B. 91.40 ft
C. 93.20 ft
D. 87.80 ft

14. In a traverse survey, what does verifying the angular closure (the sum of interior angles matching the theoretical value for the number of sides) primarily confirm?

A. That the angular measurements around the traverse are internally consistent and free of a blunder

B. That the traverse's linear distances were measured correctly

C. That the traverse ties to the correct state plane coordinate system

D. That the traverse contains the correct number of monuments

15. An inclinometer casing installed vertically through an earth slope is used to monitor which specific condition during and after construction?

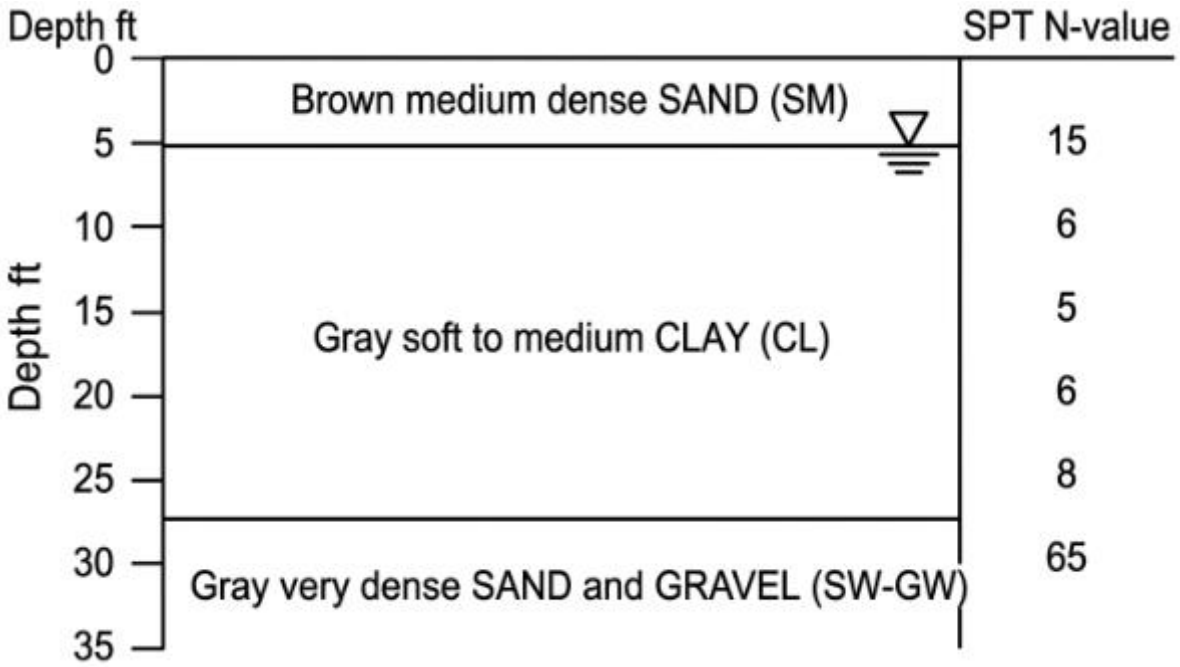
A. Vertical settlement of the ground surface only

B. Pore water pressure at a specific depth

C. Subsurface lateral movement and the depth of a developing shear surface

D. Soil temperature variation with depth

16. Based on the boring log figure shown, at what approximate depth does the profile transition from soil suitable for conventional pile driving to a very dense stratum likely to cause hammer refusal?



A. The transition occurs at 5 ft, where medium dense sand begins

B. The transition occurs at 15 ft, where soft clay begins

C. There is no such transition anywhere in this soil profile

D. The transition occurs at approximately 28 ft, where very dense sand and gravel begins

17. A concrete mix uses 500 lb of cement and 225 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. 0.50

18. What is the primary purpose of specifying a minimum concrete cover over reinforcing steel?

A. To increase the member's overall cross-sectional area for strength
B. To protect the steel from corrosion, and provide fire resistance and bond development
C. To reduce the total amount of reinforcing steel required
D. To improve the concrete's workability during placement

19. The thin, deep web of a typical wood I-joist connecting its top and bottom flanges is most commonly manufactured from which material?

A. Cross-laminated timber (CLT)
B. Glued laminated timber (glulam)
C. Oriented strand board (OSB)
D. Solid sawn dimension lumber

20. A sieve analysis of a coarse aggregate sample shows 460 g retained cumulative on the No. 4 sieve out of a total sample mass of 800 g. What percent of the sample passes the No. 4 sieve?

A. 57.5%
B. 46.0%
C. 38.0%
D. 42.5%

21. What is a primary benefit of using fly ash as a partial cement replacement in a concrete mix?

A. It improves long-term strength and reduces permeability via the pozzolanic reaction
B. It eliminates the need for any curing period after placement
C. It always accelerates the initial setting time significantly
D. It eliminates the need for air-entrainment in freeze-thaw exposures

22. A steel tension member has a cross-sectional area of 5.5 in^2 and is subjected to an axial tensile force of 165 kips. What is the axial stress in the member?

A. 24 ksi
B. 36 ksi
C. 30 ksi
D. 20 ksi

23. A rectangular concrete footing measures 7 ft by 5 ft by 1.5 ft thick. How many cubic yards of concrete are required for one footing, ignoring waste?

A. 1.30 cy
B. 1.94 cy
C. 2.59 cy
D. 0.97 cy

24. A contractor estimates that placing structural concrete costs $200 per cubic yard for materials and $100 per cubic yard for labor and equipment. What is the total estimated cost to place 250 cubic yards of concrete?

A. $50,000
B. $62,500
C. $87,500
D. $75,000

25. A contractor is deciding between purchasing equipment for $80,000 with annual operating savings of $16,000, 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. 5 years
B. 4 years
C. 6 years
D. 8 years

26. A project has a Budgeted Cost of Work Performed (earned value) of $500,000 and an Actual Cost of Work Performed of $550,000. What is the Cost Performance Index (CPI) for the project?

A. 1.10
B. 0.85
C. 1.05
D. 0.91

27. Two adjacent cross-sections along a roadway alignment, spaced 100 ft apart, have cut areas of 300 ft^2 and 340 ft^2, respectively. Using the average end area method, what is the cut volume, in cubic yards, between the two sections?

A. 948.1 cy
B. 1,185.2 cy
C. 1,422.2 cy
D. 711.1 cy

28. A contractor's direct cost estimate for a project totals $980,000. If the contractor applies a combined markup of 13% for overhead and profit, what is the total bid price?

A. $980,000
B. $1,058,400
C. $1,107,400

D. $1,166,200

29. A footing requires 30 pieces of No. 7 reinforcing bar, each 14 ft long. The unit weight of No. 7 rebar is 2.044 lb/ft. What is the total weight of reinforcing steel required, rounded to the nearest pound?

A. 858 lb
B. 715 lb
C. 1,001 lb
D. 643 lb

30. When comparing two alternatives with different service lives in a life-cycle cost analysis, why is the equivalent uniform annual cost (EUAC) method often preferred over a simple present-worth comparison?

A. EUAC eliminates the need to consider any future costs in the comparison
B. The EUAC method is only valid when the two alternatives' service lives are identical
C. EUAC assumes a zero discount rate for simplicity in every case
D. EUAC converts each alternative's costs to a common annual basis, allowing direct comparison across different service lives

31. In a typical site development sequence, which activity generally must be complete or well underway before building foundation excavation begins in an area with existing underground utilities?

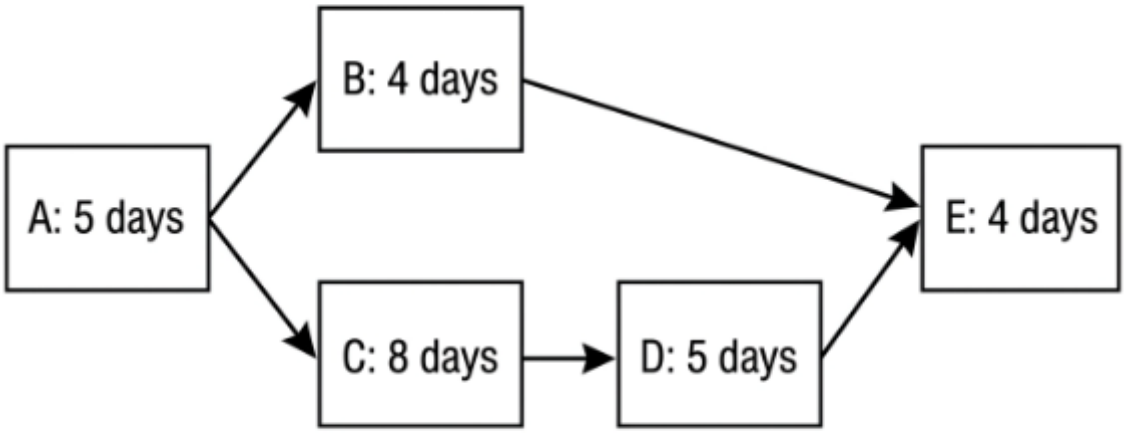
A. Exterior building signage installation work
B. Final asphalt paving of the parking areas
C. Relocation or protection of the conflicting underground utilities nearby
D. Installation of interior elevator equipment

32. An activity's duration estimates using PERT are: optimistic (a) = 6 days, most likely (m) = 10 days, pessimistic (b) = 20 days. What is the PERT expected duration (te) for this activity?

A. 12 days
B. 11 days
C. 10 days
D. 13 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



A. 18 days
B. 16 days
C. 25 days
D. 22 days

34. An activity has an Early Start of day 14, an Early Finish of day 20, and a Late Finish of day 27. What is the total float for this activity?

A. 13 days
B. 6 days
C. 7 days
D. 9 days

35. What does a negative total float value for an activity in a CPM schedule generally indicate?

A. The activity has more flexibility than a zero-float critical activity

B. The schedule cannot meet an imposed deadline; the required finish is earlier than the calculated early finish

C. The activity was completed well ahead of its planned schedule

D. A data entry error that scheduling software would never allow

36. An activity has a normal duration of 16 days at a normal cost of $11,000, and a crash duration of 11 days at a crash cost of $18,500. What is the cost slope (cost per day) to crash this activity?

A. $1,500/day

B. $1,000/day

C. $2,000/day

D. $1,250/day

37. A pipeline installation project with many nearly identical manhole-to-manhole segments, each following the same repetitive excavate-lay-backfill cycle, would most benefit from which scheduling technique to track crew progress along the alignment?

A. PERT with three-point estimates alone

B. A simple, unlinked bar chart with no logic ties

C. Linear scheduling method (line-of-balance)

D. A milestone-only schedule with no intermediate detail

38. A project's critical path must be shortened by 7 days to meet a contractual deadline. The only critical activity available to crash has a cost slope of $1,050 per day, with enough crash days available. What is the minimum additional direct cost to achieve the required 7-day reduction?

A. $6,300

B. $8,400

C. $5,250

D. $7,350

39. Three activities are scheduled to run concurrently on a given day, each requiring one crew of carpenters: Activity X needs 7 carpenters, Activity Y needs 5 carpenters, and Activity Z needs 8 carpenters. If only 15 carpenters are available that day, what is the resource shortfall?

A. 3 carpenters
B. 5 carpenters
C. 7 carpenters
D. 20 carpenters

40. In precedence diagramming, what does a 'lag' applied to a finish-to-start relationship between two activities represent?

A. A required minimum wait time between the predecessor's finish and the successor's start, such as curing time
B. The total float of the predecessor activity in the network
C. An error in the network logic that must be corrected before scheduling
D. The crew size assigned to work on the successor activity

41. A 6-in. diameter concrete test cylinder fails in compression at a load of 118,752 lb. What is the measured compressive strength of the cylinder, in psi?

A. 3,800 psi
B. 4,600 psi
C. 4,200 psi
D. 3,500 psi

42. In the tension control (TC) bolt installation method, what indicates that the bolt has reached its proper installed tension?

A. The installer's visual estimate of nut rotation alone

B. The splined end of the bolt shears off once the installation tool applies sufficient resistance

C. The bolt visibly changes color once properly tensioned

D. An audible click from the wrench, with no other mechanism involved

43. On many projects, why is quality control testing, such as concrete cylinder breaks and compaction testing, often performed by an independent, third-party testing laboratory rather than the contractor's own staff?

A. To provide unbiased, independent verification, reducing the conflict of interest in self-testing

B. Because contractors are legally prohibited from ever performing their own tests

C. Because third-party labs are always less expensive than in-house testing

D. Because building codes require a minimum of three separate testing agencies

44. What technique can help achieve a strong, well-bonded connection when a new lift of concrete must be placed over a previous lift that has begun to stiffen but not yet reached initial set?

A. Adding extra water only at the interface of the new lift

B. Applying a bonding agent, the only acceptable method regardless of timing

C. Waiting an additional 24 hours before placing the new lift

D. Revibrating the interface zone as the new lift is placed, blending the two lifts at their contact surface

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 80°F for 30 hours accumulates how much maturity (temperature-time factor), in °F-hours?

A. 1,080 °F-hr

B. 1,800 °F-hr

C. 960 °F-hr

D. 1,440 °F-hr

46. A field density test on a compacted embankment fill shows a dry unit weight of 120 pcf. The laboratory maximum dry unit weight from a standard Proctor test is 128 pcf. What is the percent (relative) compaction achieved in the field?

A. 93.75%
B. 90.00%
C. 96.20%
D. 88.50%

47. Why must a concrete delivery's slump test be performed promptly upon the truck's arrival at the site, rather than after an extended waiting period?

A. Slump increases over time, requiring an early, artificially low reading
B. Concrete trucks are never permitted to remain on site past 10 minutes
C. Slump naturally decreases over time as the mix stiffens, so a delayed test misrepresents the concrete at delivery
D. Slump testing equipment degrades quickly once exposed to fresh concrete

48. A fillet weld connecting two steel plates has a leg size of 3/4 in. What is the effective throat thickness of this fillet weld?

A. 0.375 in
B. 0.530 in
C. 0.707 in
D. 0.625 in

49. For proper compaction of a hot-mix asphalt lift, what is a commonly applied minimum ratio of compacted lift thickness to nominal maximum aggregate size?

A. Exactly 1 times the nominal maximum aggregate size
B. Approximately half the nominal maximum aggregate size
C. Approximately 10 times the nominal maximum aggregate size

D. Approximately 3 to 4 times the nominal maximum aggregate size for adequate density

50. For the maturity method to accurately reflect a specific concrete element's actual in-place strength, where should the temperature sensor used for that element be placed?

A. Embedded within the actual concrete element at a location representative of its critical section
B. In the ambient air near the site trailer, away from the concrete
C. Only within a separately cured companion cylinder, never in the structure
D. At the surface of the form, rather than within the concrete mass

51. A structural member for a construction-stage condition is subjected to a dead load of 680 lb/ft and a construction live load of 350 lb/ft. Using an unfactored D + Lc service-level combination, what is the total line load on the member?

A. 850 lb/ft
B. 1,030 lb/ft
C. 900 lb/ft
D. 1,150 lb/ft

52. A rectangular timber beam is 8 in. wide by 18 in. deep and carries a maximum bending moment of 22 kip-ft. What is the maximum bending stress in the beam?

A. 540 psi
B. 685 psi
C. 611 psi
D. 760 psi

53. A short steel column with a cross-sectional area of 6.8 in^2 has an allowable compressive stress of 21 ksi. What is the allowable axial load capacity of the column, neglecting buckling effects?

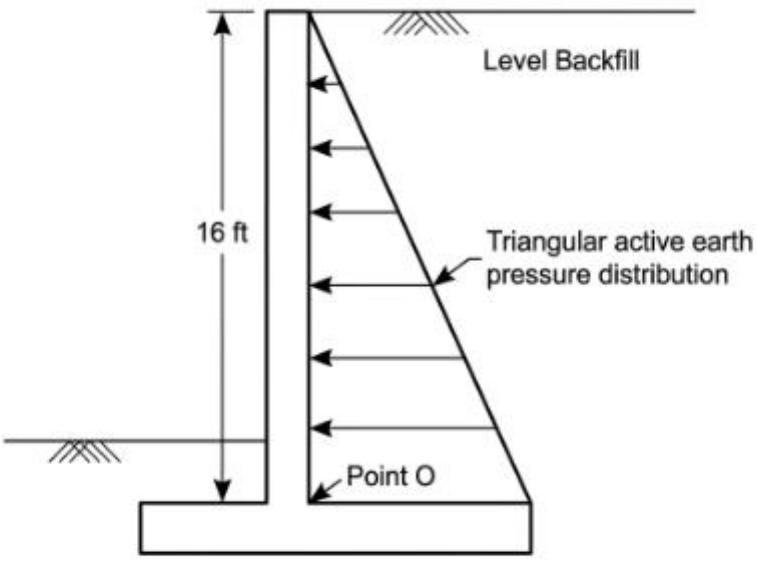
A. 120.0 kips

B. 160.0 kips
C. 130.0 kips
D. 142.8 kips

54. A simply supported steel beam spans 18 ft and carries a concentrated load of 11 kips at midspan. The beam has a moment of inertia I = 850 in^4 and modulus of elasticity E = 29,000 ksi. Using $\Delta = PL^3/48EI$, what is the maximum deflection at midspan?

A. 0.094 in
B. 0.072 in
C. 0.115 in
D. 0.130 in

55. Based on the triangular active earth pressure distribution shown in the figure, acting over a wall stem height of 16 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 a cantilever retaining wall with active earth pressure distribution]*

A. 8.00 ft
B. 4.00 ft
C. 5.33 ft
D. 10.67 ft

56. A roof purlin has a tributary width of 9 ft and carries a uniform roof live load of 18 psf. What is the total uniform line load on the purlin from this live load?

A. 140 lb/ft

B. 162 lb/ft

C. 180 lb/ft

D. 126 lb/ft

57. A parking garage concrete slab exhibits spalling (delamination and popping off of the concrete surface) directly above embedded reinforcing bars, with rust staining visible at the spall locations. What is the most likely cause?

A. Alkali-silica reaction between reactive aggregate and cement paste alkalis

B. Plastic shrinkage cracking from placement-day conditions

C. Differential settlement of the slab's underlying support

D. Corrosion of the steel, which expands and cracks the surrounding cover

58. A rectangular beam 10 in. wide by 20 in. deep carries a maximum shear force of 16 kips. Using $V_{max} = 1.5V/(bd)$ for a rectangular section, what is the maximum shear stress in the beam?

A. 100 psi

B. 140 psi

C. 120 psi

D. 160 psi

59. Why does a reinforced concrete beam design code specify a minimum flexural reinforcement ratio, even when a smaller amount of steel would satisfy the calculated bending moment demand?

A. To prevent a sudden brittle failure at first cracking, keeping some reserve capacity

B. To reduce the overall construction cost of the structure

C. To simplify the concrete placement process around congested reinforcing bars

D. To increase the beam's resistance to shrinkage cracking exclusively

60. A column carries an axial load producing a uniform stress of 9 ksi and a bending moment producing an extreme fiber bending stress of 13 ksi in the same direction. What is the maximum combined compressive stress at the extreme fiber?

A. 13 ksi
B. 22 ksi
C. 18 ksi
D. 9 ksi

61. A circular storm sewer pipe with a diameter of 42 in. flows full at a slope of 0.007 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. 65.0 cfs
B. 84.2 cfs
C. 72.5 cfs
D. 95.0 cfs

62. Using the Rational Method (Q = CiA), a drainage area of 20 acres has a runoff coefficient C = 0.38 and a design rainfall intensity of 2.8 in/hr. What is the peak runoff rate?

A. 21.28 cfs
B. 27.36 cfs
C. 16.72 cfs
D. 24.60 cfs

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

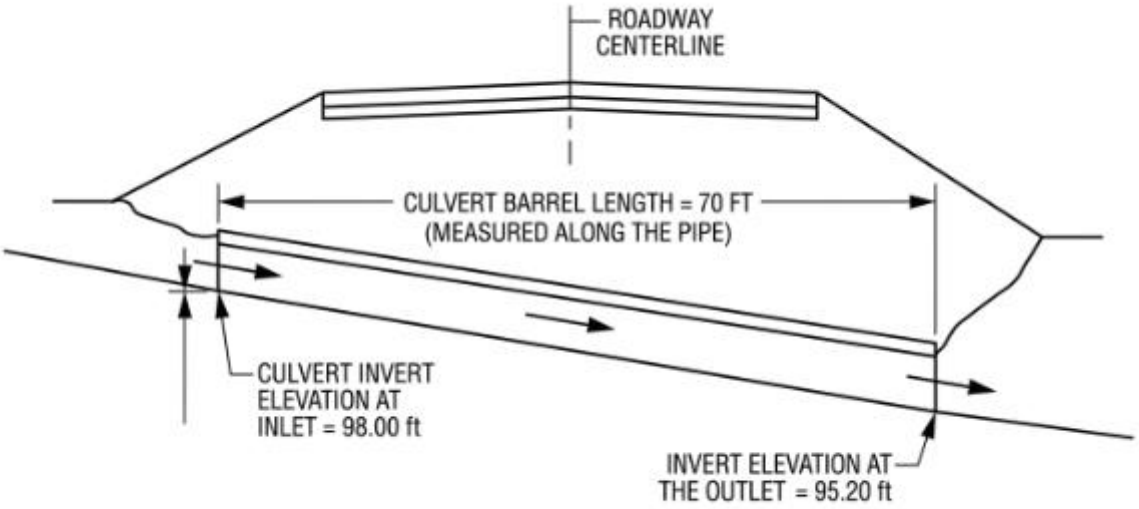


Figure PQ-4: Longitudinal profile diagram of a culvert crossing beneath a roadway embankment. [Figure PQ-4]

A. 2.5%

B. 3.0%

C. 4.0%

D. 5.0%

64. A proposed detention pond has a bottom area of 9,000 ft², a top area at the design water surface 5 ft above the bottom of 13,000 ft², and a mid-height area of 10,900 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. 48,000 ft³

B. 60,000 ft³

C. 45,833 ft³

D. 54,667 ft³

65. In the SCS (NRCS) curve number method for estimating runoff, what does a higher assigned curve number (CN) generally indicate about a drainage area's soil and cover conditions?

A. Higher infiltration capacity, resulting in less runoff being generated

B. A larger total drainage area regardless of the underlying soil type

C. Lower infiltration capacity, causing more rainfall to convert into direct runoff

D. A longer time of concentration for the overall watershed

66. In the standard weir discharge formula Q = C·L·H^1.5, what does the exponent of 1.5 applied to the head (H) reflect?

A. A simple unit conversion factor between metric and imperial units

B. The number of separate weir openings in a multi-bay structure

C. A conservative safety factor applied for structural design purposes

D. The nonlinear relationship between flow depth and discharge over the weir crest

67. A load of 14,000 lb is lifted using a two-leg sling with each leg inclined at 40° from the horizontal. What is the tension in each sling leg, assuming the load is shared equally?

A. 7,000 lb

B. 10,890 lb

C. 9,143 lb

D. 12,124 lb

68. A mobile crane's load chart lists a maximum capacity of 24,000 lb at a 45-ft operating radius. The rigging weighs 850 lb, and the load to be lifted weighs 20,500 lb. What is the remaining capacity margin at this radius after accounting for rigging weight?

A. 2,650 lb

B. 3,500 lb

C. 2,000 lb

D. 3,150 lb

69. An excavation requires dewatering at a rate of 500 gallons per minute (gpm) to maintain a dry work area. A pump is rated at 800 gpm capacity. What percentage of the pump's rated capacity is being utilized?

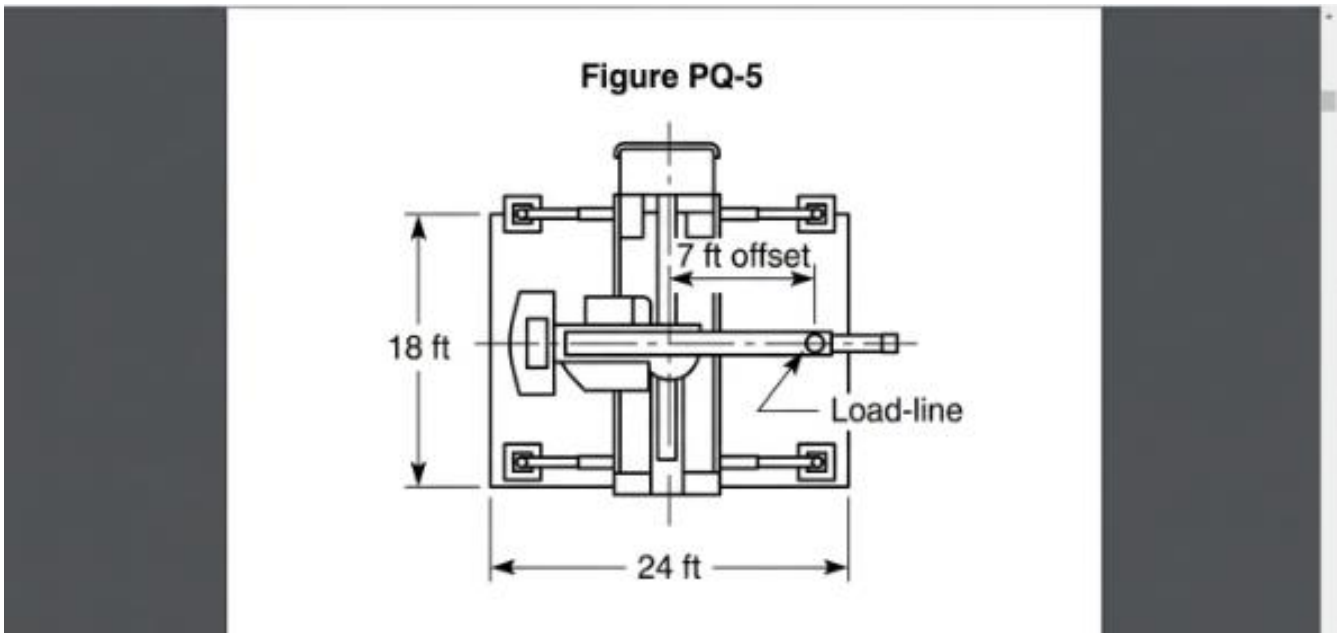
A. 70.0%

B. 55.0%

C. 80.0%

D. 62.5%

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 configuration

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

C. Because the offset load line concentrates a larger reaction share onto the nearest pad, exceeding what the average implies

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

71. For setting precast concrete wall panels at height on a building under construction, which piece of equipment is generally required rather than a rough-terrain forklift?

A. A mobile or tower crane, capable of the precise, controlled positioning panels need at height

B. A skid-steer loader with a pallet fork attachment

C. A rough-terrain forklift alone, regardless of the height involved

D. A standard highway dump truck fitted with a lift gate

72. A borrow pit excavation removes soil with an in-situ (bank) volume of 20,000 cy. If the soil has a shrinkage factor of 0.87 when placed and compacted as fill, what compacted fill volume will this borrow material yield?

A. 20,000 cy
B. 17,400 cy
C. 23,000 cy
D. 15,000 cy

73. A driven pile is being installed using a hammer with a rated energy of 32,000 ft-lb per blow, and the pile advances 0.28 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. 32,000 lb
B. 50,000 lb
C. 62,500 lb
D. 25,000 lb

74. A dump truck hauls fill material a one-way distance of 3.5 miles at an average haul speed of 22 mph, and returns empty at an average speed of 32 mph over the same distance. Ignoring loading and dumping time, what is the total round-trip travel time for one cycle?

A. 13.0 min
B. 18.5 min
C. 16.1 min
D. 14.5 min

75. What is the primary safety function of an anti-two-block device installed on a crane's boom hoist system?

A. It stops hoisting motion before the load block contacts the boom tip, preventing a two-block condition

B. It measures the total weight of the load currently being lifted

C. It automatically controls the crane's outrigger extension distance

D. It prevents the boom from being raised above a preset boom angle

76. An excavator has a bucket capacity of 1.8 cy, a fill factor of 0.92, a cycle time of 18 seconds, and an efficiency (working-time) factor of 0.82. What is the estimated production rate in cy per hour?

A. 331.2 cy/hr

B. 240.0 cy/hr

C. 298.5 cy/hr

D. 271.6 cy/hr

77. A trench shield (box) is used in a 12-ft deep trench but is only 8 ft tall, meaning the bottom 4 ft of trench wall below the shield is unsupported. Under OSHA rules, when is this configuration permitted?

A. This configuration is never permitted under any circumstances whatsoever

B. It is permitted automatically as long as the shield carries any depth rating at all

C. It is permitted only if workers avoid the bottom 4 ft entirely at all times

D. Only if the shield is designed to resist earth pressure loads for the full 12-ft depth, with no soil loss below it

78. A cut excavation removes 11,000 cy of soil measured in its in-situ (bank) state. The soil has a swell factor of 1.28 when excavated and loaded loose into trucks. What is the loose (hauled) volume of this excavated material?

A. 11,000 cy

B. 14,080 cy

C. 12,500 cy

D. 15,500 cy

79. For setting large precast segments on a bridge pier located over open water with no adjacent land access, which crane configuration is typically necessary?

A. A floating, barge-mounted crane
B. A rough-terrain crane driven along the shoreline
C. A tower crane erected on a temporary land-based foundation
D. A truck-mounted crane positioned on the nearest bridge approach

80. Concrete is placed in a wall form at a rate of 7 ft/hr, with a concrete temperature of 72°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. 1,150 psf
C. 1,025 psf
D. 800 psf

81. A scaffold frame leg has an allowable capacity of 4,500 lb. If four legs support a uniformly distributed platform load, and the total load on the scaffold bay is 16,000 lb, what is the utilization ratio of each leg, assuming equal load distribution?

A. 80.0%
B. 95.0%
C. 75.0%
D. 88.9%

82. A newly placed concrete slab imposes a construction load of 210 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. 70 psf
B. 105 psf

C. 52.5 psf
D. 140 psf

83. A temporary sign or windscreen attached to a construction hoist tower has an exposed area of 220 ft² and experiences a design wind pressure of 19 psf. What is the total design wind force acting on this exposed area?

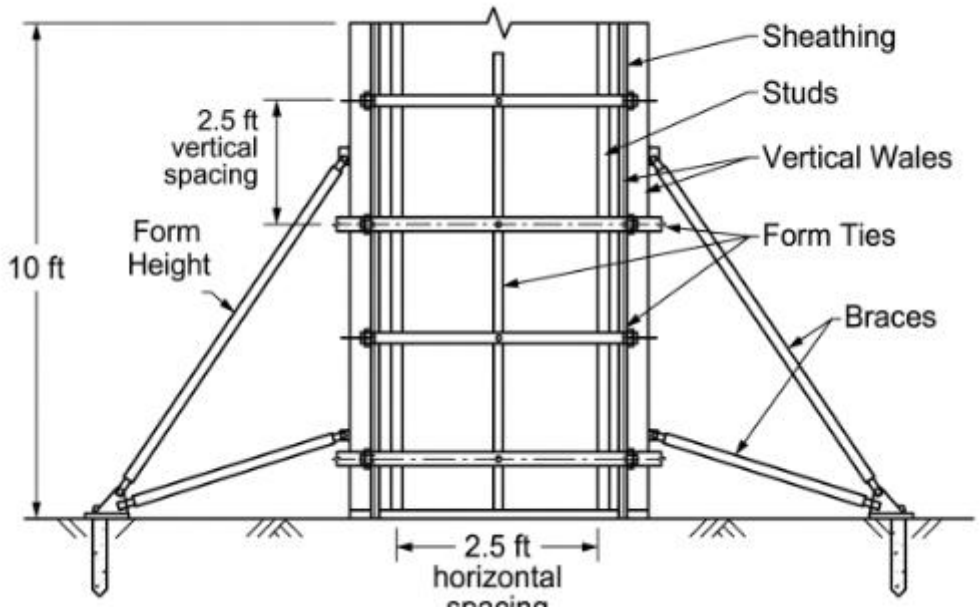
A. 3,800 lb
B. 4,180 lb
C. 4,600 lb
D. 3,500 lb

84. A braced excavation in sand, 25 ft deep, uses an apparent earth pressure diagram per Peck's method with a maximum ordinate pa = 0.65·Ka·γ·H. Given Ka = 0.29, γ = 122 pcf, and H = 25 ft, what is the value of the maximum apparent pressure ordinate, pa?

A. 500 psf
B. 625 psf
C. 575 psf
D. 450 psf

85. Based on the wall formwork cross-section shown, if the maximum lateral concrete pressure on the form is 850 psf and the tie spacing is 2.5 ft vertical by 2.5 ft horizontal, what is the design tension load on each individual form tie?

Figure PQ-6: Cross-section diagram of a wall formwork system



A. 5,313 lb

B. 4,250 lb

C. 6,375 lb

D. 3,825 lb

86. A guy wire bracing a temporary mast is anchored 8 ft horizontally from the base of the mast and attaches to the mast at a height of 15 ft, giving a wire length of 17 ft. If the horizontal force to be resisted at the attachment point is 1,600 lb, what tension in the guy wire is required to provide this horizontal resistance?

A. 3,400 lb

B. 1,600 lb

C. 3,000 lb

D. 2,720 lb

87. During steel erection, why are adjustable turnbuckle-and-cable temporary guys commonly used to plumb a steel frame before permanent bracing is installed?

A. Turnbuckles permanently replace the need for any bracing system afterward

B. The adjustable length allows fine-tuning of the frame's plumbness and alignment before locking in the permanent bracing connections

C. Turnbuckles are required by OSHA regardless of any alignment need

D. Turnbuckles increase the frame's load capacity beyond its design value

88. A structure's typical floor construction load capacity (allowable) is 90 psf once the concrete reaches adequate strength, and each freshly poured slab imposes a construction load of 250 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. 125.0 psf

B. 62.5 psf

C. 250.0 psf

D. 83.3 psf

89. A horizontal strut in a braced excavation supports a tributary height of 11 ft and a tributary width of 16 ft along the wall, with an apparent lateral earth pressure of 460 psf acting uniformly over the tributary height. What is the total axial load in the strut?

A. 80,960 lb

B. 70,000 lb

C. 92,000 lb

D. 64,000 lb

90. Under OSHA's scaffold-specific standard (1926.451), at what height above a lower level does fall protection generally become required for employees on a scaffold platform?

A. 4 ft

B. 6 ft

C. 10 ft

D. 15 ft

91. A partially cured elevated slab has a current allowable load capacity of 85 psf. A piece of construction equipment imposes an equivalent distributed load of 120 psf on the slab during a planned operation. By how much does the equipment load exceed the slab's current allowable capacity?

A. 25 psf
B. 35 psf
C. 45 psf
D. 20 psf

92. For a braced excavation adjacent to a property line where installing cross-lot struts would obstruct the entire excavation interior and equipment access, which excavation support method is typically preferred instead?

A. Timber cross-bracing installed at a closer spacing than usual
B. Eliminating lateral support entirely and relying on a steeper cut slope
C. Increasing strut size to compensate for the obstruction
D. Tieback (ground) anchors drilled behind the wall, eliminating the need for interior bracing

93. A form tie rod has an ultimate tensile capacity of 17,500 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. 7,000 lb
B. 8,750 lb
C. 6,000 lb
D. 5,833 lb

94. Why is camber, an intentional upward curvature, often built into falsework supporting a long-span concrete bridge girder during construction?

A. To make the falsework easier to disassemble after the concrete has cured
B. To increase the falsework's load capacity beyond the design requirement
C. To comply with a fixed OSHA camber requirement applying to all falsework

D. To compensate for the anticipated elastic deflection of the falsework under the wet concrete's weight

95. Per OSHA fall protection requirements, a personal fall arrest system anchorage point must be capable of supporting at least what load per employee attached, unless designed by a qualified person as part of a complete system with a safety factor of at least two?

A. 1,000 lb
B. 5,000 lb
C. 3,000 lb
D. 10,000 lb

96. Under OSHA's crane standard (1926 Subpart CC), who must direct crane assembly and disassembly operations?

A. Any employee verbally designated by the site superintendent for that shift
B. The crane manufacturer's sales representative present at delivery
C. A qualified, and for certain complex operations a competent, assembly/disassembly (A/D) director meeting specific criteria in the standard
D. No specific qualification is required for assembly or disassembly work

97. In MUTCD guidance, the recommended length of a lane-closure transition taper in a work zone is primarily a function of which two factors?

A. The total duration of the project and the contractor's crew size
B. The type of pavement material and the season of construction
C. The posted or prevailing traffic speed and the width of the lateral offset (lane width) being closed
D. The number of workers present and the time of day

98. Before entry into a permit-required confined space, who is responsible for evaluating and classifying the space's atmospheric and physical hazards?

A. Any worker planning to enter the space, without any further evaluation required

B. The space's original design engineer, exclusively, regardless of current conditions

C. The local fire department, exclusively, in every jurisdiction

D. A qualified or competent person, as defined by the applicable standard, conducting the required hazard evaluation before entry

99. Per MUTCD and typical agency guidance, positive protection barriers (such as concrete traffic barrier) are generally required in a work zone under which condition, compared to channelizing devices alone?

A. Only when the project's total duration exceeds one full year

B. When workers sit close to high-speed or high-volume traffic that channelizing devices could not contain

C. Only on projects with a construction budget above a specified dollar threshold

D. Never; channelizing devices alone are always considered sufficient protection

100. If a specific OSHA standard directly addresses a particular workplace hazard, can OSHA still cite an employer under the General Duty Clause for that same hazard?

A. Generally no; the General Duty Clause addresses hazards not covered by a specific standard, so OSHA typically cites the applicable specific standard instead when one directly applies

B. Yes, OSHA always cites both the specific standard and the General Duty Clause together for the same hazard

C. Yes, but only for hazards found within the construction industry specifically

D. Yes, but only when the specific standard carries a lower maximum penalty

Practice Exam 13: Answer Key and Explanations

1. D — The Rankine active coefficient is Ka = (1-sin28°)/(1+sin28°) ≈ 0.361. The total active force per foot is the triangular pressure diagram's area: $0.5 \times Ka \times \gamma \times H^2 = 0.5 \times 0.361 \times 118 \times 11^2 \approx 2{,}578$ lb/ft, or 2.58 kip/ft. This resultant governs design of the wall stem and base. The other options use the wrong coefficient or omit the 0.5 area factor.

2. A — Primary settlement uses $S_c = [C_c \cdot H/(1+e_0)] \cdot \log_{10}[(p_0+\Delta p)/p_0]$. With $H = 168$ in, $S_c = (0.32 \times 168/1.75) \times \log_{10}(1.636) \approx 30.72 \times 0.214 \approx 6.57$ in. This settlement develops gradually over time as excess pore pressure in the clay dissipates through drainage, unlike an immediate elastic settlement. The distractors misapply the void-ratio term or the logarithmic stress ratio.

3. C — Total stress at 20 ft is $7 \times 112 + 13 \times 124 = 2{,}396$ psf. Pore pressure from the water table 13 ft above is $13 \times 62.4 = 811.2$ psf. Effective stress is total stress minus pore pressure: $2{,}396 - 811 \approx 1{,}585$ psf. Option B wrongly reports total stress without deducting any pore pressure contribution at all.

4. B — Terzaghi's equation gives $q_u = q \cdot N_q + 0.5 \cdot \gamma \cdot B \cdot N_\gamma$, with $q = \gamma \cdot D_f = 110 \times 5 = 550$ psf. This gives $q_u = 550 \times 14 + 0.5 \times 110 \times 4 \times 10 = 7{,}700 + 2{,}200 = 9{,}900$ psf. The distractors isolate only one of the two additive terms, the surcharge term or the width term, instead of summing both together.

5. D — For a dry, cohesionless infinite slope, $FS = \tan\varphi/\tan\beta$. With $\varphi = 36°$ and $\beta = 25°$, $FS = \tan 36°/\tan 25° \approx 0.727/0.466 \approx 1.56$. 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 — Jaky's equation is an empirical correlation developed to estimate the at-rest earth pressure coefficient, K_0, for normally consolidated soils based on friction angle. It does not apply to the active or passive limit-state coefficients, which instead require the wall to yield away from or into the soil, nor to the unrelated coefficient of consolidation used in settlement-rate calculations.

7. B — Since shear strength depends directly on effective stress, driving it to zero eliminates the soil's ability to resist shear, and the soil behaves as a heavy liquid with no bearing capacity. This occurs when upward seepage forces exactly counterbalance the submerged weight of the soil grains, a hazardous condition sometimes encountered in excavations with high artesian pressure below.

8. C — When pressure bulbs from adjacent footings overlap, the stress increases from each footing superimpose within the shared zone, raising the total stress increment the soil there experiences beyond what either footing alone would produce. This interaction effect typically increases settlement compared to an isolated footing and must be checked whenever footings are placed closely together.

9. A — Curve length is $L = R \cdot \Delta$ with Δ in radians: $\Delta = 45 \times \pi/180 \approx 0.7854$ rad. Multiplying by $R = 750$ ft gives $L \approx 750 \times 0.7854 \approx 589.0$ 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. C — The middle ordinate is $M = R(1-\cos(\Delta/2))$. With $\Delta/2 = 14°$, $\cos 14° \approx 0.9703$, so $M = 1{,}100 \times (1-0.9703) \approx 32.7$ 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. D — A temporary benchmark is established at the site and tied back once to the distant permanent benchmark through careful differential leveling, then used as the convenient local reference for all subsequent elevation work. This avoids repeating a long, time-consuming leveling run back to the permanent benchmark every time an elevation needs to be checked or transferred during construction.

12. B — Fill is the difference between the higher design subgrade elevation and the lower existing ground elevation: $405.10 - 402.60 = 2.50$ ft. Since the design grade sits above existing ground here,

material must be added rather than removed, and the stake is marked with this fill amount so the grading crew knows how much material to place at that point.

13. B — The low point on a sag curve is at $x = g_1L/(g_1-g_2) = (-0.03\times400)/(-0.05) = 240$ ft from the PVC. Its elevation is $\text{elev}_{PVC} + g_1x + [(g_2-g_1)/2L]x^2 = 95 - 7.2 + 3.6 = 91.4$ ft. Option D omits the parabolic curve correction entirely, giving only the plain tangent elevation instead.

14. A — Angular closure compares the sum of measured interior angles against the theoretical sum for a polygon with that many sides, revealing whether the angle measurements are internally consistent. This check is specific to angular measurement quality; it says nothing about whether the linear distances, coordinate system tie-in, or monument count are correct, which require separate checks.

15. C — An inclinometer measures the tilt of a flexible casing at closely spaced intervals down its length, allowing lateral (horizontal) displacement profiles to be computed with depth over repeated readings. A sudden change in the slope of this displacement profile at a particular depth reveals where a shear or failure surface is developing within the monitored slope.

16. D — The N-value jumps sharply from 8 blows/ft at 25 ft to 65 blows/ft at 30 ft, marking the transition from the soft-to-medium clay into a very dense sand and gravel stratum around 28 ft. Very dense granular material with N-values this high commonly causes pile driving refusal, requiring the driving criteria and equipment to be reevaluated near that depth.

17. A — Water-cement ratio is the weight of water divided by the weight of cement: 225 lb / 500 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 given in this problem.

18. B — Concrete cover is the layer between the outer surface and the nearest bar, and it protects the steel from moisture, chlorides, and carbonation that cause corrosion, provides fire resistance, and gives enough concrete for bond development. It is not meant to increase cross-sectional strength, reduce steel quantity, or affect workability.

19. C — Wood I-joists typically use thin oriented strand board panels for the web, connecting solid or laminated veneer lumber flanges at the top and bottom, forming an efficient I-shaped cross-section. CLT and glulam are both used for larger structural panels or beams themselves, not as the thin web material within a manufactured I-joist product.

20. D — Percent passing is the complement of percent retained: 800 − 460 = 340 g passing, or 340/800×100 = 42.5%. Option B (57.5%) 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 value.

21. A — Fly ash reacts pozzolanically with calcium hydroxide released during cement hydration, continuing to refine the concrete's pore structure over time, which improves long-term strength and reduces permeability. It also reduces the heat generated during hydration, useful in mass concrete, but it

does not eliminate curing, typically slows rather than accelerates setting, and does not remove the need for air entrainment.

22. C — Axial stress equals force divided by area: $\sigma = P/A = 165 \text{ kips} / 5.5 \text{ in}^2 = 30 \text{ ksi}$. 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. B — Footing volume is $7 \times 5 \times 1.5 = 52.5 \text{ ft}^3$. Converting to cubic yards by dividing by 27 ft^3 per cy gives $52.5/27 \approx 1.94$ cy. 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. D — The combined unit cost is \$200 + \$100 = \$300 per cy. Multiplying by the 250 cy quantity gives \$300×250 = \$75,000. 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. A — Simple break-even analysis divides the purchase price by the annual savings: \$80,000/\$16,000 per year = 5 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. D — CPI equals earned value divided by actual cost: \$500,000/\$550,000 ≈ 0.91. 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 B inverts this ratio, producing a misleadingly favorable index reading for the project.

27. B — The average end area method gives volume as $[(300+340)/2] \times 100 = 320 \times 100 = 32{,}000 \text{ ft}^3$, or $32{,}000/27 \approx 1{,}185.2$ cy after converting to cubic yards. The distractors result from using only one section's area alone, or from omitting the ft^3-to-cy unit conversion step entirely at the very end of the calculation.

28. C — Applying a 13% markup multiplies the direct cost by 1.13: \$980,000×1.13 = \$1,107,400. This single multiplication correctly combines overhead and profit as one percentage applied to the direct cost base. Option B omits markup entirely, while C and D reflect different, incorrect markup percentages applied to that same direct cost base.

29. A — Total steel length is 30 bars × 14 ft each = 420 ft. Multiplying by the unit weight of 2.044 lb/ft gives $420 \times 2.044 \approx 858.5$ lb, which rounds to 858 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. D — EUAC spreads each alternative's total costs, initial and recurring, into an equivalent uniform annual amount, which can be directly compared between alternatives regardless of differing service

lives. A simple present-worth comparison instead generally requires finding a common analysis period, such as the least common multiple of the service lives, to compare alternatives fairly on that basis.

31. C — Any underground utility conflicting with the planned foundation footprint must be relocated or adequately protected before excavation begins there, to avoid damaging active utilities or exposing crews to unexpected hazards. Signage, final paving, and elevator equipment installation are all much later finishing activities that have no logical dependency on foundation excavation beginning.

32. B — PERT expected duration weights the most likely estimate four times as heavily as the optimistic and pessimistic estimates: te = (a+4m+b)/6 = (6+40+20)/6 = 66/6 = 11 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. D — Two paths run from A to E: A-B-E totals 5+4+4 = 13 days, and A-C-D-E totals 5+8+5+4 = 22 days. The critical path is the longer of the two, since it determines the minimum project duration: 22 days. Path A-B-E carries substantial float relative to this longer, governing path through the network.

34. C — Total float equals late finish minus early finish (equivalently, late start minus early start): 27 − 20 = 7 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 were actually provided.

35. B — Negative float arises when a constraint, such as a contractual deadline, forces a required finish date earlier than the date network logic calculates as achievable. This signals the schedule cannot meet that date as currently sequenced, prompting schedule compression or renegotiation, rather than indicating extra flexibility or a software error.

36. A — Cost slope is (crash cost − normal cost)/(normal duration − crash duration) = ($18,500−$11,000)/(16−11) = $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. C — The linear scheduling method, or line-of-balance, plots production against location along the pipeline alignment and time, making the repetitive excavate-lay-backfill cycle across each segment directly visible in one view. This reveals whether a faster crew on one segment might catch up to and interfere with a slower crew working the segment ahead of it.

38. D — The minimum added cost to crash an activity is its cost slope multiplied by the number of days shortened: $1,050/day × 7 days = $7,350. Since this is the only available critical activity, all 7 days of compression must come from it alone, leaving no cheaper combination of activities to achieve the required deadline reduction.

39. B — Total demand for that day is 7+5+8 = 20 carpenters, while only 15 are available, leaving a shortfall of 20−15 = 5 carpenters. 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. A — A lag represents a mandatory delay inserted between two logically linked activities beyond simple immediate succession, commonly used to model waiting periods such as concrete curing time before formwork can be stripped. It is a deliberate scheduling input reflecting a real physical or procedural constraint, not a float value, a network error, or a resource assignment.

41. C — For a 6-in. diameter cylinder, area = $\pi \times 3^2 \approx 28.27$ in². Compressive strength is failure load divided by area: 118,752/28.27 ≈ 4,200 psi. This standard cylinder-break calculation confirms whether delivered concrete achieves its specified design strength, and here the result closely matches a 4,200 psi mix requirement, confirming that the load meets acceptance criteria.

42. B — TC bolts have a splined extension on the threaded end designed to shear off at a predetermined torque level once the specified installation tension has been reached, giving a physical, verifiable indication of proper tightening. This mechanical confirmation is more reliable than a visual rotation estimate, a color change, which does not occur, or an audible click alone.

43. A — An independent third-party laboratory has no financial stake in whether a given test passes or fails, providing an unbiased check on the contractor's own work that reduces the inherent conflict of interest in self-testing. This independence is valued by owners and code officials even though contractors are not universally prohibited from ever performing any of their own quality checks.

44. D — Revibrating the contact zone as the new lift is placed re-liquefies the stiffening previous lift's surface just enough to blend intimately with the new concrete, producing a stronger, better-bonded interface than simply placing on top without revibration. Adding extra water locally, relying solely on bonding agents, or waiting 24 hours would each risk a weaker or improperly timed bond instead.

45. D — The Nurse-Saul maturity factor is $M = \Sigma(T - T0) \cdot \Delta t = (80 - 32) \times 30 = 48 \times 30 = 1{,}440$ °F-hours. This accumulated value is compared against a project-specific calibration curve relating maturity to compressive strength, giving an early estimate of in-place strength well before a companion cylinder break could be cured and tested for confirmation.

46. A — Percent compaction compares field dry unit weight to the laboratory maximum: 120/128×100 = 93.75% exactly. Specifications commonly require 95% or greater relative compaction for structural fill, so this result would fall just short of a typical 95% minimum requirement and should be checked against the project's specific compaction specification value before acceptance.

47. C — Slump is not fixed; it decreases as hydration progresses and the mix stiffens, so a reading taken after a delay reflects a later, lower value than the concrete had at delivery. Prompt testing upon arrival gives an accurate, representative measure of the delivered concrete's true condition at that moment, before any change occurs.

48. B — 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: 0.75 in × 0.707 ≈ 0.530 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. D — A lift too thin relative to aggregate size cannot be adequately densified, since larger particles interfere with compaction throughout the layer. A commonly applied rule of thumb requires compacted thickness of roughly 3 to 4 times the nominal maximum aggregate size, ensuring uniform density from top to bottom of the lift.

50. A — The maturity method's accuracy depends on the sensor recording the actual curing temperature history of the concrete element itself, so it must be embedded within the concrete mass at a location representative of the critical section. A sensor in ambient air, in a companion cylinder only, or at the form surface would not capture the true internal conditions.

51. B — An unfactored service-level combination sums the applicable loads directly: D + Lc = 680 + 350 = 1,030 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. C — Section modulus for a rectangular section is $S = bd^2/6 = 8 \times 324/6 = 432$ in³. Converting the moment, M = 22 kip-ft × 12 in/ft × 1,000 = 264,000 lb-in. Bending stress is $\sigma = M/S = 264{,}000/432 \approx 611$ psi, the maximum fiber stress at the top and bottom of the beam's cross-section.

53. D — For a short column not governed by buckling, allowable capacity is the allowable stress multiplied by the cross-sectional area: 21 ksi × 6.8 in² = 142.8 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. A — Converting the 18-ft span to 216 in, $\Delta = PL^3/48EI = (11 \times 216^3)/(48 \times 29{,}000 \times 850) \approx 0.094$ 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 floor framing members.

55. C — For a triangular pressure distribution, the resultant force acts at the centroid of the triangle, one-third of the height up from the base: 16 ft/3 ≈ 5.33 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. B — A uniform area load converts to a line load by multiplying by the tributary width the member collects: 18 psf × 9 ft = 162 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. D — Rust staining directly at spall locations above reinforcing bars is the signature of corrosion-induced spalling: rust products occupy far more volume than the original steel, generating internal expansive pressure that fractures and delaminates the concrete cover above the bar. ASR, plastic shrinkage, and settlement would each produce different crack patterns without this characteristic localized rust staining tied to bar locations.

58. C — For a rectangular section, maximum shear stress occurs at the neutral axis and equals 1.5 times the average shear stress: $\tau_{max} = 1.5V/(bd) = 1.5\times16{,}000/(10\times20) = 24{,}000/200 = 120$ 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 — If too little steel is provided, the beam could crack and fail suddenly the moment the plain concrete's tensile capacity is exceeded, with no reserve capacity to carry the released load. The minimum reinforcement ratio ensures the cracked section retains more capacity than the uncracked section, guaranteeing a ductile failure mode instead.

60. B — When axial and bending stresses act in the same sense at an extreme fiber, they superimpose directly: combined stress = axial + bending = 9 + 13 = 22 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 3.5-ft diameter pipe, area = $\pi r^2 \approx 9.62$ ft² and hydraulic radius R = D/4 = 0.875 ft. Manning's equation gives Q = (1.486/n)AR^(2/3)S^(1/2) ≈ (1.486/0.013)×9.62×0.875^0.667×0.007^0.5 ≈ 84.2 cfs. This full-flow capacity check confirms whether the pipe size can convey the design peak flow it is required to carry.

62. A — The Rational Method computes peak runoff as Q = CiA = 0.38×2.8×20 = 21.28 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: (98.00−95.20)/70×100 = 2.80/70×100 = 4.0% 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. D — The prismoidal formula gives V = (h/6)(Abottom+4Amid+Atop) = (5/6)×(9,000+4×10,900+13,000) = 0.833×65,600 ≈ 54,667 ft³. This method accounts for the changing cross-sectional area with depth in a sloped-side pond, weighting the mid-height area heavily so the final result reflects the pond's actual sloped-wall geometry more accurately than a plain average would.

65. C — A higher curve number reflects a soil and land cover combination with lower infiltration capacity, such as clay soils, impervious surfaces, or compacted ground, meaning more rainfall converts directly to runoff rather than soaking in. A lower CN instead reflects higher infiltration capacity, generating less runoff; CN itself is unrelated to drainage area size or time of concentration.

66. D — The 1.5 exponent arises directly from the hydraulic derivation of flow over a weir crest, reflecting that discharge increases nonlinearly, faster than proportionally, as the head above the crest increases. It is not a unit conversion, a count of openings, or an applied safety margin; those are all separate considerations handled elsewhere in a complete weir design.

67. B — Each leg supports half the vertical load, but because the leg is inclined, its tension exceeds that vertical component: T = (load/2)/sin40° = 7,000/0.643 ≈ 10,890 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.

68. A — The total weight the crane must support at this radius is the load plus all rigging: 20,500+850 = 21,350 lb. Subtracting this from the rated capacity of 24,000 lb gives a margin of 24,000−21,350 = 2,650 lb. Rigging weight must always be included in this check; the chart's rated capacity is not the payload weight alone.

69. D — Percent utilization compares the required flow rate to the pump's rated capacity: 500/800×100 = 62.5% exactly. Operating at this level leaves meaningful reserve margin for surges in inflow or gradual performance degradation over time, generally preferable to selecting a pump expected to run continuously near its maximum rated capacity on site.

70. C — 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.

71. A — Setting precast panels at height requires precise, controlled vertical lift combined with horizontal positioning and often rotation, capabilities a crane provides through its boom, hoist, and rigging system that a rough-terrain forklift's limited lift height and positioning range cannot match. Skid-steers and dump trucks are entirely unsuited to this heavy, precise, elevated placement task.

72. B — Shrinkage factor accounts for the volume reduction when loose, excavated soil is recompacted into denser fill: compacted fill volume = bank volume × shrinkage factor = 20,000×0.87 = 17,400 cy exactly. Ignoring this shrinkage and simply using the bank volume, as in option B, would overstate the actual compacted fill volume this borrow source can produce for the project.

73. B — Substituting into the Engineering News formula gives Ru = 2×32,000/(0.28+1.0) = 64,000/1.28 = 50,000 lb exactly. 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 3.5 mi/22 mph ≈ 0.1591 hr, and empty return time is 3.5 mi/32 mph ≈ 0.1094 hr, for a combined travel time of about 0.2685 hr, or roughly 16.1 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. A — An anti-two-block device senses when the load or hook block approaches too close to the boom tip sheave assembly and automatically stops further hoisting motion, preventing a two-block condition where continued hoisting could snap the hoist line or damage the boom tip. This is a distinct safety function from load weighing, outrigger control, or boom angle limiting devices.

76. D — Cycles per hour equal 3,600 seconds divided by the 18-second cycle time, or 200 cycles/hr. Each cycle effectively moves 1.8×0.92 = 1.656 cy, giving 200×1.656 ≈ 331.2 cy/hr before accounting for downtime. Applying the 0.82 efficiency factor for non-productive time reduces this to 331.2×0.82 ≈ 271.6 cy/hr, the realistic estimated rate.

77. D — OSHA permits excavating below a shield's bottom edge, up to 2 ft in typical practice, only when the shield is designed to resist the earth pressure forces calculated for the full trench depth, not just the shield's own height, and there are no signs of soil loss occurring from behind or beneath the shield during the work.

78. B — Swell factor accounts for the volume increase when compact, in-situ soil is excavated and loosened: loose volume = bank volume × swell factor = 11,000×1.28 = 14,080 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 loosened.

79. A — With no adjacent land access to the pier location, a floating, barge-mounted crane is typically the only configuration capable of positioning itself directly alongside the work and lifting large precast segments into place over open water. Land-based cranes, whether rough-terrain, tower, or truck-mounted, all require ground access that simply does not exist at this location.

80. C — Substituting the given values: Pmax = 150 + 9,000×(7/72) ≈ 150 + 875 ≈ 1,025 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. D — With four legs sharing the load equally, each leg carries 16,000/4 = 4,000 lb. Comparing this to the leg's allowable capacity of 4,500 lb gives a utilization ratio of 4,000/4,500×100 ≈ 88.9%. Since this is below 100%, the legs have adequate capacity for the stated load, provided load distribution in the field is reasonably even across all four legs.

82. A — 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 210 psf total: 210/3 = 70 psf exactly, a value each supported level below must be checked against for adequacy.

83. B — Total wind force equals design wind pressure multiplied by the exposed area subject to it: F = 19 psf × 220 ft² = 4,180 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. C — Substituting into Peck's apparent pressure formula: pa = 0.65×0.29×122×25 ≈ 575 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. A — Each tie's tributary area is its vertical spacing times its horizontal spacing: 2.5 ft × 2.5 ft = 6.25 ft². Multiplying by the maximum lateral concrete pressure gives the design tension load on each tie: 850 psf × 6.25 ft² ≈ 5,313 lb. This tributary-area method is standard for distributing lateral pressure to discrete form ties across a wall face.

86. A — The 8-15-17 geometry is a scaled 8-15-17 Pythagorean right triangle, where horizontal force = tension × (horizontal leg / hypotenuse). Solving for tension: tension = 1,600×(17/8) = 3,400 lb exactly, the wire force needed to provide the required 1,600-lb horizontal resistance at the mast's attachment point on the structure above.

87. B — Turnbuckles let ironworkers incrementally lengthen or shorten the temporary guy cable, fine-tuning the steel frame's plumbness and alignment in small increments until it falls within tolerance, before final, permanent bracing connections are made and the temporary guys removed. They neither replace permanent bracing nor add structural load capacity; their function is purely temporary alignment control.

88. D — Distributing the 250 psf construction load equally across 3 supporting levels gives 250/3 ≈ 83.3 psf per level. Since this is below the 90 psf allowable floor capacity per level, the 3-level shoring and reshoring scheme is adequate for this load, though the margin is tighter than in a case with a lower total construction load or more supporting levels.

89. A — The strut's tributary area is its tributary height times tributary width: 11 ft × 16 ft = 176 ft². Multiplying by the uniform apparent pressure of 460 psf gives the total axial strut load: 460×176 = 80,960 lb exactly. This tributary-area method converts the wall's distributed earth pressure into a discrete design load for the individual strut member.

90. C — OSHA's scaffold standard sets a distinct fall-protection trigger of more than 10 ft above a lower level for employees on a scaffold platform, separate from the general 6-ft trigger that applies to most other construction walking/working surfaces. Above that 10-ft threshold, guardrails, a personal fall arrest system, or both must be provided for the employee's protection.

91. B — The excess load is the imposed equipment load minus the slab's current allowable capacity: 120−85 = 35 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. D — Tieback anchors are drilled and grouted into the soil or rock behind the retaining wall, transferring lateral load without any bracing member crossing the open excavation interior, leaving it clear for equipment access and other work. Cross-lot struts, by contrast, physically span the excavation and would obstruct it, making tiebacks the preferred choice in this obstructed-access scenario.

93. A — Allowable working load is the ultimate tensile capacity divided by the specified safety factor: 17,500/2.5 = 7,000 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. D — As wet concrete's full weight is applied, falsework inevitably deflects and settles elastically, and without compensation the finished girder would end up lower than intended. Building in camber, an upward curvature calculated to offset this deflection, ensures the girder achieves its correct final profile once the falsework has fully settled under the load.

95. B — OSHA requires personal fall arrest system anchorage points to support at least 5,000 lb per employee attached, unless an alternative design path is used: the anchorage is designed, installed, and used as part of a complete system maintaining a safety factor of at least two under the supervision of a qualified person, per 29 CFR 1926.502(d)(15).

96. C — OSHA's crane standard requires that assembly and disassembly operations be directed by a person meeting specific qualified, and for certain higher-risk operations competent, criteria defined in the standard itself, not simply anyone verbally designated for the task. This assembly/disassembly (A/D) director role carries specific defined responsibilities distinct from those of the crane operator or a general site supervisor.

97. C — MUTCD taper length formulas are built around the posted or prevailing traffic speed and the lateral offset distance being closed, since faster speeds and wider offsets both need a longer, more gradual taper to safely merge. Project duration, pavement type, season, crew size, and time of day play no part in this geometric calculation.

98. D — OSHA's permit-required confined space provisions require a qualified or competent person to evaluate the space's hazards and conduct atmospheric testing before entry is authorized, ensuring conditions are understood and controls are in place. This responsibility doesn't fall to an untrained entrant, a design engineer with no current knowledge, or an outside fire department by default.

99. B — Positive protection barriers physically stop an errant vehicle, unlike channelizing devices, which only visually guide traffic and offer no real physical resistance to intrusion. They become necessary specifically where workers or the work area sit close enough to high-speed or high-volume traffic that a vehicle leaving its intended path could not be adequately kept out by channelizing devices alone.

100. A — The General Duty Clause fills gaps for hazards not addressed by any specific standard, so when a specific standard directly covers a hazard, OSHA generally cites that standard instead of the clause for the same condition. Citing both simultaneously, or reserving the clause only for construction or lower-penalty cases, does not reflect how it is actually applied.