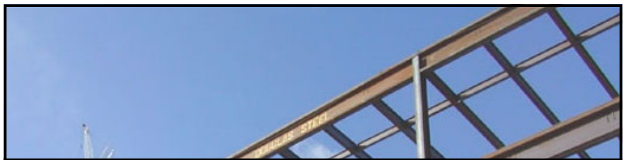
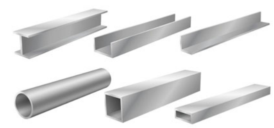


Chapter 2
Structural Steel Design

1

Chapter 2.1 – Design Philosophies

- The design of a structural member entails the selection of a cross-section that will safely and economically resist the applied loads.
- Economy usually means ***minimum weight***—that is, the minimum amount of steel.
- This amount corresponds to the cross-section with the ***smallest weight per foot***, which is the one with the smallest cross-sectional area.



2

Chapter 2.1 – Design Philosophies

- The design process begins with the selection of the ***lightest cross-sectional shape*** that will do the job.
- Having established this objective, the engineer must decide how to do it ***safely***, which is where different approaches to design come into play.
- The fundamental requirement of structural design is that the ***required strength*** not exceed the ***available strength***; that is,

Required strength ≤ Available strength

3

Chapter 2.1 – Design Philosophies

- In ***allowable strength design (ASD)***, a member is selected that has cross-sectional properties such as area and moment of inertia that are large enough to prevent the maximum applied ***axial force, shear, or bending moment*** from exceeding an allowable, or permissible, value.
- This allowable value is obtained by dividing the ***nominal***, or theoretical, strength by a ***factor of safety***. This can be expressed as

Required strength ≤ Allowable strength

$$\text{Allowable strength} = \frac{\text{nominal strength}}{\text{safety factor}}$$

4

Chapter 2.1 – Design Philosophies

- In ***allowable strength design (ASD)***, a member is selected that has cross-sectional properties such as area and moment of inertia that are large enough to prevent the maximum applied ***axial force, shear, or bending moment*** from exceeding an allowable, or permissible, value.
- ***Strength*** can be an axial force strength (as in tension or compression members), a flexural strength (moment strength), or a shear strength.

Required strength ≤ Allowable strength

$$\text{Allowable strength} = \frac{\text{nominal strength}}{\text{safety factor}}$$

5

Chapter 2.1 – Design Philosophies

- If stresses are used instead of forces or moments, the relationship:

Maximum applied stress strength ≤ Allowable stress

- This approach is called ***allowable stress design***.
- The allowable stress will be in the ***elastic range*** of the material.

6

Chapter 2.1 – Design Philosophies

- If stresses are used instead of forces or moments, the relationship:

Maximum applied stress strength ≤ Allowable stress

- This approach to design is also called ***elastic design*** or ***working stress design***.
- Working stresses are those resulting from the working loads, which are the applied loads. ***Working loads*** are also known as ***service loads***.

7

Chapter 2.1 – Design Philosophies

- ***Plastic design*** is based on a consideration of failure conditions rather than ***working load*** conditions.
- A member is selected by using the criterion that the structure will ***fail at a load substantially higher than the working load***.
- Failure in this context means either ***collapse or extremely large deformations***.
- The term ***plastic*** is used because, at failure, parts of the member will be subjected to very large strains—large enough to put the member into the ***plastic range***.

8

Chapter 2.1 – Design Philosophies

- ***Load and resistance factor design (LRFD***) is similar to plastic design in that strength, or the failure conditions, are considered.
- ***Load factors*** are applied to the service loads, and a member is selected that will have enough strength to resist the factored loads.
- In addition, the theoretical or ***nominal strength*** of the member is reduced, most of the time, by the application of a ***resistance factor***.

9

Chapter 2.1 – Design Philosophies

- The criterion that must be satisfied in the selection of a member is:

Factored load ≤ Factored strength

- The ***factored load*** is the sum of all service loads to be resisted by the member, each multiplied by its own ***load factor***.
- For example, dead loads will have ***load factors*** that are different from those for live loads.

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Chapter 2.1 – Design Philosophies

- The criterion that must be satisfied in the selection of a member is:

Factored load ≤ Factored strength

- The ***factored strength*** is the theoretical or nominal strength multiplied by a resistance factor.

$$\sum(\text{loads} \times \text{load factors}) \leq \text{resistance} \times \text{resistance factor}$$

- The ***factored load*** is a failure load greater than the total actual service load, so the load factors are usually greater than 1.

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Chapter 2.1 – Design Philosophies

- The criterion that must be satisfied in the selection of a member is:

Factored load ≤ Factored strength

- The ***factored strength*** is the theoretical or nominal strength multiplied by a resistance factor.

$$\sum(\text{loads} \times \text{load factors}) \leq \text{resistance} \times \text{resistance factor}$$

- The ***factored strength*** is a reduced, usable strength, and the resistance factor is usually less than 1

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Chapter 2.1 – Design Philosophies

- The ***factored loads*** are the loads that bring the structure or member to its limit.
- In terms of safety, this limit state can be ***fracture***, ***yielding***, or ***buckling***.
- The ***factored resistance*** is the useful strength of the member, reduced from the theoretical or nominal value by the resistance factor.
- The limit state can also be one of serviceability, such as a ***maximum acceptable deflection***.

13

Chapter 2.2 – AISC Specification

- The Specification of the ***American Institute of Steel Construction (AISC)*** is the design specification for the design of structural steel building members and their connections.
- ***Allowable stress design*** has been the primary method used for structural steel buildings since the first AISC Specification was issued in 1923.
- ***Plastic design*** was made part of the Specification in 1963.
- In 1986, AISC issued the first specification for ***load and resistance factor design*** along with a companion Manual of Steel Construction.

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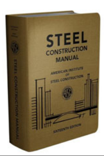
Chapter 2.2 – AISC Specification

- The ***AISC Specification*** is published as a stand-alone document, but it is also part of the Steel Construction Manual.
- Some specialized steel products, such as cold-formed steel, are covered by a different specification (AISI, 2016).
- The ***AISC Specification*** is the standard by which virtually all structural steel buildings in this country are designed and constructed.



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Chapter 2.2 – AISC Specification

- The ***Specification*** consists of three parts: the main body, the appendices, and the Commentary.
- The body is alphabetically organized into Chapters A through N. Within each chapter, major headings are labeled with the chapter designation followed by a number.
- Furthermore, subdivisions are numerically labeled.
- The main body of the ***Specification*** is followed by ***Appendixes 1–8.***
- The Appendix section is followed by the ***Commentary***.

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Chapter 2.2 – AISC Specification

- The ***Specification*** incorporates both U.S. customary and metric (SI) units.
- Where possible, equations and expressions are expressed in non-dimensional form by leaving quantities such as yield stress and modulus of elasticity in symbolic form, thereby avoiding giving units.
- When this is not possible, U.S. customary units are given, followed by SI units in parentheses.

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Chapter 2.3 – LRFD factors and loads

- Recall, the factored loads and reduced strength relationship of LRFD is

$$\sum(\textbf{loads} \times \textbf{load factors}) \leq \textbf{resistance} \times \textbf{resistance factor}$$

- This equation can be rewritten as: $\sum \gamma_i Q_i \leq \phi R_n$

where: γ_i = a load factor

Q_i = a load effect (a force or a moment)

ϕ = resistance factor

R_n = the nominal resistance, or strength, of the component under construction

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Chapter 2.3 – LRFD factors and loads

- The factored resistance ϕR_n is called the ***design strength***.
- The summation on the left side is over the total number of load effects (including, but not limited to, dead load and live load).
- This equation can be rewritten as: $\sum \gamma_i Q_i \leq \phi R_n$

where: γ_i = a load factor

Q_i = a load effect (a force or a moment)

ϕ = resistance factor

R_n = the nominal resistance, or strength, of the component under construction

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Chapter 2.3 – LRFD factors and loads

- Not only can each load effect have a different ***load factor***, but also the value of the load factor for a particular load effect will depend on the ***combination of loads*** under consideration.
- This equation can be rewritten as: $\sum \gamma_i Q_i \leq \phi R_n$

where: γ_i = a load factor

Q_i = a load effect (a force or a moment)

ϕ = resistance factor

R_n = the nominal resistance, or strength, of the component under construction

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Chapter 2.3 – LRFD factors and loads

- The general equation can be written as: $R_u \leq \phi R_n$

where: R_u = required strength

= sum of factored load effects (forces and moments)

- This equation can be rewritten as: $\sum \gamma_i Q_i \leq \phi R_n$

where: γ_i = a load factor

Q_i = a load effect (a force or a moment)

ϕ = resistance factor

R_n = the nominal resistance, or strength, of the component under construction

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Chapter 2.3 – LRFD factors and loads

- According to the **ASCE 7-22** Standard, some of the load factors and combinations that are not to be exceeded include:

1. 1.4***D***
2. 1.2***D*** + 1.6***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
3. 1.2***D*** + (1.6L_r or 1.0***S*** or 1.6***R***) + (***L*** or 0.5***W***)
4. 1.2***D*** + 1.0(***W*** or W_T) + ***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
5. 0.9***D*** + 1.0(***W*** or W_T)

where: ***D*** is dead load, ***L*** is live load due to occupancy, L_r is roof live load, ***S*** is snow load, ***R*** is rain or ice load, ***W*** is wind, and W_T is tornado load.

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Chapter 2.3 – LRFD factors and loads

- According to the **ASCE 7-22** Standard, some of the load factors and combinations that are not to be exceeded include:

1. 1.4***D***
2. 1.2***D*** + 1.6***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
3. 1.2***D*** + (1.6L_r or 1.0***S*** or 1.6***R***) + (***L*** or 0.5***W***)
4. 1.2***D*** + 1.0(***W*** or W_T) + ***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
5. 0.9***D*** + 1.0(***W*** or W_T)

- Consult **ASCE 7-22** for load combinations including flood load; atmospheric ice, or wind on ice loads; self-straining forces and effects; non-specified loads; seismic loads; and loads from water in soil.

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Chapter 2.3 – LRFD factors and loads

- According to the **ASCE 7-22** Standard, some of the load factors and combinations that are not to be exceeded include:

1. 1.4***D***
2. 1.2***D*** + 1.6***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
3. 1.2***D*** + (1.6L_r or 1.0***S*** or 1.6***R***) + (***L*** or 0.5***W***)
4. 1.2***D*** + 1.0(***W*** or W_T) + ***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
5. 0.9***D*** + 1.0(***W*** or W_T)

- The load factor on ***L*** in combinations 3 and 4 is permitted to equal 0.5 for all occupancies with minimum uniformly distributed live loads less than or equal to 100 psf.

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Chapter 2.3 – LRFD factors and loads

- According to the **ASCE 7-22** Standard, some of the load factors and combinations that are not to be exceeded include:

1. 1.4***D***
2. 1.2***D*** + 1.6***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
3. 1.2***D*** + (1.6L_r or 1.0***S*** or 1.6***R***) + (***L*** or 0.5***W***)
4. 1.2***D*** + 1.0(***W*** or W_T) + ***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
5. 0.9***D*** + 1.0(***W*** or W_T)

- In combinations with wind load, ***W***, you should use a direction that produces the largest loading.

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Chapter 2.3 – LRFD factors and loads

- According to the **ASCE 7-22** Standard, some of the load factors and combinations that are not to be exceeded include:

1. 1.4***D***
2. 1.2***D*** + 1.6***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
3. 1.2***D*** + (1.6L_r or 1.0***S*** or 1.6***R***) + (***L*** or 0.5***W***)
4. 1.2***D*** + 1.0(***W*** or W_T) + ***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
5. 0.9***D*** + 1.0(***W*** or W_T)

- Combination 5 accounts for the possibility of ***D*** and ***W*** or W_T loads counteracting each other.

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Chapter 2.3 – LRFD factors and loads

- According to the **ASCE 7-22** Standard, some of the load factors and combinations that are not to be exceeded include:

1. 1.4***D***
2. 1.2***D*** + 1.6***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
3. 1.2***D*** + (1.6L_r or 1.0***S*** or 1.6***R***) + (***L*** or 0.5***W***)
4. 1.2***D*** + 1.0(***W*** or W_T) + ***L*** + (0.5L_r or 0.3***S*** or 0.5***R***)
5. 0.9***D*** + 1.0(***W*** or W_T)

- The load factor is not the same in all load combinations.
- For example, in combination 2, the load factor for the live load ***L*** is 1.6, whereas in combination 3, it is 1.0.

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Chapter 2.3 – LRFD factors and loads

- Recall, the general equation: $R_u \le \phi R_n$
- The resistance factor ϕ for each type of resistance is given by AISC in the ***Specification*** chapter dealing with that resistance.
- In most cases, one of two values will be used:

ϕ **= 0.90** for limit states involving yielding or compression buckling

ϕ **= 0.75** for limit states involving rupture (fracture)

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Chapter 2.4 – ASD factors and loads

- For allowable strength design, the relationship between loads and strength can be expressed as

Allowable strength = nominal strength / safety factor

- This equation can be rewritten as: $R_a \le \frac{R_n}{\Omega}$

where: R_a = required strength

R_n = nominal strength (same as for LRFD)

Ω = safety factor

R_n / Ω = allowable strength

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Chapter 2.4 – ASD factors and loads

- Load combinations for ***ASD*** are also given in **ASCE 7**. The following combinations are based on **ASCE 7-22**:

1. ***D***
2. ***D*** + ***L***
3. ***D*** + (L_r or 0.7***S*** or ***R***)
4. ***D*** + 075***L*** + 0.75(L_r or 0.7***S*** or ***R***)
5. ***D*** + 0.6(***W*** or W_T)
6. ***D*** + 075***L*** + 0.75(0.6(***W*** or W_T)) + 0.75(L_r or 0.7***S*** or ***R***)
7. 0.6***D*** + 0.6(***W*** or W_T)

where: ***D*** is dead load, ***L*** is live load due to occupancy, L_r is roof live load, ***S*** is snow load, ***R*** is rain or ice load, ***W*** is wind, and W_T is tornado load.

30

Chapter 2.4 – ASD factors and loads

- Load combinations for ***ASD*** are also given in **ASCE 7**. The following combinations are based on **ASCE 7-22**:

1. D
2. $D + L$
3. $D + (L_r \text{ or } 0.7S \text{ or } R)$
4. $D + 075L + 0.75(L_r \text{ or } 0.7S \text{ or } R)$
5. $D + 0.6(W \text{ or } W_T)$
6. $D + 075L + 0.75(0.6(W \text{ or } W_T)) + 0.75(L_r \text{ or } 0.7S \text{ or } R)$
7. $0.6D + 0.6(W \text{ or } W_T)$

- The factors shown in these combinations are not load factors.

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Chapter 2.4 – ASD factors and loads

- Load combinations for ***ASD*** are also given in **ASCE 7**. The following combinations are based on **ASCE 7-22**:

1. D
2. $D + L$
3. $D + (L_r \text{ or } 0.7S \text{ or } R)$
4. $D + 075L + 0.75(L_r \text{ or } 0.7S \text{ or } R)$
5. $D + 0.6(W \text{ or } W_T)$
6. $D + 075L + 0.75(0.6(W \text{ or } W_T)) + 0.75(L_r \text{ or } 0.7S \text{ or } R)$
7. $0.6D + 0.6(W \text{ or } W_T)$

- The 0.75 factor in some of the combinations accounts for the unlikelihood that all loads in the combination will be at their ***lifetime maximum values simultaneously***.

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Chapter 2.4 – ASD factors and loads

- Corresponding to the two most common values of resistance factors in ***LRFD*** are the following values of the safety factor in ***ASD***:

$\Omega = 1.67$ for limit states involving yielding or compression buckling

$\Omega = 2.00$ for limit states involving rupture

- The relationship between resistance factors and safety factors is given by

$$\Omega \leq \frac{1.5}{\phi}$$

- For reasons that will be discussed later, this relationship will produce similar designs for ***LRFD*** and ***ASD***, under certain loading conditions.

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Chapter 2.4 – ASD factors and loads

- Recall that for ***ASD***, the relationship between loads and strength is:

$$R_a \leq \frac{R_n}{\Omega}$$

- If both sides of this equation are divided by area (in the case of axial load) or section modulus (in the case of bending moment), then the relationship becomes:

$$f \leq F$$

where: f = applied stress
F = allowable stress

- This formulation is called ***allowable stress design***.

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (D)	100 k
Floor live load (L)	40 k
Roof live load (L_r)	20 k
Snow (S)	25 k

A. Determine the controlling load combination for LRFD and the corresponding factored load.

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (D)	100 k
Floor live load (L)	40 k
Roof live load (L_r)	20 k
Snow (S)	25 k

1. $1.4D = 1.4(100 \text{ k}) = 140 \text{ k}$
2. $1.2D + 1.6L + (0.5L_r \text{ or } 0.3S \text{ or } 0.5R)$

$= 1.2(100 \text{ k}) + 1.6(40 \text{ k}) + 0.5(20 \text{ k}) = 194 \text{ k}$

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (*D*)	100 k
Floor live load (*L*)	40 k
Roof live load (L_r)	20 k
Snow (*S*)	25 k

3. 1.2***D*** + (1.6L_r or 1.0***S*** or 1.6***R***) + (***L*** or 0.5***W***)
   = 1.2(100 k) + 1.6(20 k) + 40 k = 192 k
4. 1.2***D*** + 1.0(***W*** or W_T) + L + (0.5L_r or 0.3***S*** or 0.5***R***)
   = 1.2(100 k) + 40 k + 0.5(20 k) = 170 k

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (*D*)	100 k
Floor live load (*L*)	40 k
Roof live load (L_r)	20 k
Snow (*S*)	25 k

5. 0.9***D*** + 1.0(***W*** or W_T) = 0.9(100 k) = 90 k

Combination 2 controls, and the factored load is **194 k**

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (*D*)	100 k
Floor live load (*L*)	40 k
Roof live load (L_r)	20 k
Snow (*S*)	25 k

B. If the resistance factor ϕ is 0.90, what is the required nominal strength?

$R_u \leq \phi R_n$ $\quad 194\,k \leq 0.90 R_n$ $\quad R_n \geq 215.6\,k$

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (*D*)	100 k
Floor live load (*L*)	40 k
Roof live load (L_r)	20 k
Snow (*S*)	25 k

C. Determine the controlling load combination for ***ASD*** and the corresponding required service load strength.

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (*D*)	100 k
Floor live load (*L*)	40 k
Roof live load (L_r)	20 k
Snow (*S*)	25 k

1. ***D*** = 100 k
2. ***D*** + ***L*** = 100 k + 40 k = 140 k
3. ***D*** + (L_r or 0.7***S*** or ***R***) = 100 k + 20 k = 120 k

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (*D*)	100 k
Floor live load (*L*)	40 k
Roof live load (L_r)	20 k
Snow (*S*)	25 k

4. ***D*** + 075***L*** + 0.75(L_r or 0.7***S*** or ***R***) = 100 k + 0.75(40 k) + 0.75(20 k)
   = 145 k
5. ***D*** + 0.6(***W*** or W_T) = 100 k

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (D)	100 k
Floor live load (L)	40 k
Roof live load (L_r)	20 k
Snow (S)	25 k

6. ***D*** + 075***L*** + 0.75(0.6(***W*** or ***W****T*)) + 0.75(***L****r* or 0.7***S*** or ***R***)
   = 100 k + 0.75(40 k) + 0.75(20 k) = 145 k
7. 0.6***D*** + 0.6(***W*** or ***W****T*) = 0.6(100 k) = 60 k

Combination 4 controls, and the factored load is **145 k**

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Chapter 2.4 – ASD factors and loads

Example 2.1 - A column (compression member) in the upper story of a building is subject to the following loads (Note: The minimum uniformly distributed live loads, L_o, is less than 100 psf, and the building is not a garage nor an area of public assembly):

Dead Load (D)	100 k
Floor live load (L)	40 k
Roof live load (L_r)	20 k
Snow (S)	25 k

D. If the safety factor Ω is 1.67, what is the required nominal strength based on the required service load strength?

$$R_a \le \frac{R_n}{\Omega} \qquad 145k \le \frac{R_n}{1.67} \qquad R_n \ge 242.2k$$

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Chapter 2.4 – ASD factors and loads

- When ***LRFD*** was introduced into the AISC Specification in 1986, the load factors were determined in such a way as to give the same results for ***LRFD*** and ***ASD*** when the loads consisted of a dead load and a ***live load equal to three times the dead load***.
- The resulting relationship between the resistance factor ϕ and the safety factor Ω, as expressed:

$$\left.\begin{array}{l} R_u \le \phi R_n \\ R_a \le \dfrac{R_n}{\Omega} \end{array}\right\} \quad \frac{R_u}{\phi} = R_a\Omega \qquad \frac{1.2D + 1.6L}{\phi} = (D+L)\Omega \qquad \frac{1.2D + 1.6(3D)}{\phi} = (D+3D)\Omega$$

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Chapter 2.4 – ASD factors and loads

- When ***LRFD*** was introduced into the AISC Specification in 1986, the load factors were determined in such a way as to give the same results for ***LRFD*** and ***ASD*** when the loads consisted of a dead load and a ***live load equal to three times the dead load***.
- The resulting relationship between the resistance factor ϕ and the safety factor Ω, as expressed:

$$\left.\begin{array}{l} R_u \le \phi R_n \\ R_a \le \dfrac{R_n}{\Omega} \end{array}\right\} \quad \frac{R_u}{\phi} = R_a\Omega \qquad \frac{6D}{\phi} = (4D)\Omega \qquad \Omega = \frac{1.5}{\phi}$$

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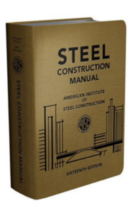
Chapter 2.6 – Steel Manual

- All structural engineers doing structural steel design in the United States must have access to ***AISC's Steel Construction Manual*** (AISC, 2022).
- This publication contains the ***AISC Specification*** and numerous design aids in the form of tables and graphs, as well as a "catalog" of the most widely available structural shapes.



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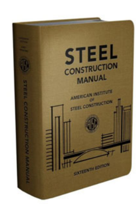
Chapter 2.6 – Steel Manual

- The first nine editions of the Manual and the accompanying specifications were based on ***ASD***.
- The 9th edition was followed by editions one through three of the ***LRFD***-based manuals.



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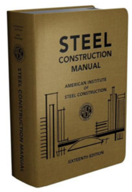
Chapter 2.6 – Steel Manual

- The edition that followed, which for the first time incorporated both ***ASD*** and ***LRFD***, was named the 13th edition, because it was the 13th manual that had been published.
- The current version, the 16th edition, also covers both ***ASD*** and ***LRFD***.



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Chapter 2.6 – Steel Manual

- The ***Manual*** is divided into 18 parts as follows:

Part 1. Dimensions and Properties.

This part contains details on standard hot-rolled shapes, pipe, and hollow structural sections.

Including all necessary cross-sectional dimensions and properties such as area and moment of inertia.

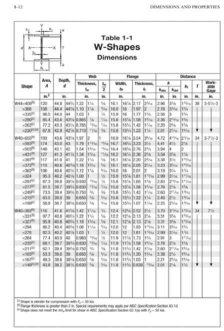
Table 1-1
W-Shapes
Dimensions

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Chapter 2.6 – Steel Manual

- The ***Manual*** is divided into 18 parts as follows:

Part 2. General Design Considerations.

This part includes a brief overview of various specifications (including a detailed discussion of the ***AISC Specification***), codes and standards, fundamental design and fabrication principles, and proper material selection.


PART 2
GENERAL DESIGN CONSIDERATIONS

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Chapter 2.6 – Steel Manual

- The ***Manual*** is divided into 18 parts as follows:

Part 3. Design of Flexural Members.

This part contains a discussion of ***Specification*** requirements and design aids for beams.

Also, it includes composite beams (in which a steel shape is combined with a reinforced concrete floor or roof slab).

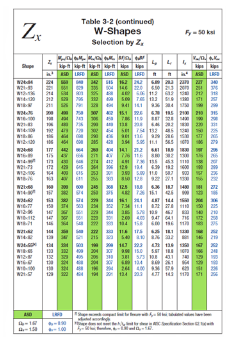
Table 3-2 (continued)
W-Shapes
Selection by Z_x

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Chapter 2.6 – Steel Manual

- The ***Manual*** is divided into 18 parts as follows:

Part 4. Design of Compression Members.

This part includes a discussion of the ***Specification*** requirements for compression members and numerous design aids.

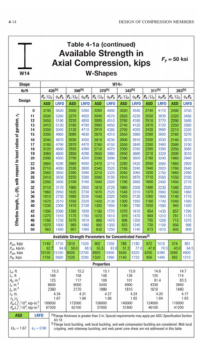
Table 4-1a (continued)
Available Strength in Axial Compression, kips
W-Shapes

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Chapter 2.6 – Steel Manual

- The ***Manual*** is divided into 18 parts as follows:

Part 5. Design of Tension Members.

This part includes design aids for tension members and a summary of the ***Specification*** requirements for tension members.

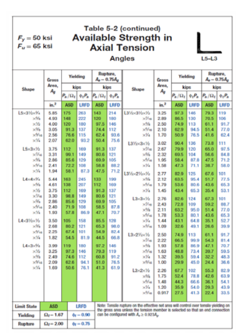
Table 5-2 (continued)
Available Strength in Axial Tension
Angles

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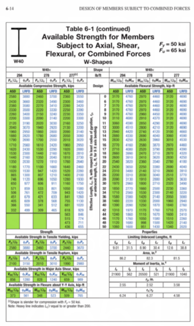
Chapter 2.6 – Steel Manual

- The ***Manual*** is divided into 18 parts as follows:

Part 6. Design of Members Subject to Combined Forces.

This part covers members subject to combined axial tension and flexure, combined axial compression and flexure, and combined torsion, flexure, shear, and/or axial force.

Of particular interest is the material on combined axial compression and flexure, "Beam–Columns."



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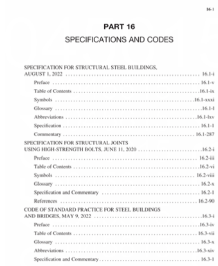
Chapter 2.6 – Steel Manual

- The ***Manual*** is divided into 18 parts as follows:

Parts 7 to 15 cover Connections.

Part 16. Specifications and Codes.

This section contains the ***AISC Specification and Commentary***, a specification for structural joints using ***high-strength bolts***, and the AISC Code of Standard Practice for Steel Buildings and Bridges.



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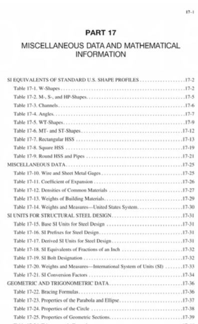
Chapter 2.6 – Steel Manual

- The ***Manual*** is divided into 18 parts as follows:

Part 17. Miscellaneous Data and Mathematical Information.

This part includes properties of standard steel shapes in ***SI units***, conversion factors, and other information on SI units, weights, and properties of building materials.

Mathematical formulas and properties of geometric shapes.



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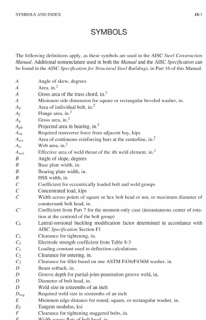
Chapter 2.6 – Steel Manual

- The ***Manual*** is divided into 18 parts as follows:

Part 18. Symbols and Index



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Chapter 2.6 – Steel Manual

- All design aids in the ***Manual*** give values for both allowable strength design (***ASD***) and load and resistance factor design (***LRFD***).

- The *Manual* uses a color-coding scheme for these values:

  ASD allowable strength values R_n/Ω are shown as ***black*** numbers on a ***green*** background.

  LRFD design strength values ϕR_n are shown as ***blue*** numbers on a ***white*** background.

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Chapter 2.6 – Steel Manual

- All design aids in the ***Manual*** give values for both allowable strength design (***ASD***) and load and resistance factor design (***LRFD***).

W14

Table 4-1a (continued)
Available Strength in Axial Compression, kips
W-Shapes

$F_y = 50$ ksi

Shape		W14×											
lb/ft		145		132		120		109		99		90	
Design		P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$	P_n/Ω_c	$\phi_c P_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
with respect to least radius of gyration, r_y	0	1280	1920	1160	1750	1060	1590	958	1440	871	1310	793	1190
	6	1250	1880	1130	1700	1030	1550	932	1400	848	1270	772	1160
	7	1240	1860	1120	1680	1020	1530	923	1390	839	1260	764	1150
	8	1230	1840	1110	1660	1010	1510	913	1370	830	1250	755	1140
	9	1210	1820	1090	1640	994	1490	901	1350	819	1230	745	1120
	10	1200	1800	1080	1620	980	1470	888	1340	807	1210	735	1100
	11	1180	1770	1060	1600	965	1450	874	1310	794	1190	723	1090
	12	1160	1750	1040	1570	948	1430	859	1290	780	1170	710	1070
	13	1140	1720	1020	1540	931	1400	843	1270	766	1150	697	1050
	14	1120	1690	1000	1510	912	1370	826	1240	750	1130	682	1030
	15	1100	1650	982	1480	892	1340	808	1210	733	1100	667	1000
	16	1080	1620	960	1440	872	1310	789	1190	716	1080	652	979
	17	1060	1590	937	1410	850	1280	770	1160	698	1050	635	955
	18	1030	1550	913	1370	828	1240	750	1130	680	1020	618	929
	19	1010	1510	888	1330	805	1210	729	1100	661	994	601	903
	20	980	1470	862	1300	782	1180	708	1060	642	964	583	877

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Chapter 2.6 – Steel Manual

- All design aids in the ***Manual*** give values for both allowable strength design (***ASD***) and load and resistance factor design (***LRFD***).

$F_y = 50$ ksi
$F_u = 65$ ksi

Table 5-2 (continued)
Available Strength in Axial Tension
Angles
L5–L3

Shape	Gross Area, A_g	Yielding kips P_n/Ω_t	Yielding kips $\phi_t P_n$	Rupture, $A_e = 0.75A_g$ kips P_n/Ω_t	Rupture, $A_e = 0.75A_g$ kips $\phi_t P_n$
	in.²	ASD	LRFD	ASD	LRFD
L5×3½×¾	5.85	175	263	143	214
×⅝	4.93	148	222	120	180
×½	4.00	120	180	97.5	146
×⅜	3.05	91.3	137	74.4	112
×5/16	2.56	76.6	115	62.4	93.6
×¼	2.07	62.0	93.2	50.4	75.6
L5×3×½	3.75	112	169	91.3	137
×7/16	3.31	99.1	149	80.6	121
×⅜	2.86	85.6	129	69.9	105
×5/16	2.41	72.2	108	58.8	88.2
×¼	1.94	58.1	87.3	47.5	71.2
L4×4×¾	5.44	163	245	133	199
×⅝	4.61	138	207	112	169
×½	3.75	112	169	91.3	137
×7/16	3.30	98.8	149	80.6	121
×⅜	2.86	85.6	129	69.9	105
×5/16	2.40	71.9	108	58.5	87.8
×¼	1.93	57.8	86.9	47.1	70.7

Shape	Gross Area, A_g	Yielding kips P_n/Ω_t	Yielding kips $\phi_t P_n$	Rupture, $A_e = 0.75A_g$ kips P_n/Ω_t	Rupture, $A_e = 0.75A_g$ kips $\phi_t P_n$
	in.²	ASD	LRFD	ASD	LRFD
L3½×3½×½	3.25	97.3	146	79.3	119
×7/16	2.89	86.5	130	70.5	106
×⅜	2.50	74.9	113	61.1	91.7
×5/16	2.10	62.9	94.5	51.4	77.0
×¼	1.70	50.9	76.5	41.6	62.4
L3½×3×½	3.02	90.4	136	73.8	111
×7/16	2.67	79.9	120	65.0	97.5
×⅜	2.32	69.5	104	56.6	84.8
×5/16	1.95	58.4	87.8	47.5	71.2
×¼	1.58	47.3	71.1	38.7	58.0
L3½×2½×½	2.77	82.9	125	67.6	101
×⅜	2.12	63.5	95.4	51.7	77.5
×5/16	1.79	53.6	80.6	43.6	65.3
×¼	1.45	43.4	65.3	35.4	53.1
L3×3×½	2.76	82.6	124	67.3	101
×7/16	2.43	72.8	109	59.2	88.7
×⅜	2.11	63.2	95.0	51.4	77.0

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Chapter 2.7 – Design Precision

- It is challenging to determine what the ***degree of precision*** should be for the typical structural steel design problem.
- Using more than ***three or four significant figures*** is probably unrealistic in most cases.
- Results based on fewer than ***three*** may be too approximate to be of any value.
- In this course, we record intermediate values to four digits or more, depending on the circumstances, and ***record the final results to three digits***.

$$\begin{array}{r} 12.34 \\ +\ 2.234 \\ \hline 14.574 \end{array}$$

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Chapter 2 - Structural Steel Design

Any questions?

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