PE

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structural

practice exam

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About NCEES

The National Council of Examiners for Engineering and Surveying (NCEES) is a nonprofit organization made up of engineering and surveying licensing boards from all U.S. states and territories. Since its founding in 1920, NCEES has been committed to advancing licensure for engineers and surveyors in order to protect the health, safety, and welfare of the American public.

NCEES helps its member licensing boards carry out their duties to regulate the professions of engineering and surveying. It develops best-practice models for state licensure laws and regulations and promotes uniformity among the states. It develops and administers the exams used for engineering and surveying licensure throughout the country. It also provides services to help licensed engineers and surveyors practice their professions in other U.S. states and territories.

Updates on exam content and procedures

Visit us at **ncees.org/exams** for updates on everything exam-related, including specifications, exam-day policies, scoring, and corrections to published exam preparation materials. This is also where you will register for the exam and find additional steps you should follow in your state to be approved for the exam.

Exam-day schedule

Be sure to arrive at the exam site on time. Late-arriving examinees will not be allowed into the exam room once the proctor has begun to read the exam script. The report time for the exam will be printed on your Exam Authorization. Normally, you will be given 1 hour between morning and afternoon sessions.

Admission to the exam site

To be admitted to the exam, you must bring two items: (1) your Exam Authorization and (2) a current, signed, government-issued identification.

Examinee Guide

The *NCEES Examinee Guide* is the official guide to policies and procedures for all NCEES exams. All examinees are required to read this document before starting the exam registration process. You can download it at ncees.org/exams. It is your responsibility to make sure that you have the current version.

NCEES exams are administered in either a computer-based format or a pencil-and-paper format. Each method of administration has specific rules. This guide describes the rules for each exam format. Refer to the appropriate section for your exam.

Scoring and reporting

NCEES typically releases exam results to its member licensing boards 8–10 weeks after the exam. Depending on your state, you will be notified of your exam result online through your MyNCEES account or via postal mail from your state licensing board. Detailed information on the scoring process can be found at ncees.org/exams.

Staying connected

To keep up to date with NCEES announcements, events, and activities, connect with us on your preferred social media network.

EXAM SPECIFICATIONS

NCEES Principles and Practice of Engineering
CIVIL BREADTH and STRUCTURAL DEPTH
Exam Specifications

Effective Beginning with the April 2015 Examinations

- The civil exam is a breadth and depth examination. This means that examinees work the breadth (AM) exam and one of the five depth (PM) exams.
- The five areas covered in the civil exam are construction, geotechnical, structural, transportation, and water resources and environmental. The breadth exam contains questions from all five areas of civil engineering. The depth exams focus more closely on a single area of practice in civil engineering.
- Examinees work all questions in the morning session and all questions in the afternoon module they have chosen. Depth results are combined with breadth results for final score.
- The exam is an 8-hour open-book exam. It contains 40 multiple-choice questions in the 4-hour AM session, and 40 multiple-choice questions in the 4-hour PM session.
- The exam uses both the International System of Units (SI) and the US Customary System (USCS).
- The exam is developed with questions that will require a variety of approaches and methodologies, including design, analysis, and application.
- The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.
- The specifications for the **AM exam** and the **Structural PM exam** are included here. The **design standards** applicable to the Structural PM exam are shown on **ncees.org**.

CIVIL BREADTH Exam Specifications

	Approximate Number of Questions
I. Project Planning	**4**
A. Quantity take-off methods	
B. Cost estimating	
C. Project schedules	
D. Activity identification and sequencing	
II. Means and Methods	**3**
A. Construction loads	
B. Construction methods	
C. Temporary structures and facilities	
III. Soil Mechanics	**6**
A. Lateral earth pressure	
B. Soil consolidation	
C. Effective and total stresses	
D. Bearing capacity	
E. Foundation settlement	
F. Slope stability	

IV. Structural Mechanics **6**

A. Dead and live loads
B. Trusses
C. Bending (e.g., moments and stresses)
D. Shear (e.g., forces and stresses)
E. Axial (e.g., forces and stresses)
F. Combined stresses
G. Deflection
H. Beams
I. Columns
J. Slabs
K. Footings
L. Retaining walls

V. Hydraulics and Hydrology **7**

A. Open-channel flow
B. Stormwater collection and drainage (e.g., culvert, stormwater inlets, gutter flow, street flow, storm sewer pipes)
C. Storm characteristics (e.g., storm frequency, rainfall measurement and distribution)
D. Runoff analysis (e.g., Rational and SCS/NRCS methods, hydrographic application, runoff time of concentration)
E. Detention/retention ponds
F. Pressure conduit (e.g., single pipe, force mains, Hazen-Williams, Darcy-Weisbach, major and minor losses)
G. Energy and/or continuity equation (e.g., Bernoulli)

VI. Geometrics **3**

A. Basic circular curve elements (e.g., middle ordinate, length, chord, radius)
B. Basic vertical curve elements
C. Traffic volume (e.g., vehicle mix, flow, and speed)

VII. Materials **6**

A. Soil classification and boring log interpretation
B. Soil properties (e.g., strength, permeability, compressibility, phase relationships)
C. Concrete (e.g., nonreinforced, reinforced)
D. Structural steel
E. Material test methods and specification conformance
F. Compaction

VIII. Site Development **5**

A. Excavation and embankment (e.g., cut and fill)
B. Construction site layout and control
C. Temporary and permanent soil erosion and sediment control (e.g., construction erosion control and permits, sediment transport, channel/outlet protection)
D. Impact of construction on adjacent facilities
E. Safety (e.g., construction, roadside, work zone)

CIVIL–STRUCTURAL DEPTH Exam Specifications

	Approximate Number of Questions
I. Analysis of Structures	**14**
A. Loads and load applications	4
1. Dead loads	
2. Live loads	
3. Construction loads	
4. Wind loads	
5. Seismic loads	
6. Moving loads (e.g., vehicular, cranes)	
7. Snow, rain, ice	
8. Impact loads	
9. Earth pressure and surcharge loads	
10. Load paths (e.g., lateral and vertical)	
11. Load combinations	
12. Tributary areas	
B. Forces and load effects	10
1. Diagrams (e.g., shear and moment)	
2. Axial (e.g., tension and compression)	
3. Shear	
4. Flexure	
5. Deflection	
6. Special topics (e.g., torsion, buckling, fatigue, progressive collapse, thermal deformation, bearing)	
II. Design and Details of Structures	**20**
A. Materials and material properties	5
1. Concrete (e.g., plain, reinforced, cast-in-place, precast, pre-tensioned, post-tensioned)	
2. Steel (e.g., structural, reinforcing, cold-formed)	
3. Timber	
4. Masonry (e.g., brick veneer, CMU)	
B. Component design and detailing	15
1. Horizontal members (e.g., beams, slabs, diaphragms)	
2. Vertical members (e.g., columns, bearing walls, shear walls)	
3. Systems (e.g., trusses, braces, frames, composite construction)	
4. Connections (e.g., bearing, bolted, welded, embedded, anchored)	
5. Foundations (e.g., retaining walls, footings, combined footings, slabs, mats, piers, piles, caissons, drilled shafts)	

III. Codes and Construction **6**

A. Codes, standards, and guidance documents 4

1. International Building Code (IBC)
2. American Concrete Institute (ACI 318, 530)
3. Precast/Prestressed Concrete Institute (PCI Design Handbook)
4. Steel Construction Manual (AISC)
5. National Design Specification for Wood Construction (NDS)
6. LRFD Bridge Design Specifications (AASHTO)
7. Minimum Design Loads for Buildings and Other Structures (ASCE 7)
8. American Welding Society (AWS D1.1, D1.2, and D1.4)
9. OSHA 1910 General Industry and OSHA 1926 Construction Safety Standards

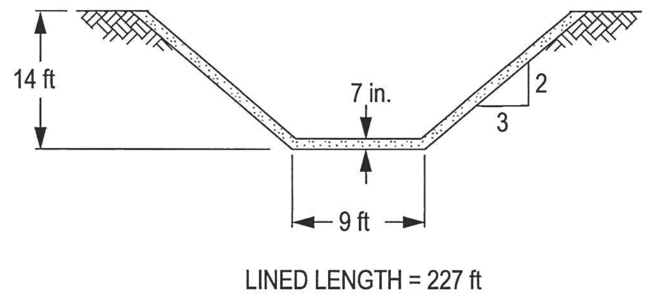
B. Temporary structures and other topics 2

1. Special inspections
2. Submittals
3. Formwork
4. Falsework and scaffolding
5. Shoring and reshoring
6. Concrete maturity and early strength evaluation
7. Bracing
8. Anchorage
9. OSHA regulations
10. Safety management

CIVIL AM PRACTICE EXAM

101. A 227-ft length of canal is to be lined with concrete for erosion control. With 12% allowance for waste and overexcavation, the volume (yd^3) of concrete that must be delivered is most nearly:

(A) 234
(B) 280
(C) 292
(D) 327



102. Based on the straight-line method of depreciation, the book value at the end of the 8th year for a track loader having an initial cost of $75,000, and a salvage value of $10,000 at the end of its expected life of 10 years is most nearly:

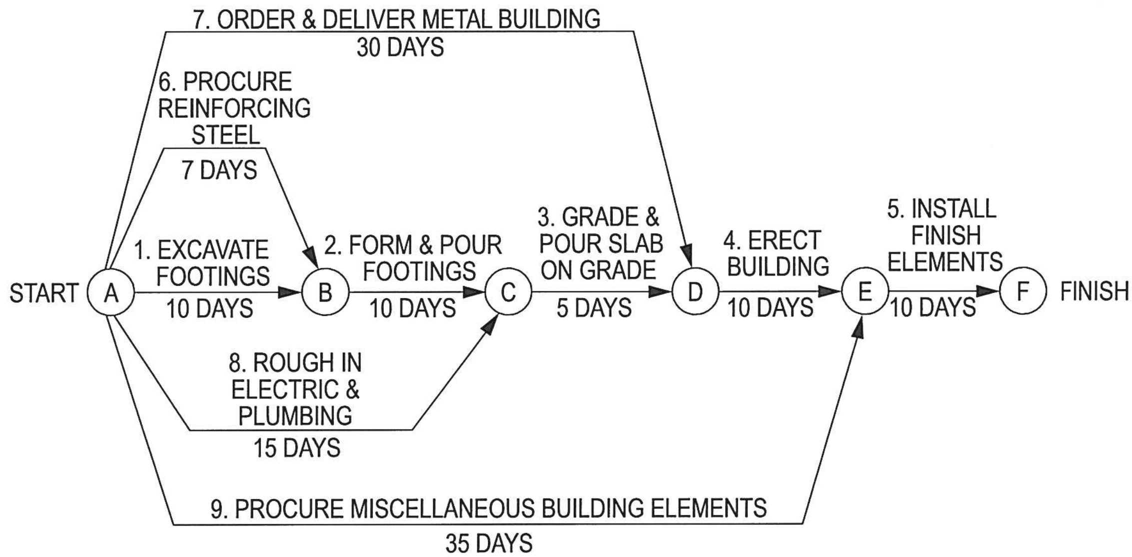
(A) $10,000
(B) $15,000
(C) $23,000
(D) $48,750

103. The budgeted labor amount for an excavation task is $4,000. The hourly labor cost is $50 per worker, and the workday is 8 hours. Two workers are assigned to excavate the material. The time (days) available for the workers to complete this task is most nearly:

(A) 3
(B) 4
(C) 5
(D) 12.5

104. A CPM arrow diagram is shown below. Nine activities have been estimated with durations ranging from 5 to 35 days. The minimum time (days) required to finish the project is most nearly:

(A) 40
(B) 42
(C) 45
(D) 50

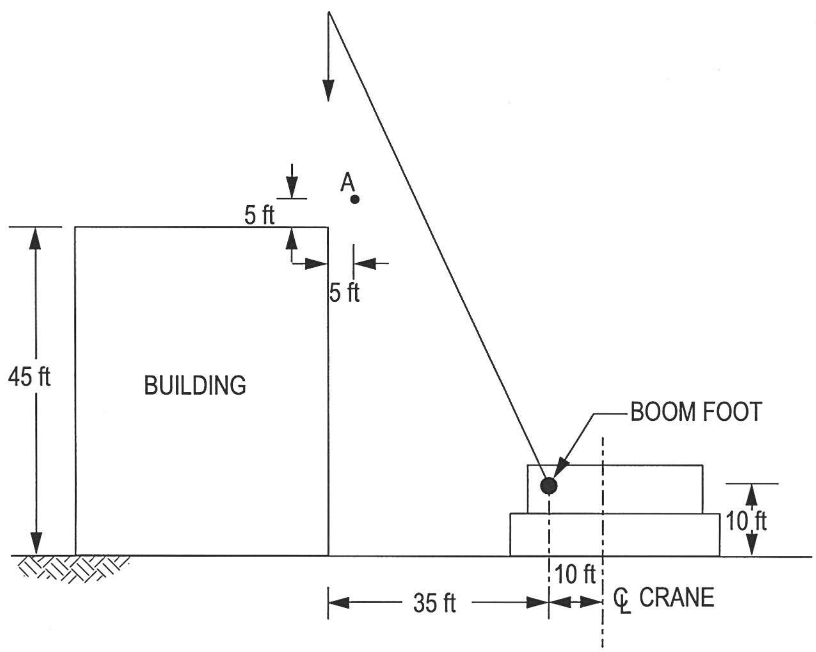


105. A bridge is to be jacked up to replace its bearings. The design requires a hydraulic ram with a minimum capacity of 1,000 kN (kilonewtons). The hydraulic rams that are available are rated in tons (2,000 lb/ton). The **minimum** size (tons) ram to use is most nearly:

(A) 1,110
(B) 250
(C) 150
(D) 100

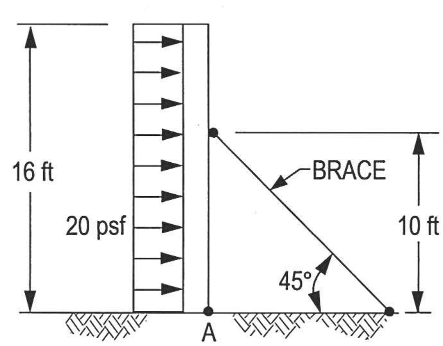
106. A crane with a 100-ft boom is being used to set a small load on the roof of the building shown. The minimum standoff (Point A) from the corner of the building to the centerline of the boom is indicated. What is the maximum distance (ft) from the edge of the building that the load can be placed on the roof?

(A) 16
(B) 25
(C) 30
(D) 36



107. A wall form subjected to a wind load of 20 psf is prevented from overturning by diagonal braces spaced at 8 ft on center along the length of the wall form as shown in the figure. The connection at the base of the form at Point A is equivalent to a hinge. Ignore the weight of the form. The axial force (lb) resisted by the brace is most nearly:

(A) 2,050
(B) 2,560
(C) 2,900
(D) 4,525



108. Which one of the following statements regarding lateral earth pressures is correct?

(A) The lateral strain required to fully mobilize the soil passive pressure is considerably smaller than the lateral strain required to fully mobilize the soil active pressure.

(B) The lateral strain required to fully mobilize the soil passive pressure is slightly smaller than the lateral strain required to fully mobilize the soil active pressure.

(C) The lateral strain required to fully mobilize the soil passive pressure is slightly greater than the lateral strain required to fully mobilize the soil active pressure.

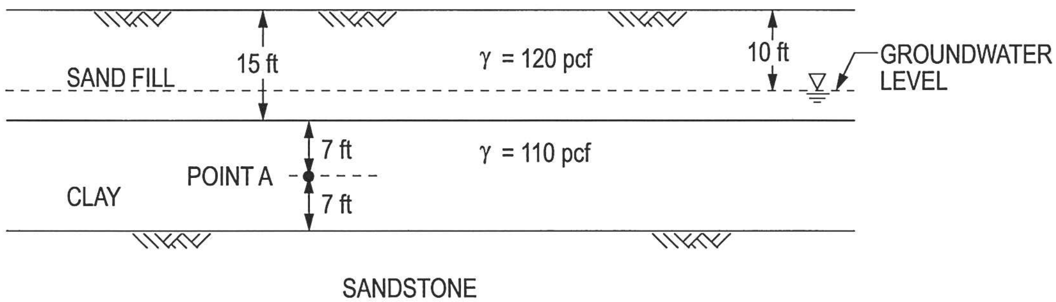
(D) The lateral strain required to fully mobilize the soil passive pressure is considerably greater than the lateral strain required to fully mobilize the soil active pressure.

109. Site preparation and grading require the placement of 20 ft of new fill. An analysis of the resulting consolidation of the underlying soft, saturated, compressible deposits reveals a mean consolidation settlement of 22 in. affecting a 21.5-acre area. Prefabricated wick drains will be used to accelerate the settlement to meet the project schedule. Because of contamination from the former site use, the effluent from the wick drains will need to be collected and treated prior to disposal at an estimated cost of $0.25 per gallon. Assuming no loss of effluent during collection, the estimated treatment and disposal cost for the wick drain effluent at this site is most nearly:

(A) $430,000
(B) $3,200,000
(C) $5,200,000
(D) $35,000,000

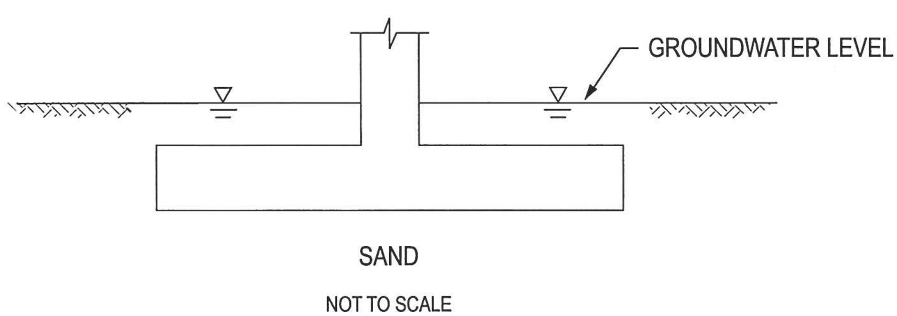
110. A soil profile is shown in the figure. The effective vertical stress (psf) at Point A is most nearly:

(A) 1,270
(B) 1,820
(C) 2,140
(D) 2,570



111. A bridge footing is to be constructed in sand. The groundwater level is at the ground surface. The ultimate bearing capacity would be based on what type of soil unit weight?

(A) Buoyant unit weight
(B) Saturated unit weight
(C) Dry unit weight
(D) Total unit weight



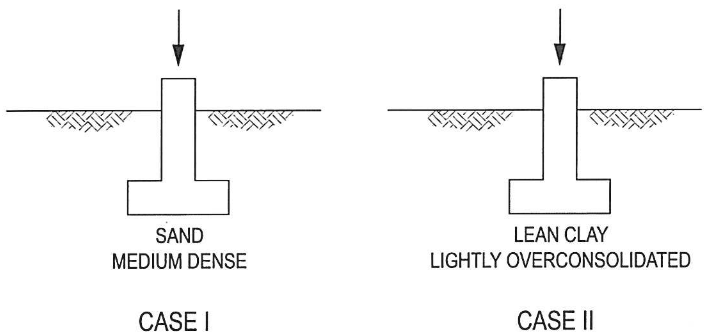
112. The figure shows two identical building footings with the same load but constructed in two different soil types. Which of the following statements is most correct?

(A) The long-term settlement for Case I is less than Case II.

(B) The long-term settlement for Case II is less than Case I.

(C) The long-term settlements are the same for both cases.

(D) Settlement is not a concern for either case.



113. The minimum factor of safety against rotational failure for permanent slopes under long-term, non-seismic conditions influencing occupied structures is closest to:

(A) 1.0
(B) 1.1
(C) 1.5
(D) 3.0

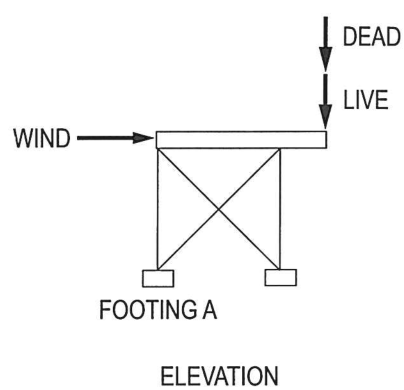
114. Referring to the figure, what load combination produces the maximum uplift on Footing A?

(A) Dead + live

(B) Dead + wind

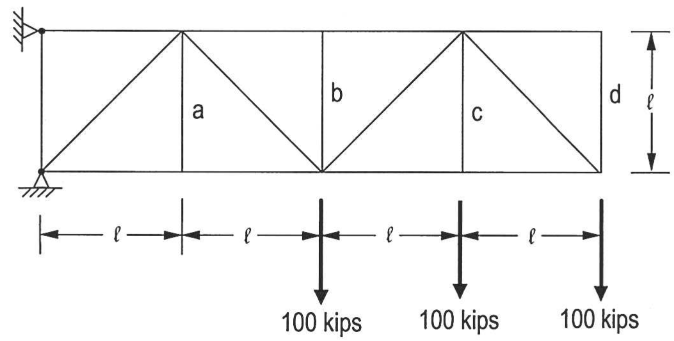
(C) Dead

(D) Dead + live + wind



115. A simply supported truss is loaded as shown in the figure. The loads (kips) for Members b and c are most nearly:

	Member b	Member c
(A)	0	0
(B)	0	100
(C)	100	0
(D)	100	100

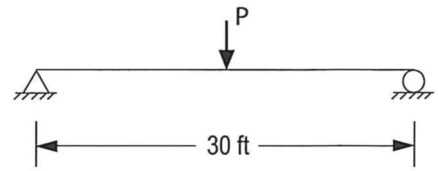


116. Consider two beams with equal cross-sections, made of the same material, having the same support conditions, and each loaded with equal uniform load per length. One beam is twice as long as the other. The maximum bending stress in the longer beam is larger by a factor of:

(A) 1.25
(B) 2
(C) 3
(D) 4

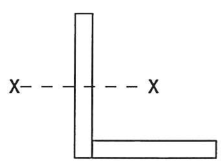
117. The point load (kips) placed at the centerline of a 30-ft beam that produces the same maximum shear in the beam as a uniform load of 1 kip/ft is most nearly:

(A) 7.5
(B) 15
(C) 30
(D) 60

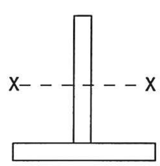


118. The beam sections shown are fabricated from 1/2-in. × 6-in. steel plates. Which of the following cross sections will provide the greatest flexural rigidity about the x-axis?

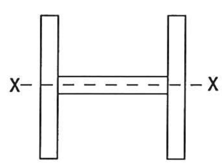
(A)



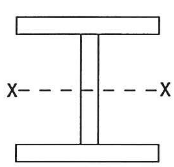
(B)



(C)

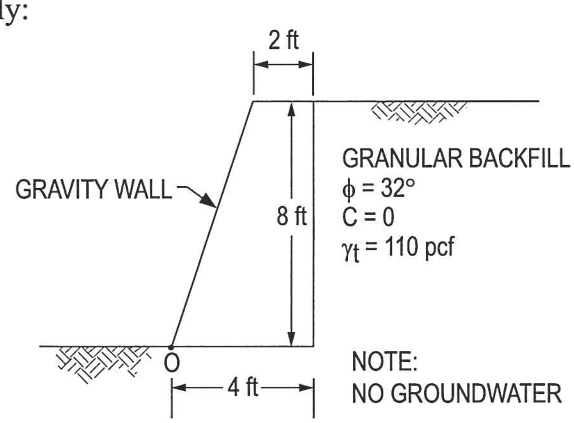


(D)



119. A concrete gravity retaining wall having a unit weight of 150 pcf is shown in the figure. Use the Rankine active earth pressure theory and neglect wall friction. The factor of safety against overturning about the toe at Point O is most nearly:

(A) 3.1
(B) 2.5
(C) 2.2
(D) 0.3



120. A drainage basin produces a stormwater runoff volume of 25.0 acre-ft, which must be drained through a rectangular channel that is 4 ft wide and 2 ft deep and has a uniform slope of 0.2%. Assume a Manning roughness coefficient of 0.022 and a constant depth of flow of 1.5 ft. The time (hours) it will take to discharge the runoff is most nearly:

(A) 12.5
(B) 16.4
(C) 18.5
(D) 25.0

121. Two identical 12-in. storm sewers flow full at a 2% slope into a junction box. A single larger pipe of the same material and slope flows out of the box. Assuming the following pipe sizes are commercially available, the minimum size of this downstream pipe (in.) designed to flow full is most nearly:

(A) 16
(B) 18
(C) 20
(D) 24

122. The following table represents the rainfall recorded from all rain gages located in and around a drainage area.

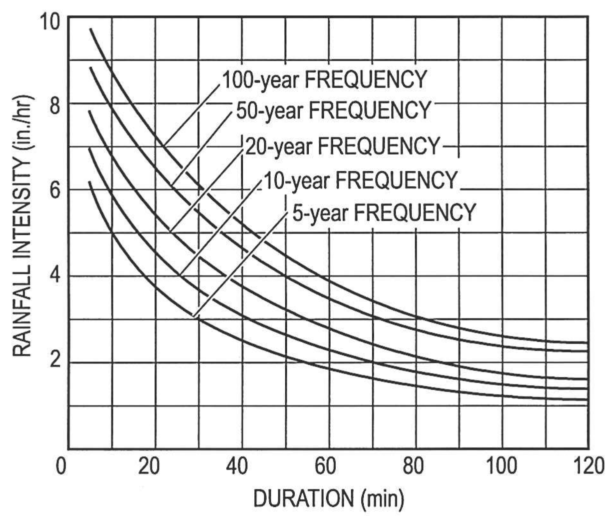
Gage	A	B	C	D	E	F	G	H	I	J	K
Rainfall (in.)	2.1	3.6	1.3	1.5	2.6	6.1	5.1	4.8	4.1	2.8	3.0

Using the arithmetic mean method, the average precipitation (in.) for the drainage area is most nearly:

(A) 3.4
(B) 3.7
(C) 4.1
(D) 37.0

123. The rational method must be used to determine the maximum runoff rate for a 90-acre downtown area. The time of concentration for the 50-year frequency storm is 1 hour. Intensity-duration-frequency curves and a table of runoff coefficients are provided. The maximum runoff rate (cfs), based on the maximum runoff coefficient for a 50-year storm, is most nearly:

(A) 160
(B) 220
(C) 300
(D) 340



INTENSITY-DURATION-FREQUENCY CURVES

123. (Continued)

Description of Area	Runoff Coefficients
Business	
Downtown areas	0.70–0.95
Neighborhood areas	0.50–0.70
Residential	
Single-family areas	0.30–0.50
Multiunits, detached	0.40–0.60
Multiunits, attached	0.60–0.75
Residential (suburban)	0.25–0.40
Apartment dwelling areas	0.50–0.70
Industrial	
Light areas	0.50–0.80
Heavy areas	0.60–0.90
Parks, cemeteries	0.10–0.25
Playgrounds	0.20–0.35
Railroad yard areas	0.20–0.40
Unimproved areas	0.10–0.30
Streets	
Asphalt	0.70–0.95
Concrete	0.80–0.95
Brick	0.70–0.85
Drives and walks	0.75–0.85

GO ON TO THE NEXT PAGE

124. A stormwater drainage ditch with a maximum capacity of 10 cfs discharges into a detention basin. The detention basin volume is 400,000 gal. During a storm event the average discharge into the detention basin was 1.5 cfs. The time (hours) to fill the empty basin would be most nearly:

(A) 1.5
(B) 9.9
(C) 11.1
(D) 74.1

125. Assume fully turbulent flow in a 1,650-ft section of 3-ft-diameter pipe. The Darcy-Weisbach friction factor f is 0.0115. There is a 5-ft drop in the energy grade line over the section. The flow rate (cfs) is most nearly:

(A) 16
(B) 29
(C) 50
(D) 810

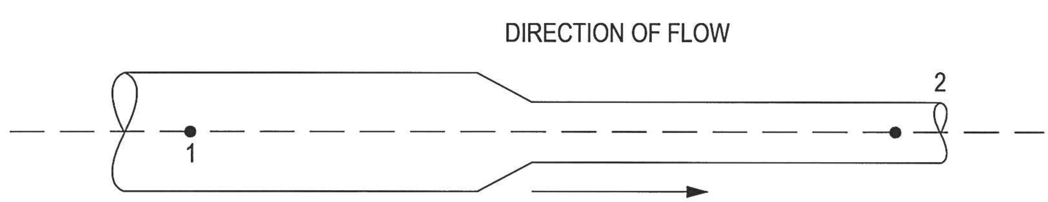
126. Assuming that Bernoulli's equation applies (ignore head losses) to the pipe flow shown in the figure, which of the following statements is most correct?

(A) Pressure head increases from 1 to 2.

(B) Pressure head decreases from 1 to 2.

(C) Pressure head remains unchanged from 1 to 2.

(D) Bernoulli's equation does not include pressure head.



127. The following information is for a proposed horizontal curve in a new subdivision:

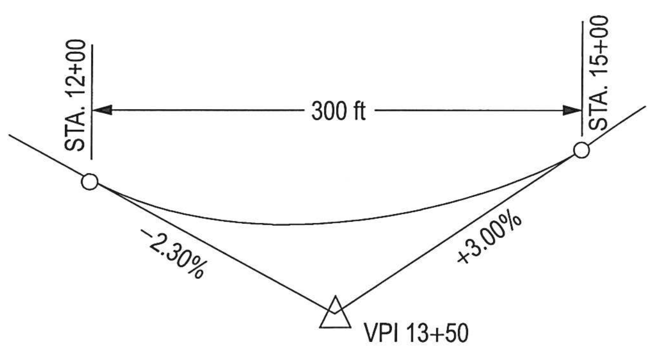
PI station	12+40.00
Degree of curve	10°
Deflection angle	12°30′

The station of the PT is most nearly:

(A) 12+79.80
(B) 12+80.10
(C) 13+02.00
(D) 13+64.75

128. For the sag vertical curve shown, the tangent slope at Station 14+00 is most nearly:

(A) +0.53%
(B) +1.23%
(C) +2.12%
(D) +2.77%



129. An interstate highway has the following traffic count data for a day in each month as shown below:

Jan.	63,500
Feb.	62,100
Mar.	64,400
Apr.	64,900
May	75,800
June	77,300
July	78,950
Aug.	77,200
Sept.	70,050
Oct.	69,000
Nov.	66,000
Dec.	64,000
Annual Total	833,200

The seasonal factor for the summer months of June through August is most nearly:

(A) 0.28
(B) 0.89
(C) 1.02
(D) 1.12

130. The most essential criteria for proper soil classification using the Unified Soil Classification or the AASHTO Soil Classification system are:

(A) water content and soil density

(B) Atterberg limits and specific gravity

(C) grain-size distribution and water content

(D) grain-size distribution and Atterberg limits

131. The Standard Penetration Test (SPT) is widely used as a simple and economic means of obtaining which of the following?

(A) A measurement of soil compressibility expressed in terms of a compression index

(B) A direct measurement of the undrained shear strength

(C) An indirect indication of the relative density of cohesionless soils

(D) A direct measurement of the angle of internal friction

132. A department of transportation must remove and replace a 12-ft × 20-ft concrete slab on an interstate facility. To minimize disruption to traffic, the work must be completed during an 8-hour nighttime work shift. Nighttime temperatures average 50°F. If the minimum required compressive strength is 3,500 psi, the concrete mix would most likely consist of:

(A) coarse aggregate, sand, Type II cement, chemical accelerator

(B) sand, Type III cement, water, chemical accelerator

(C) coarse aggregate, sand, Type V cement, water, chemical accelerator

(D) coarse aggregate, sand, Type III cement, water, chemical accelerator

133. Fatigue in steel can be the result of:

(A) a reduction in strength due to cyclical loads

(B) deformation under impact loads

(C) deflection due to overload

(D) expansion due to corrosion

134. Sample concrete cylinders that are 6 inches in diameter and 12 inches high are tested to determine the compressive strength of the concrete f'_c. The test results are as follows:

Sample	Axial Compressive Failure Load (lb)
1	65,447
2	63,617
3	79,168

Based on the above results, the average 28-day compressive strength (psi) is most nearly:

(A) 615
(B) 2,250
(C) 2,450
(D) 2,800

135. During testing of a sample in the laboratory, the following soil data were collected:

Combined weight of compacted soil sample and the mold is 9.11 lb.

Water content of soil sample is 11.5%.

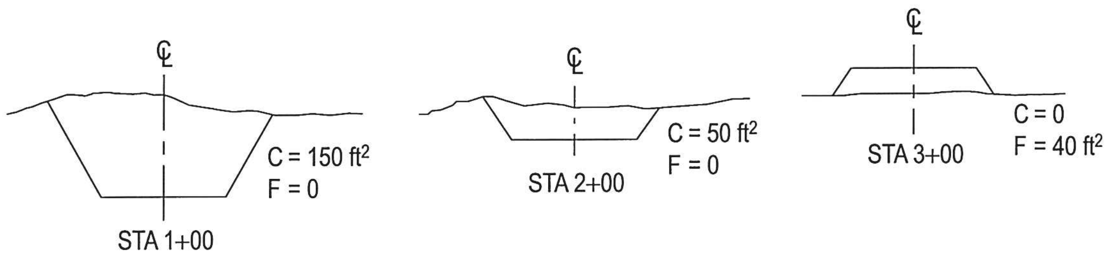
The weight and volume of mold are 4.41 lb and 0.03 ft^3, respectively.

The dry unit weight of the soil sample (pcf) is most nearly:

(A) 160
(B) 140
(C) 127
(D) 125

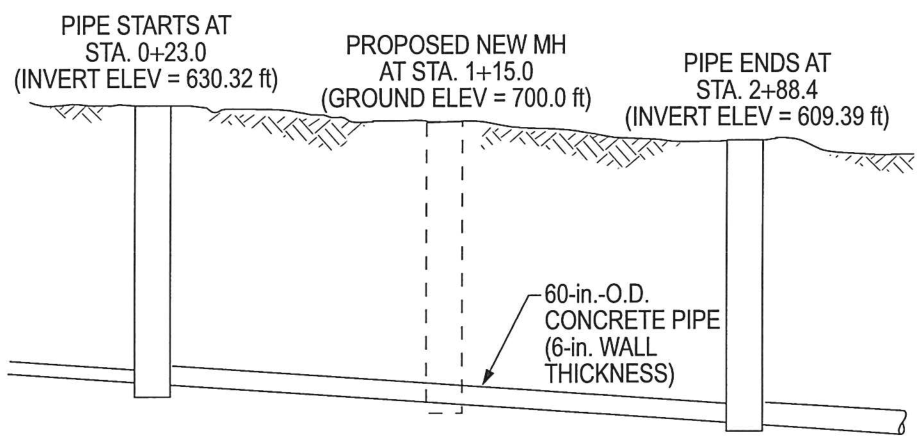
136. Refer to the figure. The net excess excavated material (yd^3) from Station 1+00 to Station 3+00 is most nearly:

(A) 160
(B) 262
(C) 390
(D) 463



137. An existing pipe connects two maintenance holes (MH). A third MH is planned between the two. At the new MH, the elevation (ft) of the top of the pipe is most nearly:

(A) 623.06
(B) 627.56
(C) 628.06
(D) 628.56

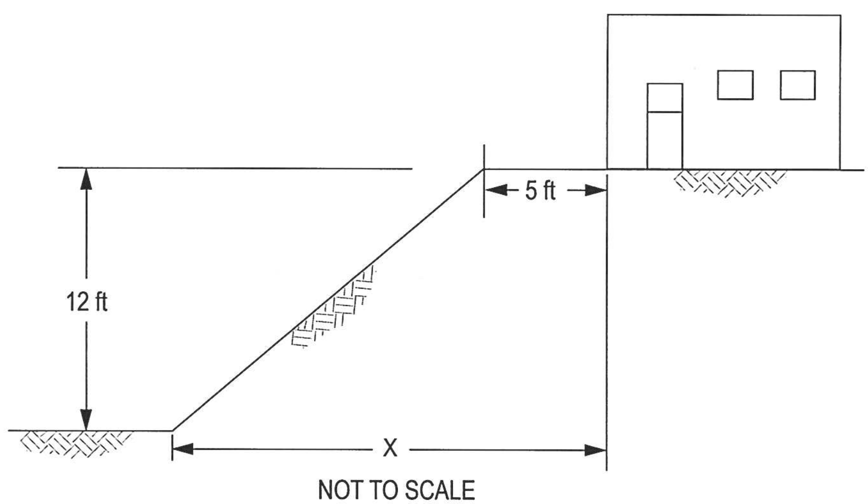


138. Which of the following is **not** a stormwater erosion classification?

(A) Sheet erosion
(B) Rill erosion
(C) Gully erosion
(D) Rushing erosion

139. Based on the soil classification system found in the federal OSHA regulation Subpart P, Excavations, the soil adjacent to an existing building has been classified as Type B. An undisturbed perimeter strip that is 5 ft wide is to be maintained along the face of the building. The excavation is to be 12 ft deep. To meet OSHA excavation requirements, the minimum horizontal distance X (ft) from the toe of the slope to the face of the structure is most nearly:

(A) 11
(B) 14
(C) 17
(D) 23



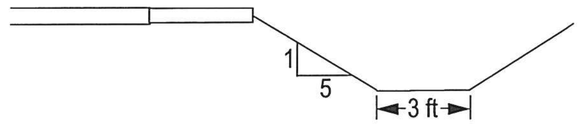
140. Based on the criteria provided, the steepest backslope (H:V) preferred in the ditch shown is most nearly:

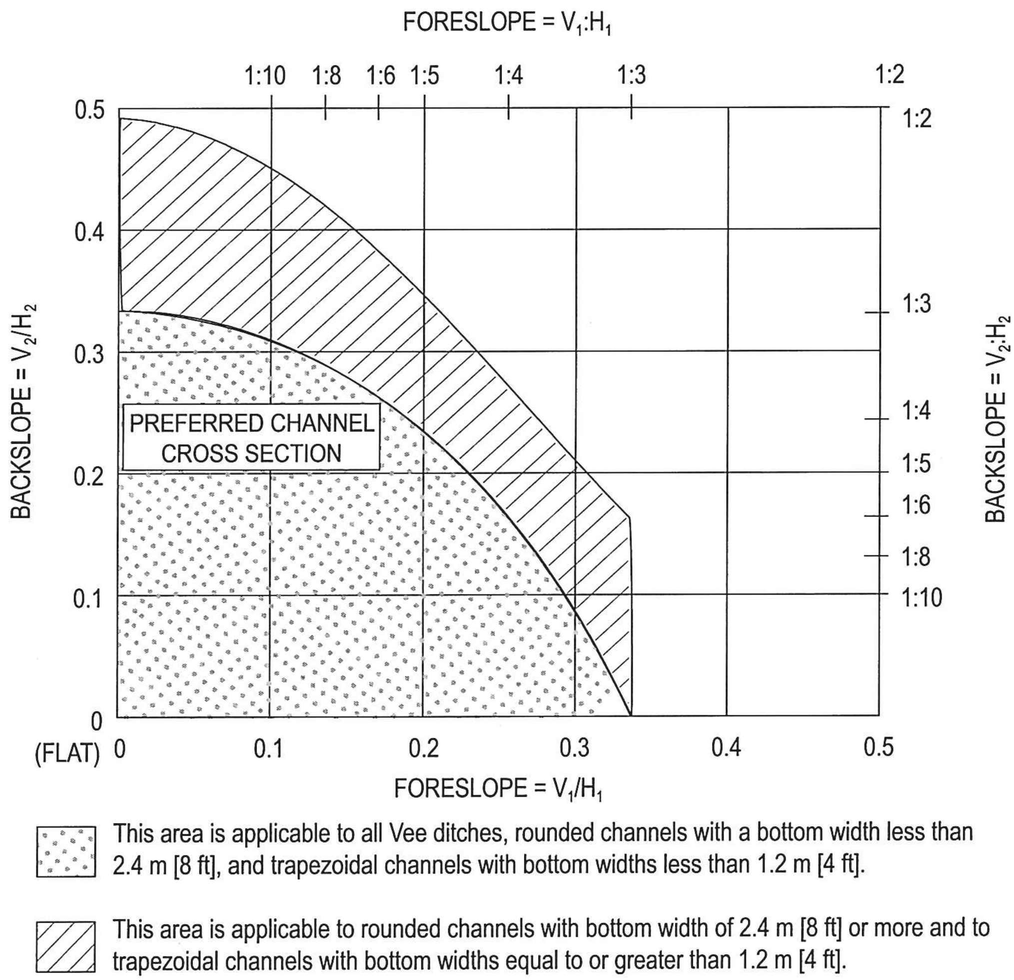
(A) 2:1

(B) 3:1

(C) 5:1

(D) 6:1





Adapted from AASHTO *Roadside Design Guide,* 4th edition, 2011.

This completes the morning session. Solutions begin on page 63.

STRUCTURAL PM PRACTICE EXAM

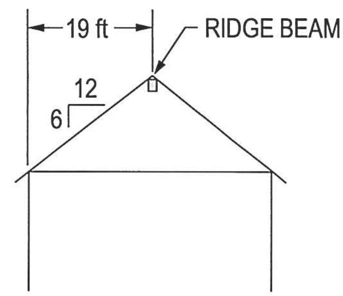
501. The following data apply to the structure shown in the figure.

Ground snow load = 20 psf
Roof is fully exposed with wood shingles
Open terrain
Risk Category I
Unheated structure

Design Code:
ASCE 7: *Minimum Design Loads for Buildings and Other Structures,* 2010.

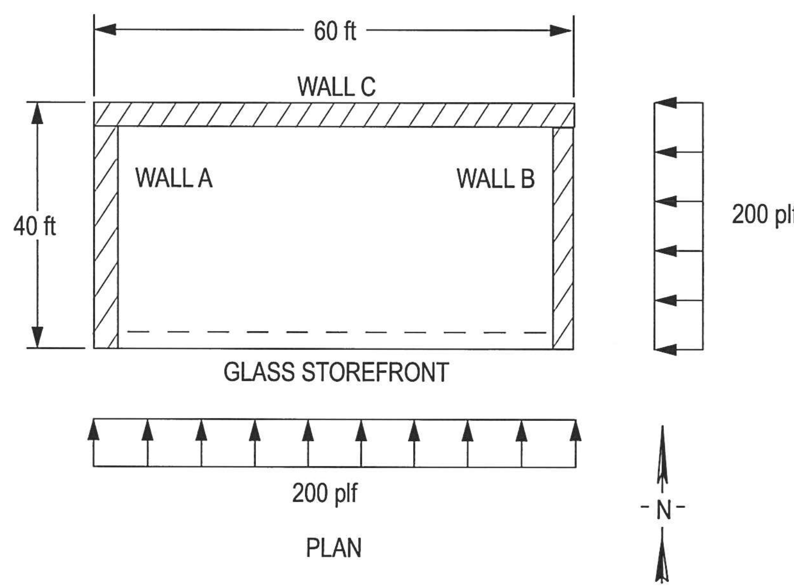
Roof joists span from the exterior walls to the ridge beam. The design snow load (psf) for roof joists is most nearly:

(A) 10
(B) 12
(C) 16
(D) 20



502. The figure shows a one-story building with CMU walls on three sides and a glass storefront. The uniform load shown in the figure is the wind reaction acting at the top of the wall, directly into the diaphragm. The resultant force (kips) on Wall B from the wind acting on the front wall is most nearly:

(A) 4
(B) 6
(C) 8
(D) 12

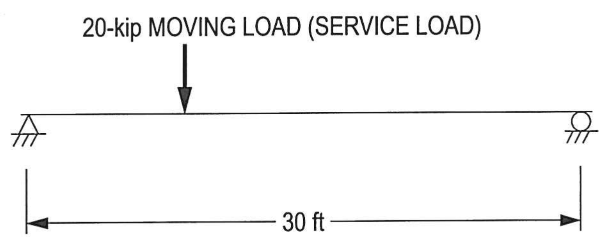


503. A two-story 100-ft × 100-ft industrial facility in Seismic Design Category A has a second floor that is used for storage and a 200-psf reduced floor live load. If the facility has a flat roof that experiences a snow load of 50 psf and the total dead load of the building is 200,000 lb, the minimum lateral force E (lb) for the entire building is most nearly:

(A) 2,000
(B) 7,000
(C) 22,000
(D) 27,000

504. A moving load is applied to a beam as shown in the figure. The maximum service moment (ft-kips) carried by the beam is most nearly:

(A) 75
(B) 115
(C) 150
(D) 300

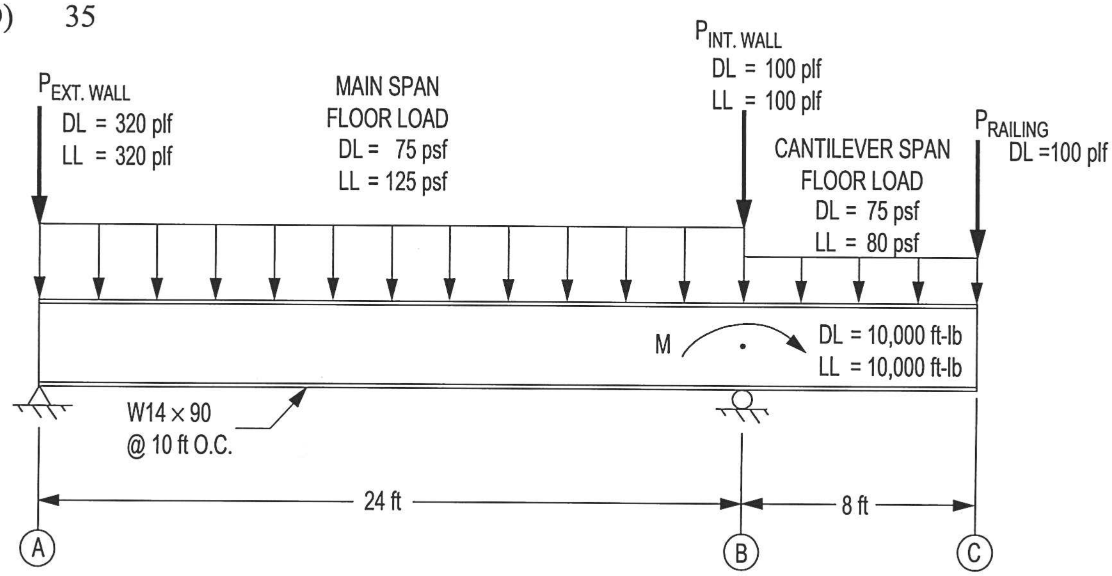


505. A building floor is supported by steel beams as shown in the figure. The floor beams are spaced 10 ft o.c. at either side of the beam shown.

Assumptions:
All loads act simultaneously.
Neglect beam self-weight.
The live loads are non-reducible.

The total service load reaction (kips) at the support at A is most nearly:

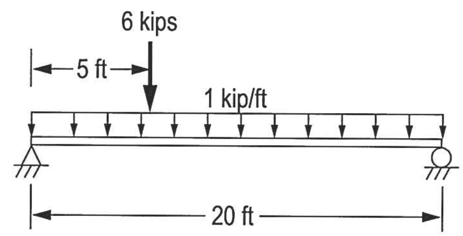
(A) 3
(B) 14
(C) 28
(D) 35



FLOOR BEAM ELEVATION
NOT TO SCALE

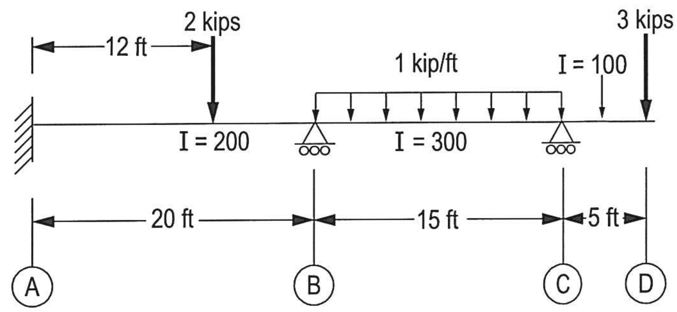
506. The beam shown in the figure is loaded with a uniform load of 1 kip/ft and a point load of 6 kips located 5 ft from the left end. The location of the maximum moment measured from the right end (ft) is most nearly:

(A) 5.0
(B) 8.5
(C) 10.0
(D) 11.5



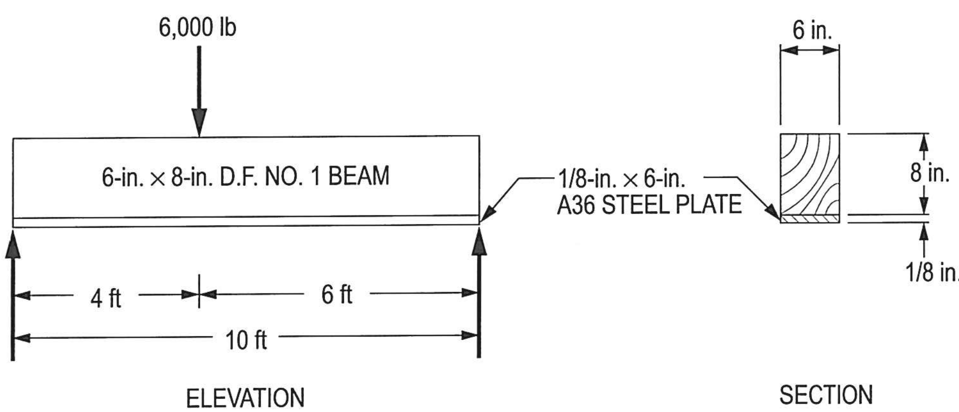
507. A loaded beam is shown in the figure. Using the method of moment distribution, the unbalanced portion of the fixed-end moments (ft-kips) at Joint B is most nearly:

(A) 19
(B) 13
(C) 6
(D) 0



508. The beam shown in the figure is simply supported, and the dead load is negligible. A steel plate is attached to the beam sufficiently to fully develop composite section. $E_{wood} = 1.6 \times 10^6$ psi and $E_{steel} = 29 \times 10^6$ psi. The tensile stress in the steel (ksi) is most nearly:

(A) 2.6
(B) 14.4
(C) 18.6
(D) 23.5

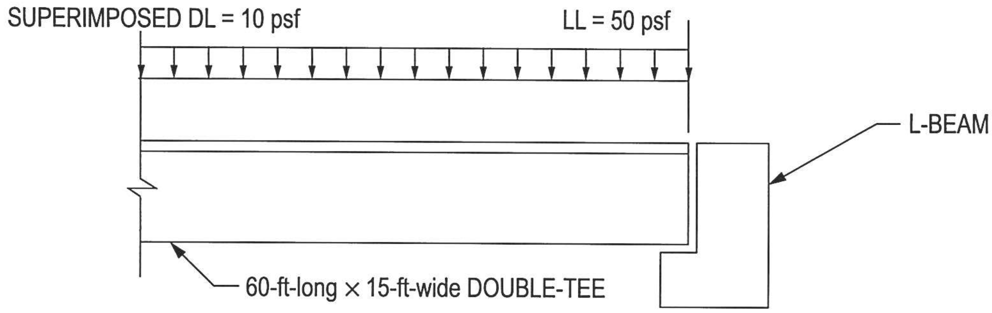


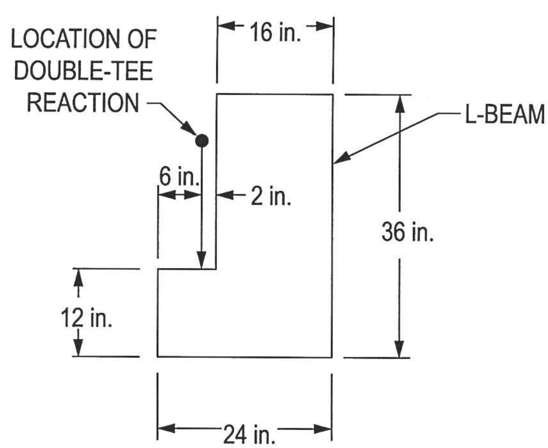
509. A double-tee supported by an L-beam is loaded as shown in the figure.

Design Code:
ACI 318: *Building Code Requirements for Structural Concrete*, 2011.

The magnitude of the ultimate torsion (ft-kips) induced into the L-beam, by superimposed dead and live load applied on the double-tee, is most nearly:

(A) 18.7
(B) 20.7
(C) 28.6
(D) 34.5

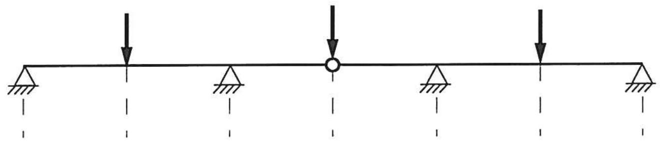




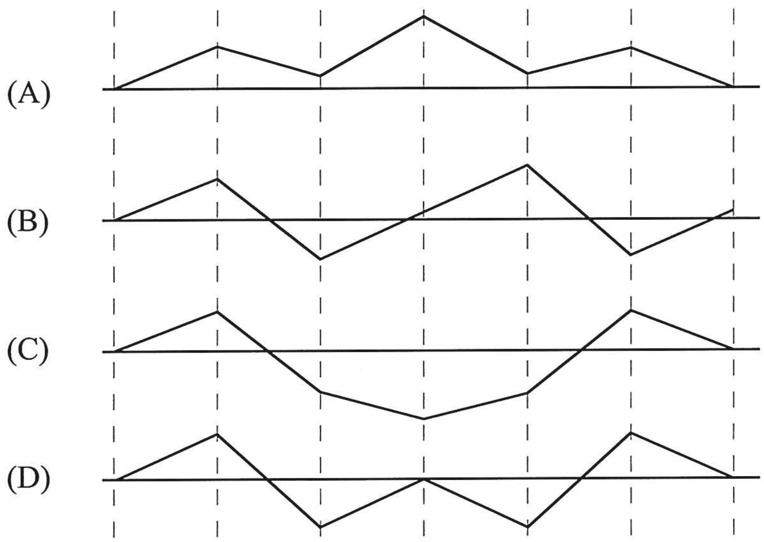
DETAIL

NOT TO SCALE

510. A beam is loaded as shown:

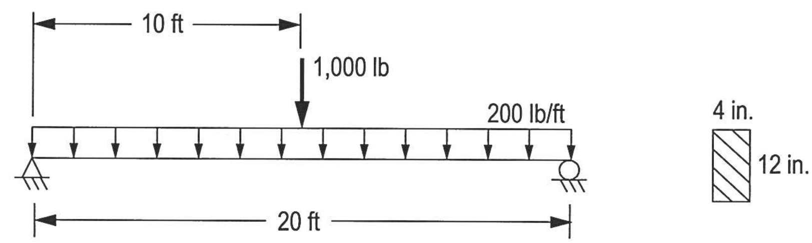


Which bending moment diagram most accurately represents the loaded beam?



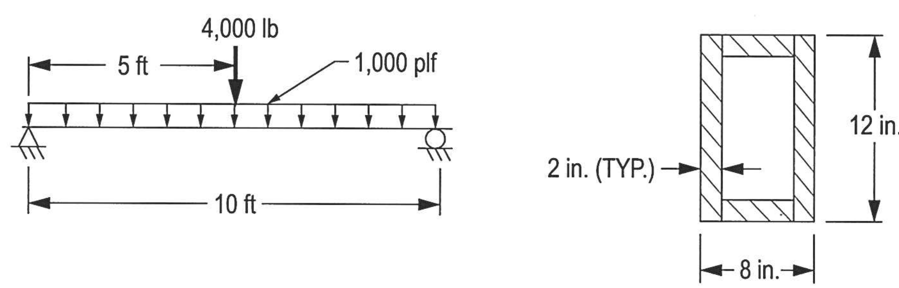
511. Referring to the figure, the maximum flexural stress (psi) in the member is most nearly:

(A) 5,625
(B) 3,125
(C) 1,875
(D) 1,565



512. The figure shows a section with elements that are adequately connected to ensure composite action. Assuming $Q = 85\ in^3$, the maximum horizontal shear stress (psi) in the member is most nearly:

(A) 90
(B) 150
(C) 300
(D) 400

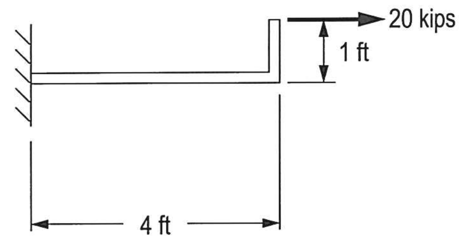


513. The pipe member shown in the figure has a constant section and the following properties:

Outside diameter	10 in.
Moment of inertia	90 in^4
Area	7 in^2

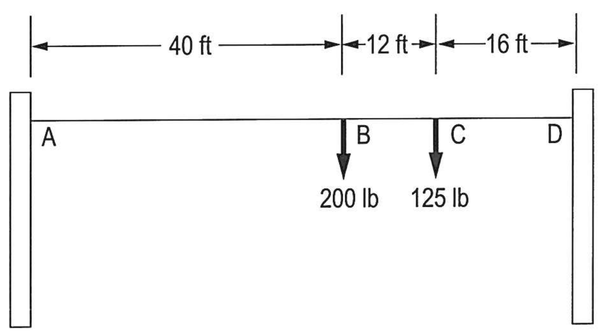
Neglecting the weight of the pipe, the maximum compressive stress (ksi) at the support is most nearly:

(A) 2.9
(B) 10.4
(C) 13.3
(D) 16.2



514. A cable carrying traffic signal loads is shown in the figure. The deflection at point B is 12 in. Neglect elongation of the cable. The tension force (lb) in the cable between C and D is most nearly:

(A) 4,685
(B) 4,476
(C) 1,816
(D) 213



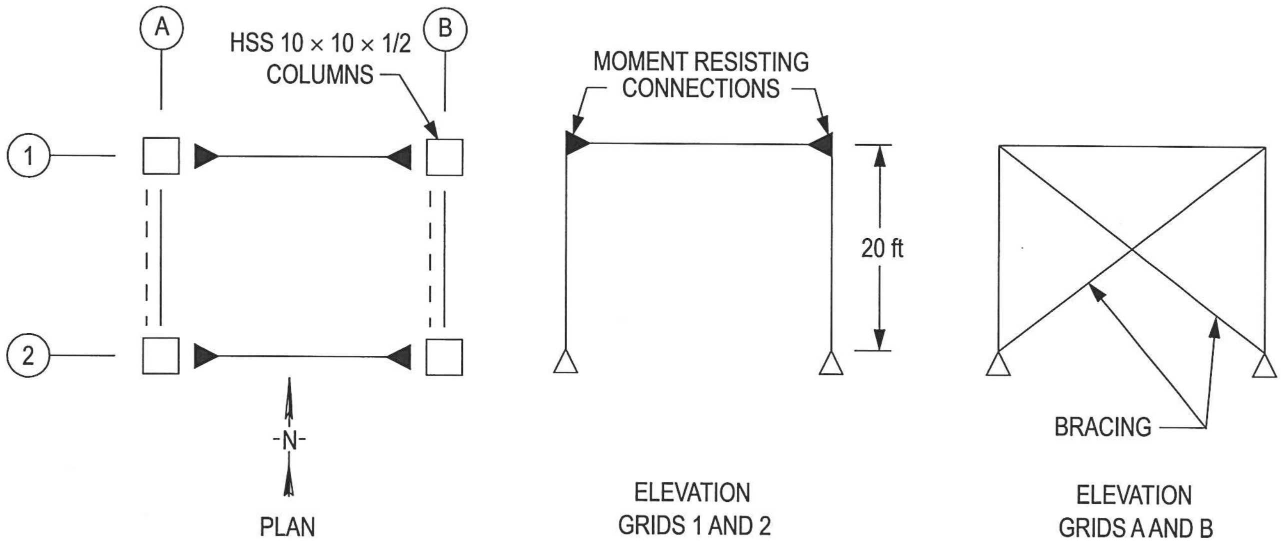
515. A structure is shown in the figure. For a stress check of column A1, which of the following statements is true?

(A) Buckling in the north-south direction will control the column capacity.

(B) Buckling in the east-west direction will control the column capacity.

(C) Buckling in either direction might control the column capacity.

(D) Buckling will not control since both directions are stable.



516. Normal-weight concrete with a maximum aggregate size of 1 1/2 in., $f'_c = 4{,}000$ psi, has moderate exposure to freezing and thawing. Neglecting tolerance, the recommended minimum air content is most nearly:

(A) 4.5%
(B) 5.0%
(C) 5.5%
(D) 6.0%

517. Which of the following characterizes the typical failure of an over-reinforced concrete beam that has a reinforcement ratio higher than the balanced ratio?

(A) The steel yields, and large deflections and tensile cracks will be observed prior to failure.

(B) The concrete crushes, and large deflections and tensile cracks will be observed prior to failure.

(C) The steel yields, and the beam fails suddenly without warning.

(D) The concrete crushes, and the beam fails suddenly without warning.

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518. The figure shows a wall construction plan.

Building Code:

NDS: *National Design Specification for Wood Construction ASD/LRFD,* 2012 edition and *National Design Specification Supplement*, *Design Values for Wood Construction*, 2012 edition.

Material:

Douglas Fir-Larch #2

Assumptions:

The gypsum board provides stud weak axis bracing.

$C_D = 1.6$

$C_M = 1.0$

$C_T = 1.0$

$C_F = 1.15$

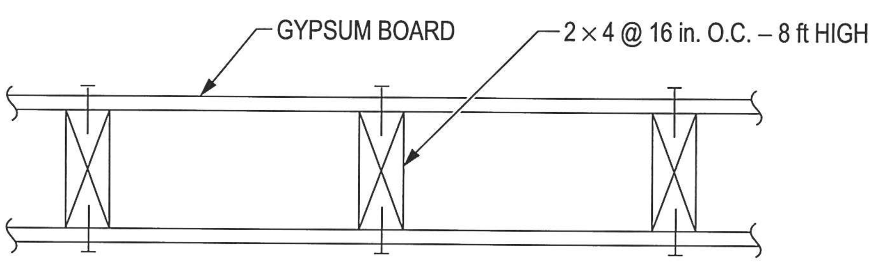
$C_i = 1.00$

$C_p = 0.33$ strong axis

$C_p = 1.0$ weak axis

Using allowable stress design, the maximum vertical load (lb) per stud is most nearly:

(A) 2,700
(B) 3,300
(C) 3,700
(D) 4,300



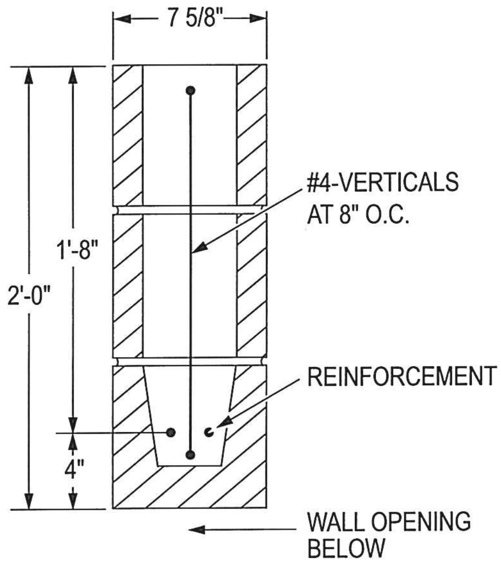
519. The following information applies to the masonry beam section shown:

f'_m = 1,500 psi
f_y = 60,000 psi

Design Code:
ACI-530/530.1: *Building Code Requirements and Specifications for Masonry Structures* (and related commentaries), 2011.

Use allowable stress design. Assume shear load is resisted by shear reinforcement only. The maximum allowable shear force (kips) for the beam is most nearly:

(A) 8
(B) 12
(C) 14
(D) 18



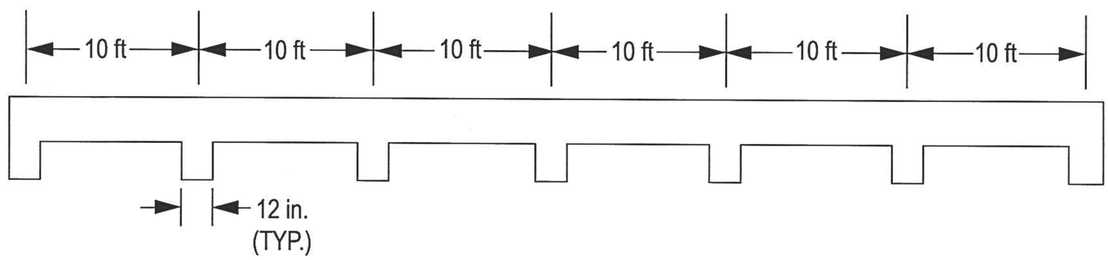
BEAM SECTION
NOT TO SCALE

520. A concrete slab of uniform thickness is continuous for six spans and is supported by 12-in.-wide concrete beams at 10 ft o.c. The following loads are applied to the slab:

DL 100 psf (includes self-weight)
LL 50 psf

Using ACI 318-11's alternate to frame analysis, the maximum factored negative moment in the slab (ft-kips/ft) is most nearly:

(A) 1.35
(B) 1.47
(C) 1.67
(D) 1.80



521. The W10 × 22 steel beam (F_y = 50 ksi) shown in the figure is only braced at the center of span.

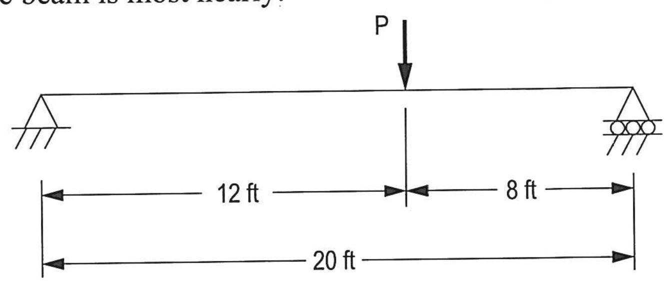
Work either the ASD or the LRFD version of the question.

ASD
The allowable moment capacity (ft-kips) of the beam is most nearly:

(A) 45
(B) 51
(C) 56
(D) 65

LRFD
The moment capacity ϕMn (ft-kips) of the beam is most nearly:

(A) 68
(B) 76
(C) 84
(D) 97



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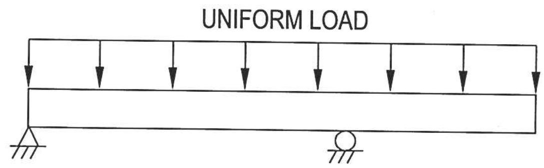
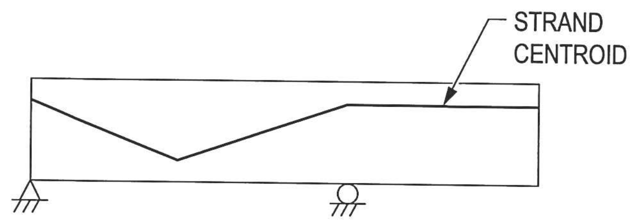
522. A loaded prestressed beam is shown in the figure.

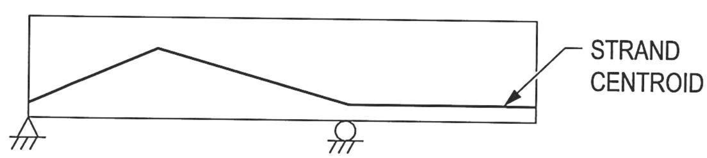


The most likely prestressing strand pattern would be:

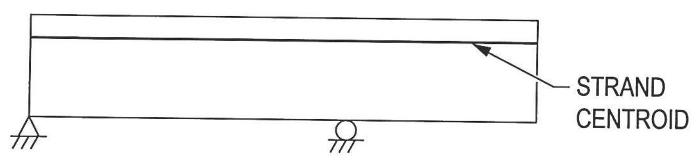
(A)



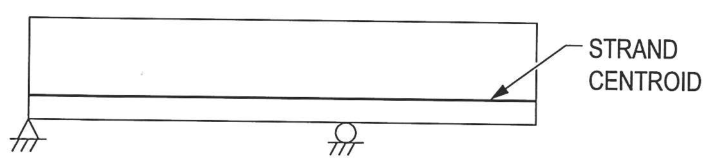
(B)



(C)



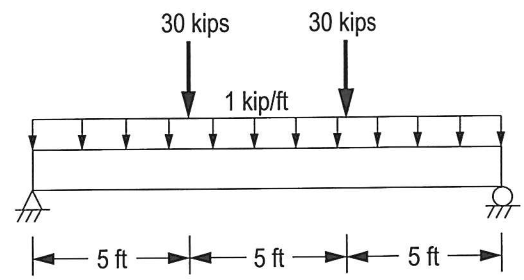
(D)



523. The following information applies to the simply-supported steel beam shown in the figure:

E	29,000 ksi
Maximum beam depth	14 in.
Uniform load includes beam self-weight	

Considering only deflection criteria, the lightest W section for which the maximum deflection is less than ℓ/240 is most nearly:



(A) W14 × 22

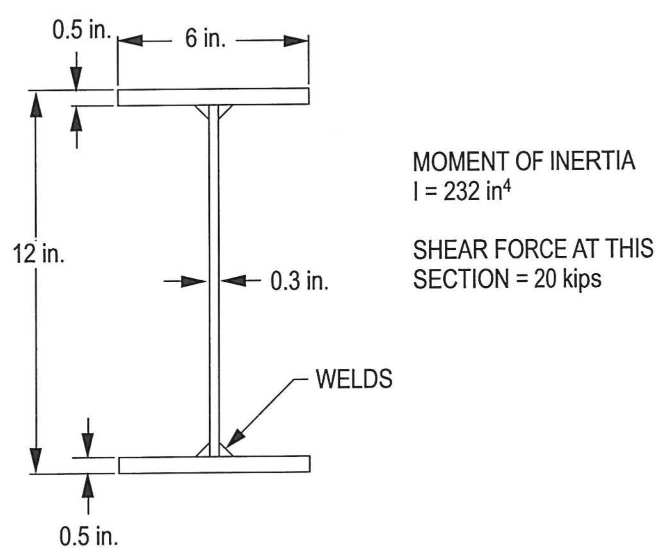
(B) W14 × 30

(C) W14 × 34

(D) W14 × 90

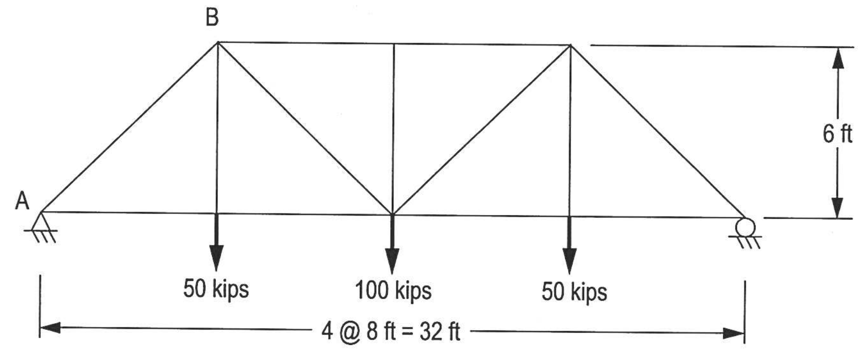
524. For the section shown, the unit shear force (kips/in.) in the welds connecting the top flange to the web (total unit shear in the two weld lines combined) is most nearly:

(A) 1.5
(B) 3.0
(C) 5.5
(D) 10.0



525. Referring to the loaded truss shown in the figure, the force (kips) in Member AB is most nearly:

(A) 100 (compression)
(B) 125 (compression)
(C) 167 (tension)
(D) 167 (compression)

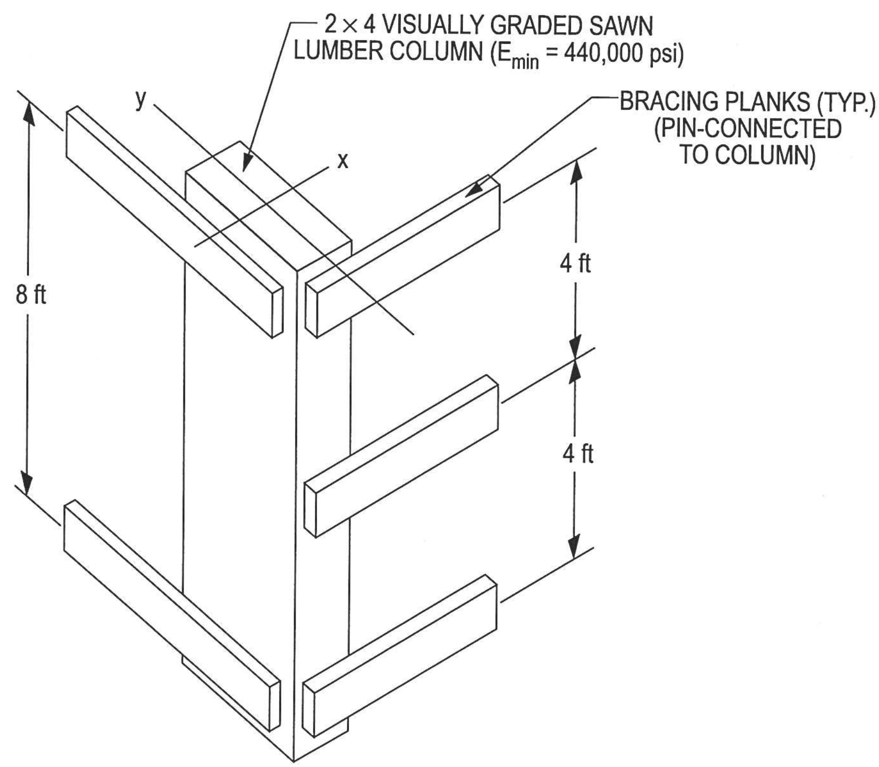


526. The figure shows a timber column.

Building Code:
NDS: *National Design Specification for Wood Construction ASD/LRFD,* 2012 edition and *National Design Specification Supplement, Design Values for Wood Construction*, 2012 edition.

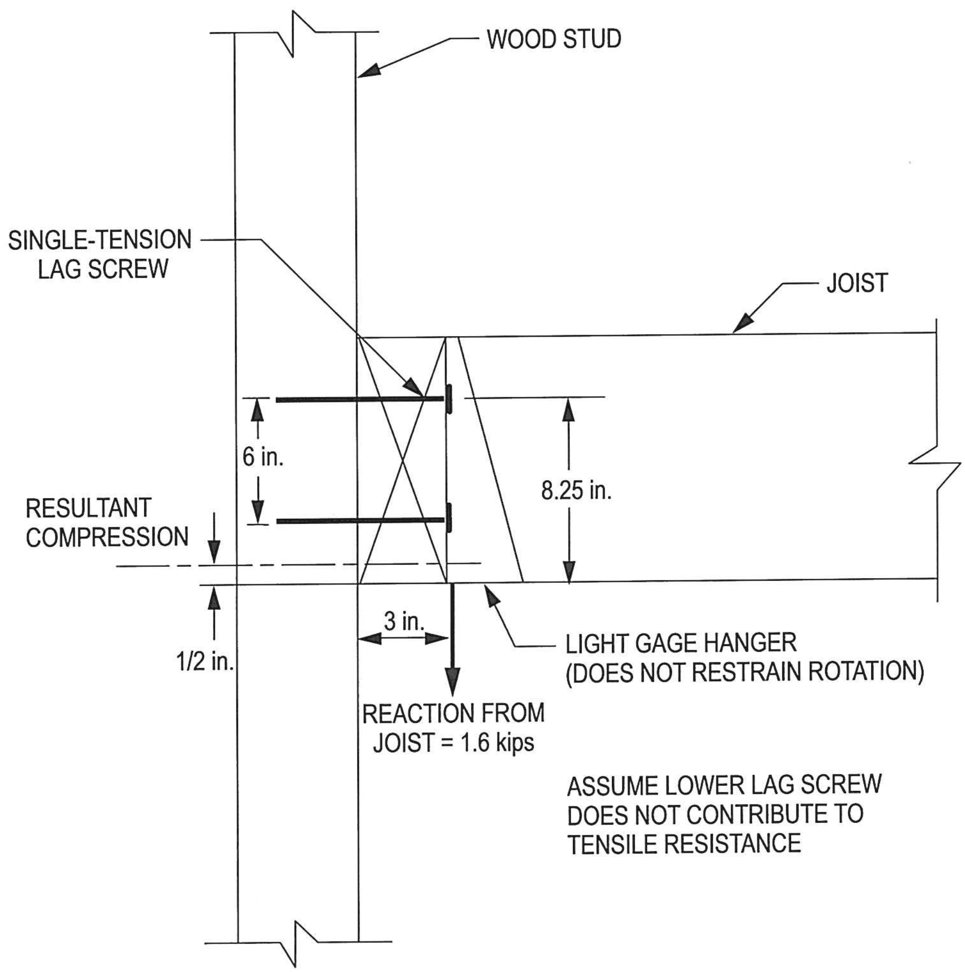
Assuming dry service, normal temperature conditions, and C_i = 1.00, the critical buckling design value F_{cE} (psi) using allowable stress design for the column is most nearly:

(A) 150
(B) 350
(C) 475
(D) 500



527. A lag screw connection is shown in the figure. The tensile force (lb) in the top lag screw is most nearly:

(A) 582
(B) 619
(C) 800
(D) 2,400



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528. A connection is shown in the figure.

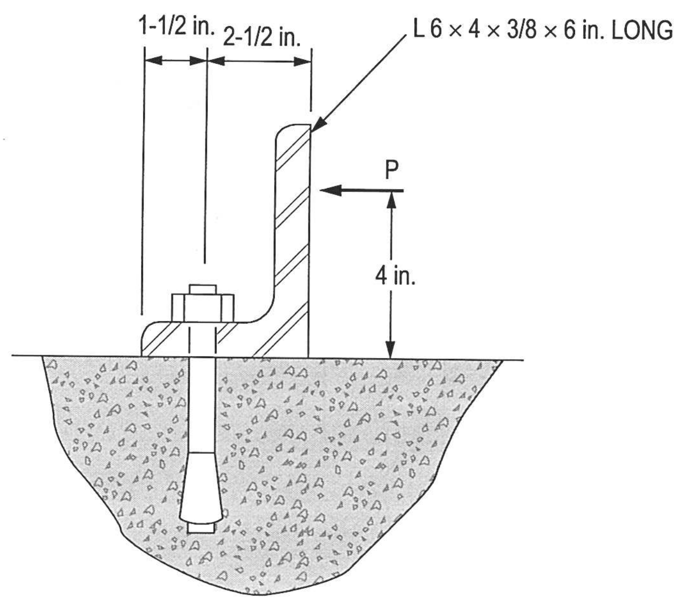
Design Code:
AISC: *Steel Construction Manual,* 14th edition.

Material:
A36 steel

Assumptions:
The bolt is sufficient.
The concrete is sufficient.
The load P is equally distributed along the entire 6-in.-long angle.

The maximum load P (ASD) or ϕP_n (LRFD) in kips that can be carried by the angle is most nearly:

	ASD	**LRFD**
(A)	1.1	1.7
(B)	1.4	2.4
(C)	1.6	2.7
(D)	2.0	3.4



529. The following information applies to the roof diaphragm shown in the figure:

Story Drifts:
Wall A 0.30 in.
Wall B 0.50 in.

Diaphragm: wood constructed in accordance with applicable codes.
Diaphragm in-plane deflection: V = 1.00 in. (of the diaphragm itself)
Diaphragm deflections can be tolerated.

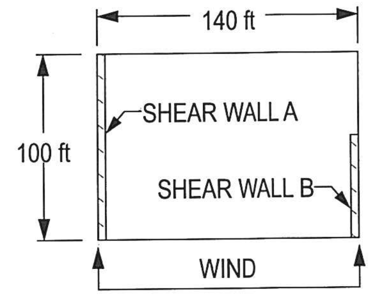
The diaphragm can be characterized as:

(A) flexible

(B) flexible, torsionally irregular

(C) rigid, torsionally irregular

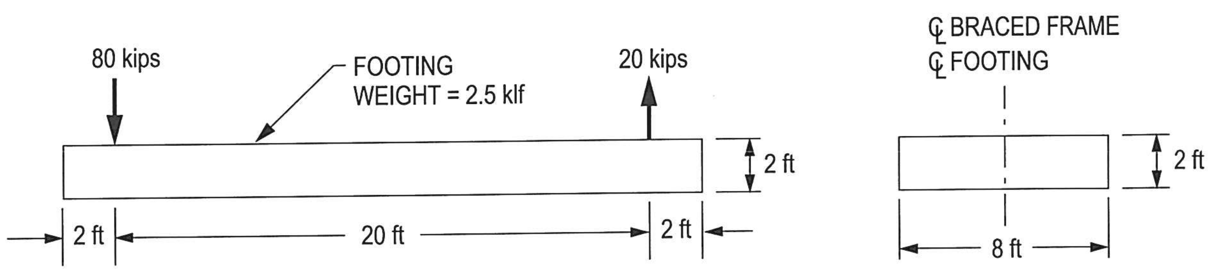
(D) rigid, torsionally regular



ROOF PLAN

530. The concrete footing shown is subjected to loads from a braced frame. Assume the footing is rigid compared to the soil. The maximum bearing pressure (ksf) under the footing is most nearly:

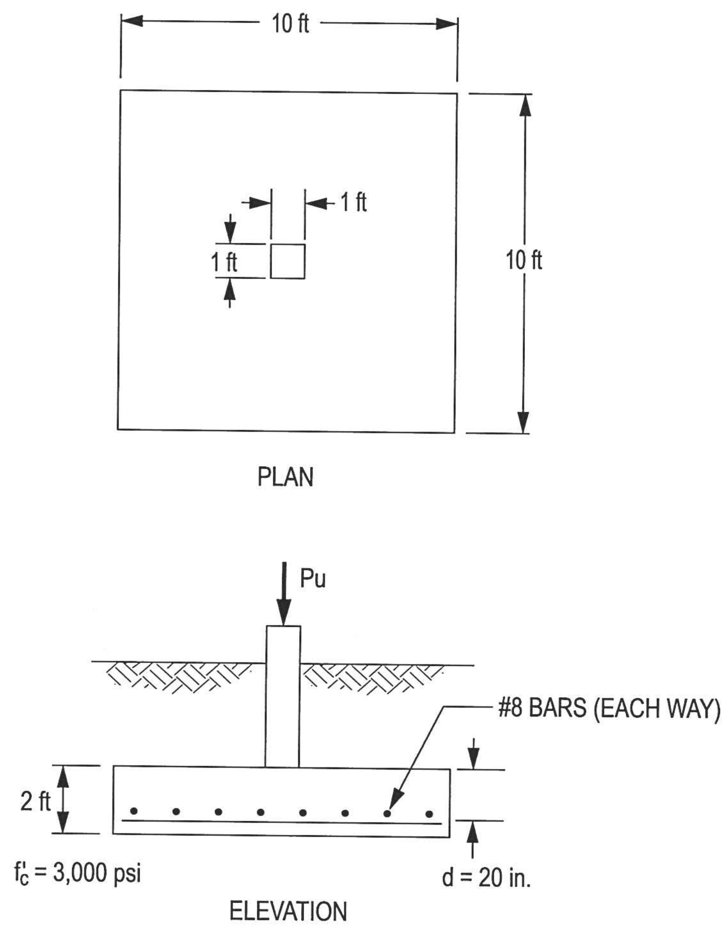
(A) 0.5
(B) 1.0
(C) 2.0
(D) 2.7



SECTION

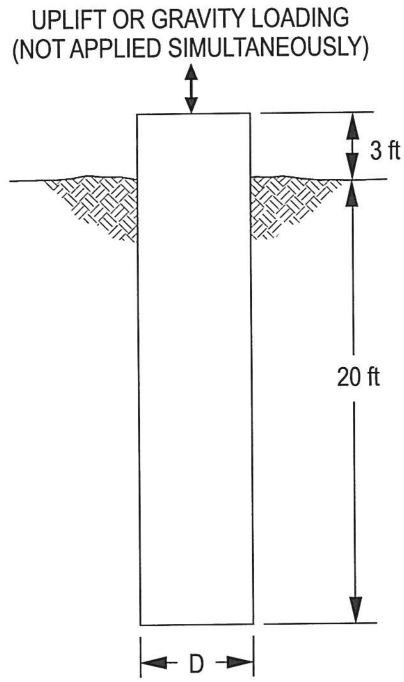
531. The figure shows a cast-in-place reinforced concrete spread footing for an interior column that is concentrically loaded. Punching shear controls the footing thickness in the design. Neglecting the shear strength of reinforcing, the design punching shear capacity of the footing (kips) per ACI 318-11, excluding Appendix C, is most nearly:

(A) 870
(B) 680
(C) 560
(D) 420



532. A concrete caisson is subjected to two separate loading conditions: a net uplift of 100 kips, or a net gravity load of 75 kips. The loads are not applied simultaneously. The allowable soil skin friction is 200 psf, and the allowable soil bearing pressure is 4,000 psf. Neglecting the weight of the caisson, the required caisson diameter (ft) is most nearly:

(A) 8
(B) 7
(C) 6
(D) 5



533. Assuming a bearing-type connection, the load capacity (kips) for a 1-in.-diameter A307 through bolt in double shear is most nearly:

	ASD	LRFD
(A)	10.6	15.9
(B)	21.2	31.9
(C)	28.4	53.0
(D)	56.9	56.7

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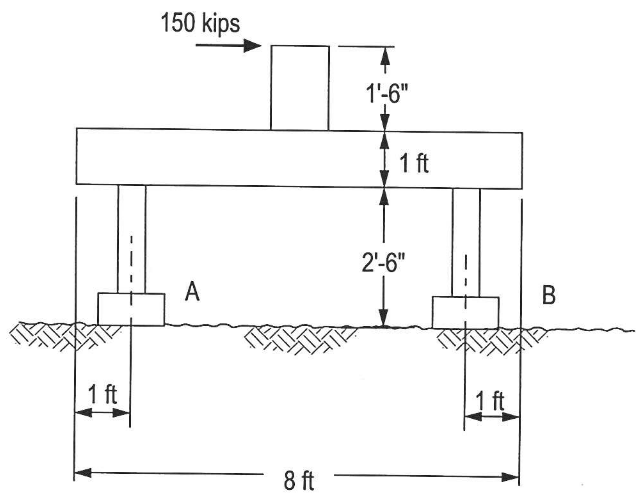
534. The following information applies to the structure shown in the figure:

Neglect beam weight.
Beam is infinitely stiff.
Footing size is 24 in. × 24 in. at each footing.
Soil vertical modulus of subgrade, $K = 100\ \text{lb/in}^3$

The vertical settlement (in.) of the footing at B is most nearly:

(A) 2.2
(B) 1.6
(C) 1.1
(D) 0.7



535. The cross section for a 50-ft-span, rectangular, prestressed beam is shown in the figure. The beam has no mild reinforcing steel.

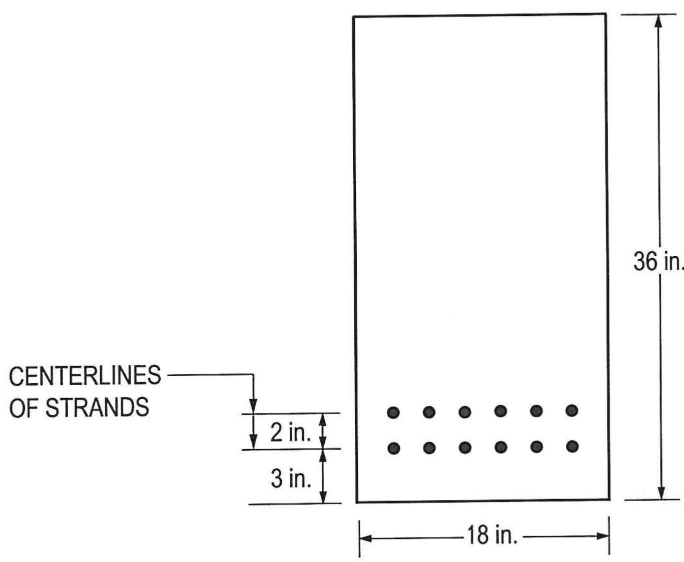
Design Code:
PCI: *PCI Design Handbook: Precast and Prestressed Concrete,* 7th edition, 2010.

Design data for prestressing strands:

Low relaxation – 1/2-in. diameter
$f_{pu} = 270$ ksi
$A_s = 0.153$ in^2 per strand
Stress at release = 175 ksi per strand (after initial losses)

If the top fiber stress at the midspan of the beam due to the beam self-weight is 0.65 ksi, the total top fiber stress (ksi) at release at midspan is most nearly:

(A) 0.01 (tension)
(B) 0.50 (tension)
(C) 0.99 (compression)
(D) 2.29 (compression)



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536. A backfill material is described as sand-silt clay mix with plastic fines. The Unified Soil Classification is SM-SC. Per ASCE 7, the estimated design lateral soil load (psf/foot of depth) for relatively non-rigid walls is most nearly:

(A) 35
(B) 45
(C) 85
(D) 100

537. A building is to be constructed on a site defined as Site Class E with a 0.2-sec mapped spectral response acceleration of 100% g. Per IBC 2012, the design spectral response acceleration at short periods is most nearly:

(A) 0.60
(B) 0.73
(C) 0.90
(D) 1.60

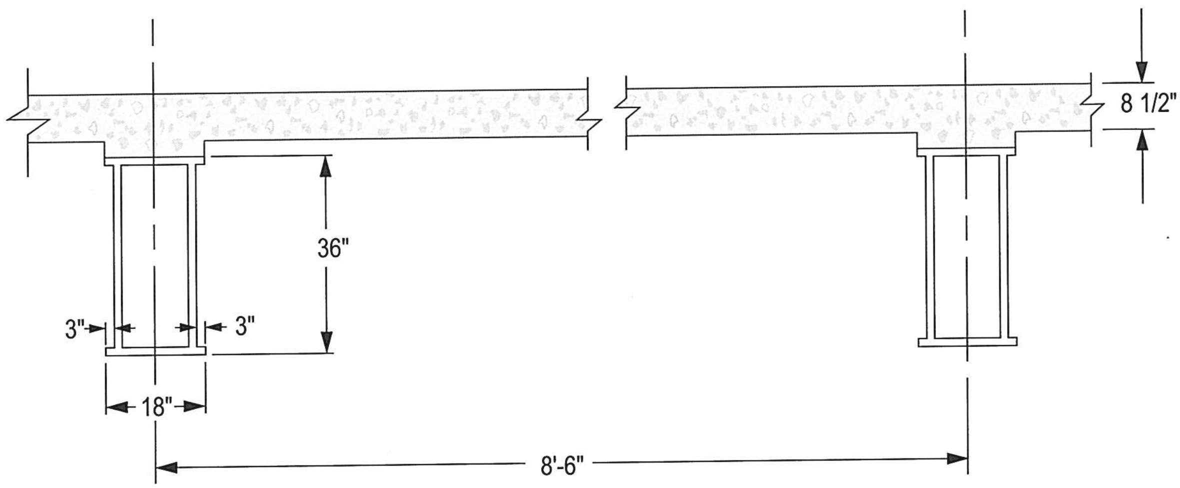
GO ON TO THE NEXT PAGE

538. The figure shows a cross section of a deck slab of a steel girder bridge.

Design Code:
AASHTO LRFD Bridge Design Specifications, 6th edition, 2012.

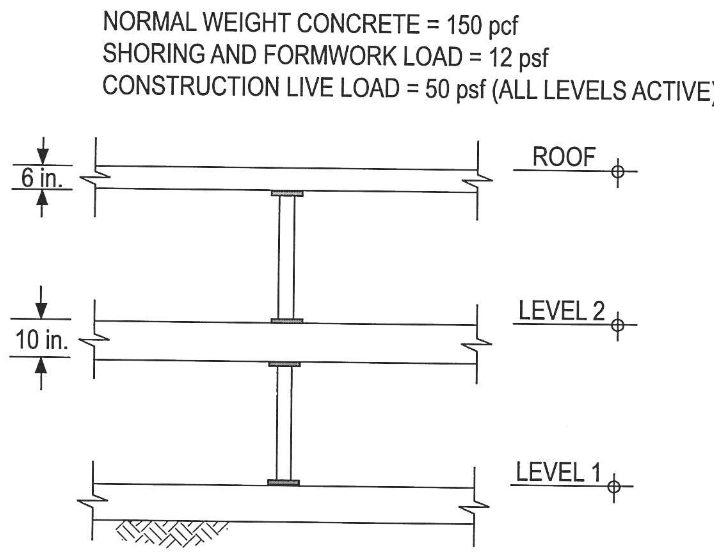
The effective span length L_{eff} to be used for the empirical design of the deck slab is most nearly:

(A) 6' 9"
(B) 7' 0"
(C) 7' 3"
(D) 8' 6"



539. The formwork and shoring are in place at both levels of the two-story building shown. Shores are spaced at 6 ft on center. Assume all Level 2 loads are carried by the formwork and shoring during the roof pour. During placement of concrete at the roof, the service load (lb) in a shore at Level 1 is most nearly:

(A) 4,930
(B) 9,860
(C) 11,650
(D) 15,420



540. The first five 28-day average standard-cured concrete strength tests are shown below.

Test	28-Day Average f'_c	Date
1	4,215	March 3
2	4,160	March 7
3	3,625	March 11
4	4,010	March 12
5	4,015	March 16

The required $f'_c = 4{,}000$ psi. Which of the following statements is true?

(A) The concrete is unsatisfactory because the average of the last three consecutive tests is less than the required f'_c.

(B) The concrete is unsatisfactory because Test 3 did not meet the required f'_c.

(C) The concrete is satisfactory because the average of the first three tests is greater than or equal to the required f'_c.

(D) The concrete is satisfactory because Test 3 is within 500 psi of the required f'_c.

This completes the afternoon session. Solutions begin on page 83.

CIVIL AM SOLUTIONS

Answers to the Civil AM Practice Exam

Detailed solutions for each question begin on the next page.

101	D	**121**	A
102	C	**122**	A
103	C	**123**	C
104	D	**124**	B
105	C	**125**	C
106	B	**126**	B
107	C	**127**	C
108	D	**128**	B
109	B	**129**	D
110	B	**130**	D
111	A	**131**	C
112	A	**132**	D
113	C	**133**	A
114	D	**134**	C
115	B	**135**	B
116	D	**136**	C
117	C	**137**	B
118	D	**138**	D
119	A	**139**	C
120	C	**140**	C

CIVIL AM SOLUTIONS

101. Reference: Peurifoy and Oberlender, *Estimating Construction Costs,* 8th ed., Chapter 10, p. 273, Quantity Takeoff.

$$\text{Horizontal length of side slope} = 14 \times \frac{3}{2} = 21.0 \text{ ft}$$

$$\text{Slope length} = \sqrt{(14)^2 + (21)^2} = 25.24 \text{ ft}$$

$$\text{Cross-sectional area of lining} = \left[(2 \times 25.24) + 9\right]\frac{7}{12} = 34.70 \text{ ft}^2$$

$$\text{Volume of lining} = \frac{(34.70 \times 227)}{27} = 291.7 \text{ yd}^3$$

$$\text{Delivered volume} = 291.7 \text{ yd}^3 \times \underset{\text{(waste)}}{1.12} = 327 \text{ yd}^3$$

THE CORRECT ANSWER IS: (D)

102. Reference: Nunnally, *Construction Methods and Management*, 8th ed., 2011, p. 299.

$$D = \frac{\$75{,}000 - \$10{,}000}{10}$$

$$D = \$6{,}500$$

$$\text{Book value after 8 years} = \$75{,}000 - (8)(\$6{,}500) = \$23{,}000$$

THE CORRECT ANSWER IS: (C)

103. Reference: AGC, *Construction Planning and Scheduling*, pub. 3500.1, 6th ed., p. 37.

$$\text{Crew cost} = 2(\$50/\text{hr}) = \$100/\text{hr}$$

$$\text{Days allowed} = \frac{\$4{,}000}{(8 \text{ hr/day})(\$100/\text{hr})} = 5 \text{ days}$$

THE CORRECT ANSWER IS: (C)

104. Reference: Nunnally, *Construction Methods and Management*, 8th ed., 2011, pp. 282–285.

Activities: ⑦ + ④ + ⑤

Days: 30 + 10 + 10 = 50 days

THE CORRECT ANSWER IS: (D)

105. Reference: Ricketts, Loftin, and Merritt, *Standard Handbook for Civil Engineers*, 5th ed., p. 4.11.

$$1{,}000 \text{ kN} = 1{,}000 \text{ kN} \times \frac{1 \text{ ton}}{8.896444 \text{ kN}} = 112.4 \text{ tons}$$

150 tons > 112.4 tons

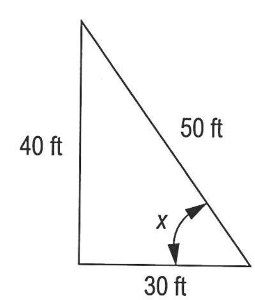
THE CORRECT ANSWER IS: (C)

106. Reference: Shapiro, Shapiro, and Shapiro, *Cranes and Derricks*, 3rd ed., 2000, p. 244.

$$\tan(x) = \frac{40}{30} \quad x = 53.13°$$

$$\cos(51.13°) * 100 \text{ ft} = 60 \text{ ft}$$

$$60 \text{ ft} - 35 \text{ ft} = 25 \text{ ft}$$



THE CORRECT ANSWER IS: (B)

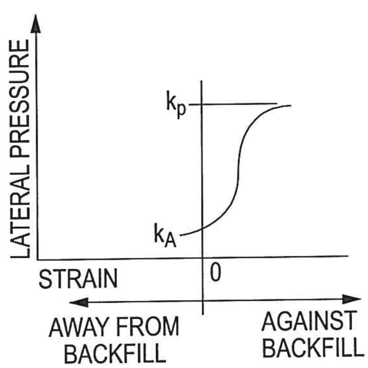
107. Reference: Hurd, *Formwork for Concrete*, ACI SP-4, 7th ed., 2005.

$$w = (20 \text{ lb/ft}^2)(8 \text{ ft}) = 160 \text{ lb/vertical ft per brace location}$$
$$\sum M_a = 0$$
$$\sum M_a = (160 \text{ lb/ft})(16 \text{ ft})(16 \text{ ft}/2) - 10 \text{ ft } (R_x) = 0$$
$$R_x = 2{,}048 \text{ lb}$$
$$\text{Axial load in brace} = \frac{(2{,}048)\sqrt{2}}{1} = 2{,}896 \text{ lb}$$

THE CORRECT ANSWER IS: (C)

108. Reference: NAVFAC, DM 7.2-60.

The wall translation (or strain) required to achieve the passive state is at least twice that required to reach the active state.



THE CORRECT ANSWER IS: (D)

109. The solution is based on the knowledge that consolidation settlement is the result of the expulsion of pore water from saturated soil due to imposed load. Therefore, the volume of the wick drain effluent (water) to be treated equals the consolidation settlement volume over the affected site area, and is computed as follows:

Affected area	$= 21.5 \text{ acres} \times 43{,}560 \text{ ft}^2/\text{acre} = 936{,}540 \text{ ft}^2$
Mean consolidation settlement over affected area	$= 22 \text{ in.} = 1.83 \text{ ft}$
Settlement volume = effluent volume	$= 936{,}540 \text{ ft}^2 \times 1.83 = 1{,}713{,}868 \text{ ft}^3$
Convert to gal: $1{,}713{,}868 \text{ ft}^3 \times 7.48 \text{ gal/ft}^3$	$= 12{,}819{,}733 \text{ gal}$
Cost for effluent treatment and disposal	$= 12{,}819{,}733 \text{ gal} \times \$0.25/\text{gal}$
	$= \$3{,}204{,}934$

THE CORRECT ANSWER IS: (B)

110. Reference: Terzaghi, Peck, Mesri, *Soil Mechanics in Engineering Practice*, 3rd ed., p. 84,

Effective vertical stress at Point A, σ'_v

$$= 10\text{ ft} \times 120\text{ pcf} + 5\text{ ft}(120\text{ pcf} - 62.4\text{ pcf}) + 7\text{ ft}(110\text{ pcf} - 62.4\text{ pcf})$$
$$= 1{,}200\text{ psf} + 288\text{ psf} + 333\text{ psf}$$
$$= 1{,}821\text{ psf}$$

THE CORRECT ANSWER IS: (B)

111. The ultimate bearing capacity would be based on buoyant unit weight, also referred to as the effective unit weight.

Effective unit weight = saturated unit weight – unit weight of water

THE CORRECT ANSWER IS: (A)

112. References: Coduto, *Foundation Design Principles and Practice*, 2nd ed., p. 250.

The long-term settlement for Case I is less than Case II because clay is subject to long-term settlement.

THE CORRECT ANSWER IS: (A)

113. References: Day, *Geotechnical and Foundation Engineering*, 1999, p. 10-27, and NAVFAC 7.1-329.

The minimum factor of safety for permanent slopes is 1.5. Other references use a factor of safety greater than or equal to 1.3, but of the options presented 1.5 is the closest.

THE CORRECT ANSWER IS: (C)

114. Since the structure is cantilevered, in addition to the wind, dead load and live load will contribute to uplift.

THE CORRECT ANSWER IS: (D)

115. By inspection, Member b = 0 kips, and Member c = 100 kips.

THE CORRECT ANSWER IS: (B)

116. Beam stress, $f = M/S$, where $M = wL^2/8$ and $S = bh^2/6$.
S is equal for both beams, but M varies because it depends on beam length.

Beam 1 (shorter beam): $M_1 = wL^2/8$

Beam 2 (longer beam): $M_2 = w(2L)^2/8 = 4wL^2/8$

M_2 is four times greater than M_1. Therefore the maximum bending stress is four times greater in the longer beam.

THE CORRECT ANSWER IS: (D)

117. Uniform load: $V = \frac{wL}{2} = \frac{1(30)}{2} = \frac{30\text{ kips}}{2} = 15\text{ kips}$

Point load: $V = \frac{P}{2} = 15\text{ kips}$

$P = 2(15) = 30\text{ kips}$

THE CORRECT ANSWER IS: (C)

118. I_x is maximum for this section by inspection, or calculate $I_x \approx \Sigma Ad^2$ for each section.

THE CORRECT ANSWER IS: (D)

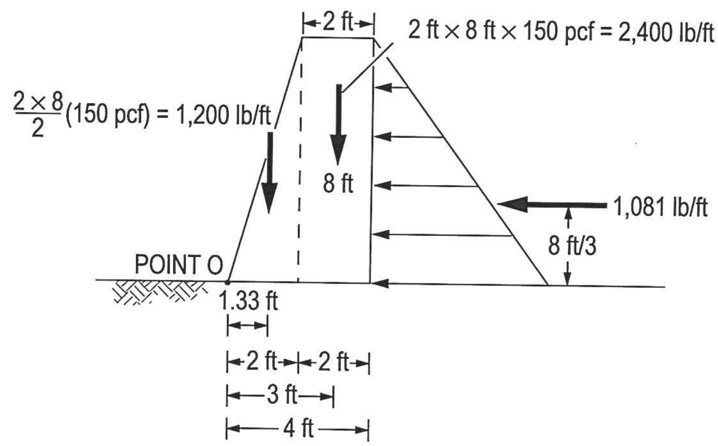
119. $\phi = 32°$ $\quad K_a = \tan^2(45 - \phi/2) = 0.307$

$\gamma_t = 110 \text{ pcf} \quad P_a = (0.5)(110)(8)^2(0.307) = 1{,}081 \text{ lb/ft}$

$M_a = (1{,}081)(8/3) = 2{,}883 \text{ ft-lb/ft}$

$$\left.\begin{array}{l}(2)(8)(150)(1)(3) = 7{,}200 \text{ ft-lb/ft} \\ (1/2)(2)(8)(150)(1)(2)(2/3) = 1{,}600 \text{ ft-lb/ft}\end{array}\right\} \text{total} = 8{,}800 \text{ ft-lb/ft}$$

$SF = 8{,}800/2{,}883 = 3.05$



THE CORRECT ANSWER IS: (A)

120. Reference: Mott, *Applied Fluid Mechanics*, 6th ed., 2005, p. 450.

$$Q = VA = \left\{\frac{1.49}{n} R^{2/3} S^{1/2}\right\} A$$

$$= \left\{\frac{1.49}{0.022}\left[\frac{(1.5\text{ ft} \times 4\text{ ft})}{4\text{ ft} + 2(1.5\text{ ft})}\right]^{2/3} (0.002)^{1/2}\right\}(1.5\text{ ft} \times 4\text{ ft})$$

$$= 16.4\text{ cfs}$$

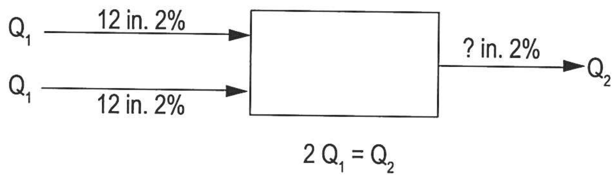
$$\text{Volume} = 25\text{ acre-ft} \times \frac{43{,}560\text{ ft}^3}{1\text{ acre-ft}} = 1.089 \times 10^6\text{ ft}^3$$

$$\text{Time} = \frac{1.089 \times 10^6\text{ ft}^3}{16.4\text{ ft}^3/\text{sec}} \times \frac{1\text{ min}}{60\text{ sec}} \times \frac{1\text{ hr}}{60\text{ min}}$$

$$= 18.5\text{ hours}$$

THE CORRECT ANSWER IS: (C)

121.



Reference: Viessman and Lewis, *Introduction to Hydrology*, 4th ed., 1996, p. 252.

$$2[V_1A_1]=[V_2A_2]$$

$$2\left[\left(\frac{1.49}{n}\right)(A_1)R_1^{2/3}S^{1/2}\right]=\left[\left(\frac{1.49}{n}\right)(A_2)R_2^{2/3}S^{1/2}\right]$$

$$2\left[(A_1)\left(\frac{A_1}{P_1}\right)^{2/3}\right]=\left[(A_2)\left(\frac{A_2}{P_2}\right)^{2/3}\right]$$

$$A_1=\frac{\pi D^2}{4}=\frac{\pi(1)^2}{4}=0.785\ \text{ft}^2$$

$$P_1=\pi(D)=\pi(1)=3.14\ \text{ft}$$

$$2\left[(0.785)\left(\frac{0.785}{3.14}\right)^{2/3}\right]=\left[\left(\frac{\pi D_2^2}{4}\right)\left(\frac{\frac{\pi(D_2)^2}{4}}{(\pi D_2)}\right)^{2/3}\right]$$

$$0.623=\left(\frac{\pi D_2^2}{4}\right)\left(\frac{D_2}{4}\right)^{2/3}$$

$$=\pi\left(\frac{D_2^2}{4}\right)\left(\frac{D_2}{4}\right)^{2/3}$$

$$=\pi(D_2)^{8/3}\left(\frac{1}{4}\right)\left(\frac{1}{4}\right)^{2/3}$$

$$0.623=0.311(D_2)^{8/3}$$

$$\left(\frac{0.623}{0.311}\right)^{3/8}=D_2$$

$$D_2=1.297\ \text{ft}\times\frac{12\ \text{in.}}{\text{ft}}=15.6\ \text{in.}\approx 16\ \text{in.}$$

THE CORRECT ANSWER IS: (A)

122. Reference: Mays, *Water Resources Engineering*, 2001, p. 211.

According to the arithmetic mean method, the average precipitation is simply the average of all the rainfall gages.

Average precipitation = (2.1 + 3.6 + 1.3 + 1.5 + 2.6 + 6.1 + 5.1 + 4.8 + 4.1 + 2.8 + 3.0)/11

Average precipitation = 3.4 in.

THE CORRECT ANSWER IS: (A)

123. Reference: *Water Supply and Pollution Control,* Viessman and Hammer, 6th ed., 1998, p. 229.

From the IDF curve, read a rainfall intensity of 3.5 in./hr for a 50-year frequency rainfall with a 60-min duration.

From the table, the runoff coefficient for a downtown area is 0.70 – 0.95. For the maximum runoff rate, use the high value of 0.95.

$Q = CiA = 0.95 \times 3.5$ in./hr $\times$ 90 ac

$Q = 300$ cfs

THE CORRECT ANSWER IS: (C)

124. Reference: Davis and Cornwell, *Introduction to Environmental Engineering*, 4th ed., 2008, p. 61.

$$\text{Time} = \frac{\text{V}}{\text{Q}}$$

$$\text{V} = 400{,}000 \text{ gal} \times \frac{\text{ft}^3}{7.48 \text{ gal}} = 53{,}476 \text{ ft}^3$$

$$\text{Q} = 1.5 \text{ ft}^3/\text{sec}$$

$$\text{Time} = \frac{53{,}476 \text{ ft}^3}{1.5 \text{ ft}^3/\text{sec}} \times \frac{1 \text{ hr}}{3{,}600 \text{ sec}} = 9.9 \text{ hours}$$

THE CORRECT ANSWER IS: (B)

125. Reference: Merritt, Loftin, and Ricketts, *Standard Handbook for Civil Engineers*, 4th ed., 1996, pp. 21.22 and 21.42.

The Darcy-Weisbach equation is $h_f = f\frac{L}{D}\frac{V^2}{2g}$

where

h_f = headloss, ft
f = friction factor, unitless
L = length, ft
D = diameter of pipe, ft
V = velocity, ft/sec
g = gravitational constant, 32.2 ft/sec^2

Substituting gives

$$5\text{ ft} = 0.0115 \times \frac{1{,}650\text{ ft}}{3.0\text{ ft}} \times \frac{V^2}{2 \times 32.2\text{ ft/sec}^2}$$

$$V^2 = 50.91\text{ ft}^2/\text{sec}^2$$

$$V = 7.135\text{ ft/sec}$$

$$Q = VA = V \times \frac{\pi}{4}D^2 = 7.135\text{ ft/sec} \times \frac{\pi}{4}(3.0\text{ ft})^2$$

$$Q = 50\text{ cfs}$$

THE CORRECT ANSWER IS: (C)

126. Reference: Lin, Shundar, and C.C. Lee, *Water and Wastewater Calculations Manual*, 2001, p. 240.

$$z_1 + \frac{P_1}{\gamma} + \frac{v_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{v_2^2}{2g}$$

$$z_1 = z_2$$

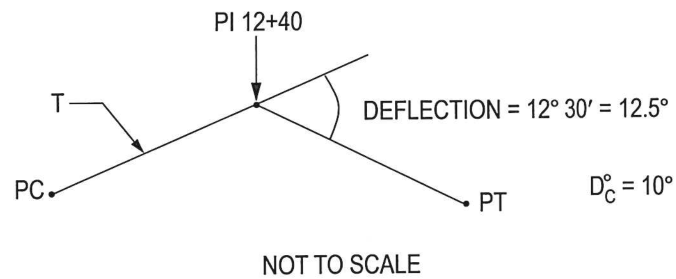
Since $A_1 > A_2$, $v_1 < v_2$.

$$\therefore \frac{v_1^2}{2g} < \frac{v_2^2}{2g}$$

so $P_1 > P_2$ to balance

THE CORRECT ANSWER IS: (B)

127. Reference: Hickerson, *Route Location and Design*, 5th ed., p. 64.



$R = 5{,}729.648/D^{\circ}_{C}$

$= 5{,}729.648/10 = 572.96$ ft

$T = R \tan\left(\frac{1}{2}\Delta\right) = R \tan(6.25°)$

$= 572.96 (\tan 6.25°)$

$= 572.96 (0.1095178)$

$= 62.75$ ft

Station PC $=$ Station PI $-$ T

$= [12+40] - 62.75$

$= 11 + 77.25$

Station PT $=$ Station PC $+$ length of curve

Length of curve $= L = 100\ \Delta/D^{\circ}_{C}$

$= 100(12.5)/10 = 125$ ft

Station PT $=$ Station PC $+ 125$ ft $= [11+77.25] + 125 = 13 + 02.25$

THE CORRECT ANSWER IS: (C)

128. Reference: Hickerson, *Route Location and Design*, 5th ed., pp. 154, 160.

$L = KA$
$K = L/A$
L = length of vertical curve, ft
A = algebraic difference in grades, percent $(g_2 - g_1)$
Given: VPC = 12+00
VPI = 13+50
VPT = 15+00
$g_1 = -2.30\%$
$g_2 = +3.00\%$
$L = 300$ ft

$$K = \frac{L}{A} = \frac{300}{3-(-2.3)} = 56.60 \text{ ft/percent for the vertical curve.}$$

The length from Station 14+00 to Station 15+00 = 100 ft

$$K = \frac{L}{A}$$

$$A = \frac{L}{K} = \frac{100}{56.60} = 1.77\%$$

$$A = g_2 - g_1$$

Tangent slope at Station 14+00 = g_1

$$g_1 = g_2 - A = 3.00\% - 1.77\% = 1.23\%$$

Alternate solution:

Y = elevation at a point X ft from VPC
Y' = slope at a point X ft from VPC
$X = [14+00] - [12+00] = 200$ ft
g_1 = slope 1 in ft/ft
g_2 = slope 2 in ft/ft
L = length of vertical curve, ft

$$Y = Y_{VPC} + g_1 X + \left(\frac{g_2 - g_1}{2L}\right) X^2$$

$$Y' = g_1 + \left(\frac{g_2 - g_1}{L}\right) X$$

$$Y' = -0.023 + \left(\frac{0.03 - (-0.023)}{300}\right) 200 = 0.0123 \text{ ft/ft or } 1.23\%$$

THE CORRECT ANSWER IS: (B)

129. Reference: Garber and Hoel, *Traffic & Highway Engineering,* 4th ed., pp. 130–132.

$$\text{AADT} = \frac{\Sigma(\text{Jan. through Dec.})}{12}$$
$$= 833{,}200 / 12 = 69{,}433$$

$$\Sigma(\text{June through Aug.}) = 77{,}300$$
$$78{,}950$$
$$\underline{77{,}200}$$
$$233{,}450 / 3 = 77{,}817$$

Seasonal factor for June through August

$$= 77{,}817 / 69{,}433$$
$$= 1.121$$

THE CORRECT ANSWER IS: (D)

130. Reference: Garber and Hoel, *Traffic & Highway Engineering*, 3rd ed., p. 841.

The commonly used soil classification systems for engineering applications are USCS and AASHTO. Both of these systems use gradation and Atterberg limits as two of the criteria.

THE CORRECT ANSWER IS: (D)

131. Reference: Coduto, Yeung, and Kitch, *Geotechnical Engineering: Principles and Practices,* 2nd ed., p. 184.

The Standard Penetration Test (SPT) N-value provides an indication of the relative density of cohesionless soils.

THE CORRECT ANSWER IS: (C)

132. Reference: *Design and Control of Concrete Mixtures*, 14th ed., p. 242.

An early-strength concrete is needed with a minimum compressive strength of 3,500 psi. To achieve the requirements, a Type III cement and chemical accelerators would be necessary.

THE CORRECT ANSWER IS: (D)

133. Reference: NCEES, *FE Reference Handbook.*

Reduction in strength due to cyclical loads

THE CORRECT ANSWER IS: (A)

134. Area $= \pi d^2/4 = 28 \text{ in}^2$

Compressive stress = axial load/area

Sample 1 $\quad f'_c = \dfrac{65{,}447}{28} = 2{,}313 \text{ psi}$

Sample 2 $\quad f'_c = \dfrac{63{,}617}{28} = 2{,}248 \text{ psi}$

Sample 3 $\quad f'_c = \dfrac{79{,}168}{28} = 2{,}797 \text{ psi}$

Average $= \dfrac{(2{,}313 + 2{,}248 + 2{,}797)}{3} = 2{,}452 \text{ psi}$

THE CORRECT ANSWER IS: (C)

135. Reference: Garber and Hoel, *Traffic & Highway Engineering,* 4th ed., p. 901.

$$\text{Total density}\left(\gamma\right)=\frac{W}{V}=\frac{W_s+W_w}{V_s+V_w+V_a}$$

where γ = total density

W = total weight

V = total volume

W_s = weight soil

W_w = weight of water

V_s = volume of soil

V_w = volume of water

V_a = volume of air

$$\gamma=\frac{9.11\ \text{lb}-4.41\ \text{lb}}{0.03\ \text{ft}^3}=156.67\ \text{lb/ft}^3\ (\text{pcf})$$

$$\text{Dry unit weight of soil}\left(\gamma_d\right)=\frac{\gamma}{1+w}$$

where w = moisture content

$$\gamma_d=\frac{156.67\ \text{pcf}}{1+0.115}=140.51\ \text{pcf}$$

THE CORRECT ANSWER IS: (B)

136. Reference: Kavanagh, *Surveying with Construction Applications*, 6th ed., 2007, pp. 569–573.

Use Average End Area Method.

Stationing	Excavation (yd^3)	Embankment (yd^3)
1+00 to 2+00	$\frac{50+150}{2}\times\frac{100}{27}=370$	
2+00 to 3+00	$\frac{50+0}{2}\times\frac{100}{27}=93$	$\frac{0+40}{2}\times\frac{100}{27}=74$
Total	**463**	**74**

Net excess excavated material = $463-74=389\ yd^3$

THE CORRECT ANSWER IS: (C)

137. Reference: Kavanagh, *Surveying with Construction Applications*, 6th ed., 2007, pp. 493–501.

Existing:

$$\Delta H=(2+88.4)-(0+23.0)=288.4-23.0=265.4\ \text{ft}$$

$$\Delta V=630.32-609.39=20.93\ \text{ft}$$

New:

$$\Delta H=(1+15.0)-(0+23.0)=115.0-23.0=92\ \text{ft}$$

$$\Delta V=\frac{92}{265.4}\times 20.93=7.26\ \text{ft}$$

Inv Elev. = 630.32 – 7.26 = 623.06 ft

The top of the pipe will be above the invert elevation by (60 in. – 6 in.)/12 in./ft = 4.50 ft

623.06 + 4.50 = 627.56 ft

THE CORRECT ANSWER IS: (B)

138. Reference: *Developing Your Stormwater Pollution Prevention Plan*, USEPA, May 2007, p. 3. Victor Miguel Ponce, *Engineering Hydrology*, 1st ed., p. 538.

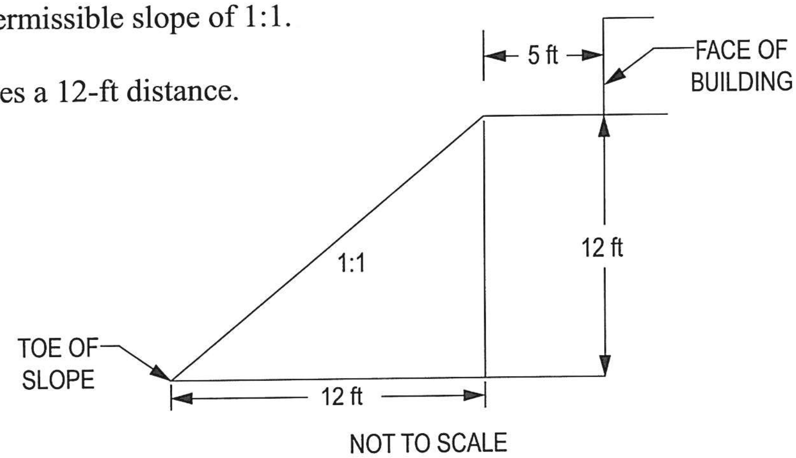
Rushing erosion is not identified in either reference.

THE CORRECT ANSWER IS: (D)

139. Reference: 29 CFR 1926 OSHA Regulations, Subpart P, Appendix B.

Type B soil has a maximum permissible slope of 1:1.

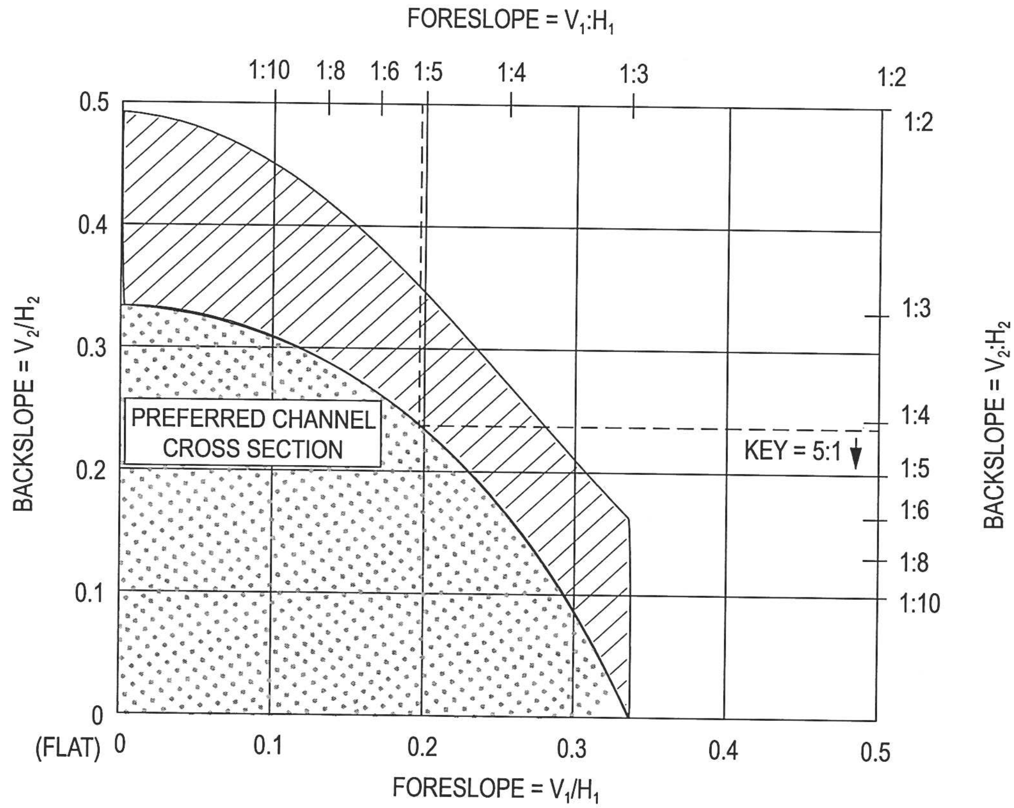
Therefore, a 12-ft depth requires a 12-ft distance.



Since there is a 5-ft perimeter strip, the minimum distance from the toe of the slope to the face of the structure = 12 ft +5 ft = 17 ft.

THE CORRECT ANSWER IS: (C)

140. Reference: AASHTO: *Roadside Design Guide,* 4th ed., 2011, pp. 3-9 and 3-10.



This area is applicable to all Vee ditches, rounded channels with a bottom width less than 2.4 m [8 ft], and trapezoidal channels with bottom widths less than 1.2 m [4 ft].

This area is applicable to rounded channels with bottom width of 2.4 m [8 ft] or more and to trapezoidal channels with bottom widths equal to or greater than 1.2 m [4 ft].

Adapted from AASHTO *Roadside Design Guide,* 4th edition, 2011.

THE CORRECT ANSWER IS: (C)

STRUCTURAL PM SOLUTIONS

Answers to the STRUCTURAL PM Practice Exam

Detailed solutions for each question begin on the next page.

501	C	**521**	B
502	B	**522**	A
503	A	**523**	C
504	C	**524**	A
505	C	**525**	D
506	D	**526**	B
507	B	**527**	B
508	D	**528**	A
509	C	**529**	A
510	D	**530**	D
511	C	**531**	D
512	B	**532**	A
513	B	**533**	B
514	B	**534**	A
515	B	**535**	A
516	A	**536**	C
517	D	**537**	A
518	D	**538**	C
519	A	**539**	C
520	A	**540**	A

STRUCTURAL PM SOLUTIONS

501. $p_f = 0.7\ C_e C_t I_s\ p_g$ eq. 7.3−1

where $C_e = 0.9$ (Table 7-2)

$C_t = 1.2$ (Table 7-3)

$I_s = 0.8$ (Table 1.5-2)

$p_g = 20$ psf

$p_f = (0.7)(0.9)(1.2)(0.8)(20)$

$= 12.1$ psf

$p_s = C_s p_f$ (Eq. 7.4-1) and $C_s = 1.0$ (Figure 7-2)

$= 1.0(12.1) = 12.1$

Unbalanced snow load $= I_s p_g$ (Paragraph 7.6.1)

$= 0.8(20)$

$= 16$ psf

16 psf controls

THE CORRECT ANSWER IS: (C)

502. $\dfrac{60(200)}{2} = 6$ kips

THE CORRECT ANSWER IS: (B)

503. Reference: IBC 2012/ASCE 7-10. IBC 2012 refers to ASCE 7-10.
Per ASCE 7-10, 11.7, (Seismic Design Category A)

$F = 0.01w$ w = dead load (eq. 1.4-1)

$= 0.01(200,000)$

$= 2,000$ lb

THE CORRECT ANSWER IS: (A)

504. Maximum moment occurs when load is at beam midspan.

$M = \dfrac{Pl}{4} = \dfrac{(20\text{ kips})(30\text{ ft})}{4} = 150$ ft-kips

THE CORRECT ANSWER IS: (C)

505. Take moments about Support B:

$$R_a \times 24 - 6.4 \times 24 - 2 \times 24^2/2 + 20 + 1.55 \times 8^2/2 + 1 \times 8 = 0$$

$$R_a = 28 \text{ kips}$$

THE CORRECT ANSWER IS: (C)

506. Calculate reactions by taking moments about Support A:

$$(6 \text{ kips})(5 \text{ ft}) + (1 \text{ kip/ft})(20 \text{ ft})(20 \text{ ft}/2) = R_B(20 \text{ ft})$$

$R_B = 11.5$ kips; $R_A = 14.5$ kips

Location of maximum moment is where shear diagram = 0

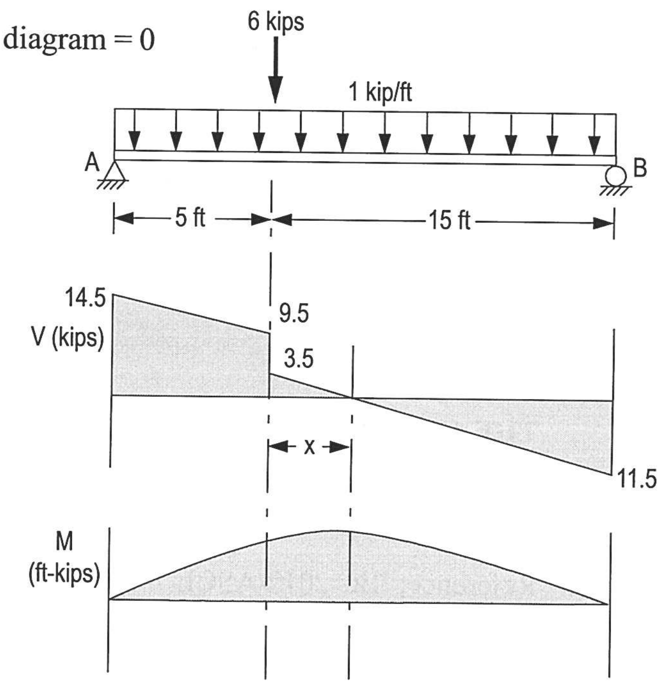
$$\frac{3.5 \text{ kips}}{x} = \frac{11.5 \text{ kips}}{(15 \text{ ft} - x)}$$

$$3.5(15 - x) = 11.5x$$

$$x = 3.5 \text{ ft}$$

Distance from right end:

$$20 \text{ ft} - (5 \text{ ft} + 3.5 \text{ ft}) = 11.5 \text{ ft}$$



THE CORRECT ANSWER IS: (D)

507. $FEM_{BA} = \dfrac{Pa^2b}{L^2} = \dfrac{(2)(12)^2(8)}{20^2} = 5.76$ ft-kips

$FEM_{BC} = \dfrac{wL^2}{12} = \dfrac{(1)(15)^2}{12} = 18.75$ ft-kips

$18.75 - 5.76 = 12.99$ ft-kips

THE CORRECT ANSWER IS: (B)

508. $n = \frac{E_{steel}}{E_{wood}} = \frac{29 \times 10^6}{1.6 \times 10^6} = 18.125$

$A'_{steel} = nwh = (18.125)(6)(0.125) = 13.6 \text{ in}^2$

$A_{wood} = wh = (6)(8) = 48 \text{ in}^2$

$A = A'_{steel} + A_{wood} = 13.6 + 48 = 61.6 \text{ in}^2$

$\Sigma \bar{y}A = (\bar{y}_{steel} \times A'_{steel}) + (\bar{y}_{wood} \times A_{wood}) = (0.0625)(13.6) + (4.125)(48) = 198.85 \text{ in}^3$

$c = \bar{y} = \frac{\Sigma \bar{y}A}{A} = \frac{198.85}{61.6} = 3.23 \text{ in.}$

$I_{wood} = \frac{b \times d^3}{12} + \left[A_{wood} \times (\bar{y}_{wood} - \bar{y})^2\right] = \frac{(6)(8)^3}{12} + (48)(4.125 - 3.23)^2 = 294.4 \text{ in}^4$

$I_{steel} = \frac{b' \times d^3}{12} + \left[A'_{steel} \times (\bar{y} - \bar{y}_{steel})^2\right]$

$= \frac{(18.125)(6)(0.125)^3}{12} + (13.6)(3.23 - 0.0625)^2 = 136.5 \text{ in}^4$

$I = I_{wood} + I_{steel} = 294.4 + 136.5 = 430.9 \text{ in}^4$

$S_{bottom} = \frac{I}{c} = \frac{430.9}{3.23} = 133 \text{ in}^3$

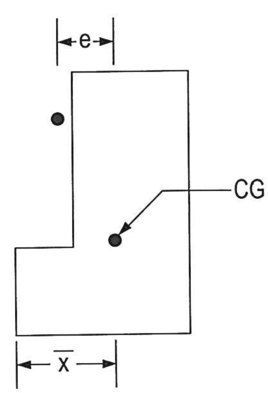
$M = \frac{P \times a \times b}{L} = \frac{(6)(4)(6)}{10} = 14.4 \text{ ft-kips}$

$f'_b = \frac{M}{S} = \frac{(14.4)(12 \text{ in./ft})}{133} = 1.3 \text{ ksi}$

$f_b = f'_b \times n = (1.3)(18.125) = 23.5 \text{ ksi}$

THE CORRECT ANSWER IS: (D)

509. $\bar{x} = \frac{(12 \text{ in.} \times 8 \text{ in.} \times 4 \text{ in.}) + (16 \text{ in.} \times 36 \text{ in.} \times 16 \text{ in.})}{(12 \text{ in.} \times 8 \text{ in.}) + (16 \text{ in.} \times 36 \text{ in.})} = 14.3 \text{ in.}$



$e = 8.3 \text{ in.}$

$W_{u/DT} = [1.2(10\text{psf}) + 1.6(50\text{psf})]15 \text{ ft} = 1{,}380 \text{ plf}$

$R_{u/DT} = \frac{1}{2}(1.38 \text{ klf})(60 \text{ ft}) = 41.4 \text{ kips}$

$T_u = 41.4 \text{ kips}\left(\frac{8.3 \text{ in.}}{12 \text{ in./ft}}\right) = 28.6 \text{ ft-kips}$

THE CORRECT ANSWER IS: (C)

510. Referring to the beam shown in the question, there is a zero moment at the hinge.

THE CORRECT ANSWER IS: (D)

511. $M_{max} = \frac{(200\text{ lb/ft})(20\text{ ft})^2}{8} + \frac{(1{,}000\text{ lb})(20\text{ ft})}{4}$

$= 10{,}000\text{ ft-lb} + 5{,}000\text{ ft-lb} = 15{,}000\text{ ft-lb}$

$I = \frac{(4\text{ in.})(12\text{ in.})^3}{12} = 576\text{ in}^4$

$f_b = \frac{Mc}{I}$

$= \frac{(15{,}000\text{ ft-lb})(6\text{ in.})}{576\text{ in}^4}(12\text{ in./ft})$

$f_b = 1{,}875\text{ psi}$

THE CORRECT ANSWER IS: (C)

512. $I = \frac{bd^3}{12} - \frac{b_1 d_1{}^3}{12} = \frac{8(12)^3 - 4(8)^3}{12} = 981\text{ in}^4$

$V = 1{,}000\text{ plf}\left(\frac{10\text{ ft}}{2}\right) + \left(\frac{4{,}000\text{ lb}}{2}\right) = 7{,}000\text{ lb}$

$v_{horizontal} = \frac{VQ}{IB} = \frac{7{,}000\text{ lb }(85\text{ in}^3)}{981\text{ in}^4(2 \times 2\text{ in.})} = 151\text{ psi}$

THE CORRECT ANSWER IS: (B)

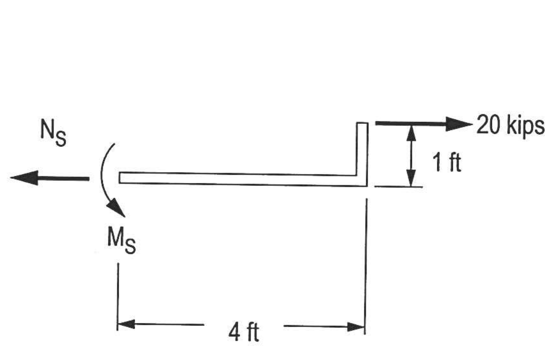
513. $M_S = 20\text{ ft-kips}$

$N_S = 20\text{ kips}$

$\sigma_{flexure} = \frac{(20\text{ ft-kips})(5\text{ in.})(12\text{ in./ft})}{90\text{ in}^4} = \pm 13.3\text{ ksi}$

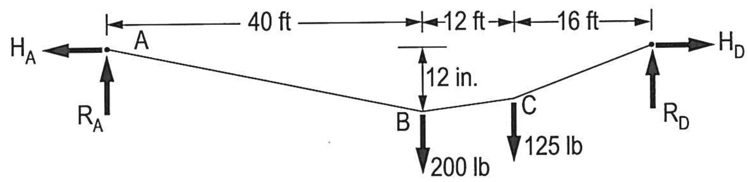
$\sigma_{axial} = \frac{20\text{ kips}}{7\text{ in}^2} = +2.9\text{ ksi}$

$\sigma_{total\ comp} = -13.3\text{ ksi} + 2.9\text{ ksi} = -10.4\text{ ksi}$



THE CORRECT ANSWER IS: (B)

514.



$$R_A = \frac{200\text{ lb} \times 28\text{ ft} + 125\text{ lb} \times 16\text{ ft}}{68\text{ ft}} = 111.76\text{ lb}$$

$$R_D = \frac{200\text{ lb} \times 40\text{ ft} + 125\text{ lb} \times 52\text{ ft}}{68\text{ ft}} = 213.24\text{ lb}$$

$$H_A = \frac{40\text{ ft}}{1\text{ ft}} \times R_A = 4{,}470.4\text{ lb}$$

$$H_A = H_D$$

$$F_{CD} = \sqrt{213.24^2 + 4{,}470.4^2}$$

$$F_{CD} = 4{,}475.5\text{ lb}$$

THE CORRECT ANSWER IS: (B)

515. $r_{EW} = r_{NS}$ $K_{EW} > K_{NS}$ Buckling in east-west direction will control.

THE CORRECT ANSWER IS: (B)

516. ACI 318-11, Table 4.2.1, 4.3.1, and Table 4.4.1 give 4.5%, with 1.5% tolerance.
$\therefore$ minimum = 4.5%

THE CORRECT ANSWER IS: (A)

517. Concrete reaches ultimate strain and fails prior to steel yielding. Failure is sudden without warning (brittle failure).

THE CORRECT ANSWER IS: (D)

518. Douglas Fir-Larch #2, $F_c = 1{,}350$ psi — Table 4A

$F_c^* = (F_c)(C_D)(C_M)(C_T)(C_F)(C_i)$ — Table 4.3.1

$= (1{,}350)(1.6)(1.0)(1.0)(1.15)(1.0) = 2{,}484$ psi

$F_c' = (F_c^*)(C_P)$ — Table 4.3.1

$= (2{,}484)(0.33) = 819.72$ psi

$A = bd = (1.5)(3.5) = 5.25\ \text{in}^2$

$P = F_c'\,A = (819.72)(5.25) = 4{,}303$ lb — Table 4.3.1

THE CORRECT ANSWER IS: (D)

519. Reference: ACI 530-11, Paragraph 2.3.6.1.5

The allowable shear stress resisted by the steel reinforcement is given by:

$$F_{vs} = 0.5\left[\frac{A_v F_s d}{A_n s}\right]$$ — Equation 2-30

where

0.5 is an empirical factor — Commentary Section 3.3.4.1.2.2

A_v = cross-sectional area of shear reinforcement

$F_s = 32{,}000$ psi for Grade 60 reinforcement — Section 2.3.3.1 (b)

A_n = net cross-sectional area of member

The allowable shear force V is given by:

$V = F_{vs}\,A_n$

Rearranging Equation 2-30:

$$V = 0.5\left[\frac{A_v F_s d}{s}\right]$$

$$= 0.5\left(\frac{0.2(32{,}000)(20)}{8(1{,}000)}\right)$$

$$= 0.5(16)$$

$$= 8 \text{ kips}$$

THE CORRECT ANSWER IS: (A)

520. Reference: ACI 318-11, Section 8.3.3

Two or more spans.
Spans are equal.
Loads are uniformly distributed.
$LL \leq 3DL$
Prismatic members

$l_n = 10 \text{ ft} - 1 \text{ ft} = 9 \text{ ft per Sec. 8.3.3}$

$W_u = 1.2 \times 100 + 1.6 \times 50 = 200 \text{ plf}$

Use $W_u l_n^2/12$ for ALL supports.

Note: Beam/column stiffness not applicable to slabs

$M_u = W_u l_n^2/12 = 1.35 \text{ ft-kips/ft}$

THE CORRECT ANSWER IS: (A)

521. The properties of a W10 × 22 are as follows: AISC, 14th ed., Table 3-2.

$\phi_b M_p x = 97.5 \text{ ft-kips}$

$M_p x/\Omega_b = 64.9 \text{ ft-kips}$

$BF = 2.68 \text{ kips (ASD) or } 4.02 \text{ kips (LRFD)}$

$L_p = 4.7 \text{ ft}$

$L_b = 10 \text{ ft}$

ASD: $M_p x/\Omega_b - BF(L_b - L_p) = M_n/\Omega_b$

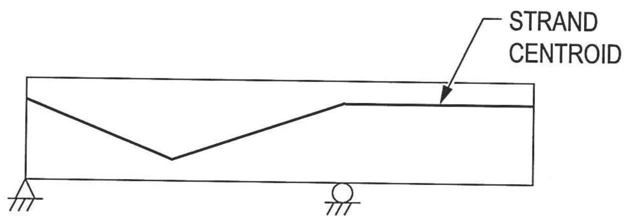
$64.9 - 2.68(10 - 4.7) = 50.7 \text{ ft-kips}$

LRFD: $\phi_b M_p x - BF(L_b - L_p) = \phi_b M_n$

$97.5 - 4.02(10 - 4.7) = 76.2 \text{ ft-kips}$

THE CORRECT ANSWER IS: (B)

522.



THE CORRECT ANSWER IS: (A)

523. $\Delta_{conc.\ load} = \frac{Pa}{24\ EI}(3\ L^2 - 4\ a^2)$ AISC, 14th ed., Beam Design

$$\Delta_{uniform} = \frac{5\ WL^4}{384\ EI} \Rightarrow \text{Set } \Delta_{conc.\ load} + \Delta_{uniform} = L/240$$

$$I\left(\frac{L}{240}\right) = \frac{Pa}{24\ E}(3\ L^2 - 4\ a^2) + \frac{5\ WL^4}{384\ E}$$

$$I_{\ required} = \frac{240}{L}\left[\frac{Pa}{24\ E}(3\ L^2 - 4\ a^2) + \frac{5\ WL^4}{384\ E}\right]$$

$$= \frac{240}{(15)(12)}\left[\frac{30(5\times 12)}{24\ (29{,}000)}\left(3\ (15\times 12)^2 - 4\ (5\times 12)^2\right) + \frac{5\ (1/12)(15\times 12)^4}{384\ (29{,}000)}\right]$$

$$= 1.33(214 + 39.3) = 337\ \text{in}^4$$

$W14\times 34 \rightarrow I = 340\ \text{in}^4$

THE CORRECT ANSWER IS: (C)

524. Reference: Gaylord, Gaylord, and Stallmeyer, *Design of Steel Structures,* 3rd ed., pp. 343–44.

Area of flange = 6 in.(0.5 in.) = 3 in^2

$X_{i\ flange}$ = 5.75 in.

Q_{flange} = 3 in^2 (5.75 in.) = 17.25 in^3

$$v = \frac{VQ}{I} = \frac{20\ \text{kips}(17.25\ \text{in}^3)}{232\ \text{in}^4} = 1.5\ \text{kips/in.}$$

THE CORRECT ANSWER IS: (A)

525. Reaction at Joint A $= 1/2$ total applied load (due to symmetry)

$= (1/2)(50 + 100 + 50) = 100$ kips

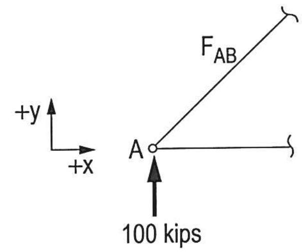
Considering Joint A:

$\sum F_y = 0$

$+\frac{3}{5}F_{AB} + 100 = 0$

$F_{AB} = -\frac{5}{3}(100)$

$= -167$ kips (compression)



THE CORRECT ANSWER IS: (D)

526. $F_{cE} = \frac{0.822\, E'_{min}}{(l_e/d)^2}$ NDS Section 3.7.1

$E'_{min} = E_{min} \times C_M \times C_t \times C_i \times C_T$

where:

$E_{min} = 440{,}000$ psi (given)

$C_m = 1.0$ (dry service)

$C_t = 1.0$ (normal temperature)

$C_i = 1.0$ (given)

$C_T = 1.0$ (not a truss member)

$E'_{min} = 440{,}000 \text{ psi} \times 1.0 \times 1.0 \times 1.0 \times 1.0$

$= 440{,}000$ psi

Check l_e/d: 3 1/2-in. direction $8 \times 12 / 3.5 = 27.5$

1 1/2-in. direction $4 \times 12 / 1.5 = 32$ Controls

$F_{cE} = \frac{0.822 \times 440{,}000}{32^2} = 353$ psi

THE CORRECT ANSWER IS: (B)

527. $\frac{(1.6 \text{ kips})(3 \text{ in.})}{(8.25 \text{ in.} - 0.50 \text{ in.})} = 0.619 \text{ kips} = 619 \text{ lb}$

THE CORRECT ANSWER IS: (B)

528. By inspection P controls.

$M_n = M_p = F_y Z_x \le 1.6\,M_y$

$F_y = 36$ ksi

$S_x = 1/6\,bd^2 = 1/6\,(6)(0.375)^2 = 0.141\text{ in}^3$

$M_y = F_y S_x = (36)(0.141) = 5.08$ in.-kips

$Z_x = 1/4\,bd^2 = 1/4\,(6)(0.375)^2 = 0.211\text{ in}^3$

$M_p = F_y Z_x = (36)(0.211) = 7.6$ in.-kips

$M_p = 7.6$ in.-kips $< 1.6\,M_y = 8.1$ in.-kips   OK

AISC ASD:

$M_n/\Omega = 7.6/1.67 = 4.55$ in.-kips

$P_{allow} = 4.55/4 = 1.14$ kips

AISC LRFD:

$\phi M_n = 0.9(7.6) = 6.84$ in.-kips

$\phi P_n = 6.84/4 = 1.71$ kips

THE CORRECT ANSWER IS: (A)

529. Reference: ASCE 7-10, Section 12.3.1.3.

Lateral diaphragm deflection = 1.0 in.

Average shear wall drift $= \dfrac{0.30 + 0.50}{2} = 0.40$ in.

$\dfrac{\Delta_D}{\Delta_{avg}} = \dfrac{1.0}{0.40} = 2.5 > 2.0 \Rightarrow$ flexible diaphragm

Also, torsionality does not exist with flexible diaphragms $\Rightarrow$ forces distribute to walls based on tributary areas.

THE CORRECT ANSWER IS: (A)

530. Overturning moment, $M_{ot} = 20 \text{ kips} \times 22 \text{ ft} = 440 \text{ ft-kips}$

Restoring moment, $M_r = 80 \text{ kips} \times 2 \text{ ft} + \dfrac{2.5 \text{ kips/ft} \times (24 \text{ ft})^2}{2} = 880 \text{ ft-kips}$

Footing weight, $W_{ftg} = 2.5 \text{ kips/ft} \times 24 \text{ ft} = 60 \text{ kips}$

Total vertical load, $P_{tot} = 80 \text{ kips} - 20 \text{ kips} + 60 \text{ kips} = 120 \text{ kips}$

Resultant location, $y = \dfrac{M_r - M_{ot}}{P_{tot}} = \dfrac{880 \text{ ft-kips} - 440 \text{ ft-kips}}{120 \text{ kips}} = 3.7 \text{ ft}$

Since resultant is outside the middle third of the footing base:

$$P_{max} = \frac{2}{3} \times \frac{(P_{tot})}{(y \times \text{footing width})} = \frac{2\,(120 \text{ kips})}{3\,(3.7 \text{ ft} \times 8 \text{ ft})} = 2.7 \text{ ksf}$$

THE CORRECT ANSWER IS: (D)

531. $d \approx 24 \text{ in.} - (3 \text{ in.})_{cov} - (1 \text{ in.})_{\#8} = 20 \text{ in.}$ (given) Use d at ℄ of # 8 layers

b_o at d/2 from face (critical section)

$b_o = 4(32 \text{ in.}) = 128 \text{ in.}$

Per ACI 318-11, 11.11.2.1, use smallest of the following:

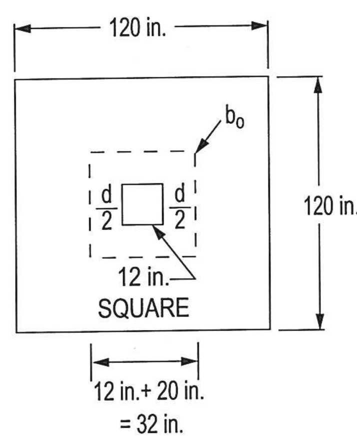
a. $\left(2 + \dfrac{4}{1/1}\right) = 6$

b. $\left[\dfrac{(40)(20 \text{ in.})}{128 \text{ in.}} + 2\right] = 8.3$

c. 4 Controls

$\phi V_n = 0.75(4)(1)(\sqrt{3,000})(128 \text{ in.})(20 \text{ in.})$

$= 420.6 \text{ kips}$



THE CORRECT ANSWER IS: (D)

532. Critical case is skin friction resistance = applied uplift load.

$$\frac{(20\text{ ft})\pi D(200\text{ psf})}{1{,}000} = 100\text{ kips}$$

$$D = \frac{100\text{ kips} \times 1{,}000}{(200\text{ psf} \times 20\text{ ft} \times \pi)}$$

$$D = 7.96\text{ ft}$$

THE CORRECT ANSWER IS: (A)

533. AISC, 14th ed.

ASD: Table 7-1

$F_{nv}/\Omega = 13.5\text{ ksi}$

Allowable load $= 2(12)(0.79) = 21.2\text{ kips}$

LRFD:

$\phi R_n = \phi F_{nv}\ Ab$

$\phi F_{nv} = 20.3\text{ ksi (A307 bolts)}$

$\phi R_n = (20.3)(0.79)(2) = 31.9\text{ kips}$

THE CORRECT ANSWER IS: (B)

534. Vertical reaction to Footing $B = 150\text{ kips} \times 5\text{ ft}/6\text{ ft} = 125\text{ kips}$

Footing spring constant $K = 100\text{ lb/in}^3 \times 24\text{ in.} \times 24\text{ in.} = 57{,}600\text{ lb/in.}$

$F = K\Delta$

$\Delta = F/K = 125 \times 1{,}000/57{,}600 = 2.2\text{ in.}$

THE CORRECT ANSWER IS: (A)

535. Reference: PCI, Chapter 4.

Total prestress force, P = 2 × 6 strands × 0.153 in^2/strand × 175 ksi = 321.3 kips
Axial stress = P/A = 321.3/(36 × 18) = 0.496 ksi (compression)
Bending stress due to prestress = Pe/S $S = bd^2/6 = 18 \times 36^2/6 = 3{,}888\ in^3$
$e = 36/2 - 3 - 2/2 = 14$ in.

Bending stress due to prestress = 321.3 × 14/3,888 = 1.158 ksi (tension at top)

Bending stress due to beam self-weight = 0.65 ksi (compression at top)
Thus, stress at top at release = 0.49 – 1.15 + 0.65 = –0.01 ksi (tension)

THE CORRECT ANSWER IS: (A)

536. Reference: ASCE 7-10 Design Loads Table 3.2-1, p. 11.

85 lb/ft^2

THE CORRECT ANSWER IS: (C)

537. Design spectral response acceleration at short periods: IBC 2012, 1613.3.4

$$S_{DS} = \frac{2}{3} S_{MS}$$

Adjusted maximum considered earthquake spectral response acceleration for short periods: IBC 2012, 1613.3.3

$$S_{MS} = F_a S_s$$

For Site Class E and mapped short period maximum considered earthquake spectral acceleration: IBC 2012, Table 1613.3.3(1)

$$S_S = 100\%\ g$$

$$F_a = 0.9$$

$$\therefore\ S_{MS} = 0.9 \times 1.0 = 0.9$$

$$S_{DS} = \frac{2}{3} \times 0.9 = 0.6$$

THE CORRECT ANSWER IS: (A)

538. Reference: AASHTO Section 9.7.2.3.

$$\begin{aligned} L_{eff} &= 8.5\text{ ft} - b_f + \text{flange overhang} \\ &= 8.5\text{ ft} - 1.5\text{ ft} + 0.25\text{ ft} \\ &= 7.25\text{ ft (7 ft 3in.)} \end{aligned}$$

THE CORRECT ANSWER IS: (C)

539. Reference: McCormac, *Design of Reinforced Concrete*, 5th ed.

$$\begin{aligned} R &= \left[\left(0.5'(150\text{ pcf}) + 50\text{ psf} + 12\text{ psf}\right) + \left(0.83'(150\text{ pcf}) + 50 + 12\right)\right](6' \times 6') \\ &= 11{,}646\text{ lb} \end{aligned}$$

THE CORRECT ANSWER IS: (C)

540. Reference: ACI 318-11.

ACI 318 5.6.3.3(a)

Concrete is unsatisfactory – the average of any three consecutive tests is less than required f'_c.

$$\frac{4{,}215 + 4{,}160 + 3{,}625}{3} = 4{,}000; \quad \frac{4{,}160 + 3{,}625 + 4{,}010}{3} = 3{,}931; \quad \frac{3{,}625 + 4{,}010 + 4{,}015}{3} = 3{,}883$$

THE CORRECT ANSWER IS: (A)

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