Comparison of Allowable Compressive Stress Solutions: AISC 2005 vs ASME BTH-1 2017

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1 Introduction

This document compares the allowable compressive stress calculations for the spreader bar as performed in `spreaderbar.ipynb`, following both AISC 2005 and ASME BTH-1 2017 codes.

Warning!! The rigging calculations provide these axial compressive stress checks for the spreader bar neglect the load combinations stipulated in ASCE 7.

2 Parameters

- Outer diameter (O_d): 588 mm
- Thickness (t): 25 mm
- Length (L): 5520 mm
- Young's modulus (E) for S355 steel: 210,000 MPa
- Yield strength (F_y) for S355 steel: 345 MPa
- Effective length factor (K): 1
- Safety factor (N_d): 2 (ASME BTH-1 2017: section 2-2.1)

3 ASME BTH-1 2017 Allowable Axial Compressive Stress

The code uses a slenderness parameter KL/r and a critical slenderness C_c. The critical slenderness ratio C_c is given by:

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = \sqrt{\frac{2\pi^2 \cdot 2100000\ (MPa)}{345\ (MPa)}} = 109.62$$

- For $KL/r \leq C_c$ (eq. 3.3):

$$F_a = \left[1 - \frac{(KL/r)^2}{2C_c^2}\right] \frac{F_y}{N_d} \left[1 + \frac{9KL/r}{40C_c} - \frac{3(KL/r)^3}{40C_c^4}\right]$$

- For $KL/r > C_c$ (eq. 3.5):

$$F_a = \frac{\pi^2 E}{1.15 N_d (KL/r)^2}$$

Result from notebook:

- $\frac{KL}{r} = 27.71$ then $KL/r < C_c$

- Allowable axial compressive stress: 88.24 MPa
- Applied compressive stress: 37.43 MPa
- Conclusion: Applied stress is within allowable limits.

4 AISC 2005 Allowable Compressive Stress

The code uses the flexural buckling equations (E3-2 and E3-3):

- For $KL/r \leq 4.71\sqrt{E/F_y}$:

$$F_{cr} = [0.658^{F_y/F_e}]F_y$$

- For $KL/r > 4.71\sqrt{E/F_y}$:

$$F_{cr} = 0.877F_e$$

- Where $F_e = \frac{\pi^2 E}{(KL/r)^2}$

The nominal compressive stress P_n is indicated as:

$$P_n = F_{cr}A_g$$

- Design compressive strength (LRFD):

$$Pu \leq \phi_c P_n$$

- Allowable compressive strength (ASD):

$$Pu \leq \frac{P_n}{\Omega_c}$$

- where $\phi_c = 0.9$ and $\Omega_c = 1.67$ (AISC 2005, chapter E section E1)

Result from notebook:

- Slenderness limit $4.71\sqrt{E/F_y} = 116.21$, then we use the equation E3-2
- Critical stress F_{cr}: 327.04 MPa
- Design compressive strength (LRFD): 294.33 MPa
- Allowable compressive strength (ASD): 195.83 MPa
- Applied compressive stress: 37.43 MPa
- Conclusion: Applied stress is within allowable limits.

5 Summary Table

Code	Allowable Stress (MPa)	Applied Stress (MPa)	Pass/Fail
ASME BTH-1 2017	88.24	37.43	Pass
AISC 2005 (ASD)	195.83	37.43	Pass

6 Discussion

The updated calculations show that the AISC 2005 (ASD) code provides a significantly higher allowable compressive stress compared to ASME BTH-1 2017 for the same spreader bar geometry and material. This difference is primarily due to the more conservative safety factors and slenderness criteria in the ASME BTH-1 2017 code. Despite this, the applied compressive stress remains well below the allowable limits in both codes, confirming that the spreader bar design is adequate and safe under the specified loading conditions.

7 References

- AISC 2005, Specification for Structural Steel Buildings
- ASME BTH-1 2017, Design of Below-the-Hook Lifting Devices