CE311 Fall 2016

Exam 6 Study Guide

CE311 EXAM 6 STUDY GUIDE
Exam 6 Date: Monday, December 5, 2016

Exam Format
50 minute time limit. You will be allowed to use your steel manual, a calculator, and pencils. Some questions will be purely conceptual in nature, while others will be computational.

Coverage
Lesson Objectives from Lessons 30 to 36

Lesson Objectives and Examples
The main body of this Study Guide is a list of every lesson objective from Lessons 30 through 36. Example problems are given for most.

List and Apply the limitations of each of the AISC Part 3 design aids to beam design/analysis problems.

1. (3 points). An A36 W16x31 is in strong-axis bending due to a center-point-loading over a simple-span, with continuous lateral support of the compression flange. Which AISC design aids can be directly used to determine the maximum allowable moment or load?
   a. $M_p/\Omega$ from Table 3-2
   b. $M_p/\Omega$ from Table 3-2 and Table 3-6
   c. $M_p/\Omega$ from Table 3-2 and Table 3-10
   d. $M_p/\Omega$ from Table 3-2, and Tables 3-6, and 3-10
   e. None of the above

2. (3 points). An A992 W16x31 is in strong-axis bending due to a center-point-loading over a simple-span, with lateral support of the compression flange at the supports and at the load point, such that $L_b$ is less than $L_c$. Which AISC design aids can be directly used to determine the maximum allowable moment or load?
   a. $M_p/\Omega$ from Table 3-2
   b. $M_p/\Omega$ from Table 3-2 and Table 3-6
   c. $M_p/\Omega$ from Table 3-2 and Table 3-10
   d. $M_p/\Omega$ from Table 3-2, and Tables 3-6, and 3-10
   e. None of the above

3. (3 points). An A992 W16x31 is in weak-axis bending due to a center-point-loading over a simple-span, without any lateral support of the compression flange. Which AISC design aids can be directly used to determine the maximum allowable moment or load?
   a. $M_p/\Omega$ from Table 3-2
   b. $M_p/\Omega$ from Table 3-2 and Table 3-6
   c. $M_p/\Omega$ from Table 3-2 and Table 3-10
   d. $M_p/\Omega$ from Table 3-2, and Tables 3-6, and 3-10
   e. None of the above

Select a steel beam using the AISC Part 3 design aids, as applicable, using the easiest legitimate method.(with next objective).

Design a rolled beam, considering bending moment, shear, and deflection.

4. (6 points). Determine $V_n$ for an A992 W18x35 beam in strong-axis bending.

5. (3 points). A W beam is to be selected to assure adequacy with respect to shear, moment, and live-load deflection. If the beam is very short (relative to its depth) and will be subjected to a very high uniform live load, which of the following is most likely to control the design (circle the best answer):
   a. Shear
   b. Moment
   c. Live-Load Deflection

6. (3 points). A W beam is to be selected to assure adequacy with respect to shear, moment, and live-load deflection. If the beam is very long (relative to its depth) and will be subjected to a moderate uniform live load, which is most likely to control the design (circle the best answer):
   a. Shear
   b. Moment
   c. Live-Load Deflection

7. (3 points). W beam’s are selected to assure adequacy with respect to shear, moment, and live-load deflection. Which limit state controls most designs? (circle the best answer):
   a. Shear
   b. Moment
8. (5 points) Explain why live-load deflection is normally a design criteria, rather than total load deflection.

9. (5 points) Explain why the flange area is neglected when computing the nominal shear strength $V_n$ for an I-shaped beam in strong-axis bending.

10. (10 points) An A992 W18x35 beam is subjected to a service uniform load of 10 kips per foot, including its self-weight, over a simple span of 10 feet. Using ASD, determine if the beam is safe for the shear yielding mode (note: the ASD $\Omega$ factor for beam shear is 1.5).

11. (10 points) An A992 W18x35 beam is subjected to a uniform live load of 1 kip per foot and a uniform dead load of 0.5 kip per foot (including its self-weight), over a simple span of 45 feet, in strong-axis bending. If the conventional deflection limitation is enforced, whereby live load deflections are not to exceed $L/360$, determine if an A992 W18x35 beam meets the serviceability criteria.

12. (20 points) Using ASD, determine the maximum load $P$ that may be applied to the rolled shape shown, considering shear, only. $F_y = 50$ ksi. Assume that self-weight is negligible.

13. (15 points) Using ASD, determine the maximum live load $P$ that the A992 W16x26 beam can be subjected to in strong axis bending if the beam is simply supported over a span of six feet, with lateral supports provided at the point loads. Each point load is $P/2$, located at one-third points, as shown. Assume that self-weight is negligible and that deflection is not a consideration.

14. (40 points) Use the ASD method to select the lightest possible A992 W section for a typical interior girder, considering shear, moment, and deflection (live load deflection not to exceed $L/360$). All beams support a 4.5" thick slab, cast on metal deck that is welded to the top flanges of the beams. All connections are simple.

**Loads:** Slab: Normal Weight Concrete (150 pcf)
Fill beams weigh 40 plf
Live Load = 50 psf (live load reduction factor has already been applied. Do not reduce further).
Use the Principle of Superposition and the Table 3-23 formulae to determine the deflections of beams.

15. (15 points). The beam shown is a W16x31 in strong-axis bending. If it is subjected to a uniformly distributed live load of 1 kip/ft and a center-point live load of 12 kips, determine the maximum live load deflection.

Compute the adequacy of any steel member subjected to combined axial and bending, considering all three possible bending “weak links” (e.g., in bending, plastic bending, local buckling, and lateral-torsional buckling) using the bilinear interaction (equations H1-1a and H1-1b) (with subsequent objectives)

Define second-order effects and identify cases in which they are applicable.

16. (3 points). TRUE or FALSE. If the analyst ignores 2nd order effects for the problem below (i.e., considers B1=1), it is conservative.

17. (3 points). TRUE or FALSE. If the analyst ignores 2nd order effects for the problem below (i.e., considers B1=1), it is conservative.

18. (3 points). For which Case (A or B) would the B1 factor be greater?
Compute first-order moments (i.e., “statics”) and first-order deflections (using beam formula) (with subsequent objectives)

Compute higher-order moments and deflections using the Kurtz Method and state the assumption of the Kurtz Method.

19. (20 points). The beam shown has $EI=10,000,000$ kip-in$^2$, a span of 200 inches, a center-point transverse load of 48 kips, and an axial force of 1000 kips. Determine the total moment, including 2nd order effects using a simplified 2nd order analysis which assumes that the 2nd order moment function has the same shape as the 1st order moment function (i.e., “the Kurtz Method”). Ignore self-weight.

Incorporate second-order effects in a PM interaction problem and KNOW that AISC requires some kind of second-order (P-delta) analysis in all cases.

20. (35 points) Determine if a W14x90 A992 beam-column is safe per ASD (with adequate $\Omega$) for the following conditions.

Lateral bracing is provided at the end-supports. Note that the transverse loads are applied via cables, so that weak axis movement is only prevented at the simple end-supports. For 2nd Order effects, assume that the moment magnifier $B_1$ is 1.05 (i.e., amplify the 1st Order moment by a factor of 1.05 to account for 2nd Order effects). Do not consider shear or deflection.
21. (30 points) Determine if the 30’-long W14x48 is safe, per ASD. For the 2nd Order (PΔ) effect, assume that the 2nd Order Moment Magnifier $B_1$ is 1.05 (i.e., amplify the 1st Order moment by a factor of 1.05 to account for 2nd Order effects).

**Given:** A992 W14x48 shape, braced at the ends, only. It is subjected to an applied axial load $P$ of 45 kips and a midspan Live Load of 1.5 kips, causing weak-axis bending. Do not ignore the self-weight of the beam (gravity is directed down). Do not consider shear or deflection.

\[ P_{\text{applied}} = 45 \text{ kips} \]

\[ \text{Live Load} = 1.5 \text{ kips} \]

22. (20 points) Estimate the maximum moment, considering 2nd Order Effects, using the Kurtz Method (i.e., determine the 1st order deflection, use this to find the additional moment caused by the 1st order deflection, use this new moment to determine the additional deflection, which causes additional moment, which causes additional deflection….). Assume the beam self-weight is negligible.

**Given:** Steel ($E=29000$ ksi), $I_x = 500 \text{ in}^4$, $I_y = 100 \text{ in}^4$, $A = 10 \text{ in}^2$

Continue this cyclical analysis until 3 digits of precision are achieved.

Hint (for this and any deflection problem): find out if there is a formula for this deflection; do not use double-integration if you can avoid it.

\[ P_{\text{app}} = 250 \text{ kips} \]

\[ \text{Brace, typ.} \]

\[ 40 \text{ kips} \]

\[ P = 250 \text{ kips} \]

\[ 8' \]

\[ 8' \]

23. (35 points) Determine the maximum uniform live load $w_L$ that may be safely applied per ASD to the A992 W10x33 shape. Second order effects are obviously not applicable because the beam is subjected to axial tension.

**Given:** The 20’-long A992 W10x33 shape is simply supported with continuous bracing along the length that prevents lateral movement (i.e., in and out of the page). It is subjected to strong-axis bending due to a uniformly distributed load $w_L$, plus its own distributed self-weight. It is also subjected to axial tension of 100 kips.

\[ w_L = \text{you determine} \]

\[ 100^k \]

\[ \text{Continuous lateral bracing} \]

\[ W10x33 \]

\[ 20 - \text{feet} \]

24. (35 points) Determine the maximum axial compression $P$ that may be safely applied per ASD to the A992 W10x33 shape. Second order effects: assume that the second order moment magnifier $B_1$ is 1.05.
Given: The 20'-long A992 W10x33 shape is simply supported with continuous bracing along the length that prevents lateral movement (i.e., in and out of the page). It is subjected to strong-axis bending due to a uniformly distributed load \( w = 1 \text{ kip/ft} \), which already includes self-weight. It is also subjected to axial compression.

25. (35 points) Determine if the 13'-long A992 W12x87 pin-ended beam-column is safe according ASD specifications for an axial load of 500 kips and equal-magnitude strong-axis end-moments of 25 ft-kips, as shown. The column is in a braced frame, braced at its ends, only, for both axes. Assume that self-weight and second-order effects are negligible (both are excellent assumptions; e.g., zero \( \delta \) at midspan means \( P\delta \) cannot be significant).

26. (35 points) Determine if the 13'-long A992 W12x87 pin-ended beam-column is safe according ASD specifications for an axial load of 500 kips and equal-magnitude weak-axis end-moments of 25 ft-kips, as shown. The column is in a braced frame, braced at its ends, only, for both axes. Assume that self-weight and second-order effects are negligible (both are excellent assumptions; e.g., zero \( \Delta \) at midspan means \( P\Delta \) cannot be significant.).
27. (40 points) Determine if the 13'-long A992 W16x36 pin-ended beam-column is safe according ASD specifications for an axial load of 120 kips, equal-magnitude strong-axis end-moments of 15 ft-kips, and equal-magnitude weak-axis end-moments of 2 ft-kips, as shown. The column is in a braced frame, braced at its ends, only, for both axes. Assume that self-weight and second-order effects are negligible (the latter assumption is unconservative, but is used for simplicity).

Define the moment magnifier B₁.

28. (2 points). Given: The first order applied moment is 100 kip-ft and the total moment, after considering 2nd order effects is 103 kip-ft. What is B₁?

29. (30 points). Draw the influence line for the vertical reaction at A, then determine the maximum positive (upward) and negative (downward) reaction magnitudes at A, as applicable, given the following loads:
30. (30 points). Draw the influence line for the internal shear at pinned connection C, then determine the maximum positive and negative shear magnitudes at C, as applicable, given the following loads:

- Uniformly Distributed Dead Load: 1 kip/ft
- Uniformly Distributed Live Load: 3 kip/ft
- (1) 10 kip live point load

Note: Pinned foundation at A, roller foundation at B, pinned connection at C, roller foundation at D.

31. (30 points). Draw the influence line for the internal moment over the roller support B, then determine the maximum positive and negative moment magnitudes at B, as applicable, given the following loads:

- Uniformly Distributed Dead Load: 1 kip/ft
- Uniformly Distributed Live Load: 3 kip/ft
- (1) 10 kip live point load

Note: Pinned foundation at A, roller foundation at B, pinned connection at C, roller foundation at D.