PE

structural engineering

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
Beginning in April 2024, the PE Structural Engineering exam will be computer based. The exam will include two components—vertical and lateral. Examinees must obtain acceptable results on both components to pass the entire exam. Once acceptable results are obtained on a component, those results do not expire.

Each component includes a breadth section and a depth section. Breadth and depth sections may be taken and passed at different times. Breadth section exam appointments will be 6 hours. This includes 10 minutes for a tutorial and review of the nondisclosure agreement, a 20-minute break, and 5.5 hours of exam time. All 55 questions in the breadth sections will be multiple choice with one correct response.

The depth section of each component is given in two topic areas: buildings and bridges. Examinees must choose one area and complete the same area on both components. Depth section exam appointments will be 5.5 hours. This includes 10 minutes for a tutorial and review of the nondisclosure agreement, a 20-minute break, and 5 hours of exam time. The depth sections will have five descriptive scenarios with 12 alternative item types (AITs) in each scenario. AITs include the following:

- Multiple correct options—allows multiple answer 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 numerical response to the question. Only numerals, decimals, and negative signs are allowed in the blank.

Refer to the PE Exams tab on the NCEES website for more information about the format of the PE Structural exam.

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
You will receive an email notification from NCEES when results are available in your MyNCEES account.

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.
VERTICAL FORCES BREADTH QUESTIONS
20. The figure shows a portion of a multistory, unbraced reinforced concrete frame.

Design Codes:
- IBC: *International Building Code*
- ACI 318: *Building Code Requirements for Structural Concrete*

Design Data:
- $f_{c'} = 4,000$ psi

Assumptions:
- Section 6.6.3.1.1(a) of ACI 318-14 is applicable.
- Column ends are fixed.

The effective length factor $k$ of the 16-in. $\times$ 16-in. column indicated on the figure is most nearly:

- A. 1.25
- B. 1.45
- C. 1.75
- D. 2.0
VERTICAL FORCES DEPTH
BRIDGES QUESTIONS
A three-span continuous composite steel girder bridge is located in Seismic Zone 1. The girders are 48 in. deep.
1. Select the two bolted splices for the girder.

![Diagram of bridge structure with labeled splices]

2. Design Data:
   
   \[ t_{ft} = t_{fb} = 1 \text{ in.} \]
   
   \[ b_{ft} = b_{fb} = 16 \text{ in.} \]
   
   \[ f_y = 50 \text{ ksi} \]
   
   \[ E = 29,500 \text{ ksi} \]
   
   \[ V_u = 150 \text{ kips} \]

   The **minimum** thickness (in.) of the unstiffened web is __________.

   Enter your response in the blank.

![Diagram of 48" girder with labeled dimensions]
19. \[ d_e = d_s = 60 - 1.5 - \frac{1.128}{2} - 0.625 = 57.31 \text{ in.} \quad \text{AASHTO 5.3} \]

\[ a = \frac{A_s f_y}{\alpha f_c' b} = \frac{10 \times 1.00 \times 60}{0.85 \times 4 \times 36} = 4.902 \text{ in.} \quad \text{AASHTO 5.6.2.2} \]

\[ \therefore d_v = \frac{d_e}{2} = 57.31 - \frac{4.902}{2} \]

\[ = 54.86 \text{ in.} \quad \text{Controls} \]

0.9 \( d_e = 51.58 \text{ in.} < 54.86 \text{ in.} \quad \text{AASHTO 5.7.2.8} \]

0.72 \( h = 43.2 \text{ in.} < 54.86 \text{ in.} \]

**THE CORRECT ANSWER IS: C**

20. \[ I_{beam} = (0.35)(11,000) = 3,850 \text{ in}^4 \]

\[ I_{col} = (0.70)(5,460) = 3,822 \text{ in}^4 \]

\[ \sum \frac{EI_{col}}{L} = \frac{(2)(3,822)}{13.67} = 559 \quad \text{(Ignore } E \text{ for } f_c' \text{; same for beams and columns)} \]

\[ \sum \frac{EI_{beam}}{L_c} = \frac{(2)(3,850)}{20} = 385 \]

\[ \Psi_A = \Psi_B = \frac{559}{385} = 1.45 \]

From ACI 318, Figure R6.2.5 (b), \( k = 1.45 \)

**THE CORRECT ANSWER IS: B**
VERTICAL FORCES DEPTH
BRIDGES SOLUTIONS
Questions begin on page 77.

1. Reference: AASHTO Art. 6.13.6.1.3

   Options B and D: Inflection points where moment is minimal and can be set in a stable sequence.

   Options A and E: Inflection points will not occur at midspan.

   Option C is at the high moment location.

   **THE CORRECT ANSWERS ARE: B, D**
Vertical Forces Depth—Bridges Solutions

2. \[
\frac{D}{t_w} \leq 150 \quad t_{w_{\text{min}}} = \frac{46}{300} = 0.153
\]

or

0.3125 in.

or

\[V_u \leq \phi_v v_n\]

\[v_n = v_{cr} = CV_p\]

\[\phi_v = 1.0\]

\[t_w\] must be greater than 0.3125; therefore, \(D/t_w\) must be at least \(\frac{46}{0.3125} = 147.25\)

Determine \(C\)

\[1.4 \sqrt{\frac{E(k)}{F_{yw}}} = 1.4 \sqrt{\frac{29,500 (5.0)}{50 \text{ ksi}}} = 76.04\]

\[k = 5.0\]

\[\frac{D}{t_w} > 76.04\]

therefore

\[C = \frac{1.57}{(\frac{D}{t_w})^2} \left( \frac{E(k)}{F_{yw}} \right) = \frac{1.57}{(\frac{46}{t_w})^2} \left( \frac{2,950}{t_w} \right) = \frac{4,631.5}{(2,116/t_w^2)}\]

\[C = 2.19 t_w^2\]

\[V_p = 0.58 F_{yw} D t_w\]

\[V_p = 0.58 (50)(46) t_w = 1,334 t_w\]

\[V_n = 2.19 (t_w^2)(1,334)(t_w) = 2,921.46 t_w^3\]

\[V_u \leq (1.0)(V_n)\]

150 kips \(\leq 2,921.46 t_w^3\)

\[\sqrt[3]{\frac{150}{2,921.46}} = t_w\]

\[t_w = 0.372 \text{ in.} \quad \leftarrow \text{ Controls} \quad \text{Round up to nearest 0.125 in.}\]

THE CORRECT ANSWER IS: 0.375
LATERAL FORCES BREADTH QUESTIONS
Lateral Forces Breadth Questions

1. The figure shows a diagram for an agricultural building.

Design Codes:
IBC: International Building Code
ASCE 7: Minimum Design Loads and Associated Criteria for Buildings and Other Structures

Design Data:
Basic wind speed, \( V \)
Risk Category I: 120 mph
Risk Category II: 132 mph
Risk Category III-IV: 143 mph

Assumptions:
Topographic factor, \( K_{zt} = 1.0 \)
Building is located in flat open country.

The wind velocity pressure (psf) at mean roof height for MWFRS is most nearly:

- A. 21.9
- B. 27.4
- C. 33.2
- D. 40.0
LATERAL FORCES DEPTH
BUILDINGS QUESTIONS
Lateral Forces Depth—Buildings Questions

**Scenario 2**

**Figure A** shows a one-story office building with a wood roof framing system and masonry exterior walls.

Use the following as a basis of design unless otherwise noted in the individual questions.

**Material Specifications:**
- Masonry: $f_{m''} = 2,000$ psi
- Grout: $f_{c'} = 2,000$ psi
- Wood joists and studs: Douglas Fir-Larch No. 2
  - $C_m = 1.0$
  - $C_T = 1.0$
  - $C_L = 1.0$
  - $C_f = 1.0$
  - $C_i = 1.0$
- Plywood sheathing: 15/32 in. Structural I
- Steel bolts: ASTM A325
- Steel anchors (to masonry): $f_y = 36$ ksi

**Loading Criteria:**
- Roof dead load = 20 psf
- Wall dead load = 60 psf
- Roof live load = 20 psf (nonreducible)

Wind load:
- Basic wind speed (ultimate): 129 mph Risk Category I
  - 142 mph Risk Category II
  - 154 mph Risk Category III
  - 161 mph Risk Category IV

Exposure C
Lateral Forces Depth—Buildings Questions

(Continued)

Scenario 2

WALL SECTION

FIGURE A
Scenario 2

Lateral Forces Depth—Buildings Questions

(Continued)

FIGURE B
(Continued)

FOUNDATION PLAN

FIGURE C

NOTE: ALL OPENINGS IN WALLS ARE 12'-0" TALL FROM THE FIRST- FLOOR SLAB.
Lateral Forces Depth—Buildings Questions

1. Design Data:
   Base wind speed = 142 mph
   Exposure B
   $K_2 = 1.0$
   $K_e = 1.0$

   The wind velocity pressure $q_n$ (psf) at the top of the building's parapet is __________.

   Enter your response in the blank.

2. Based on a wind velocity pressure of 40 psf and vertical reinforcement at 16 in. o.c., the wind design force $p$ (psf) at the top of the windward parapet at Grid Line 5 is __________.

   Enter your response in the blank.

3. Based on a wind velocity pressure of 40 psf and vertical reinforcement at 16 in. o.c., the building's leeward parapet design wind pressure $P_{total}$ (psf) at Grid Line 5 is __________.

   Enter your response in the blank.
LATERAL FORCES BREADTH SOLUTIONS
Questions begin on page 154.

1. \[ q_h = 0.00256 \cdot K_h \cdot K_{zt} \cdot K_c \cdot V^2 \]  
   \[ h = \left( \frac{(4)(30 \text{ ft/2}) + 15}{12} \right) + 15 = 17.5 \text{ ft} \]

   Surface Roughness: C  
   Exposure Category: C  
   \( K_h = K_{17.5} = 0.875 \)  
   \( K_{zt} = 1.0 \)  
   \( K_e = 1.0 \)  
   \( K_d = 0.85 \)  
   \( V = 120 \) (Risk Category I—IBC Table 1604.5)

   \[ q_z = 0.00256(0.875)(1.0)(0.85)(1.0)(120)^2 = 27.4 \text{ psf} \]

   **THE CORRECT ANSWER IS: B**
LATERAL FORCES DEPTH
BUILDINGS SOLUTIONS
Lateral Forces Depth—Buildings Solutions

Questions begin on page 210.

Reference: ASCE 7

1. 142 mph, Exposure B
   RC II, parapet 20–24 ft

   \[ q_n = 0.00256(K_2)(K_{d})(K_e)(e^2) \]
   at \( e \) of 20 ft, \( K_2 = 0.90 \); at \( e \) of 24 ft, \( K_2 = 0.94 \)
   \( K_{d} = 1.0, K_e = 1.0 \)

   \[ q_n = 0.00256(0.94)(1.0)(0.85)(1.0)(142)^2 = 28.6 \text{ psf} \]

   Range: 0.652 to 0.66
   28.6 to 28.958

   THE CORRECT ANSWER IS: 28.5 to 29.0

2. Effective wind area = \( 4(\text{ft})/3 = 3.33 < 10 \text{ psf} \); use 10 psf
   Wall Zone 4 positive coefficient = +1.0
   Roof Zone 2 uplift pressure = –2.3

   \( GC_{pi} = 0 \) for solid parapet

   \( q_p = 40 \text{ psf} \), given
   \[ p = q_p[(CGC_p) – (GC_{pi})] = 40[1.0(0.9) – 0] = 40(-2.3 – 0) = 40(32) \]
   \[ p = 128 \text{ psf} \]

   THE CORRECT ANSWER IS: 126 to 130

3. \( q_2 = 40 \text{ psf} \)
   \( GC_{pi} = 0.00 \) (solid parapet, open building)
   Effective wind area = \( 4.0 \text{ ft} \times 4.0 \text{ ft}/3 = 5.32 \text{ ft}^2 \)
   \( GC_p = \) Figure 30.3-1

   \[ 4) = -1.1 \times 0.9 = -0.99 = GC_p \text{ for } P_4 \]
   \[ -1.0 \times 0.9 = +0.9 = GC_p \text{ for } P_3 \]

   \( P_3 = 40 \text{ psf} \)
   \( P_4 = 40 \text{ psf} \)
   \( P_{total} = 75.6 \text{ psf} \)

   THE CORRECT ANSWER IS: 74.0 to 77.0