PE
civil: structural
practice exam
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About NCEES
NCEES is a nonprofit organization made up of the U.S. engineering and surveying licensing boards in all 50 states, the U.S. territories, and the District of Columbia. We develop and score the exams used for engineering and surveying licensure in the United States. NCEES also promotes professional mobility through its services for licensees and its member boards.

Engineering licensure in the United States is regulated by licensing boards in each state and territory. These boards set and maintain the standards that protect the public they serve. As a result, licensing requirements and procedures vary by jurisdiction, so stay in touch with your board (ncees.org/licensing-boards).

Exam format
The PE Civil: Structural exam is computer-based. It contains 80 questions and is administered year-round via computer at approved Pearson VUE test centers. A 9-hour appointment time includes a tutorial, the exam, and a break. You have 8 hours to complete the actual exam.

In addition to traditional multiple-choice questions with one correct answer, the exam uses common alternative item types such as

- Multiple correct options—allows multiple choices to be correct
- Point and click—requires examinees to click on part of a graphic to answer
- Drag and drop—requires examinees to click on and drag items to match, sort, rank, or label
- Fill in the blank—provides a space for examinees to enter a response to the question

To familiarize yourself with the format, style, and navigation of a computer-based exam, view the video tutorials on the NCEES YouTube channel.

Examinee Guide
The NCEES Examinee Guide is the official guide to policies and procedures for all NCEES exams. During exam registration and again on exam day, examinees must agree to abide by the conditions in the Examinee Guide, which includes the CBT Examinee Rules and Agreement. You can download the Examinee Guide at ncees.org/exams. It is your responsibility to make sure you have the current version.

Scoring and reporting
Results for computer-based exams are typically available 7–10 days after you take the exam. You will receive an email notification from NCEES with instructions to view your results in your MyNCEES account. All results are reported as pass or fail.

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.
3. A soil profile is shown. The effective vertical stress (psf) at Point A is most nearly:

- A. 1,270
- B. 1,820
- C. 2,140
- D. 2,570

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

- A. Buoyant unit weight
- B. Saturated unit weight
- C. Dry unit weight
- D. Total unit weight
18. 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

19. 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?

- Option A
- Option B
- Option C
- Option D

- A. Option A
- B. Option B
- C. Option C
- D. Option D
24. A beam is loaded as shown:

Select the two diagrams that most accurately represent the shear and bending moment for the loaded beam shown.
37. According to IBC 2018 and applicable quality assurance inspection requirements, which of the following inspection tasks are required for ASTM A325N high-strength bolts used in a steel-framed structure?

Select the two that apply.

□ A. Verification of the magnitude of the clamping force
□ B. Calibration of the torque wrench
□ C. Confirmation that the proper fastener components are used
□ D. Confirmation that the faying surfaces are brought into firm contact during installation of the bolts
□ E. Confirmation that the bolt installer has an AWS D1.1 certification

38. To result in a compressive force of 15 kips on the diagonal brace shown, the horizontal force $H$ (kips) on the top of the form wall shown must be __________.

Enter your response in the blank.
55. The figure shows a wall construction plan.

Design Code:

Material:
Douglas Fir-Larch No. 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
62. Label the correct characteristics of each figure of a roof diagram.
67. 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:


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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1. \( 1,000 \text{ kN} = 1,000 \text{ kN} \times \frac{1 \text{ ton}}{8.896444 \text{ kN}} = 112.4 \text{ tons} \)

150 tons > 112.4 tons

**THE CORRECT ANSWER IS: C**

2. 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**

3. Effective vertical stress at Point A, \( \sigma'_v \)
   
   \[ \begin{align*}
   &= 10 \text{ ft} \times 120 \text{ pcf} + 5 \text{ ft} \left( 120 \text{ pcf} - 62.4 \text{ pcf} \right) + 7 \text{ ft} \left( 110 \text{ pcf} - 62.4 \text{ pcf} \right) \\
   &= 1,200 \text{ psf} + 288 \text{ psf} + 333 \text{ psf} \\
   &= 1,821 \text{ psf}
   \end{align*} \]

**THE CORRECT ANSWER IS: B**

4. 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**

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

**THE CORRECT ANSWER IS: D**
16. By inspection, Member b = 0 kips, and Member c = 100 kips.

THE CORRECT ANSWER IS: B

17. Beam stress, \( f = \frac{M}{S} \), where \( M = \frac{wL^2}{8} \) and \( S = \frac{bh^2}{6} \).

\( S \) is equal for both beams, but \( M \) varies because it depends on beam length.

- Beam 1 (shorter beam): \( M_1 = \frac{wL^2}{8} \)
- Beam 2 (longer beam): \( M_2 = \frac{w(2L)^2}{8} = 4\frac{wL^2}{8} \)

\( M_2 \) 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

18. 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

19. \( I_x \) is maximum for this section by inspection, or calculate \( I_x \approx \sum Ad^2 \) for each section.

THE CORRECT ANSWER IS: D
24. Referring to the beam shown in the question, there is a zero moment at the hinge.

![Moment Diagram](image)

**THE CORRECT DIAGRAMS ARE SHOWN ABOVE.**

25. \[
M_{\text{max}} = \frac{(200 \text{ lb/ft})(20 \text{ ft})^2}{8} + \frac{(1,000 \text{ lb})(20 \text{ ft})}{4}
\]
\[
= 10,000 \text{ ft-lb} + 5,000 \text{ ft-lb} = 15,000 \text{ ft-lb}
\]
\[
I = \frac{(4 \text{ in.})(12 \text{ in.})^3}{12} = 576 \text{ in}^4
\]
\[
f_b = \frac{Mc}{I}
\]
\[
= \frac{(15,000 \text{ ft-lb})(6 \text{ in.})}{576 \text{ in}^4}(12 \text{ in./ft})
\]
\[
f_b = 1,875 \text{ psi}
\]

**THE CORRECT ANSWER IS: C**

26. \[
I = \frac{bd^3}{12} - \frac{bhd_1^3}{12} = \frac{8(12)^3 - 4(8)^3}{12} = 981 \text{ in}^4
\]
\[
V = 1,000 \text{ plf}\left(\frac{10 \text{ ft}}{2}\right) + \left(\frac{4,000 \text{ lb}}{2}\right) = 7,000 \text{ lb}
\]
\[
\nu_{\text{horizontal}} = \frac{VQ}{IB} = \frac{7,000 \text{ lb}(85 \text{ in}^3)}{981 \text{ in}^4(2 \times 2 \text{ in.})} = 151 \text{ psi}
\]

**THE CORRECT ANSWER IS: B**
36. The temporary structure must be designed in compliance with applicable building codes, regulations, and safety standards. The submittal review process helps to identify and address potential safety issues or design flaws before the structure is installed, ensuring that the temporary structure is safe and fit for its intended use.

**THE CORRECT ANSWER IS: A**

37. IBC 2018, Section 1705.2.1 (Structural steel), states that "Special inspections and nondestructive testing of structural steel elements in buildings, structures, and portions thereof shall be in accordance with the quality assurance inspection requirements of AISC 360."

Therefore, per AISC 360-16 *AISC Steel Construction Manual*, Chapter N (Quality Control and Quality Assurance), N5.6 (Minimum Requirements for Inspection of Structural Steel Buildings - Inspection of High-Strength Bolting) on p. 16.1-500:

Snug-tightened joints are required to be inspected to ensure the following:
1. Proper fastener components are used; therefore, proper product marking in accordance with the applicable ASTM standard
2. The faying surfaces are brought into firm contact during installation of the bolts.

Note that the magnitude of the clamping force that exists in a snug-tightened joint is not a consideration and need not be verified. ASTM A325N bolts would indicate that the bolts are a snug-tightened joint and not pre-tensioned or slip-critical joints.

**THE CORRECT ANSWERS ARE: C, D**

38. The angle between the brace and horizontal is \( 50.9^\circ = \arctan \left( \frac{6 \text{ ft}}{5 \text{ ft}} \right) \)

Therefore, the 15-kip compressive force on the diagonal brace would be a horizontal force at the top of the brace:

\[
\text{Horizontal force at the top of the brace} = 15 \text{ kips} \times \cos (50.2^\circ) = 9.6 \text{ kips}
\]

Therefore, the \( H \) force is 6 ft/8 ft (9.6 kips) = 7.2 kips

**THE CORRECT ANSWER IS: \( \geq 7.1 \text{ to } \leq 7.3 \)**
\[ r_{EW} = r_{NS} \quad K_{EW} > K_{NS} \]
Buckling in east-west direction will control.  

THE CORRECT ANSWER IS: B

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

THE CORRECT ANSWER IS: D

55. Reference: NDS 2018

Douglas Fir-Larch No. 2, \( F_c = 1,350 \text{ psi} \)  

\[ F^*_c = (F_c)(C_D)(C_M)(C_I)(C_F)(C_I) \]
\[ = (1,350)(1.6)(1.0)(1.0)(1.15)(1.0) = 2,484 \text{ psi} \]

\[ F'_c = (F^*_c)(C_P) \]
\[ = (2,484)(0.33) = 819.72 \text{ psi} \]

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

\[ P = F'_c A = (819.72)(5.25) = 4,303 \text{ lb} \]

THE CORRECT ANSWER IS: D
62. Reference: ASCE 7-16, Section 12.3.

The correctly labeled diagrams are shown above.
66. Vertical reaction to Footing B = 150 kips × 5 ft/6 ft = 125 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**


   Total prestress force, \( P = 2 \times 6 \text{ strands} \times 0.153 \text{ in}^2 / \text{strand} \times 175 \text{ ksi} = 321.3 \text{ kips} \)
   Axial stress = \( P / A = 321.3 / (36 \times 18) = 0.496 \text{ ksi} \) (compression)
   Bending stress due to prestress = \( Pe / S \)
   \[ S = bd^2 / 6 = 18 \times 36^2 / 6 = 3,888 \text{ in}^3 \]
   \[ e = 36 / 2 - 3 - 2 / 2 = 14 \text{ in.} \]
   Bending stress due to prestress = \( 321.3 \times 14 / 3,888 = 1.158 \text{ ksi} \) (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**

68. Reference: AASHTO, 8th ed., Section 9.7.2.3

   \( L_{eff} = 8.5 \text{ ft} - b_f + \text{flange overhang} \)
   \[ = 8.5 \text{ ft} - 1.5 \text{ ft} + 0.25 \text{ ft} + 0.25 \text{ ft} \]
   \[ = 7.5 \text{ ft (7 ft 6 in.)} \]
   
   **THE CORRECT ANSWER IS: C**

69. Reference: IBC 2018

   The presumptive soil values are allowable stress values.
   The presumptive vertical foundation pressure for a sandy gravel and gravel (GW and GP) material is 3,000 psf (3 ksf). (Table 180 6.2)
   Using the stated foundation plan size of 8 ft × 8 ft, the allowable vertical load in kips is 3 (ksf) × 8 ft × 8 ft = 192 k.
   
   **THE CORRECT ANSWER IS: ≥ 190 to ≤ 194**