
Load and Resistance Factor Design Specification for Single-Angle Members

November 10, 2000

Supersedes the *Specification for Load and Resistance
Factor Design of Single-Angle Members* dated
December 1, 1993

Prepared by the
American Institute of Steel Construction, Inc.
Under the Direction of the
AISC Committee on Specifications and approved by
the AISC Board of Directors



AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC.
One East Wacker Drive, Suite 3100
Chicago, IL 60601-2001

AVA Documents
Document Sharing Hub



PREFACE

The intention of the AISC Specification is to cover the common everyday design criteria in routine design office usage. It is not feasible to also cover the many special and unique problems encountered within the full range of structural design practice. This separate Specification and Commentary addresses one such topic—single-angle members—to provide needed design guidance for this more complex structural shape under various load and support conditions.

The revised single-angle design criteria were developed through a consensus process by the AISC Task Committee 12 on Single Angles:

James M. Fisher, Chairman
 Leroy A. Lutz, Vice-Chairman
 Mohamed Elgaaly
 Shu-Jin Fang
 Theodore V. Galambos
 Subhash Goel
 Charlotte S. Harman
 Todd Helwig
 Donald W. White
 Sergio Zoruba, Secretary

The full AISC Committee on Specifications has reviewed and approved this Specification.

A non-mandatory Commentary provides background for the Specification provisions and the user is encouraged to consult it.

The principal changes in this edition include:

Revisions to flexural design strength criteria

- a. For the limit state of local buckling when the angle leg is in compression
- b. For the limit state of yielding when the tip of an angle leg is in tension
- c. For the limit state of lateral-torsional buckling
- d. For bending about geometric axes

The reader is cautioned that professional judgment must be exercised when data or recommendations in this Specification are applied. The publication of the material contained herein is not intended as a representation or warranty on the part of the American Institute of Steel Construction, Inc.—or any other person named herein—that this information is suitable for general or particular use, or freedom from infringement of any patent or patents. Anyone making use of this information assumes all liability arising from such use. The design of structures is within the scope of expertise of a competent licensed structural engineer, architect, or other licensed professional for the application of principles to a particular structure.



Load and Resistance Factor Design Specification for Single-Angle Members

November 10, 2000

1. SCOPE

This document contains Load and Resistance Factor Design (LRFD) criteria for hot-rolled, single-angle members with equal and unequal legs in tension, shear, compression, flexure, and for combined forces. It is intended to be compatible with, and a supplement to, the 1999 AISC *Load and Resistance Factor Design Specification for Structural Steel Buildings* and repeats some common criteria for ease of reference. For design purposes, the conservative simplifications and approximations in the Specification provisions for single angles are permitted to be refined through a more precise analysis. As an alternative to this Specification, the 1989 AISC *Specification for Allowable Stress Design of Single-Angle Members* is permitted.

The Specification for single-angle design supersedes any comparable but more general requirements of the AISC LRFD. All other design, fabrication, and erection provisions not directly covered by this document shall be in compliance with the AISC LRFD. For design of slender, cold-formed steel angles, the AISI *LRFD Specification for the Design of Cold-Formed Steel Structural Members* referenced in Section A6 of the AISC LRFD is applicable.

2. TENSION

The tensile design strength $\phi_t P_n$ shall be the lower value obtained according to the limit states of yielding, $\phi_t = 0.9$, $P_n = F_y A_g$, and fracture, $\phi_t = 0.75$, $P_n = F_u A_e$.

- a. For members connected by bolting, the net area and effective net area shall be determined from AISC LRFD Specification Sections B1 to B3 inclusive.
- b. When the load is transmitted by longitudinal welds only or a combination of longitudinal and transverse welds through just one leg of the angle, the effective net area A_e shall be:

$$A_e = A_g U \quad (2-1)$$

where

A_g = gross area of member

$$U = \left(1 - \frac{\bar{x}}{l}\right) \leq 0.9$$

$\bar{x}$ = connection eccentricity

l = length of connection in the direction of loading

- c. When a load is transmitted by transverse weld through just one leg of the angle, A_e is the area of the connected leg and $U = 1$.

For members whose design is based on tension, the slenderness ratio l/r preferably should not exceed 300. Members in which the design is dictated by tension loading, but which may be subject to some compression under other load conditions, need not satisfy the compression slenderness limits.

3. SHEAR

For the limit state of yielding in shear, the shear stress, f_{uv} , due to flexure and torsion shall not exceed:

$$\begin{aligned} f_{uv} &\leq \phi_v 0.6 F_y \\ \phi_v &= 0.9 \end{aligned} \quad (3-1)$$

4. COMPRESSION

The design strength of compression members shall be $\phi_c P_n$

where

$$\phi_c = 0.90$$

$$P_n = A_g F_{cr}$$

- a. For $\lambda_c \sqrt{Q} \leq 1.5$

$$F_{cr} = Q(0.658^{Q\lambda_c^2}) F_y \quad (4-1)$$

- b. For $\lambda_c \sqrt{Q} > 1.5$

$$F_{cr} = \left[\frac{0.877}{\lambda_c^2} \right] F_y \quad (4-2)$$

where

$$\lambda_c = \frac{Kl}{r\pi} \sqrt{\frac{F_y}{E}}$$

F_y = specified minimum yield stress of steel

Q = reduction factor for local buckling

The reduction factor Q shall be:

$$\text{when } \frac{b}{t} \leq 0.446 \sqrt{\frac{E}{F_y}}:$$

$$Q = 1.0 \quad (4-3a)$$

$$\text{when } 0.446 \sqrt{\frac{E}{F_y}} < \frac{b}{t} < 0.910 \sqrt{\frac{E}{F_y}}:$$

$$Q = 1.34 - 0.761 \frac{b}{t} \sqrt{\frac{F_y}{E}} \quad (4-3b)$$

$$\text{when } \frac{b}{t} \geq 0.910 \sqrt{\frac{E}{F_y}}:$$

$$Q = \frac{0.534E}{F_y \left(\frac{b}{t} \right)^2} \quad (4-3c)$$

where

b = full width of longest angle leg

t = thickness of angle

For members whose design is based on compressive force, the largest effective slenderness ratio preferably should not exceed 200.

5. FLEXURE

The flexure design strengths of Section 5.1 shall be used as indicated in Sections 5.2 and 5.3.

5.1. Flexural Design Strength

The flexural design strength shall be limited to the minimum value $\phi_b M_n$ determined from Sections 5.1.1, 5.1.2, and 5.1.3, as applicable, with $\phi_b = 0.9$.

5.1.1. For the limit state of local buckling when the tip of an angle leg is in compression:

$$\text{when } \frac{b}{t} \leq 0.54 \sqrt{\frac{E}{F_y}}:$$

$$M_n = 1.5 F_y S_c \quad (5-1a)$$

when $0.54 \sqrt{\frac{E}{F_y}} < \frac{b}{t} \leq 0.91 \sqrt{\frac{E}{F_y}}$:

$$M_n = F_y S_c \left[1.5 - 0.93 \left(\frac{b/t}{0.54 \sqrt{\frac{E}{F_y}}} - 1 \right) \right] \quad (5-1b)$$

when $\frac{b}{t} > 0.91 \sqrt{\frac{E}{F_y}}$:

$$M_n = 1.34 Q F_y S_c \quad (5-1c)$$

where

b = full width of angle leg with tip in compression

Q = reduction factor per Equation 4-3c

S_c = elastic section modulus to the tip in compression relative to axis of bending

E = modulus of elasticity

5.1.2. For the limit state of yielding when the tip of an angle leg is in tension

$$M_n = 1.5 M_y \quad (5-2)$$

where

M_y = yield moment about the axis of bending

5.1.3. For the limit state of lateral-torsional buckling:

when $M_{ob} \leq M_y$:

$$M_n = [0.92 - 0.17 M_{ob}/M_y] M_{ob} \quad (5-3a)$$

when $M_{ob} > M_y$:

$$M_n = [1.92 - 1.17 \sqrt{M_y/M_{ob}}] M_y \leq 1.5 M_y \quad (5-3b)$$

where

M_{ob} = elastic lateral-torsional buckling moment, from Section 5.2 or 5.3 as applicable

5.2. Bending about Geometric Axes

- 5.2.1. a.** Angle bending members with lateral-torsional restraint along the length shall be designed on the basis of geometric axis bending with the nominal flexural strength M_n limited to the provisions of Sections 5.1.1 and 5.1.2.