Exam Format

50 minute time limit. You will be allowed to use your steel manual, a calculator, and writing supplies, only.

Coverage

Lessons 18 through 23

Lesson Objectives and Examples

The main body of this Study Guide is a list of every lesson objective from Lessons 18 through 23. Example problems are given for most.

Lesson 19. Distinguish between N, X, and SC bolts and describe where each would be specified.

1. (3 points) TRUE or FALSE. Given the same loads, a bolted connection that uses Group A (A325) N bolts requires a greater number than a connection that uses the same sized Group A (A325) SC bolts.

2. (3 points) TRUE or FALSE. Group A (A325) Slip Critical Bolts are made from a stronger high-carbon steel than Group A (A325) N bolts.

3. (3 points) TRUE or FALSE. It is conservative to specify N bolts rather than X bolts because the specification of X bolts requires that the detailer assure that the bolt’s threads are always excluded from the shearing planes.

4. (3 points) TRUE or FALSE. Slip Critical bolts look the same as N bolts and both are installed the same way, with the same level of torque.

5. (3 points) TRUE or FALSE. Slip Critical bolts are specified for any connection in which slip is not permitted when the working (actual maximum) loads are applied to the connection.

6. (3 points) TRUE or FALSE. Even though bearing type bolts (e.g., N or X) are installed the same way as slip critical bolts (i.e., torqued until the bolts are significantly pre-tensioned so that the connection is compressed together), it is understood that the bolted connection may slip under working loads, in the case of bearing type bolts.

Lesson 19. Compute the nominal bolt-shear strength of an N or X bolt, \( r_n \), and use this to compute the nominal strength of the entire connection, \( R_n \).

7. (15 points) A ½” diameter bolt was tested in tension, failing at a load of 11.78 kips. Three (3) ¾” diameter bolts from the same manufacturer, manufactured from the same steel (assume the strength is identical) will be used in a double shear application, as shown, and threads will not be excluded from the shearing planes. Determine: \( P_n/\Omega \) for the bolted connection, assuming that bolt shear controls.

Lesson 19. Compute the bolt-slip allowable strength of an SC bolt, \( r_{n/\Omega} \), and use this to compute the capacity of the entire connection, \( R_{n/\Omega} \).

8. (7 points) Compute the nominal strength \( R_n \) of the double-angle tension angle connection shown, with respect to the limit state of bolt slip. Given: (3) ¾” Group A (A325) SC bolts in standard holes and a Class A faying surface on double L4x3x1/4” sections. Material is A36.
9. (10 points) Determine \( R_n/\Omega \) with respect to the limit state of bolt slip for the connection shown per ASD specifications. 

Given: The bolts were pretensioned to 11 kips. Class B faying surface. Standard holes.

Lesson 19. Determine bolt nominal strengths via Part 7 tables.

10. (5 points) What is the nominal strength (breaking strength) of a ¾” Group A (A325) N bolt if it is loaded in double shear?

11. (5 points) What is the allowable strength \( r_n/\Omega \) of a ¾” Group A (A325) N bolt if it is loaded in single shear?

Lesson 19. Select the number of bolts needed for a connection

12. (10 points) Problem: For the 70 kip applied (ASD) load, specify the number of ¾” Group A (A325) N bolts needed for the connection shown, considering bolt shear, only.

Given: 2L4x4x1/4”A36 double angle with a ½” thick gusset plate. Single line of bolts is assumed.

Lesson 21. Explain why yielding must never be allowed along any structural member, but it is allowed (locally) on a connection (around bolt holes). Explain why yielding is allowed at the connection, so that the limiting stress for connections is the ultimate (fracture) stress.

13. (7 points) Explain why yielding is actually considered acceptable at or around bolt holes, so that the limiting stress for connections is the ultimate (fracture) stress, rather than the yield stress.

Lesson 21. Calculate the controlling nominal strength \( P_n \), allowable tensile load (ASD) \( P_n/\Omega \) and the design strength (LRFD) \( \phi P_n \), based on yielding, fracture (and bolt) limit states.

14. (20 points) Use the ASD method to compute the allowable tensile load \( P_n/\Omega \) with respect to the fracture mode for the A36 Double Channel section (each channel is a C10x15.3) if it is connected to the gusset using ¾” bolts in standard holes. Do not analyze the gusset.
15. (20 points): Determine the allowable (ASD) load $R_{allow} = R_n/\Omega$ with respect to yielding, fracture, and bolt limit states for the double channel tension member shown, which consists of two C3x6 A36 channel shapes, back-to-back on a ¾” thick gusset plate. The double channel section is connected with (4) ¾” A325-N bolts in standard holes. 

**Note:** Do not consider the gusset plate or any other modes.

Lesson 22. *Judge* when the shear lag factor will tend to be lower (greater reduction in strength).

16. (3 points) For which double-angle connection is shear lag a more serious problem (i.e., leads to a lower fracture strength), assuming the gross areas are the same?

Lesson 22. *Determine* the shear lag factor $U$, using the “Case 2 equation” or by using one of the generic $U$ values (cases 1, 3, 4, 5, 6, 7, 8) from Table D3.1.

17. (10 points) What is the fracture strength of the 2L5x3x1/4” A36 double-angle tension member, if a single line of (4) ¾” bolts in standard holes is used? The spacing between each bolt is 3”. Note the orientation of the angles.

18. (10 points) What is the fracture strength of the 2L5x3x1/4” A36 double-angle tension member, if a single line of (4) ¾” bolts in standard holes is used? The spacing between each bolt is 3”. Note the orientation of the angles.
Lesson 22. Compute the nominal strength $R_n$ and the allowable (ASD) load $R_n/\Omega$ corresponding with the limit states of block shear and bolt bearing.

Lesson 22. Compute the nominal strength $R_n$ and allowable (ASD) load $R_n/\Omega$ of a bolted tension connection, considering all five failure modes, as applicable.

19. (50 points) Problem: Determine $P_{all} = P_n/\Omega$ for the 2L5x3x1/4” double angle member, considering all possible modes. Circle the final allowable loads for each failure mechanism and clearly identify the controlling allowable load.

Given:
- The short legs are back to back (SLBB)
- Gusset is already adequate (do not check the gusset)
- A36 material
- 3/4” Group A (A325) N bolts in standard holes

20. (20 points) Problem: Determine $P_{all} = P_n/\Omega$ for the 2L5x3x1/4” double angle member, considering bolt bearing/tearout, only.

Given:
- Gusset is 3/8” thick
- A36 material for all.
- 3/4” Group A (A325) N bolts in standard holes

Select bolt spacing (with the next objective)
Select a bolted tension member that is adequate for all failure modes.

21. (50 points). Three 3D views of a two-story building are shown below. Design a single-angle tension member to serve as a brace between the ground and 2nd floor, along column line 2, between columns A and B, due to wind pressure of 20 psf (note: the actual wind pressure is 33.3 psf, but the ASD factor for wind is 0.6, therefore do the analysis using 20 psf).

Given:
- Use 20 psf wind pressure, either directed from South to North or from East to West. No other loads or pressures are relevant to the brace. Consider the worst case: either South-North or East-West.
- All connections are simple (non-moment-resisting) and the foundations are pinned. Each floor (incl the roof) acts as a diaphragm.
- The bracing consists of redundant cross-bracing, as shown, such that the brace that is in compression is assumed to buckle (and is, therefore, disregarded).
- The angle is A36 material
Bolts are Group A (A325). Use either 5/8” or 3/4” diameter bolts, as appropriate. Assume that bolt slip is not a design consideration. Assume standard holes.

Use ASD.

Specify:
- The size of the single angle, considering yield, fracture, holes (bearing/tearout), and specify the bolts. **Do not consider block shear.**
- The dimensions of the hole locations, based on AISC standards.

Fig. 1a: 3D view, showing floor diaphragms and exterior wall studs

Fig. 1b. 3D view, showing bracing and main framing

Fig. 1c. 3D view, showing 3 braced bays, only