# PE

## civil engineering

## transportation

# practice exam

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NCEES

*advancing licensure for engineers and surveyors*

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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.

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

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# EXAM SPECIFICATIONS

## NCEES Principles and Practice of Engineering
## CIVIL BREADTH and TRANSPORTATION 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 **Transportation PM exam** are included here. The **design standards** applicable to the Transportation 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–TRANSPORTATION DEPTH Exam Specifications

| | Approximate Number of Questions |
|---|---|
| **I. Traffic Engineering (Capacity Analysis and Transportation Planning)** | **11** |
| A. Uninterrupted flow (e.g., level of service, capacity) | |
| B. Street segment interrupted flow (e.g., level of service, running time, travel speed) | |
| C. Intersection capacity (e.g., at grade, signalized, roundabout, interchange) | |
| D. Traffic analysis (e.g., volume studies, peak hour factor, speed studies, modal split) | |
| E. Trip generation and traffic impact studies | |
| F. Accident analysis (e.g., conflict analysis, accident rates, collision diagrams) | |
| G. Nonmotorized facilities (e.g., pedestrian, bicycle) | |
| H. Traffic forecast | |
| I. Highway safety analysis (e.g., crash modification factors, *Highway Safety Manual*) | |
| **II. Horizontal Design** | **4** |
| A. Basic curve elements (e.g., middle ordinate, length, chord, radius) | |
| B. Sight distance considerations | |
| C. Superelevation (e.g., rate, transitions, method, components) | |
| D. Special horizontal curves (e.g., compound/reverse curves, curve widening, coordination with vertical geometry) | |
| **III. Vertical Design** | **4** |
| A. Vertical curve geometry | |
| B. Stopping and passing sight distance (e.g., crest curve, sag curve) | |
| C. Vertical clearance | |
| **IV. Intersection Geometry** | **4** |
| A. Intersection sight distance | |
| B. Interchanges (e.g., freeway merge, entrance and exit design, horizontal design, vertical design) | |
| C. At-grade intersection layout, including roundabouts | |
| **V. Roadside and Cross-Section Design** | **4** |
| A. Forgiving roadside concepts (e.g., clear zone, recoverable slopes, roadside obstacles) | |
| B. Barrier design (e.g., barrier types, end treatments, crash cushions) | |
| C. Cross-section elements (e.g., lane widths, shoulders, bike lane, sidewalks) | |
| D. Americans with Disabilities Act (ADA) design considerations | |
| **VI. Signal Design** | **3** |
| A. Signal timing (e.g., clearance intervals, phasing, pedestrian crossing timing, railroad preemption) | |
| B. Signal warrants | |
| **VII. Traffic Control Design** | **3** |
| A. Signs and pavement markings | |
| B. Temporary traffic control | |

**VIII. Geotechnical and Pavement** — **4**

A. Design traffic analysis (e.g., equivalent single-axle load [ESAL])
B. Sampling and testing (e.g., subgrade resilient modulus, CBR, R-Values, field tests)
C. Mechanistic design procedures (e.g., flexible and rigid pavement)
D. Pavement evaluation and maintenance measures (e.g., skid, roughness, structural capacity, rehabilitation treatments)
E. Settlement and compaction
F. Soil stabilization techniques
G. Excavation, embankment, and mass balance

**IX. Drainage** — **2**

A. Hydrology (e.g., Rational method, hydrographs, SCS/NRCS method)
B. Culvert design, including hydraulic energy dissipation
C. Stormwater collection systems (e.g., inlet capacities, pipe flow)
D. Gutter flow
E. Open-channel flow
F. Runoff detention/retention/water quality mitigation measures

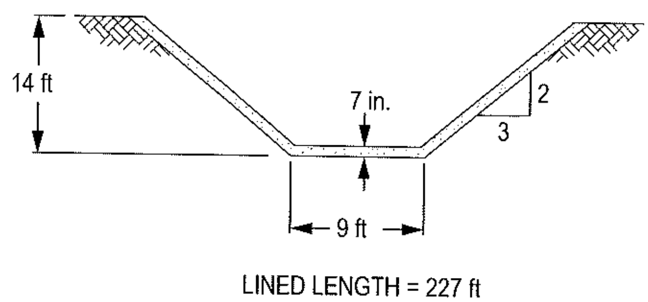
**X. Alternatives Analysis** — **1**

A. Economic analysis (e.g., present worth, lifecycle costs)

# 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:

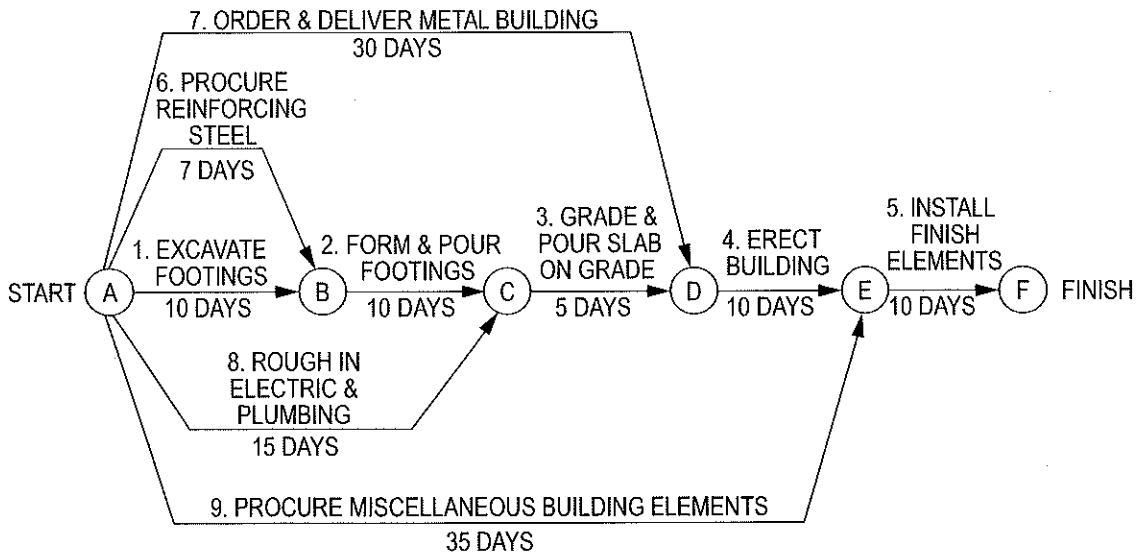
(A) $10,000
(B) $15,000
(C) $23,000
(D) $48,750

**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

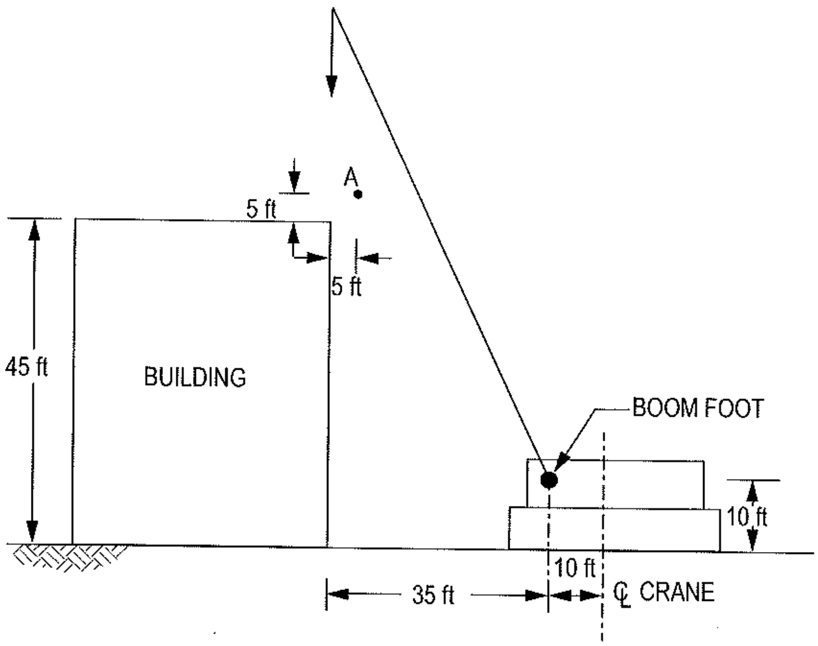



**105.** A bridge is to be jacked up to replace its bearings. The design requires a hydraulic ram with a minimum capacity of 1,000 kN (kilonewtons). The hydraulic rams that are available are rated in tons (2,000 lb/ton). The **minimum** size (tons) ram to use is most nearly:

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

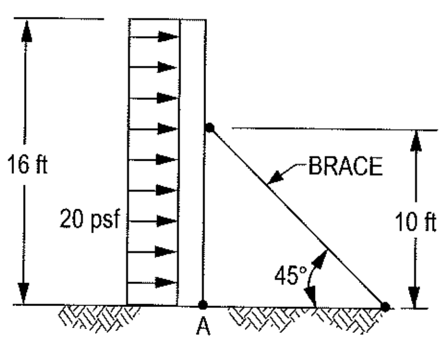
**106.** A crane with a 100-ft boom is being used to set a small load on the roof of the building shown. The minimum standoff (Point A) from the corner of the building to the centerline of the boom is indicated. What is the maximum distance (ft) from the edge of the building that the load can be placed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

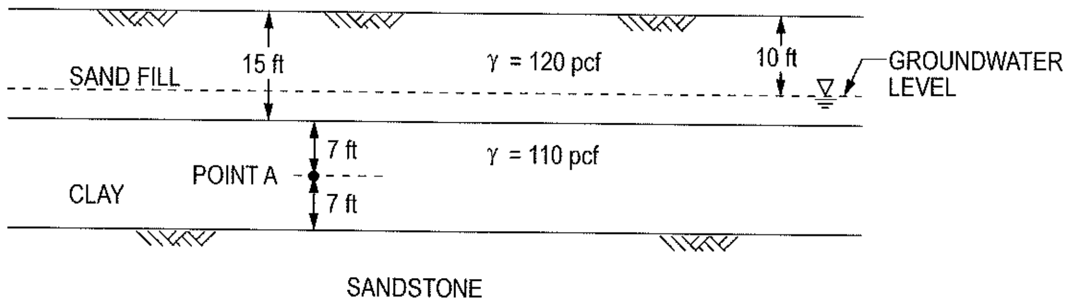
(D) The lateral strain required to fully mobilize the soil passive pressure is considerably greater than the lateral strain required to fully mobilize the soil active pressure.

**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

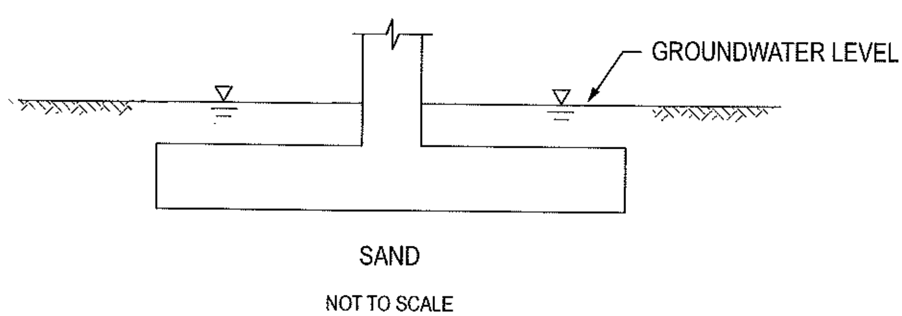
**110.** A soil profile is shown in the figure. The effective vertical stress (psf) at Point A is most nearly:

(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



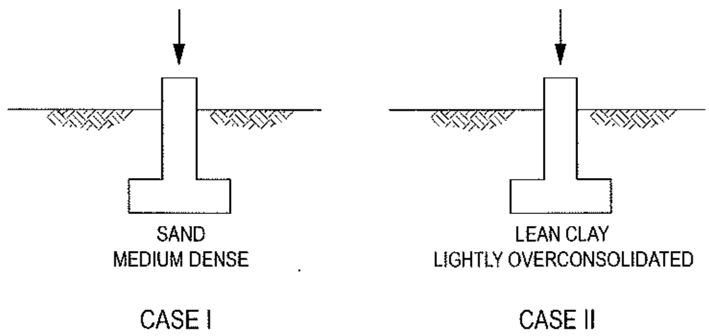
**112.** The figure shows two identical building footings with the same load but constructed in two different soil types. Which of the following statements is most correct?

(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

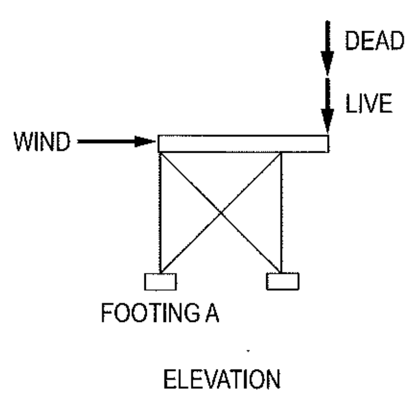
**114.** Referring to the figure, what load combination produces the maximum uplift on Footing A?

(A) Dead + live

(B) Dead + wind

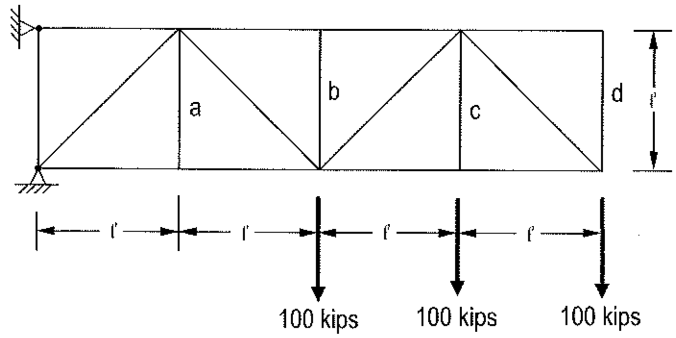
(C) Dead

(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



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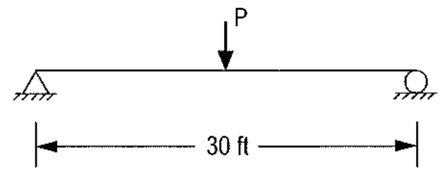
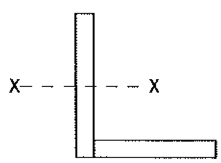
**117.** The point load (kips) placed at the centerline of a 30-ft beam that produces the same maximum shear in the beam as a uniform load of 1 kip/ft is most nearly:

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

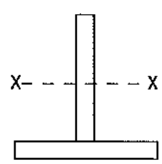



**118.** The beam sections shown are fabricated from 1/2-in. × 6-in. steel plates. Which of the following cross sections will provide the greatest flexural rigidity about the x-axis?

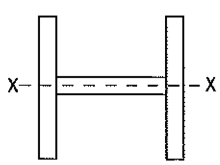
(A)



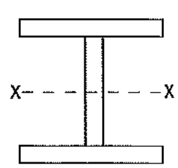

(B)




(C)

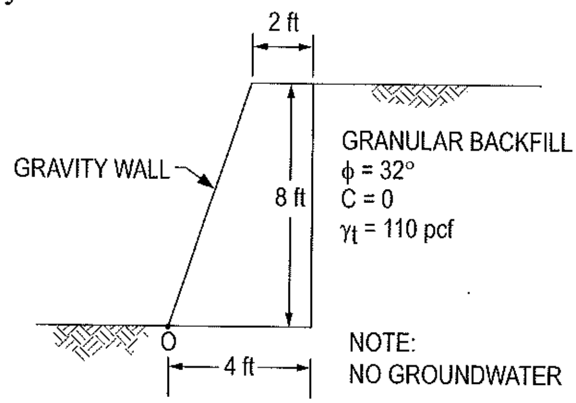



(D)



**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

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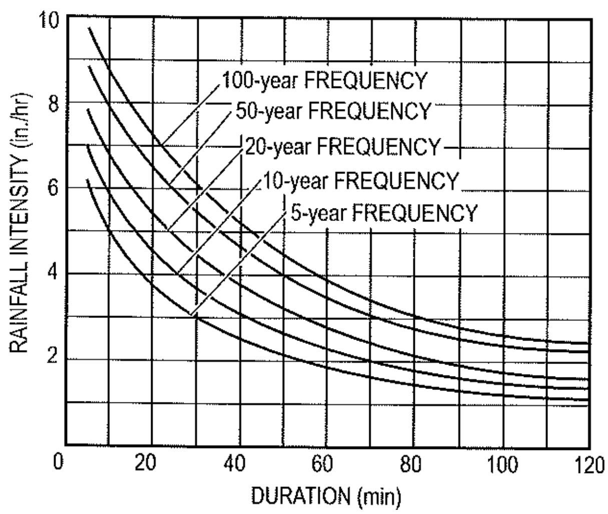
**123.** The rational method must be used to determine the maximum runoff rate for a 90-acre downtown area. The time of concentration for the 50-year frequency storm is 1 hour. Intensity-duration-frequency curves and a table of runoff coefficients are provided. The maximum runoff rate (cfs), based on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



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**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

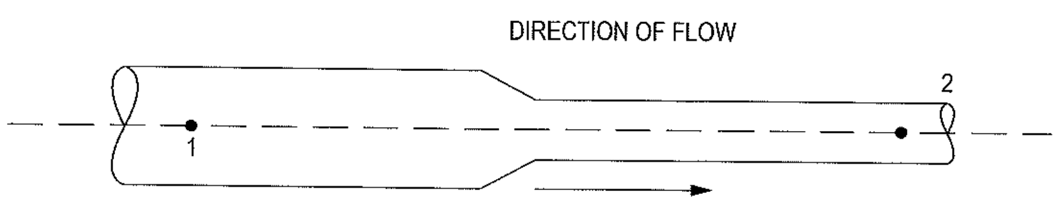
**126.** Assuming that Bernoulli's equation applies (ignore head losses) to the pipe flow shown in the figure, which of the following statements is most correct?

(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:

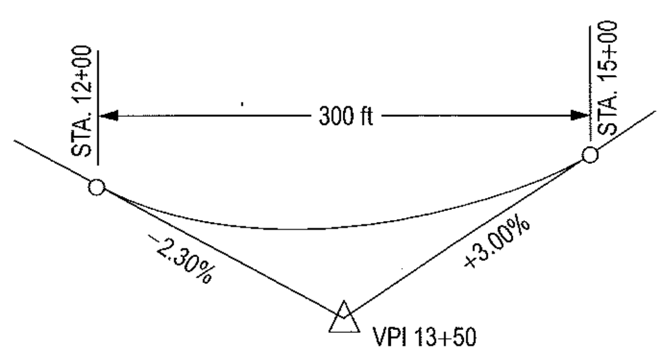
| | |
|---|---|
| PI station | 12+40.00 |
| Degree of curve | 10° |
| Deflection angle | 12°30′ |

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%.

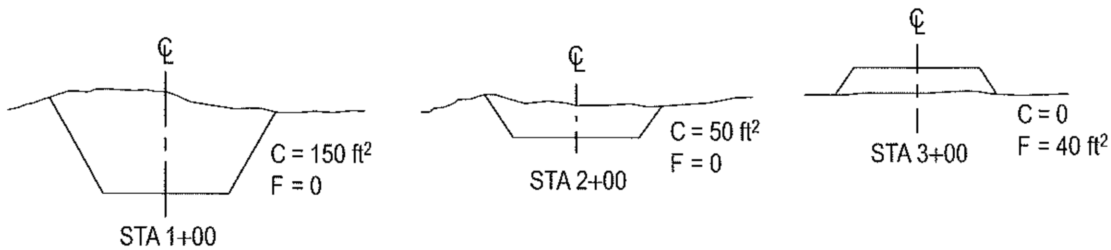
The weight and volume of mold are 4.41 lb and 0.03 $ft^3$, respectively.

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

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

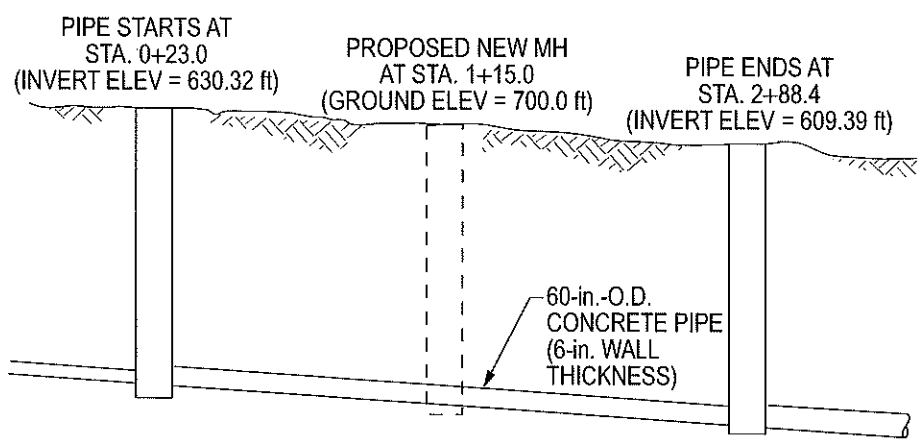
**136.** Refer to the figure. The net excess excavated material ($yd^3$) from Station 1+00 to Station 3+00 is most nearly:

(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

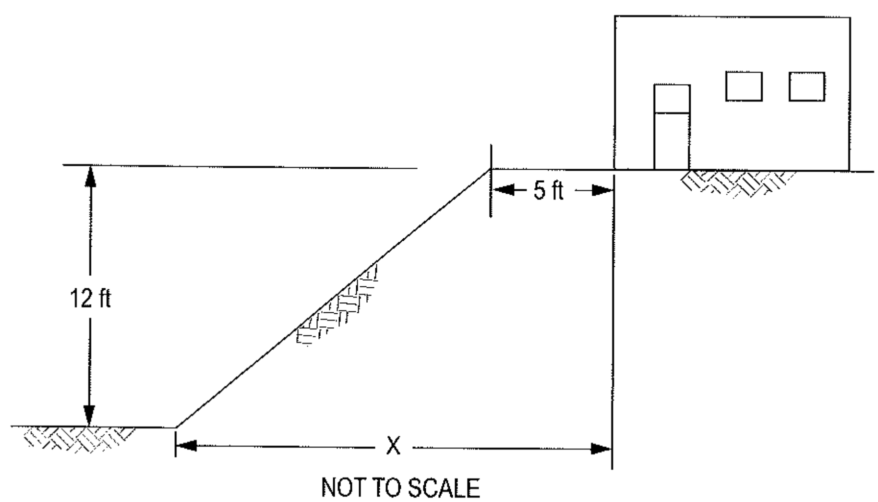
(B) Rill erosion

(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



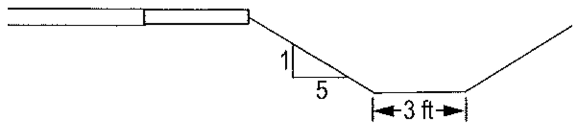
**140.** Based on the criteria provided, the steepest backslope (H:V) preferred in the ditch shown is most nearly:

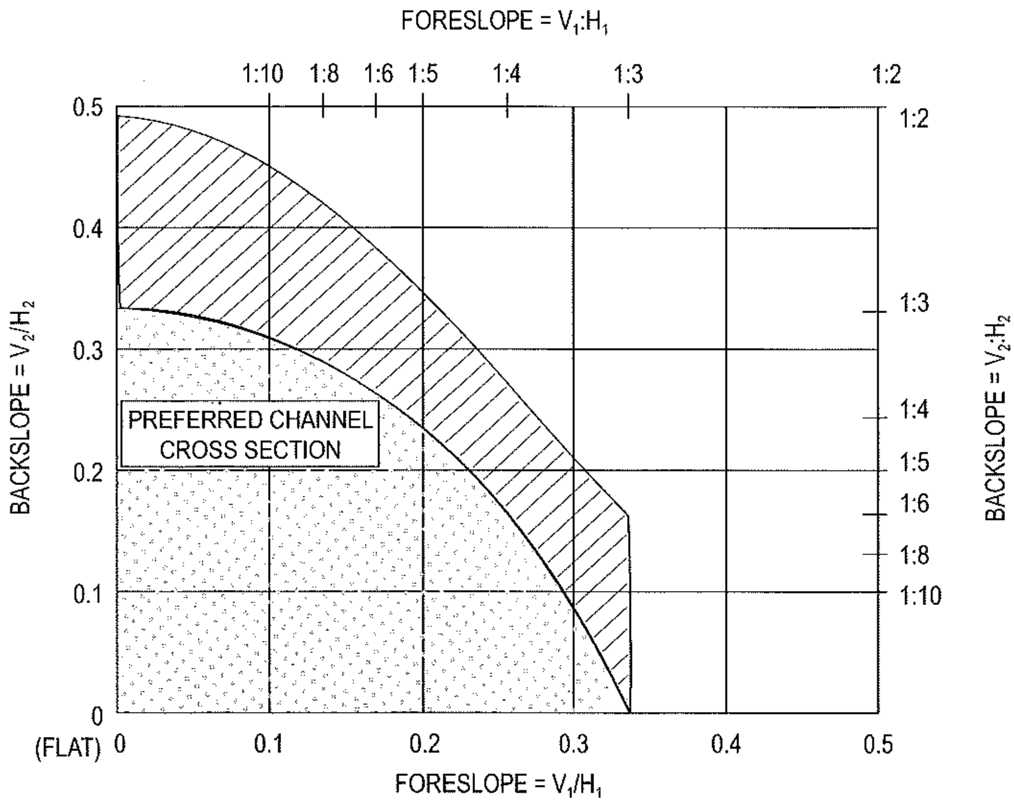
(A) 2:1

(B) 3:1

(C) 5:1

(D) 6:1




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.

This completes the morning session. Solutions begin on page 55.

# TRANSPORTATION PM PRACTICE EXAM

**501.** The following information applies to a four-lane freeway.

| | |
|---|---|
| Volume | 2,400 vph (in one direction) |
| Peak hour factor | 0.90 |
| Base free-flow speed | 60 mph |
| 5% truck traffic | |
| 12-ft lanes | |
| 10-ft outside shoulders | |
| 2-mile interchange spacing | |
| Level terrain | |
| No recreational vehicles | |
| Commuter traffic familiar with facility | |

The level of service (LOS) for the freeway is most nearly:

(A) LOS A

(B) LOS B

(C) LOS C

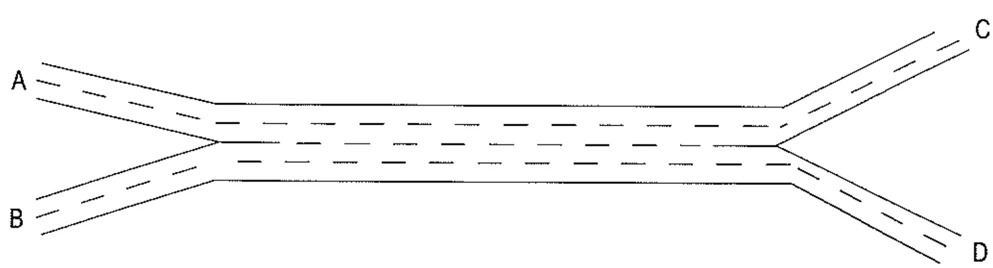
(D) LOS D

**502.** The figure shows a ramp-weaving segment of a freeway. The following data apply:

Flow rate A-C = 4,200 pcph
Flow rate B-C = 600 pcph
Flow rate A-D = 500 pcph
Flow rate B-D = 400 pcph

If the mean speed of the traffic in the weave segment is 56 mph, the density (pc/mile/lane) is most nearly:

(A) 34
(B) 32
(C) 28
(D) 25



**503.** For a lane group at a signalized intersection, which of the following factors will change the saturation flow rate from the base saturation flow rate provided in the *Highway Capacity Manual*?

(A) Intersection located in a suburban school zone

(B) Level terrain

(C) Peak hour factor of 0.92

(D) Inclusion of left-turns with protected phasing

**504.** A speed study concludes that the 85th percentile speed of free-flowing traffic is 56.2 mph. Which of the following posted speed limit signs most nearly meets the guidance for speed limit signs?

(A) 50 mph, 55 mph, 60 mph, 65 mph

(B) 50 mph, 55 mph

(C) 55 mph, 60 mph

(D) 60 mph, 65 mph



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**505.** Continuous daily traffic counts on an urban arterial street (Street A) were recorded as shown in the following table:

| Daily Traffic Counts on Urban Arterial Street A | |
|---|---|
| **Day** | **24-hour Volume** |
| Sunday | 6,950 |
| Monday | 9,450 |
| Tuesday | 7,340 |
| Wednesday | 10,300 |
| Thursday | 9,850 |
| Friday | 11,250 |
| Saturday | 8,450 |

On a similar arterial street (Street B) in the same city, a total of 7,450 vehicles were counted in a 24-hour period on a Wednesday. The estimated average daily traffic volume for Street B for the week is most nearly:

(A) 6,570
(B) 7,080
(C) 7,450
(D) 8,450

**506.** A multiple regression analysis for trip generation purposes shows the following relationship for the number of trips per household:

Trips generated per household per day = 0.58 + 1.5P + 2.2A

where:

P = number of persons per household
A = number of autos per household

If a zone under study contains 600 households with an average of 4.1 persons and 2.3 autos for each household, the number of trips generated per day is most nearly:

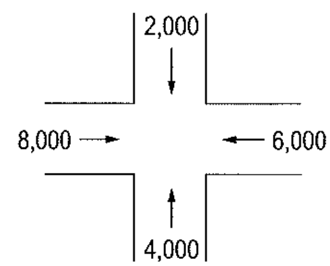
(A) 7,100
(B) 6,700
(C) 6,600
(D) 6,200

**507.** The approach to an intersection has a 27-sec green time, a 3-sec yellow time including all red time, and a 90-sec cycle. The saturation headway is 2.4 sec/vehicle, start-up lost time is 2 sec per phase, and the clearance lost time is 1 sec per phase. The capacity (vph) for this approach movement is most nearly:

(A) 840
(B) 825
(C) 675
(D) 450

**508.** An intersection had 25 reported traffic accidents during the months of January through September. The ADT for this intersection is shown in the following figure. The accident rate per million entering vehicles (RMEV) for this intersection is most nearly:

(A) 4.6
(B) 3.4
(C) 0.5
(D) 0.2




**509.** A 10-ft-wide sidewalk has an effective walkway width of 6.5 ft. The peak 15-min pedestrian flow is 1,200 pedestrians. The platoon-adjusted LOS is most nearly:

(A) LOS B
(B) LOS C
(C) LOS D
(D) LOS E

**510.** A segment of a roadway has an average daily traffic of 12,350 and an annual growth rate of 7%. If this rate of traffic volume growth continues, the average daily traffic volume (vpd) in 10 years will be most nearly:

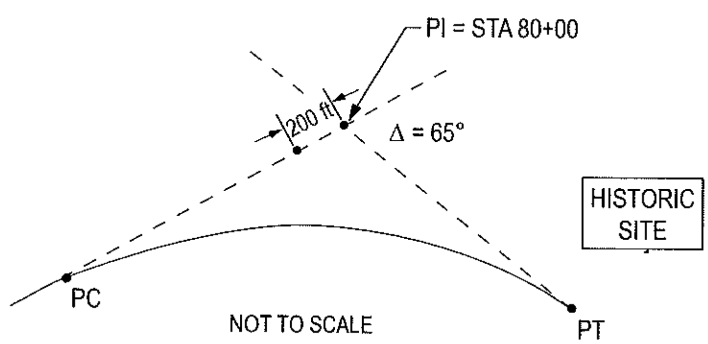
(A) 8,650
(B) 17,650
(C) 21,000
(D) 24,300

**511.** An alert driver with a perception-reaction time of 2.5 sec is driving at the posted speed of 45 mph and must stop suddenly to avoid an obstacle in the roadway. An impaired driver with a perception-reaction time of 3.5 sec is traveling 10 mph over the speed limit. The increase in the distance (ft) traveled by the impaired driver before the brakes are applied is most nearly:

(A) 37
(B) 66
(C) 118
(D) 283

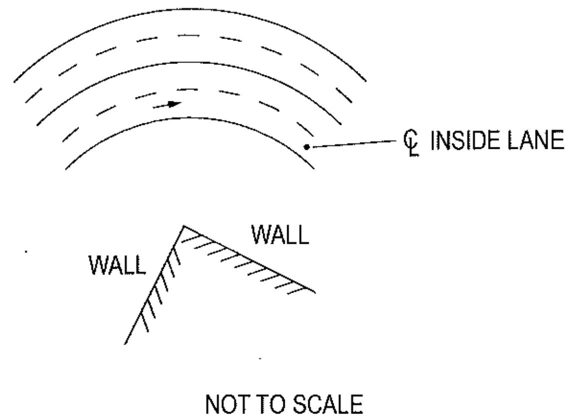
**512.** An existing highway has a historic site located at the PT of an existing curve with a PI located at Station 80+00, an external angle of 65°, and a radius of 1,200 ft. The curve must be relocated, moving the PI to Station 78+00. The external angle and the PC will remain the same. The radius (ft) of the new curve is most nearly:

(A) 263
(B) 314
(C) 886
(D) 1,200



**513.** A section of a four-lane undivided highway forms a horizontal curve with a radius of 800 ft for the centerline of the inside lane. The highway is flat at this section and has a design speed of 45 mph. An architectural wall is being constructed by a local community center as shown in the figure. Assume a brake reaction time of 2.5 sec and a deceleration rate of 11.2 ft/sec$^2$. The minimum distance (ft) that the architectural wall can be constructed from the centerline of the inside lane of the curve based on sight distance is most nearly:

(A) 15
(B) 21
(C) 28
(D) 38




**514.** A horizontal curve on a two-lane rural highway has the following characteristics:

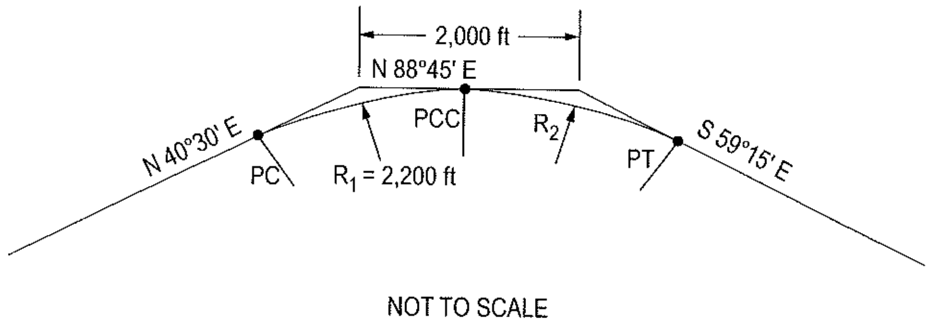
| | |
|---|---|
| Design speed, V | 60 mph |
| Radius (minimum) | 1,091 ft |
| Coefficient of side friction | 0.12 |
| Lane width | 12 ft |

The rate of superelevation required for this curve is most nearly:

(A) 7%
(B) 10%
(C) 11%
(D) 33%

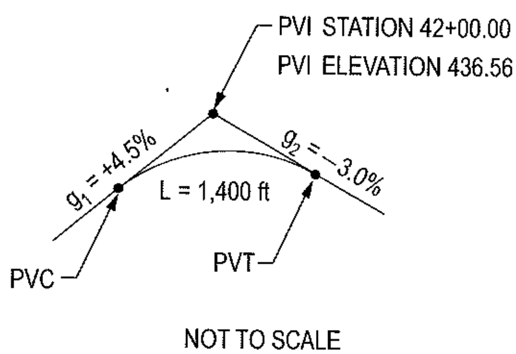
**515.** A compound curve is shown in the figure. The length of the radius (ft) of the second curve, $R_2$, is most nearly:

(A) 3,490
(B) 3,540
(C) 3,850
(D) 4,240



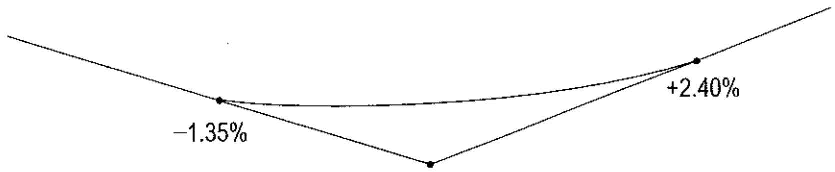

**516.** The tangent vertical alignment of a section of proposed highway is shown in the figure. The station of the high point is most nearly:

(A) 35+00
(B) 42+00
(C) 43+40
(D) 45+15



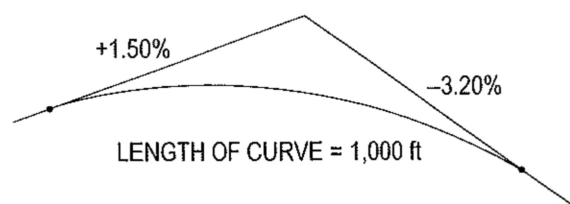
**517.** If the vertical curve shown has a design speed of 60 mph, the minimum length of curve (ft) required to provide adequate stopping sight distance is most nearly:

(A) 150
(B) 420
(C) 510
(D) 570




**518.** According to AASHTO, the passing sight distance (ft) for the vertical curve shown is most nearly:

(A) 1,285
(B) 1,130
(C) 780
(D) 680

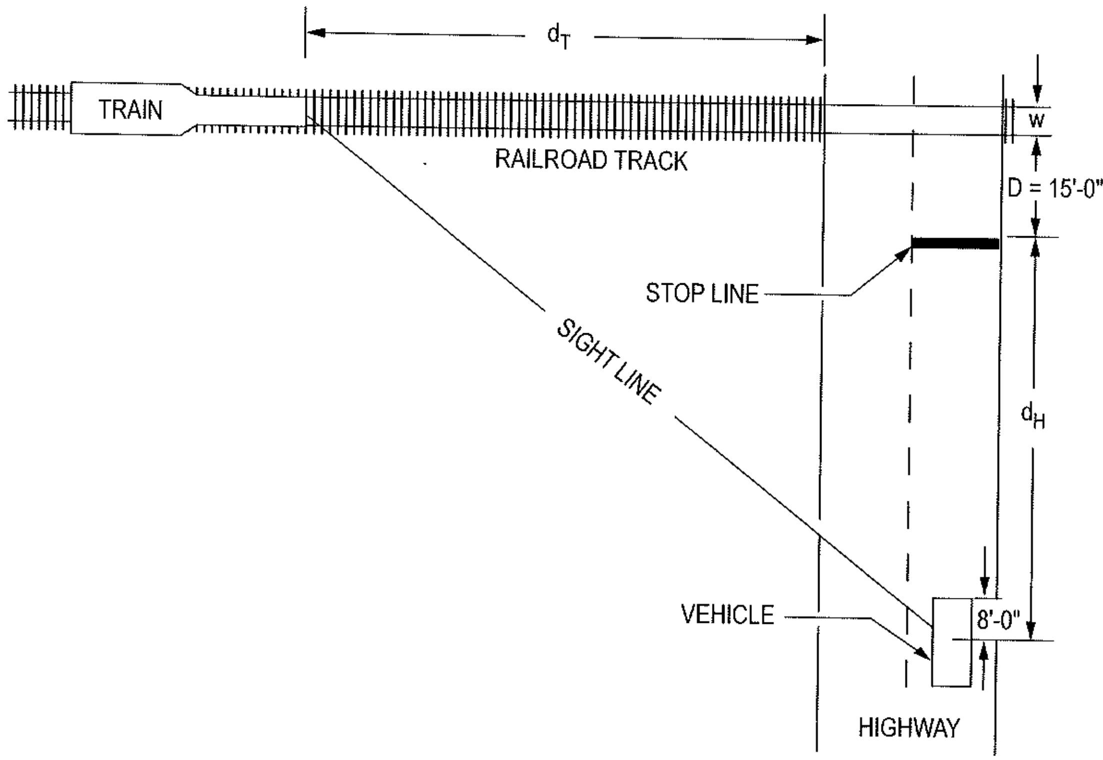



**519.** An overhead sign is located at the PVI station of a crest vertical curve. The grades are +3% and −2% with a vertical curve length of 500 ft. The PVI of the curve is at Station 85+00 with an elevation of 202.30. In order to provide a clearance of 16 ft, the minimum elevation of the bottom of the sign is most nearly:

(A) 214.14
(B) 215.18
(C) 217.68
(D) 218.30

**520.** A vehicle is approaching a train intersection at 45 mph as shown in the figure. Assume AASHTO-recommended design values for perception-reaction time. The stop line is located 15 ft from the nearside rail, and the driver is located 8 ft back from the front bumper of the vehicle. The required sight triangle distance (ft) along the highway for a vehicle to stop at the stop line for an approaching train is most nearly:

(A) 295
(B) 347
(C) 383
(D) 438



**521.** A freeway ramp has the following characteristics:

Radius on inner edge of pavement is 100 ft.
One-lane, one-way operation with no provision for passing a stalled vehicle
Design traffic Condition A
Barrier curb on both sides

The ramp pavement width needed (ft) is most nearly:

(A) 15
(B) 16
(C) 17
(D) 18

**522.** A single-lane entrance ramp joins a tangent section of freeway mainline as a parallel-type entrance. The entrance ramp design speed is 30 mph, and the highway design speed is 70 mph. The grade is +1.0%. The **minimum** acceleration length L (ft) needed for the entrance is most nearly:

(A) 110
(B) 520
(C) 1,230
(D) 1,350

**523.** Which of the following are typical characteristics of a modern roundabout in the United States:

I. Yield on entry
II. Clockwise circulation
III. Deflection of entering traffic
IV. Central island

(A) I, II, III
(B) I, II, IV
(C) I, III, IV
(D) II, III, IV

**524.** The **minimum** horizontal clear-zone width (ft) for a rural local road is most nearly:

(A) 24
(B) 18
(C) 14
(D) 7

**525.** A vehicle weighing 2,000 lb traveling at a speed of 45 mph strikes a sand-filled barrel crash cushion system. The front barrel weighs 600 lb. The speed (mph) of the vehicle after impact with the front barrel is most nearly:

(A) 35
(B) 32
(C) 14
(D) 10

**526.** A two-lane facility with 11-ft lanes has concrete barriers on both sides at the outside of the paved shoulder. The design speed is 40 mph with the minimum horizontal curve radius of 600 ft. The **minimum** shoulder width (ft) that meets AASHTO stopping sight distance requirements is most nearly:

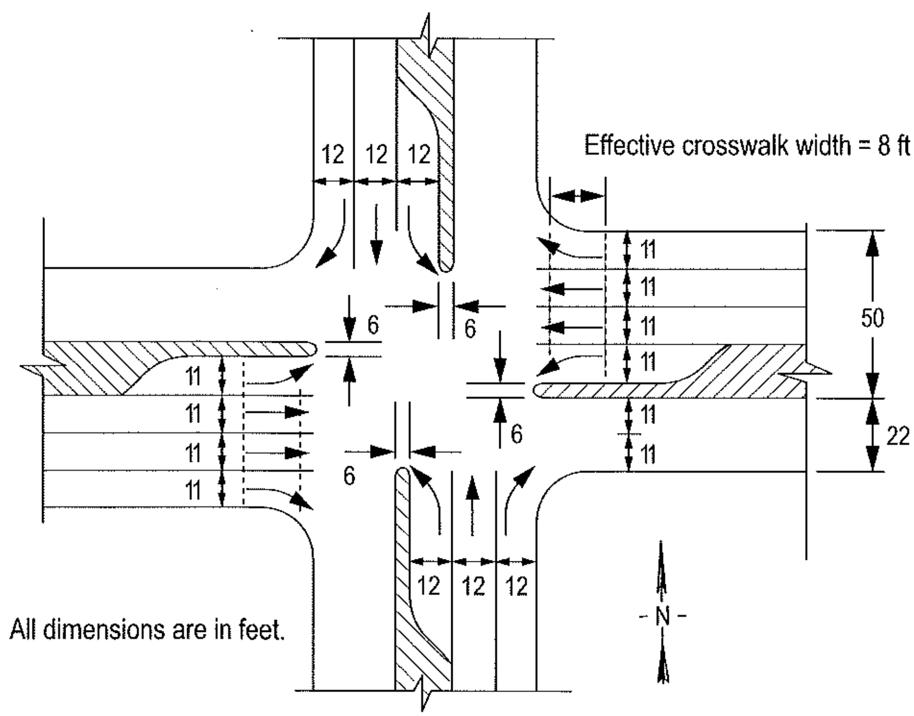
(A) 8
(B) 10
(C) 14
(D) 20

**527.** For a project that includes curbs and adjacent sidewalks, the maximum curb ramp grade to meet Americans with Disabilities Act (ADA) requirements is:

(A) 8.33%
(B) 5.00%
(C) 2.00%
(D) 0.60%

**528.** The signalized intersection shown in the figure has a pedestrian demand of 0.9 pedestrians per cycle and an average pedestrian speed of 4.0 fps. The **minimum** service time (sec) for pedestrians traveling in the North-South direction is most nearly:

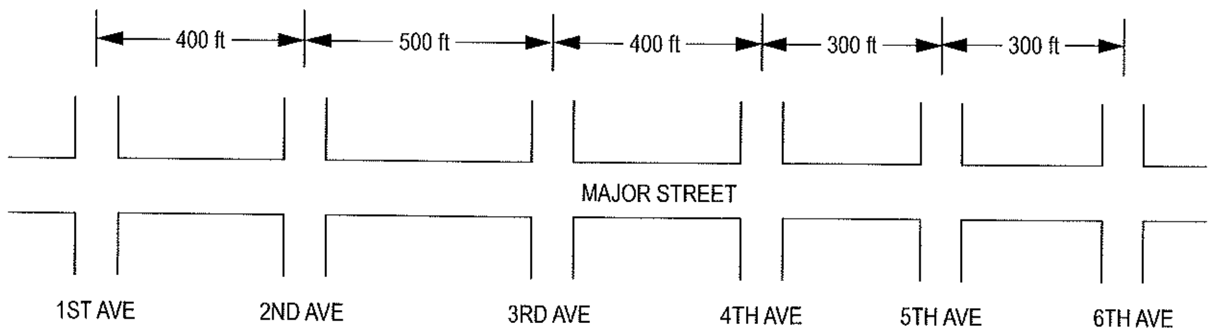
(A) 22
(B) 27
(C) 29
(D) 32




INTERSECTION PLAN
NOT TO SCALE

**529.** A section of a major street—an urban arterial with six traffic signalized intersections—is shown below. The traffic signals at each intersection have a total cycle length of 90 sec with 50 sec of green (and yellow) time on the major street. The design requires a progressive signal system having a maximum bandwidth of green for movement from the 1st Avenue intersection toward the 6th Avenue intersection with a progressive speed of 30 mph. The offset (sec) at 6th Avenue is most nearly:

(A) 36
(B) 43
(C) 50
(D) 63



**530.** The intersection of a major street and a minor street is configured as shown. Traffic counts are shown in the table. The minor street is currently stop-sign controlled. An 8-hour, 4-hour, and crash experience warrant analysis is requested for the intersection. The following data apply:

85th percentile speed: 45 mph
Population: 12,000
9-month accident history:
3 right angle
2 rear-end
1 left-turning
Alternatives to reduce crash frequency have not resulted in any reductions in the accident rate.

Based on FHWA Standards (including optional criteria), which warrants are met?

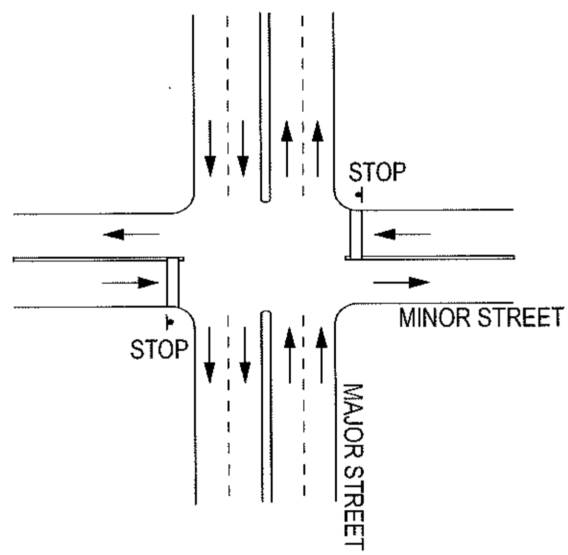
(A) Warrant 2

(B) Warrants 1, 7

(C) Warrants 2, 7

(D) Warrants 1, 2, 7

| Hour | Total Vehicles Major Street | Higher Volume Minor Street Approach (One Direction Only) |
|---|---|---|
| 6–7 a.m. | 735 | 105 |
| 7–8 a.m. | 985 | 120 |
| 8–9 a.m. | 1,050 | 135 |
| 9–10 a.m. | 1,040 | 104 |
| 10–11 a.m. | 825 | 92 |
| 11 a.m.–12 p.m. | 835 | 77 |
| 12–1 p.m. | 847 | 84 |
| 1–2 p.m. | 855 | 111 |
| 2–3 p.m. | 900 | 122 |
| 3–4 p.m. | 1,050 | 116 |
| 4–5 p.m. | 1,100 | 122 |
| 5–6 p.m. | 1,150 | 125 |



**531.** Delineators are to be placed on the outside of a horizontal roadway curve of 5°. The approximate spacing (ft) for the delineators along the curve is most nearly:

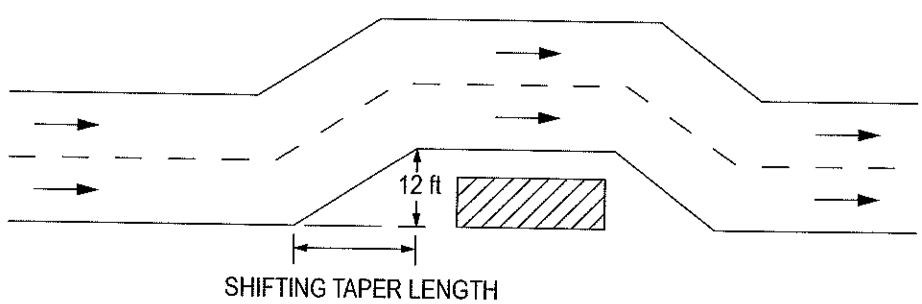
(A) 50
(B) 90
(C) 95
(D) 100

**532.** A rural intersection of two two-lane roads with approach speeds of 45 mph has a four-way stop in place, and it has a pattern of rear-end collisions. The preferred countermeasure to correct this problem is the installation of:

(A) centerline striping
(B) "Stop Ahead" warning signs
(C) a traffic signal
(D) upgraded roadway shoulders

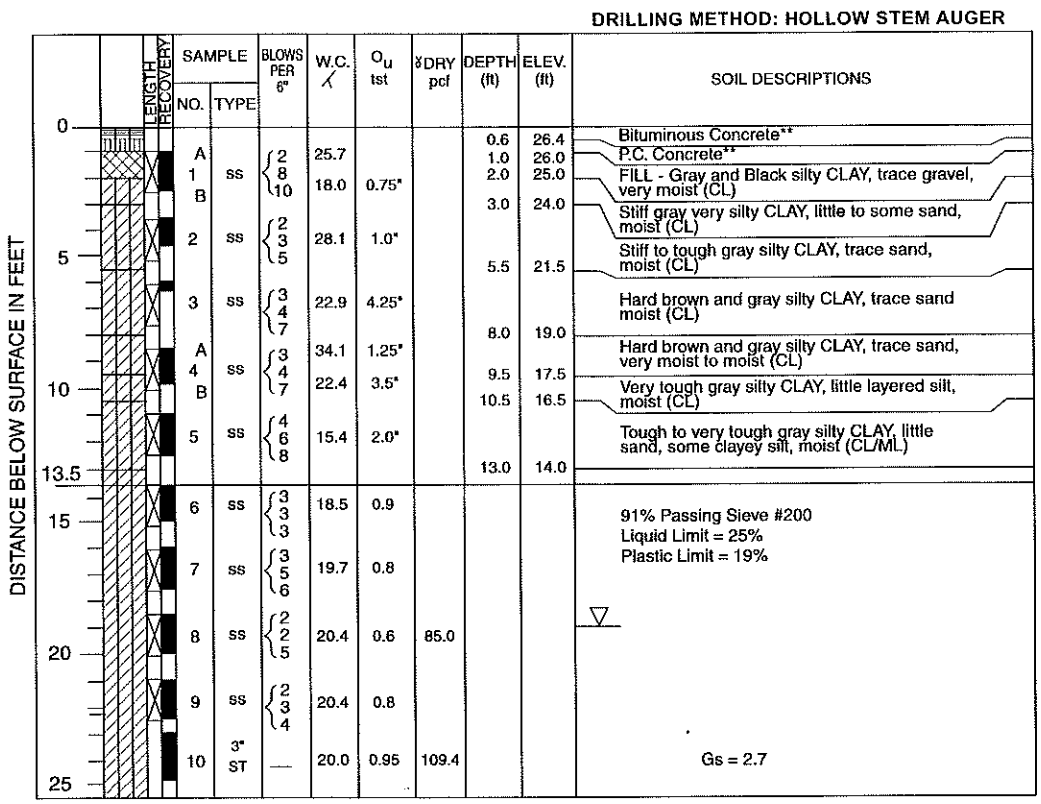
**533.** A freeway with a work zone speed limit of 55 mph and 12-ft lanes requires a work zone lane shift as shown. The minimum recommended length (ft) for the shifting taper is most nearly:

(A) 220
(B) 305
(C) 330
(D) 660



**534.** Based on the borehole log shown, the standard penetration test $N$ value (blow count) for Sample 7 is most nearly:

(A) 6
(B) 8
(C) 11
(D) 14



535. Which of the following is **not** a typical contributing factor to the development of alligator cracking?

(A) Lack of adequate support from a shoulder
(B) Weakness of the base course or subgrade
(C) Fatigue failure of the HMA surface from repeated traffic loadings
(D) Insufficient pavement thickness

536. Which of the following soil groupings is **least** likely to present embankment and settlement problems?

(A) Gravels, sands
(B) Gravels, sands, organic silts
(C) Plastic silts, clays
(D) Organic soils, clays



GO ON TO THE NEXT PAGE

**537.** Given the earthwork volumes shown in the table, the first balance point on the mass haul diagram is:

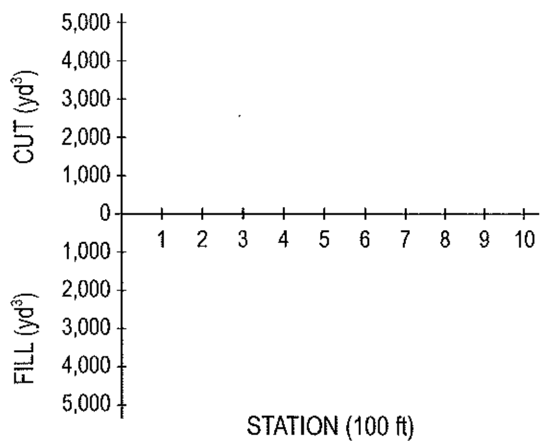
(A) Station 5+00

(B) Station 6+00

(C) Station 8+00

(D) Station 10+00

| Station (ft) | Excavation ($yd^3$) | Embankment ($yd^3$) |
|---|---|---|
| 0+00 | 0 | 0 |
| 1+00 | 3,000 | 1,000 |
| 2+00 | 1,000 | 500 |
| 3+00 | 1,500 | 1,000 |
| 4+00 | 2,000 | 500 |
| 5+00 | 1,000 | 1,000 |
| 6+00 | 500 | 2,000 |
| 7+00 | 0 | 2,000 |
| 8+00 | 0 | 1,000 |
| 9+00 | 500 | 1,000 |
| 10+00 | 500 | 0 |

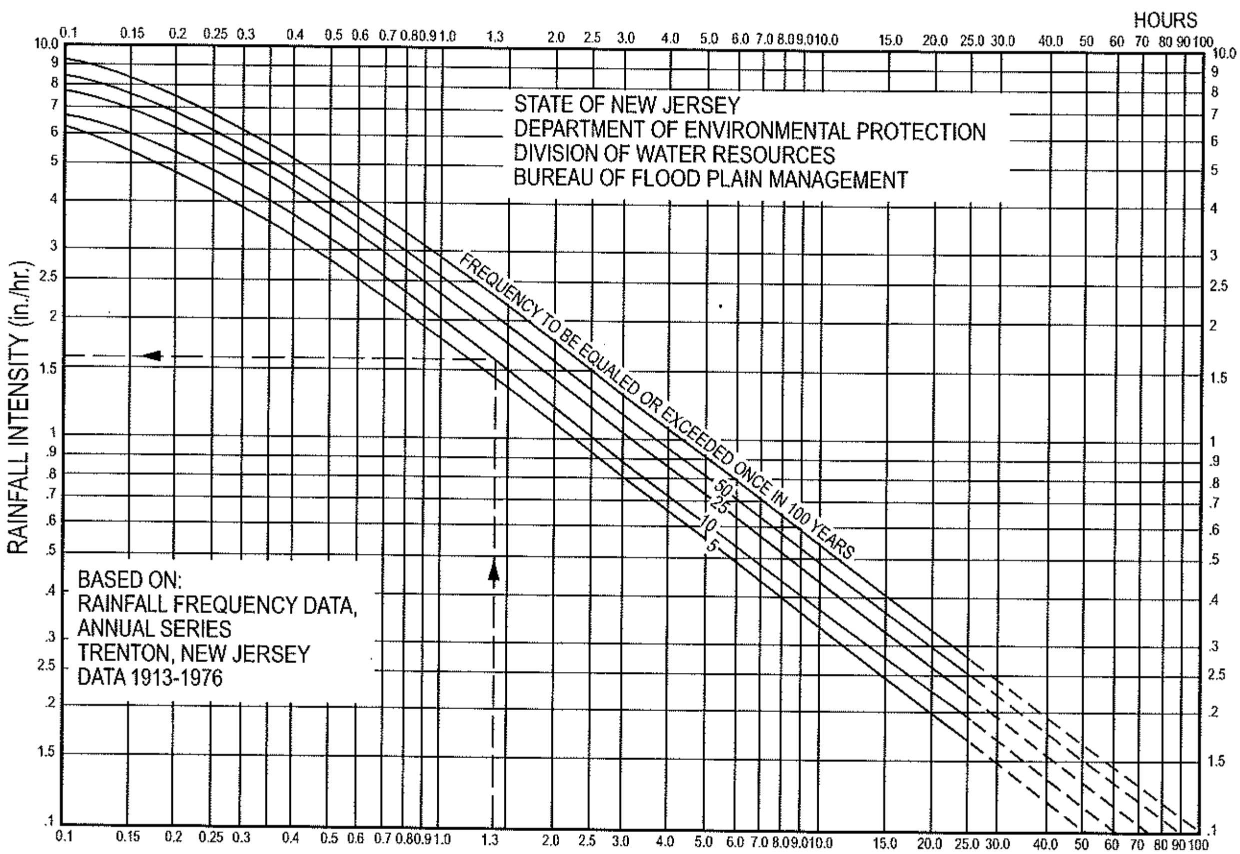


**538.** An existing watershed has the following characteristics:

| Land Use | Area (acres) | *C* Value |
|---|---|---|
| Forest | 20 | 0.20 |
| Meadow | 10 | 0.35 |
| Residential | 18 | 0.50 |
| Commercial | 2 | 0.65 |

The existing average *C* value for the total watershed is 0.36. A 10-acre commercial development has been proposed within the forested land. The existing time of concentration is 0.5 hour. The increase in impervious surfaces from the proposed commercial development will decrease the time of concentration by 30%. Based on the Rational Formula, the increase in peak runoff from the watershed (cfs) for a 10-year storm due to the commercial development is most nearly:

(A) 14
(B) 33
(C) 43
(D) 92




New Jersey Department of Environmental Protection, Division of Water Resources, Bureau of Flood Plain Management, 1976.

**539.** A new rectangular open channel needs to convey 1,800 cfs without exceeding a depth of 4 ft. To ease construction, an even-numbered width is desired. Assume $n = 0.012$ and slope = 6%. The minimum channel width (ft) is most nearly:

(A) 6
(B) 10
(C) 12
(D) 16

**540.** The total cost to construct a new highway is $6,987,500. The annual debt service to retire a bond in this amount over a 25-year period at 4% interest is most nearly:

(A) $290,680
(B) $363,350
(C) $372,550
(D) $447,270

This completes the afternoon session. Solutions begin on page 75.

# 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.

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

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

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

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

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.

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

$$D = \$6,500$$

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.

Crew cost = 2($50/hr) = $100/hr

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

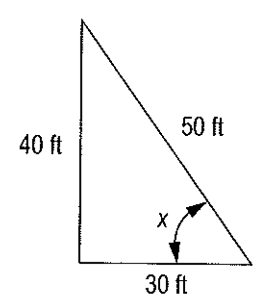
**THE CORRECT ANSWER IS: (C)**

**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.

$w = (20\ \text{lb/ft}^2)(8\ \text{ft}) = 160\ \text{lb/vertical ft per brace location}$

$\sum M_a = 0$

$\sum M_a = (160\ \text{lb/ft})(16\ \text{ft})(16\ \text{ft}/2) - 10\ \text{ft}\ (R_x) = 0$

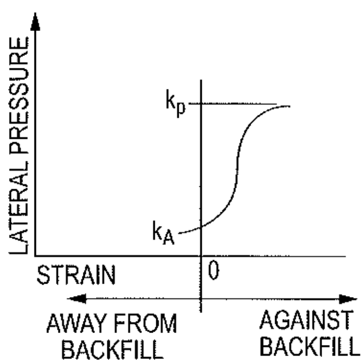
$R_x = 2{,}048\ \text{lb}$

$$\text{Axial load in brace} = \frac{(2{,}048)\sqrt{2}}{1} = 2{,}896\ \text{lb}$$

**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, $\sigma'_v$

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

**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)**

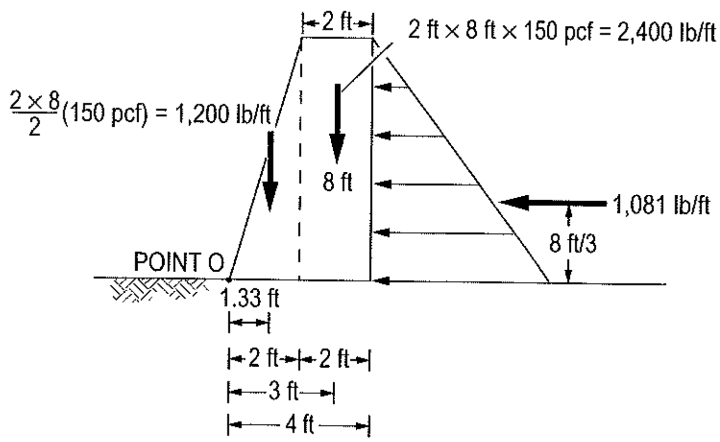
**119.** $\phi = 32°$ $\quad K_a = \tan^2(45 - \phi/2) = 0.307$

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

$M_a = (1,081)(8/3) = 2,883$ 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.

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

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

$$= 16.4\text{ cfs}$$

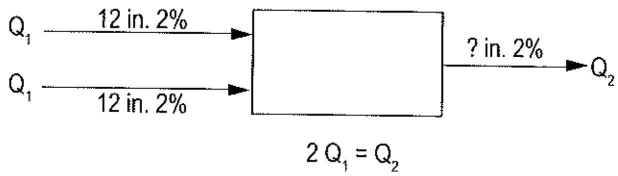
$$\text{Volume} = 25\text{ acre-ft} \times \frac{43{,}560\text{ ft}^3}{1\text{ acre-ft}} = 1.089 \times 10^6\text{ ft}^3$$

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

$$= 18.5\text{ hours}$$

**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.

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

$Q = 300\ \text{cfs}$

**THE CORRECT ANSWER IS: (C)**

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

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

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

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

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

**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.

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

$$z_1 = z_2$$

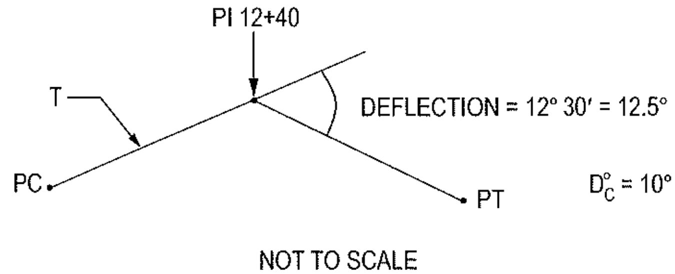
Since $A_1 > A_2$, $v_1 < v_2$.

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

so $P_1 > P_2$ to balance

**THE CORRECT ANSWER IS: (B)**

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




$$R = 5{,}729.648/D_C^\circ$$
$$= 5{,}729.648/10 = 572.96 \text{ ft}$$
$$T = R \tan\left(\frac{1}{2}\Delta\right) = R \tan(6.25°)$$
$$= 572.96(\tan 6.25°)$$
$$= 572.96(0.1095178)$$
$$= 62.75 \text{ ft}$$

Station PC = Station PI − T
$= [12 + 40] - 62.75$
$= 11 + 77.25$

Station PT = Station PC + length of curve

Length of curve $= L = 100\ \Delta/D_C^\circ$
$= 100(12.5)/10 = 125$ 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.

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

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

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 = $\pi d^2/4 = 28\ in^2$

Compressive stress = axial load/area

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

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

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

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

**THE CORRECT ANSWER IS: (C)**

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

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

where $\gamma$ = 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

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

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

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.

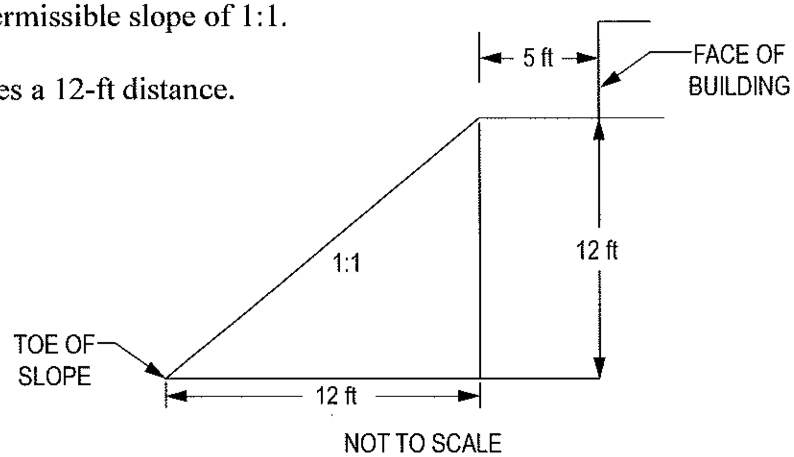
Rushing erosion is not identified in either reference.

**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.

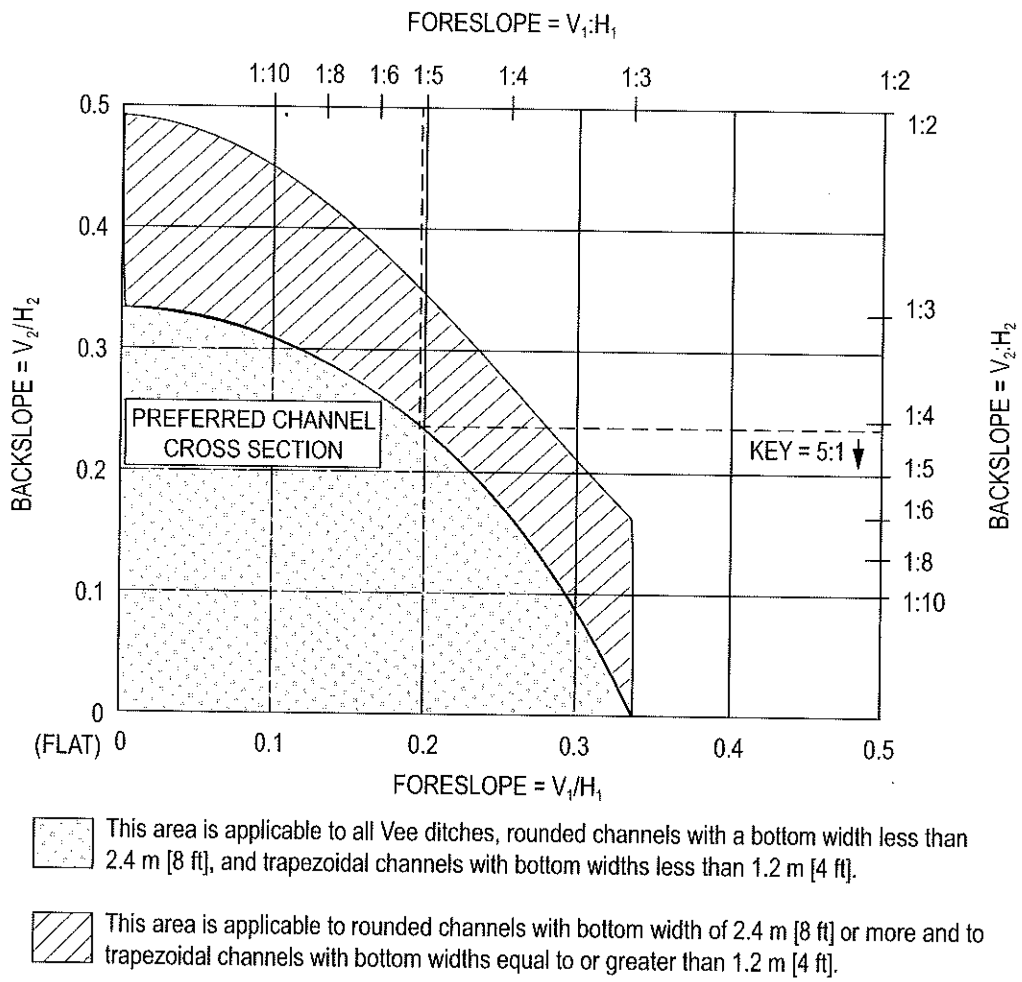
Therefore, a 12-ft depth requires a 12-ft distance.




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.




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

**THE CORRECT ANSWER IS: (C)**

# TRANSPORTATION PM SOLUTIONS

## Answers to the TRANSPORTATION PM Practice Exam

Detailed solutions for each question begin on the next page.

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

**501.** Reference: Transportation Research Board, *Highway Capacity Manual*, 2010, pp. 11-7 to 11-19.

Compute the free flow speed (FFS):

$$FFS = BFFS - f_{LW} - f_{LC} - f_N - f_{id}$$

where:

BFFS = 60 mph (given)

$f_{LW} = 0$ 12-ft lanes

$f_{LC} = 0$ 10-ft shoulders

$f_N = 4.5$ two lanes in each direction

$f_{id} = 0$ 2-mile spacing between interchanges

$$FFS = 60 - 4.5 = 55.5 \text{ mph}$$

Compute $f_{HV}$, p. 11-13, level terrain $E_T = 1.5$:

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)} = \frac{1}{1 + 0.05\,(1.5 - 1)} = 0.9756$$

Compute flow rate:

$$v_p = \frac{V}{(PHF)(N)(f_{HV})(f_p)} = \frac{2,400}{0.9 \times 2 \times 0.976 \times 1.00} = 1,366 \text{ pcphpl}$$

Compute density:

$$\text{Density} = \frac{\text{volume}}{\text{speed}} = \frac{1,366}{55.5} = 24.6 \text{ pcpmpl}$$

Find LOS:

From p. 11-7, LOS = C

**THE CORRECT ANSWER IS: (C)**

**502.** Reference: Transportation Research Board, *Highway Capacity Manual*, 2010, pp. 12-10 to 12-33.

Total volume = 4,200 + 500 + 600 + 400 = 5,700
Speed given = 56 mph
Number of lanes, N = 4
See p. 12-23 Eqn. 12-22

$$D = \frac{\left(\frac{V}{N}\right)}{S} = \frac{\left(\frac{5,700}{4}\right)}{56} = \frac{1,425}{56} = 25.44 \text{ pc/mile/lane}$$

**THE CORRECT ANSWER IS: (D)**

**503.** Reference: Transportation Research Board, *Highway Capacity Manual*, 2010, pp. 18-35 to 18-37.

Left-turns with protected phasing (exclusive or shared lanes) decrease saturation flow rate.

**THE CORRECT ANSWER IS: (D)**

**504.** Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, pp. 437–446.

When a speed limit is to be posted, it should be within 10 km/hr or 5 mph of the 85th percentile speed of the free-flowing traffic.

$$\left.\begin{array}{l} 56.2 + 5 \text{ mph} = 61.2 \\ 56.2 - 5 \text{ mph} = 51.2 \end{array}\right\} 55 \text{ or } 60 \text{ mph}$$

**THE CORRECT ANSWER IS: (C)**

**505.** Reference: Roess, Prassas, and McShane, *Traffic Engineering*, 3rd ed., pp. 189–193.

Given:

| | |
|---|---|
| Vehicles on Street A on Wednesday | 10,300 |
| Vehicles on Street B on Wednesday | 7,450 |

Calculate the ratio of vehicles on Street B on Wednesday to the vehicles on Street A on Wednesday:

$$\frac{7,450}{10,300} = 0.7233$$

Calculate the average daily traffic volume for Street B:

$$\text{ADT} = 0.7233 \times \left( \frac{6,950 + 9,450 + 7,340 + 10,300 + 9,850 + 11,250 + 8,450}{7} \right) = 6,570$$

**THE CORRECT ANSWER IS: (A)**

**506.** Reference: Garber and Hoel, *Traffic & Highway Engineering*, 4th ed., 2009, pp. 593.

Total trips = trips per household × total households

$= (0.58 + 1.5\,P + 2.2A) \times 600$

$= [0.58 + 1.5\,(4.1) + 2.2(2.3)] \times 600$

$= 11.79 \times 600$

$= 7{,}074$

**THE CORRECT ANSWER IS: (A)**

**507.** Reference: Transportation Research Board, *Highway Capacity Manual*, 2010, p. 18-41.

Saturation flow rate, s = 3,600/hr

Using the formula $c = Ns\dfrac{g}{C}$

$$c = (1)(3{,}600/2.4)\left(\frac{27+3-2-1}{90}\right) = 450 \text{ vph}$$

**THE CORRECT ANSWER IS: (D)**

**508.** Reference: Khisty, *Transportation Engineering*, 1990, p. 634.

Total vehicles entering intersection = 2,000 + 6,000 + 4,000 + 8,000 = 20,000 vpd.

$$\text{Rate} = \frac{(\text{number of accidents})(10^6)}{(\text{ADT})(\text{number of years})(365 \text{ days/year})}$$

$$= \frac{(25)(10^6)}{(20{,}000)(9/12)(365)} = 4.6 \text{ RMEV}$$

or

$$\text{Rate} = \frac{(\text{number of accidents})(10^6)}{(\text{ADT})(\text{number of days})}$$

Number of days during Jan. through Sept. $= 31+28+31+30+31+30+31+31+30 = 273$

$$\text{Rate} = \frac{(25)(10^6)}{(20{,}000)(273)} = 4.6 \text{ RMEV}$$

**THE CORRECT ANSWER IS: (A)**

**509.** Reference: Transportation Research Board, *Highway Capacity Manual*, 2010, pp. 23-3, 23-9, 23-11.

$$V_p = \frac{V_{15}}{15 \times W_E}$$

where

$V_p$ = pedestrian unit flow rate (p/min/ft)

$V_{15}$ = peak 15-min flow rate

$W_E$ = effective walkway width (ft)

$$V_p = \frac{1,200}{15(6.5)} = \frac{1,200}{97.5} = 12.3$$

Using Exhibit 23-2 and $V_p = 12.3$, platoon-adjusted LOS = E.

**THE CORRECT ANSWER IS: (D)**

**510.** Reference: Newnan, *Engineering Economic Analysis*, 9th ed., p. 74.

Given:
ADT = 12,350 vpd
Growth rate = 7%

Determine ADT 10 years in future assuming growth rate continues:

$$\begin{aligned} ADT_{future} &= ADT_{exist}(1 + 0.07)^{10} \\ &= 12,350(1.967) \\ &= 24,294 \text{ vpd} \end{aligned}$$

**THE CORRECT ANSWER IS: (D)**

**511.** Reference: Garber and Hoel, *Traffic & Highway Engineering*, 4th ed., pp. 88–90.

Distance traveled, D = vt
where v = speed
t = perception-reaction time

Distance traveled by alert driver, $D_1$:

$$v_1 = \frac{45 \text{ miles}}{\text{hour}} \times \frac{5,280 \text{ ft}}{\text{mile}} \times \frac{\text{hr}}{3,600 \text{ sec}} = 66 \text{ ft/sec}$$

$t_1 = 2.5$ sec
$D_1 = 66$ ft/sec × 2.5 sec = 165 ft

Distance travelled by impaired driver, $D_2$:

$v_2 = 55 \times 5{,}280/3{,}600 = 80.67$ ft/sec
$t_2 = 3.5$ sec
$D_2 = 80.67 \times 3.5 = 282.3$ ft

Difference = 282.3 – 165 = 117.3 ft

**THE CORRECT ANSWER IS: (C)**

**512.** Reference: Hickerson, *Route Location and Design*, 5th ed., pp. 64–65.

Determine existing tangent distance:

$$T_{existing} = R \times \tan\frac{\Delta}{2}$$
$$= 1,200 \times \tan 32.5°$$
$$= 1,200 \times 0.637$$
$$= 764.48 \text{ ft}$$

Determine new tangent:

$$T_{new} = 764.48 - 200 = 564.48 \text{ ft}$$

Determine new radius:

$$R = \frac{T}{\tan\frac{\Delta}{2}} = \frac{564.48}{0.637}$$
$$= 886.06 \text{ ft}$$

**THE CORRECT ANSWER IS: (C)**

**513.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, pp. 3-4, 3-108, and 3-109.

Stopping sight distance, $SSD = 1.47\ Vt + 1.075\dfrac{V^2}{a}$

where

$t$ = brake reaction time, 2.5 sec
$V$ = design speed, mph
$a$ = deceleration rate, ft/sec$^2$

$$SSD = 1.47(45)(2.5) + 1.075\left[\frac{(45)^2}{11.2}\right]$$
$$= 165 + 194 = 359 \text{ ft}$$

Horizontal sightline offset, $HSO = R\left[1 - \cos\dfrac{28.65\,S}{R}\right]$

where

$S$ = SSD = stopping sight distance, ft
$R$ = radius of curve, ft

$$HSO = 800\left[1 - \cos\frac{28.65\,(359)}{800}\right]$$
$$= 800(0.025) \doteq 20.06 \text{ ft}$$

Can also be solved graphically using Figure 3-22b in AASHTO.

**THE CORRECT ANSWER IS: (B)**

**514.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, p. 3-20.

The rate of superelevation is given by the following equation:

$$0.01e + f = V^2/15R$$

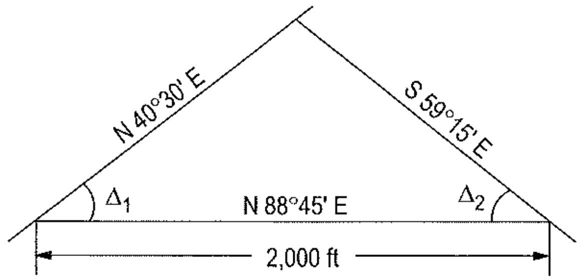
where:

$e$ = Rate of roadway superelevation (%)
$f$ = Side friction factor
$V$ = Vehicle speed (mph)
$R$ = Radius of curve (ft)

$$0.01e + 0.12 = 60^2/(15)(1{,}091)$$
$$e = 10\%$$

**THE CORRECT ANSWER IS: (B)**

**515.** Reference: Garber and Hoel, *Traffic & Highway Engineering*, 4th ed., p. 773.




$$\Delta_1 = 88.75 - 40.5 = 48.25°$$

$$R_1 = 2,200 \text{ ft}$$

$$T_1 = 2,200 \tan \frac{48.25}{2} = 985.26 \text{ ft}$$

$$T_2 = 2,000 - 985.26 = 1,014.74 \text{ ft}$$

$$\Delta_2 = 1.25 + 30.75 = 32°$$

$$R_2 = \frac{T_2}{\tan \frac{\Delta_2}{2}} = \frac{1,014.74}{\tan \frac{32}{2}} = 3,538.82 \text{ ft}$$

**THE CORRECT ANSWER IS: (B)**

**516.** Reference: Hickerson, *Route Location and Design*, 5th ed., p. 149.

Compute the rate of change of grade, r.

$r = (g_2 - g_1) / L = [-3.0\% - (+4.5\%)]/14 \text{ sta.} = -0.5357\%/\text{sta.}$

Compute the distance from the PVC to the high point.

$X_{PVC} = -g_1/r = -(+4.5\%)/(-0.5357\%/\text{sta}) = 8.4002 \text{ sta}$

Compute the PVC station.

PVC = PVI – L/2 = (42+00) – (7+00) = 35+00

Compute the station of the high point.

High point station = $\text{PVC} + X_{PVC}$

= (35+00) + (8+40.02)

= 43+40.02

**Alternate Solution:**

Define X as the horizontal distance from the PVC to any point on the curve

Elev. at X: $Y_X = Y_{PVC} + g_1 X + \left(\frac{g_2 - g_1}{2L}\right) X^2$

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

At high point, slope = 0; rearrange for X

$$X = \frac{-g_1 L}{g_2 - g_1} = \frac{(-0.045)(1{,}400)}{(-0.03) - (0.045)} = 840.00 \text{ ft}$$

Compute PVC station: $\text{PVC} = \text{PVI} - \frac{L}{2} = (42+00) - \frac{1{,}400}{2} = 35+00$

Compute high point station: PVC + X = (35+00) + 840 = 43+40

**THE CORRECT ANSWER IS: (C)**

**517.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, p. 3-161, Ex. 3-75.

K for 60 mph is 136.

L = KA

L = 136[2.40 – (–1.35)] = 510 ft

**THE CORRECT ANSWER IS: (C)**

**518.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, p. 3-156.

$$\text{Where } S < L,\ L = \frac{AS^2}{2{,}800}$$

$$1{,}000 = \frac{[1.5-(-3.2)](S^2)}{2{,}800}$$

$$2{,}800{,}000 = 4.7\,S^2$$

$$S^2 = 595{,}744$$

$$S = 772 \text{ ft}$$

$$\text{Verify } S < L \quad \Rightarrow 772 < 1{,}000 \qquad \therefore \text{OK}$$

**THE CORRECT ANSWER IS: (C)**

**519.** Reference: Garber and Hoel, *Traffic & Highway Engineering*, 4th ed., pp. 765–767.

$$E = \frac{AN}{8}$$

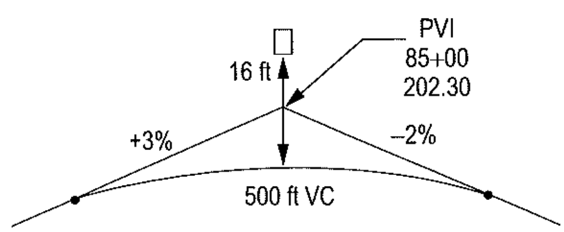
where $E$ = external distance from PVI to the curve

$A$ = algebraic difference of grades, $G_1 - G_2$

$N$ = length of the curve in stations

$$E = \frac{(3-(-2))(5)}{8} = 3.12$$

| | |
|---|---|
| Elevation of PVI | 202.30 |
| −E | −3.12 |
| | 199.18 |
| +16 | +16 |
| | 215.18 |




**THE CORRECT ANSWER IS: (B)**

**520.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, pp. 9-187 and 9-188.

$$d_H = AV_v t + \frac{\left(BV_v^2\right)}{a} + D + d_e$$

$$= (1.47)(45)(2.5) + \left(\frac{1.075(45)^2}{11.2}\right) + 15 + 8$$

$$= 383 \text{ ft}$$

**THE CORRECT ANSWER IS: (C)**

**521.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, pp. 3-103 and 10-102.

From Table 3-29:

Width = 15 ft + 2 ft for vertical curb on both sides
= 17 ft

**THE CORRECT ANSWER IS: (C)**

**522.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, p. 10-110.

The acceleration length given in Table 10-3 is 1,350 ft.

**THE CORRECT ANSWER IS: (D)**

**523.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, pp. 9-21 and 9-22.

Traffic is required to yield to circulating traffic and to follow channelization (deflection) to prevent straight path through roundabout. Center islands are typical. Traffic flows **counterclockwise,** not clockwise. (I, III, IV).

**THE CORRECT ANSWER IS: (C)**

**524.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, p. 5-8.

"A clear zone of 7 to 10 ft or more…is desirable."

**THE CORRECT ANSWER IS: (D)**

**525.** Reference: AASHTO, *Roadside Design Guide*, 4th ed., 2011, p. 8-36.

Conservation of momentum principle, $v_1 = \dfrac{m_v \times v_0}{(m_v + m_1)}$

$m_v = 2{,}000$ lb $\qquad v_0 = 45$ mph $\qquad m_1 = 600$ lb

$$v_1 = \frac{2{,}000 \times 45}{2{,}000 + 600} = 34.6 \text{ mph}$$

**THE CORRECT ANSWER IS: (A)**

**526.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, p. 3-109.

$$\text{HSO} = R\left(1 - \cos\frac{28.65(S)}{R}\right)$$

$S = 305$ ft

$$\text{HSO} = 600\left(1 - \cos\frac{28.65(305)}{600}\right) = 19.28 \text{ ft}$$

Subtract 1/2 of travel lane $\qquad 19.28 - 5.5 = 13.78$ ft

**THE CORRECT ANSWER IS: (C)**

**527.** Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2011, p. 4-61.

Paragraph 3 states "maximum curb ramp grade should be 8.33 percent."

**THE CORRECT ANSWER IS: (A)**

**528.** Reference: Transportation Research Board, *Highway Capacity Manual*, 2010, pp. 18-63, 18-66, 18-67.

$$t_{ps,do} = 3.2 + \frac{L_d}{S_p} + 0.27N_{ped,do} \qquad \text{(for } W_d \leq 10 \text{ ft)} \qquad \text{Equation 18-65}$$

$$= 3.2 + \frac{72}{4} + (0.27)(0.9)$$

$$= 21.4 \text{ sec}$$

**THE CORRECT ANSWER IS: (A)**

**529.** Reference: Roess, McShane, Prassas, *Traffic Engineering*, 2nd ed., 1998, pp. 596–597.

Offset, $t = \frac{L}{S}$, where $L$ = block length, ft

$S$ = vehicle speed, fps

$$L = 400 \text{ ft} + 500 \text{ ft} + 400 \text{ ft} + 300 \text{ ft} + 300 \text{ ft} = 1{,}900 \text{ ft}$$

$$S = 30 \times 1.47 = 44.1 \text{ fps}$$

$$t = \frac{1{,}900}{44.1} = 43.08 \text{ sec}$$

**THE CORRECT ANSWER IS: (B)**

**530.** Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, pp. 437–446.

Warrant 1: 8-hour Vehicular Volume
Check Condition A in Table 4C-1.
Since the 85th percentile speed exceeds 40 mph, use the 70% column.
Use the second row of the table for 2 lanes on major street, 1 lane on minor street.
Major street volume meets or exceeds 420 vph all 12 hours (>8)
Minor street volume meets or exceeds 105 vph for 8 of the 12 hours
Therefore, Warrant 1 is met.

Warrant 2: 4-hour Vehicular Volume
Using Figure 4C-2 (above 40 mph on major street), plot the major and minor street volumes. Each of the first 4 hours plot above the 2 lane major and 1 lane minor curve. Therefore, Warrant 2 is met.

Warrant 7: Crash Experience
Condition A is met; alternatives have not reduced crash frequency.
Condition B is met; all accidents are subject to correction by a signal; 6 in 9 months exceeds 5 in 12 months.
Condition C is met; since speed exceeds 40 mph, use the 56% column and the second row of Table 4C-1; major and minor volumes exceed table values for 8 hours or more. Therefore, Warrant 7 is met.

**THE CORRECT ANSWER IS: (D)**

**531.** Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, pp. 426–427.

Calculate the radius since the degree of curve is given.

$$R = \frac{5{,}730}{D} = \frac{5{,}730}{5} = 1{,}146 \text{ ft}$$ From Chen, *Civil Engineering Handbook*, 2nd ed., p. 63-10.

Since the radius is greater than the largest value shown on Table 3F-1, calculate the spacing by the formula given below Table 3F-1.

$$\text{Spacing, } S = 3\sqrt{R - 50} = (3)\sqrt{1{,}146 - 50}$$
$$= (3)\sqrt{1{,}094} = 3(33.08) = 99.24 \text{ ft}$$

**THE CORRECT ANSWER IS: (D)**

**532.** References: ITE, *Manual of Transportation Engineering Studies*, 2000, pp. 213–215;
FHWA, *Manual on Uniform Traffic Control Devices*, 2009, p. 537.

Stop ahead warning signs should advise driver of the pending need to slow down and stop.

**THE CORRECT ANSWER IS: (B)**

**533.** Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Figure 6C-2 and Table 6C-4.

A shifting taper is at least 0.5 L. (Table 6C-3)

L = WS = 12(55) = 660 ft (Table 6C-4)

Shifting taper = 0.5 L = 330 ft minimum

**THE CORRECT ANSWER IS: (C)**

**534.** Reference: Chen and Liew, *The Civil Engineering Handbook*, 2nd ed., pp. 27-3 and 27-4.

The standard penetration value ($N$ value) is the number of blows required to penetrate the last 12 in.

$N$ value (sample 7) = 5 + 6 = 11

**THE CORRECT ANSWER IS: (C)**

**535.** Reference: Asphalt Institute, *Asphalt Handbook* (MS-4), 7th ed., pp. 542–543.

Lack of shoulder support is a cause of edge cracking.

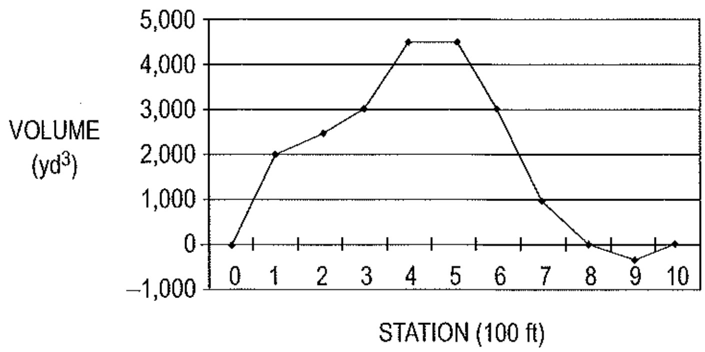
**THE CORRECT ANSWER IS: (A)**

**536.** Reference: Atkins, *Highway Materials, Soils, and Concretes*, 2nd ed., pp. 24, 45, and 51.

Common knowledge for properties of soils not subject to consolidation includes gravel and sands.

**THE CORRECT ANSWER IS: (A)**

**537.** Reference: Ricketts, Loftin, and Merritt, *Standard Handbook for Civil Engineers*, 5th ed., pp. 13-18 to 13-20.




| STATION | EXC. | EMB. | Δ | Σ |
|---|---|---|---|---|
| 0+00 | 0 | 0 | 0 | 0 |
| 1+00 | 3,000 | 1,000 | 2,000 | 2,000 |
| 2+00 | 1,000 | 500 | 500 | 2,500 |
| 3+00 | 1,500 | 1,000 | 500 | 3,000 |
| 4+00 | 2,000 | 500 | 1,500 | 4,500 |
| 5+00 | 1,000 | 1,000 | 0 | 4,500 |
| 6+00 | 500 | 2,000 | –1,500 | 3,000 |
| 7+00 | 0 | 2,000 | –2,000 | 1,000 |
| **8+00** | **0** | **1,000** | **–1,000** | **0** |
| 9+00 | 500 | 1,000 | –500 | –500 |
| 10+00 | 500 | 0 | 500 | 0 |

**THE CORRECT ANSWER IS: (C)**

**538.** Reference: Garber and Hoel, *Traffic & Highway Engineering*, 4th ed., 2009, pp. 819–821.

Existing $t_c = 0.5$ hr ($t_1$)

10-yr storm

From chart, $I_1 = 3.25$ in/hr

Average C = 0.36 (given)

$Q_{exist} = C_1 I_1 A = (0.36)(3.25)(50) = 58.5$ cfs

Calculate C for proposed development:

$$= \frac{(10 \times 0.2) + (10 \times 0.35) + (18 \times 0.5) + (12 \times 0.65)}{50}$$

$$= \frac{2 + 3.5 + 9 + 7.8}{50}$$

$C_2 = 0.446$

Calculate new time of concentration:

$$t_2 = t_1 \times 0.7 = 0.5 \times 0.7 = 0.35 \text{ hr}$$

From chart for $t_2 = 0.35$ hr and 10-yr storm:

$I_2 = 4.1$ in./hr

$$Q_{proposed} = C_2 I_2 A = (0.446)(4.1)(50) = 91.4$$

Increase = 91.4 – 58.5 = 32.9 cfs

**THE CORRECT ANSWER IS: (B)**

**539.** Reference: Chow, *Open-Channel Hydraulics*, 1959, p. 21.

Using Manning's equation:

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

$$Q = 1{,}800 \text{ cfs}$$

Given:

maximum depth = 4 ft

slope = 6%

$n = 0.012$

$$1{,}800 = \left(\frac{1.49}{0.012}\right)(A)\left(\frac{(A)}{WP}\right)^{2/3}(0.06)^{1/2}$$

$$(A)\left(\frac{(A)}{WP}\right)^{2/3} = 59.18$$

Trial and error at 4-ft depth:

| **Width** | **Area** | **Wetted Perimeter** | $(A)\left(\frac{(A)}{WP}\right)^{2/3}$ |
|---|---|---|---|
| 6 ft | $4 \times 6 = 24$ | $2 \times 4 + 6 = 14$ | 34.38 |
| 8 ft | $4 \times 8 = 32$ | $2 \times 4 + 8 = 16$ | 50.80 |
| 10 ft | $4 \times 10 = 40$ | $2 \times 4 + 10 = 18$ | 68.12 |

$68.12 > 59.18$

$\therefore$ a 10-ft channel width is required

Alternate solution using fewer calculations:

$A = w \times d$

$WP = 2d + w$

$$(w \times d)\left(\frac{w \times d}{2d + w}\right)^{2/3} = 59.182$$

$$(4w)\left(\frac{4w}{8 + w}\right)^{2/3} = 59.182$$

Use the same trial and error method as above by substituting w at 6, 8, 10, etc., until greater than 59.182.

**THE CORRECT ANSWER IS: (B)**

**540.** Reference: Ricketts, Loftin, and Merritt, *Standard Handbook for Civil Engineers*, 5th ed., p. 1.15.

Determine the annual debt service:

$$R = P\frac{i}{1-(1+i)^{-n}}$$

where

$R$ = annual payment

$P$ = present worth of investment

$i$ = interest rate

$n$ = number of interest periods

$$R = (\$6,987,500)\left(\frac{0.04}{1-(1+0.04)^{-25}}\right)$$

$$= \$447,283.59$$

Alternatively, from economic factor tables available in various references, capital recovery factor (CRF) = 0.06401

$$A = P(A/P, 4\%, 25)$$
$$= (\$6,987,500)(0.0640)$$
$$= \$447,271.56$$

**THE CORRECT ANSWER IS: (D)**

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