Julius Blum & Co. Inc.

A Beautiful Railing:

Pre-Engineered Railing Systems and Components for Architectural Metal Work

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Learning Objectives

By the end of this course, design professionals will be able to

- Discuss the benefits of utilizing stock components for architectural metal work, such as sustainability and durability, as well as compare metal alloys and finishes.
- List the five major engineering considerations for component systems to ensure products are specified and installed correctly for safe use.
- Evaluate different profiles of stock components in order to select the best component for each project's needs based on design and durability.
- Illustrate the different ways architectural metal work can be utilized in a wide variety of applications by analyzing case studies.

Course Description

- **For over a century, pre-engineered components have simplified the fabrication of handrails and other decorative elements.**

- **Join us in this one-hour course as we discuss key considerations when specifying stock components for architectural metal work.**

- **Participants will not only be able to articulate the benefits of utilizing stock components but also how to evaluate different types of metal alloys and finishes in order to specify and install the best profiles in a variety of applications.**

Introduction

Stock Components

- **Systems and products designed to work together eliminate the need for custom components**
- **Allow for a timely delivery**
- **Architects and designers will need to utilize experienced fabricators who specialize with different metals or systems**
- **Cost-effective, code-compliant, quality pieces for any type of project**

Trade Background

- **100+ years in the architectural metal supply business**
- **High-quality parts available from stock for immediate shipment**
- **Check that domestic sourcing/Buy America is a priority for the supplier**
- **Components that comply with structural requirements**

Benefits of Using Stock Components

- **Large quantities available off the shelf**
- **Quality products meet quality control**
- **Products designed & engineered to meet code**
- **Complete systems aid in ease of design & installation**
- **Installation drawings & details supplied for all products**
- **Cost advantages to prefabricated & pre-engineered items**

Sustainability

- **Metals:** Recycled and Recyclable
- **Packing:** Eco-Conscious Packing

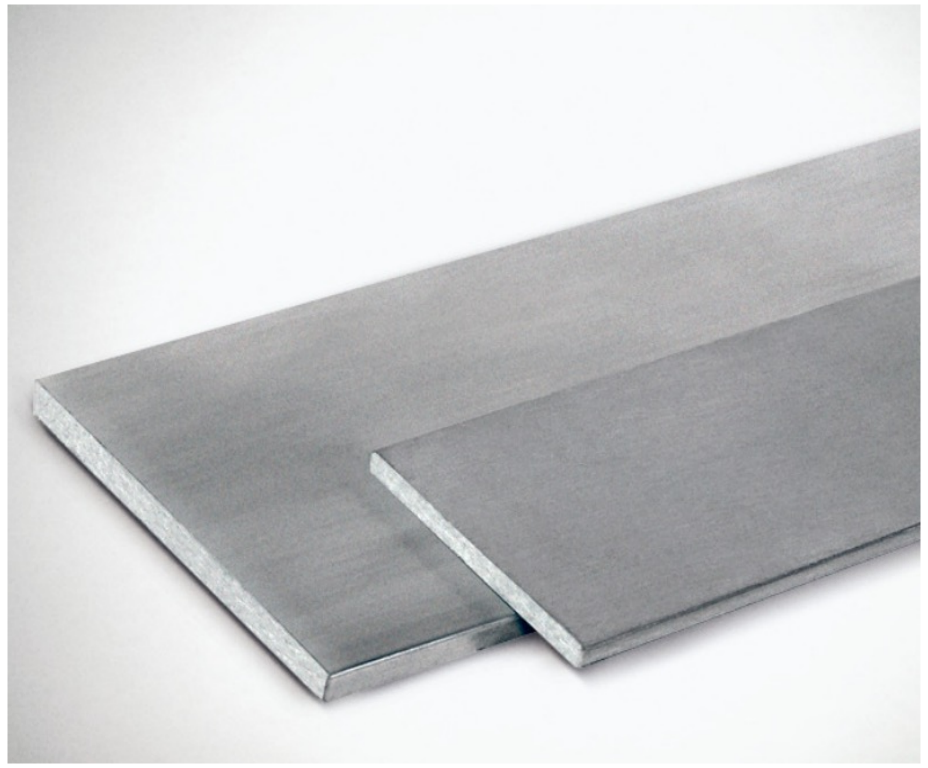
Durability and Finish

- **Metal is resistant to fire and pests.**
- **When properly finished and maintained, the metal will keep its beauty or get more beautiful over time.**
- **Choose the metal and finish based on the location of the job.**
- **Specify stock components that have been properly finished or whose surface is suitable for polishing.**

Examples of Architectural Metal Alloys

- **Aluminum: 6063-T52, 6063-T832, 6061-T6**
- **Bronze: Alloy C38500**
- **Stainless Steel: Alloy 304**
- **Nickel-Silver: Alloy C79800**
- **Steel: Alloy C1010**
- **Malleable Iron**
- **Cast Iron**






Metal Alloy Interactions

- Aluminum should be coated with either a mechanical or chemical coating and should not be left unfinished against cement/lime mortar.

- Bronze/nickel-silver left untreated will develop a patina, e.g., the Statue of Liberty.

- Stainless steel is not affected by contact with other metals or by the environment.

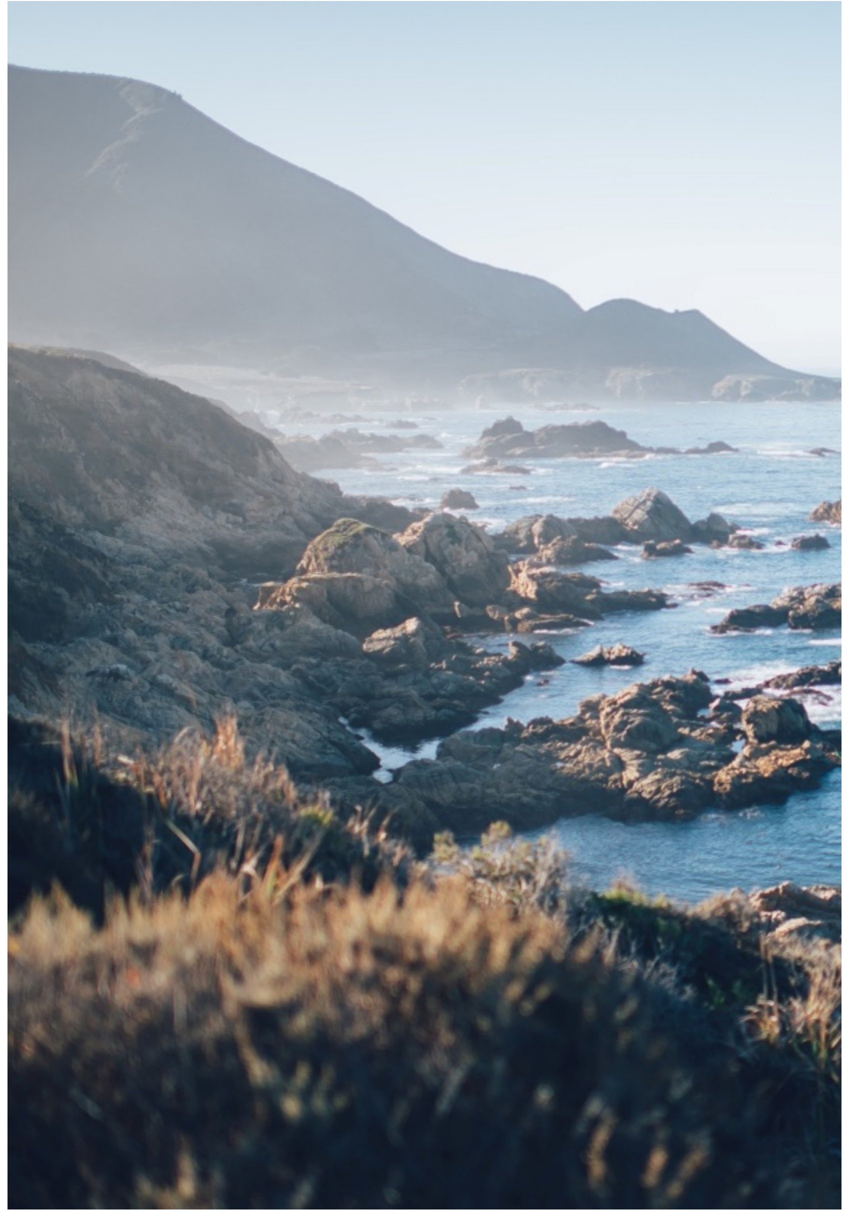
- Steel will corrode if not properly protected by paint or other coatings.

Metal Finishes

- **Mill Finishes: Applied by a basic rolling mill, the extrusion press, or a casting mold**
- **Mechanical Finishes: Applied by the fabricator, and are the result of physically affecting the surface of the metal by some mechanical means**
- **Chemical Finishes: Usually a pre-finish, are applied by the fabricator, and they may or may not have a physical effect upon the surface of the metal**
- **Coatings: Formed by the metal itself by a chemical or electrical conversion process, or formed by application of added material applied by the fabricator or specialist**

Finish	Aluminum	Copper Alloys	Stainless Steel	Carbon Steel and Iron
Mill (as supplied)	X	X	X	X
Mechanical	X	X	X	-
Chemical	X	X	-	-
Coatings	X	X	X	X

Selecting the Best Material for Your Job



Job Location

Fabricator Expertise*

Cost

The Look

*Always make sure there is an experienced metal fabricator on the job. Your material supplier can suggest the names of fabricators to ensure quality of work.

Part Two:
Engineering and Structural Information

Load Requirements: Five Major Considerations

1. **Structural loading criteria as established by governing building codes or special design requirements**

2. **Properties of railing materials and allowable stresses for design**

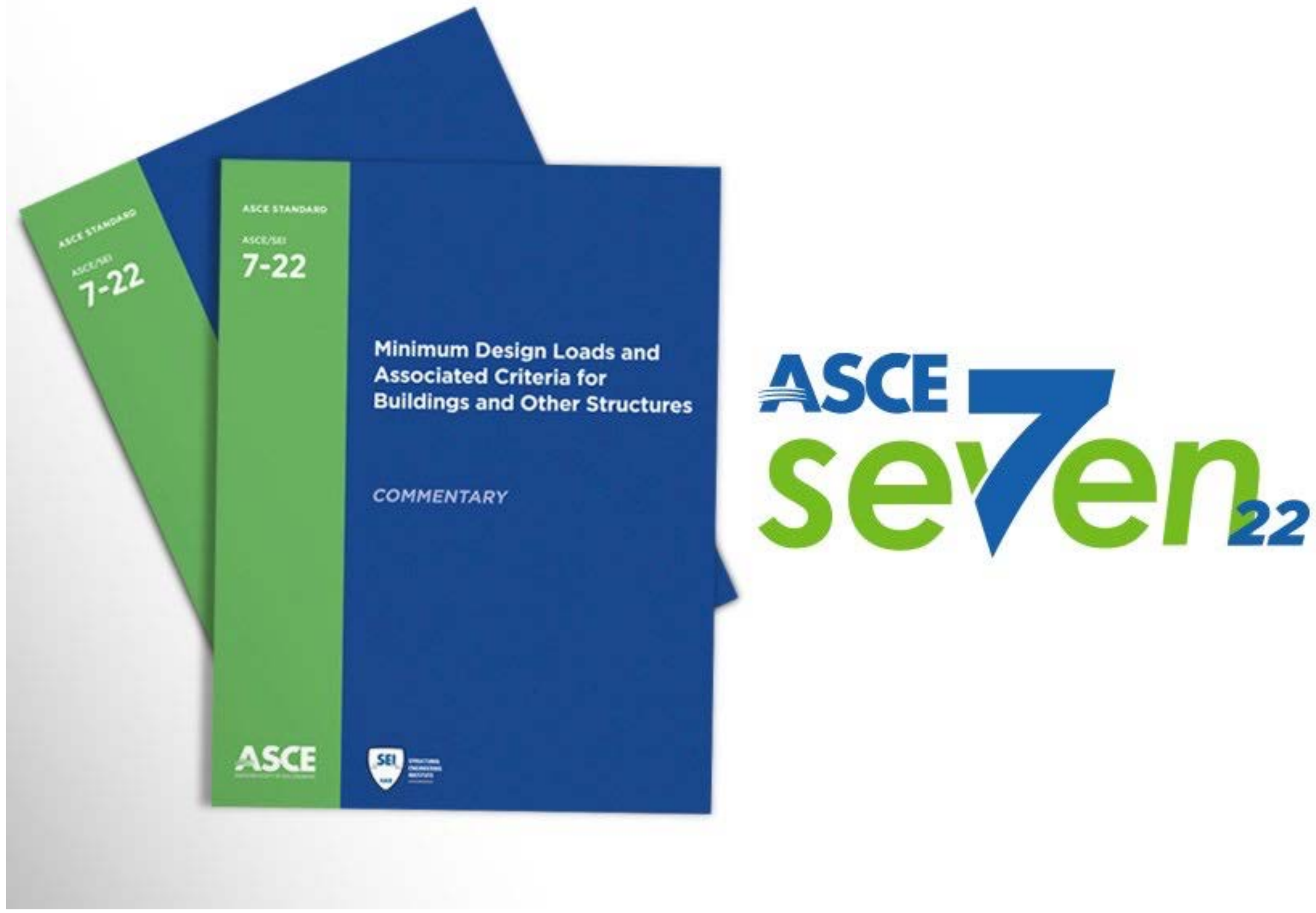
3. **Elements of sections for railing components**

4. **Load, stress, and deflection relationships expressed as formulas for engineering design**

5. **Proper attachment and a sound supporting structure**

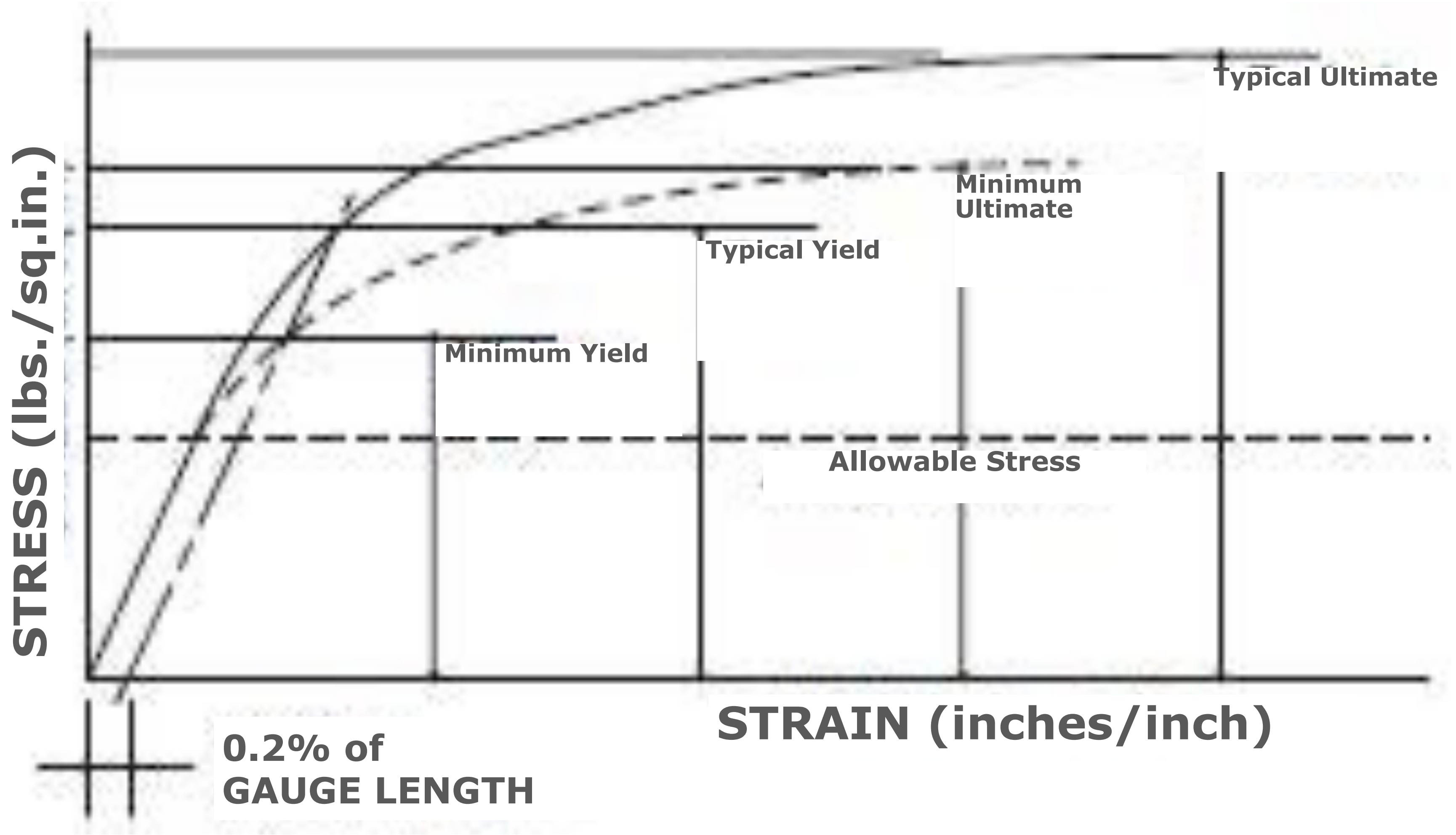
Structural Requirements

- **ASCE/ANSI 7 *Minimum Design Loads for Buildings and Other Structures*, published by the American Society of Civil Engineers**



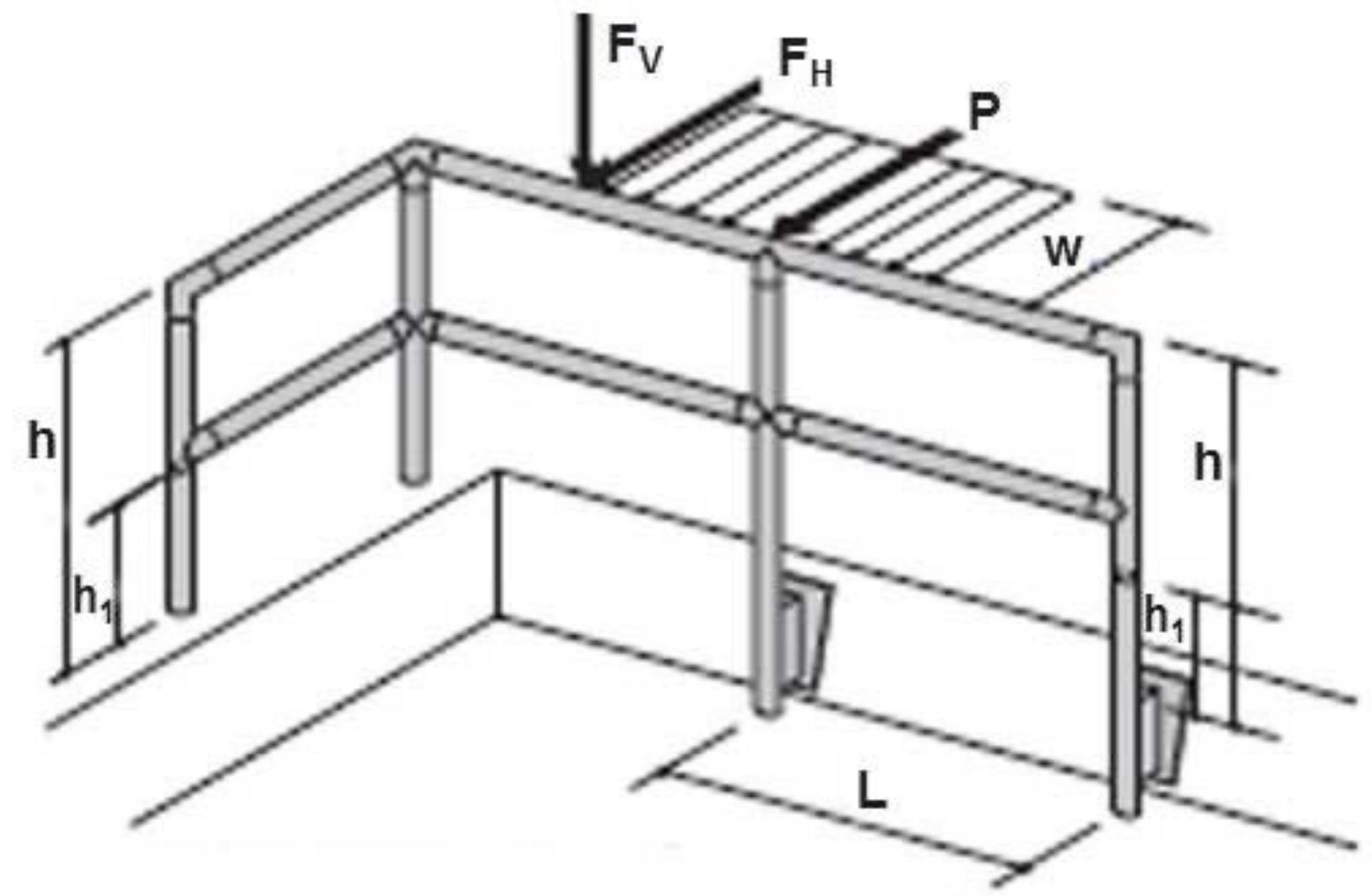
Allowable Stresses

- **Vary with the composition and temper of the material and, to some degree, with the kind of shape and the direction of stress**



Loading Diagram & Symbols

w* = Uniform horizontal loading, perpendicular to the rail (lb/ft).
L = Span between centerlines of posts or brackets (in.).
P = Horizontal force, perpendicular to rail applied at top of post (lb).
F_H = Horizontal force, perpendicular to rail at any point along the railing (lb)
F_V = Vertical force, perpendicular to rail at any point between posts (lb).
h = Height of post. Distance from point of load application above top of attachment (in.).
h_1 = Distance from top of post attachment to top of reinforcing insert (in.).
M = Bending moment (in.-lb).
f = Unit stress (psi).
f_s = Allowable fiber stress for design (psi).
S_x & S_y = Section modulus about the x- or y-axis respectively (in^3).
I_x & I_y = Moment of inertia about the x- or y-axis respectively (in^4).
k = Stiffness of member.
K = Bending moment constant.
c = Distance from the neutral axis to the extreme fiber of any section (in.).
E = Modulus of elasticity (psi × 106).
Δ = Deflection (in.).
R = Stiffness ratio.
P_f = Load proportion factor.
F_r = Reaction factor (psi).
* Values for w (uniform load in lb/ft) converted to lb/in by dividing by 12



Key Terms

- **Section Modulus - a geometric property for a given cross-section used in the design of beams or flexural members.**
- **Allowable Design Stress - a design philosophy civil engineers use to ensure the stresses developed in a structure due to service loads do not exceed the elastic limit**
- **Applied Bending Moment - exists in a structural element when a moment (the perpendicular distance from a point to a line or a surface) is applied to the element so that the element bends**
- **Moment of Inertia - a measure of an object's resistance to changes to its rotation**
- **Moduli of Elasticity - the mathematical description of an object or material's tendency to be deformed elastically when a force is applied to it**
- **Maximum Allowable Deflection -** the maximum permissible deflection value where no reinforcement is necessary

Bending Moments & Stresses

Determination of bending moments and stress in structural railing members follows conventional engineering design procedures. The resisting moment—calculated from the *Section Modulus* (S, which equals I/c) and *Allowable Design Stress* (f_s)—must equal the *Applied Bending Moment* (M).

$$\frac{I}{c} \times f_s = S \times f_s = M$$

Bending Moments & Stresses: Rails

The effect of different numbers of spans may be taken into account by varying the *Bending Moment Constant* (K). *Calculation of Unit Stress* (f) and *Length of Span* (L) are accomplished by using the following formulas:

1. Uniform vertical or horizontal loads (w):

$$M = \frac{w/12 \times L^2}{K}$$

$$f = \frac{w/12 \times L^2}{S \times K}$$

$$L = \sqrt{\frac{f \times K \times S}{w/12}}$$

$M = S \times f$
$K = 8$ for one or two spans
$K = 9.5$ for three or more spans of a continuous rail

2. Concentrated loads (F) applied at mid-span:

$$M = \frac{F \times L}{K}$$

$$f = \frac{F \times L}{S \times K}$$

$$L = \frac{S \times K \times f}{F}$$

$M = S \times f$
$K = 4$ for one span
$K = 5$ for two or more spans of a continuous rail

***Note**: Values of K are defined based on the maximum bending moment developed under various numbers of spans.*

Bending Moments & Stresses: Posts

1. For uniform horizontal loading (w):

$M = P \times h$

$P = w/12 \times L$

$M = S \times F$

$f = \frac{w/12 \times L \times h}{S}$

$L = \frac{S \times f}{w/12 \times h}$

2. For concentrated horizontal loading (F_h):

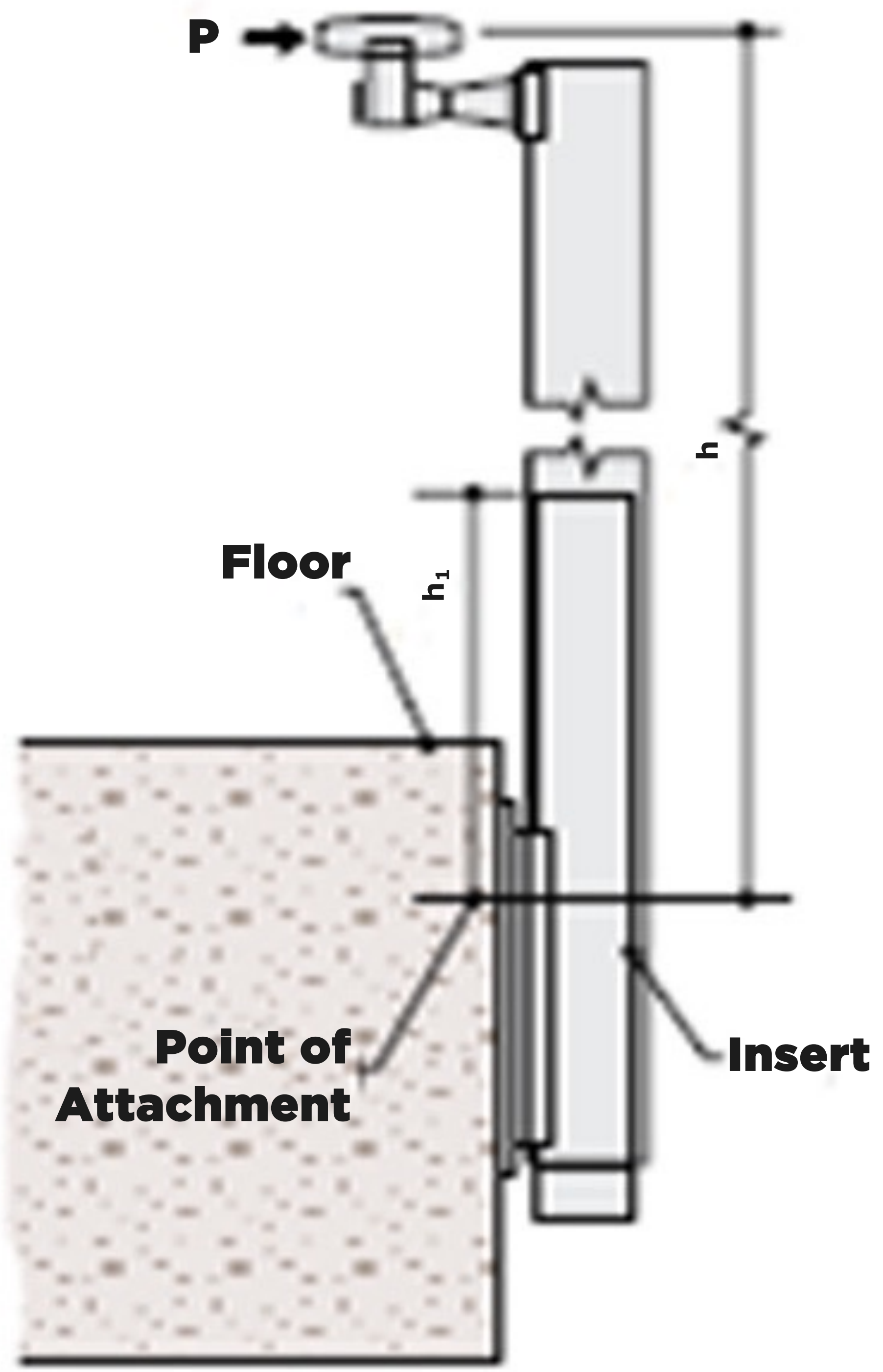
$M = P \times h$

$f = \frac{F_h \times h \times P_f}{S}$

$P = F_h \times P_f$

Internally Reinforced Posts

- **The load-carrying capacity of a post with reinforcing insert is limited by the allowable fiber stress at one of three points:**
  - The post at the top of the insert, above which it is not reinforced
  - The insert at its base, at the highest point of its attachment to the supporting structure
  - The post at the same point of attachment
- **The lowest of these three loading limits controls design for the combined post and reinforcing insert.**



Internally Reinforced Posts

1. Post at top of insert:

Moment in Post:

$$M = P \times (h - h_1)$$

Fiber Stress in Post:

$$f = \frac{M}{S} = \frac{P \times (h - h_1)}{S}$$

Loading Limit:

$$P = \frac{f_s \times S}{h - h_1}$$

At the point of contact between the railing post and the reinforcing insert, the deflection of each is assumed to be the same, but the resisting force of each is a function of its *Moment of Inertia* (I) and *Modulus of Elasticity* (E). The resultant combined *Reaction Factor* (F_r) at the top of the insert is determined as follows:

$$F_r = \left(\frac{h}{2 \times h_1} - 0.617\right) \div \left(\frac{E_p \times I_p}{3 \times E_r \times I_r} + 0.333\right)$$

E_r and I_r refer to the reinforcing insert
E_p and I_p refer to the post

Internally Reinforced Posts

The loading limits for points 2 and 3 are then determined as follows:

2. Insert at Base:

Moment in Post:

$$M = P \times (h - h_1)$$

Fiber Stress in Post:

$$f = \frac{M}{S_r} = \frac{P \times F_r \times h_1}{S_r}$$

Loading Limit:

$$P = \frac{f_s \times S_r}{F_r \times h_1}$$

3. Post at Base:

Moment in Post:

$$M = P \times [h - (Fr \times h_1)]$$

Fiber Stress in Post:

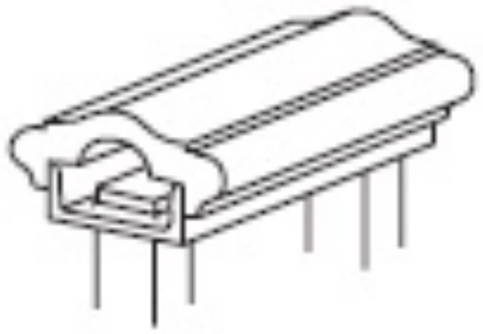
$$f = \frac{M}{S_p} = \frac{P \times [h - (F_r \times h_1)]}{S_p}$$

Loading Limit:

$$P = \frac{f_s \times S_p}{h - (F_r \times h_1)}$$

Combined Handrail Sections

When two sections of the same metal are combined by being fastened together to form a handrail, the sections develop the same deflection under load but act independently about their respective neutral es.



Steel handrail with steel channel

I_a and I_b are the moments of inertia of the two sections. Since the *Section Modulus* (S) equals I/c, the combined value for S of the two sections would be:

$$S = \frac{I_a + I_b}{c_{max}}$$

c_{max} is either c_a or c_b, whichever is greater

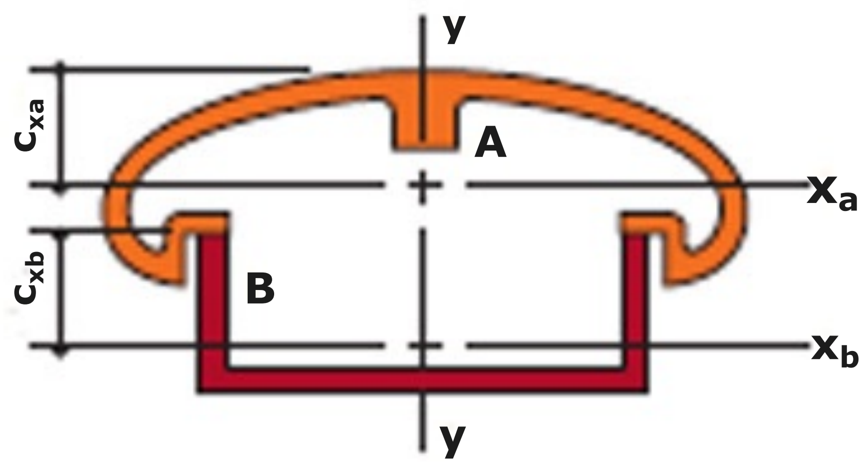
In the railing formulas, substitute the above equation for the value of S whenever combined sections of the same material are used.

Combined Sections of Dissimilar Materials

The load distribution is a function of the relative stiffness of the two sections, which is determined by the Moments of Inertia (I) and their Moduli of Elasticity (E). The distribution of the total load between two sections is determined as follows:

1. **Load carried by A:**

$$A = \frac{\text{Total Load}}{1 + \frac{E_b \times I_b}{E_a \times I_a}}$$



2. **Load carried by B:**

$$B = \text{Total Load} - \text{Total Load Carried by A}$$

Individual calculation to determine the fiber stress for each material, using the load portion of each section, will then determine which section controls design: namely, the section giving the lesser result.

Deflection Considerations

Lateral deflection of posts or vertical deflection of horizontal rails under load are computed as follows—these formulas must be used with caution:

1. **For posts without reinforcing insert:**

$$\Delta = \frac{P \times h^3}{3 \times E \times I} \text{ or } \frac{w/12 \times L \times h^3}{3 \times E \times I}$$

2. **For posts with reinforcing insert of similar or dissimilar material:**

$$\Delta = \frac{P \times (h - h_1)^3}{3 \times E_p \times I_p} + \frac{P \times [h^3 - (h - h_1)^3]}{3 \times [(E_p \times I_p) + (E_r \times I_r)]}$$

E_p and I_p apply to post
E_r and I_r apply to reinforcing insert

Deflection Considerations

3. For rails (concentrated load, F):

$$\Delta = \frac{F \times L^3}{K \times E \times I}$$

K = 48 for simple span
K = 66 for two or more spans, load on end span
K = 87 for three or more spans, load on intermediate span

4. For rails (uniform load, w):

$$\Delta = \frac{5 \times w/12 \times L^4}{384 \times E \times I} \text{ for simple spans}$$

$$\Delta = \frac{w/12 \times L^4}{145 \times E \times I} \text{ for two or more spans}$$

There are few, if any, regulations or code requirements limiting deflection in a railing, but ASTM has put forth the following criteria regarding *Maximum Allowable Deflection* (Δ_{max}) in their specification E985.

For horizontal load at mid-span:

$$\Delta_{max} = h/24 + L/96$$

For horizontal load at top of post:

$$\Delta_{max} = h/12$$

For vertical load at mid-span:

$$\Delta_{max} = L/96$$

Sample Problem and Solution

Determine required section modulus of post requirements:

- Concentrated load, F = 200 lbs.
- Railing height, h = 42 in.

Material specified:

- Post: Steel tubing
- Allowable stress, fs = 16,800 psi

Determine:

- Section modulus, S, and select a suitable section
- Resisting bending moment, M(resisting) = fs × S
- Applied bending moment, M(applied) = F × h
- M(resisting) must equal M(applied)

$$f_s \times S = F \times h$$

$$S = \frac{F \times h}{f_s}$$

$$S = \frac{200 \times 42}{16{,}800}$$

$$S = 0.500 \text{ in}^3$$

Engineering Data

- **Look for manufacturers that offer easily accessible engineering data on their materials and products.**

- **Some offer this on the back of their product catalogue.**

Part Three: Railing Systems

Glass Railing System and Components

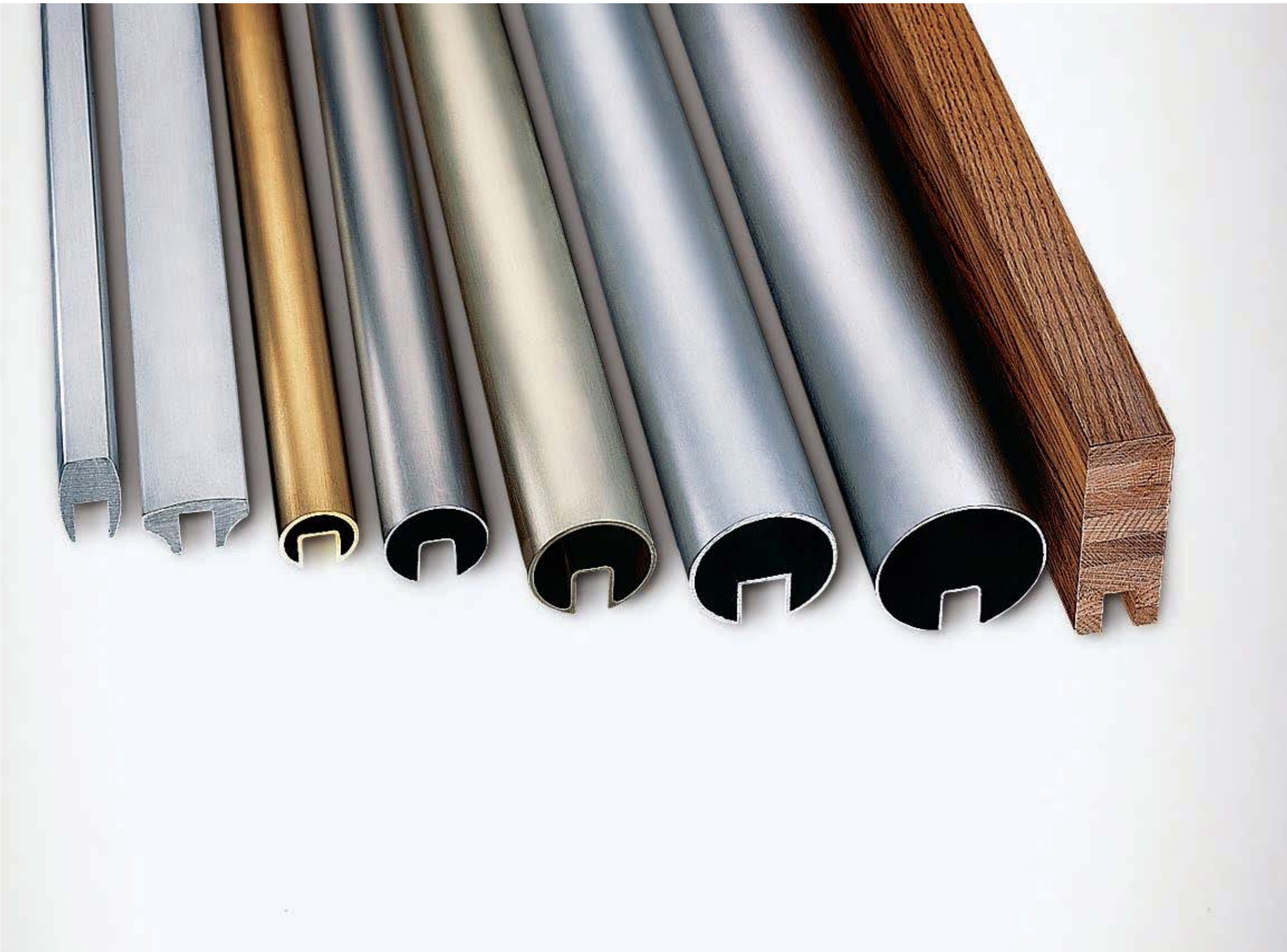
- Shoe mouldings are designed to support the load of a glass railing.
- Metal handrail and components designed for use with ½” or ¾” glass panels as structural balusters
- Ensure the system has been load tested by an independent contractor and that a test report can be supplied.

Glass Railing System and Components

Glass Mounting

Handrail Assembly

Glass Railing System and Components



Glass Rail Profiles

Fittings: Corner Bends, Miter Corners, Glass Adapter and End Caps

Welded and Non-Welded Pipe Railing Systems

- **Pipe Railing can be welded or not welded depending on the system you are using and application of the railing.**

- **When using a non-weld system, components slip together and are joined by concealed mechanical fasteners at intersections and epoxy structural adhesive at splice joints.**

- **Ensure material is installed per manufacturers details and that the installation meets local and national safety standards and guidelines.**

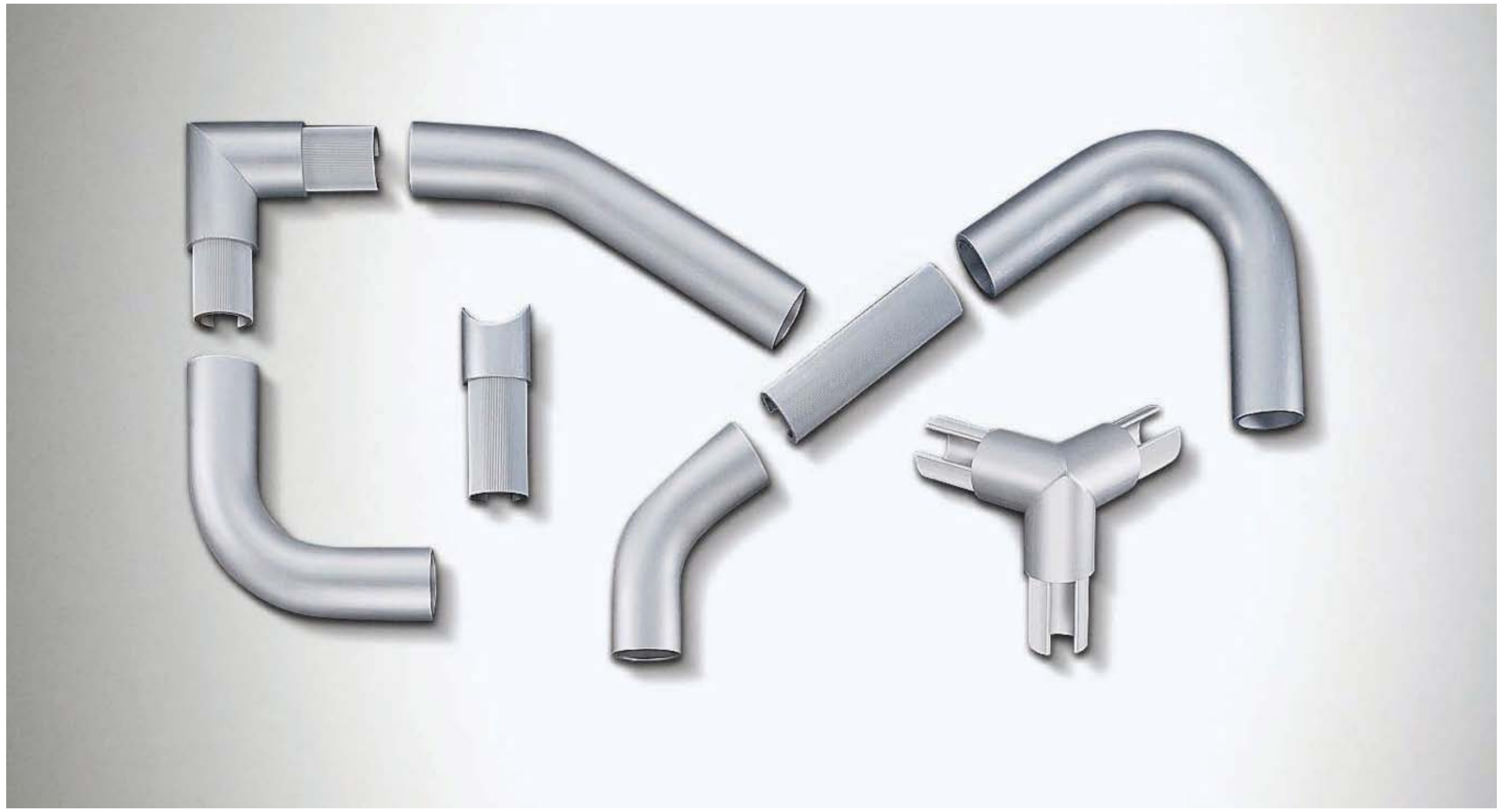
Pipe Railing System Assembly Detail

Continuous Posts and Rails

Mechanical Connections

Pipe Railing System Components

Mounting options



Range of Fittings

Post and Panel System

- **Complete selection of fittings available**
- **Self-aligning wall, post, and mounting brackets are usually recommended for unusual ramp or stair angles.**
- **Wide range of cover flanges, fascia flanges, reinforcing bars, and post caps are also available.**

Weld-Free Post and Panel Railing System

- **A panel rail system that does not require welding.**
- **Other non-weld railing systems are also available that do not have circular shapes.**

Components Used with a Post and Panel System

- **Handrails**
- **Precut Posts**
- **Extensions**
- **Brackets**
- **Flanges**
- **Plugs**
- **Caps**

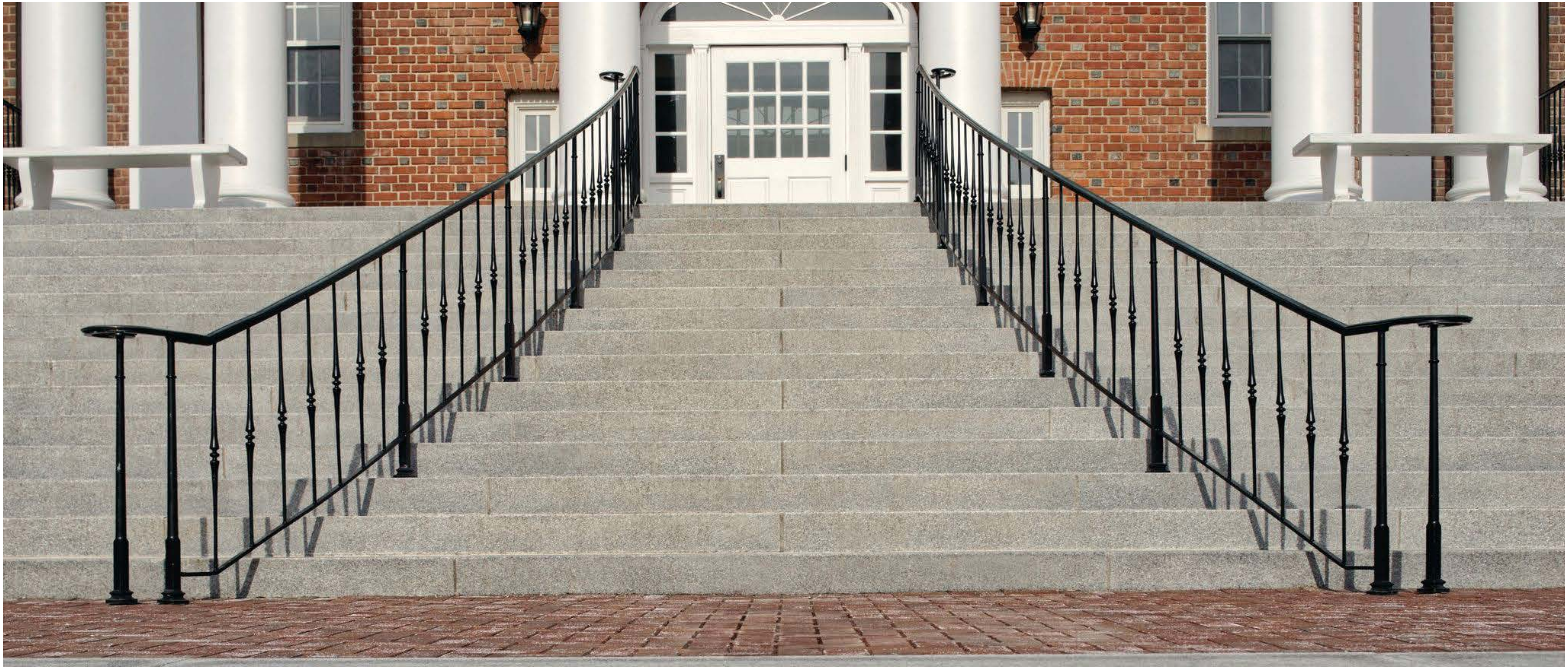



Weld-Free Post and Panel Railing System

Handrails and Tubing

Full Range of Fittings

Traditional Railing Components



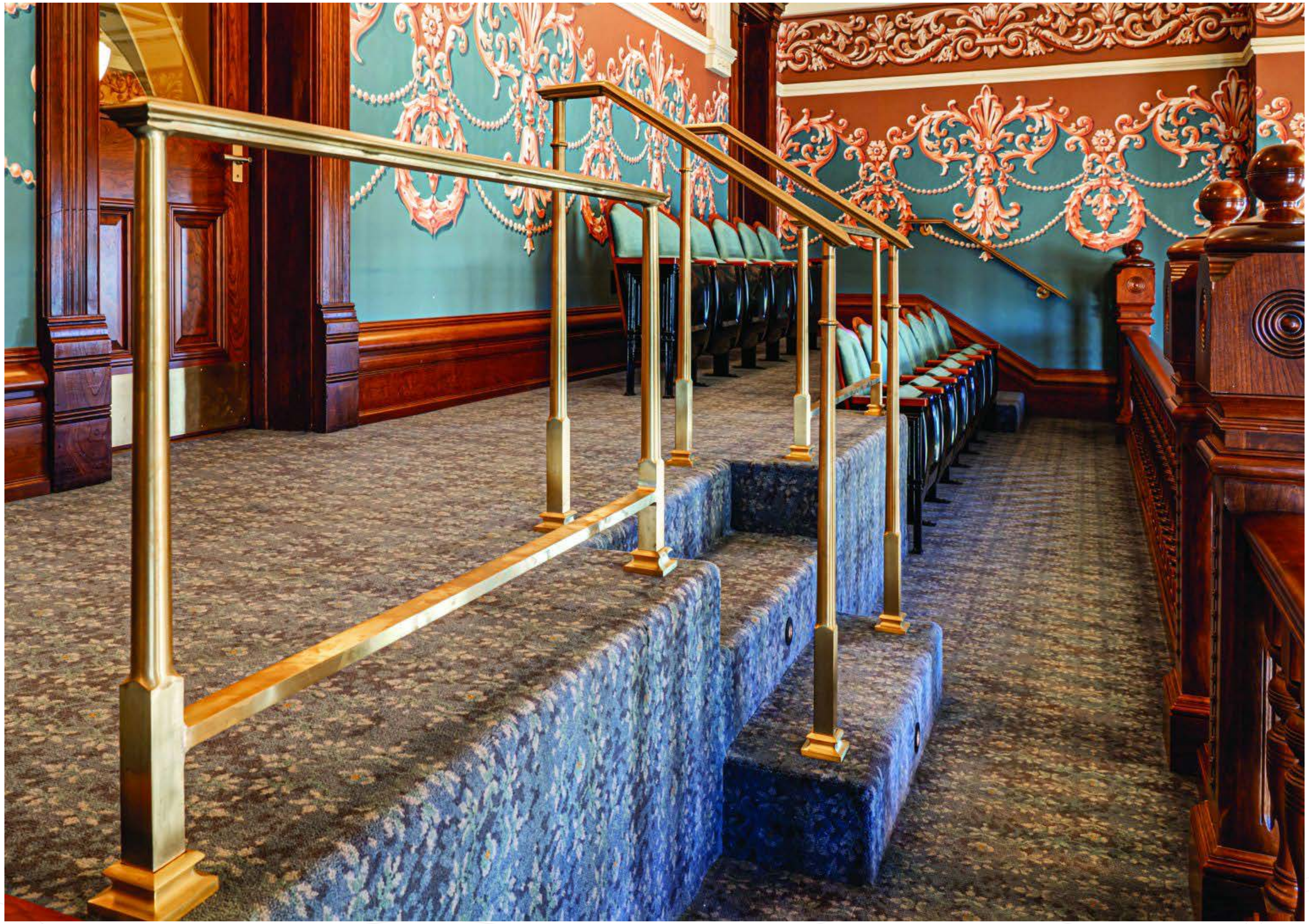
Examples of Traditional Railing Components







Traditional Railing Components



Traditional Railing Fittings

Straight Lambs Tongue

Left and Right Lateral Scroll

Volute

Treillage & Ornamental Railing Panels

- **Treillage and Ornamental Railing Panels** provide architectural details on stairs and straight runs.

- Panels are designed to meet current code requirements.

Treillage & Ornamental Railing Components

Ornamental Railing Panels used to create a screen at a restaurant in Brooklyn, NY

Ornamental Railing Panels

Handrail Brackets

- **Used in many railing applications**
- **Designed for use as wall brackets, post brackets, center rail, and vertical mounting brackets**
- **Independent test reports should be available upon request from your supplier.**

Handrail Brackets








Tubing, Bars, Shapes

- **Stock sizes of tubing bars and shapes are selected to especially meet the requirements for ornamental and miscellaneous metal work.**

- **Mill finish with a surface suitable for polishing**

Elevator Cab Components

- **A large inventory of elevator saddles in both single and double speed meet the needs of almost every elevator build and replacement application..**

- **Saddles, in bronze, aluminum, nickel silver and stainless steel, are widely used by both local and national elevator companies throughout the United States and Mexico.**

- **Vertical mounting brackets and handrail mouldings can be used in the interior of each cab.**

Elevator Cab Components

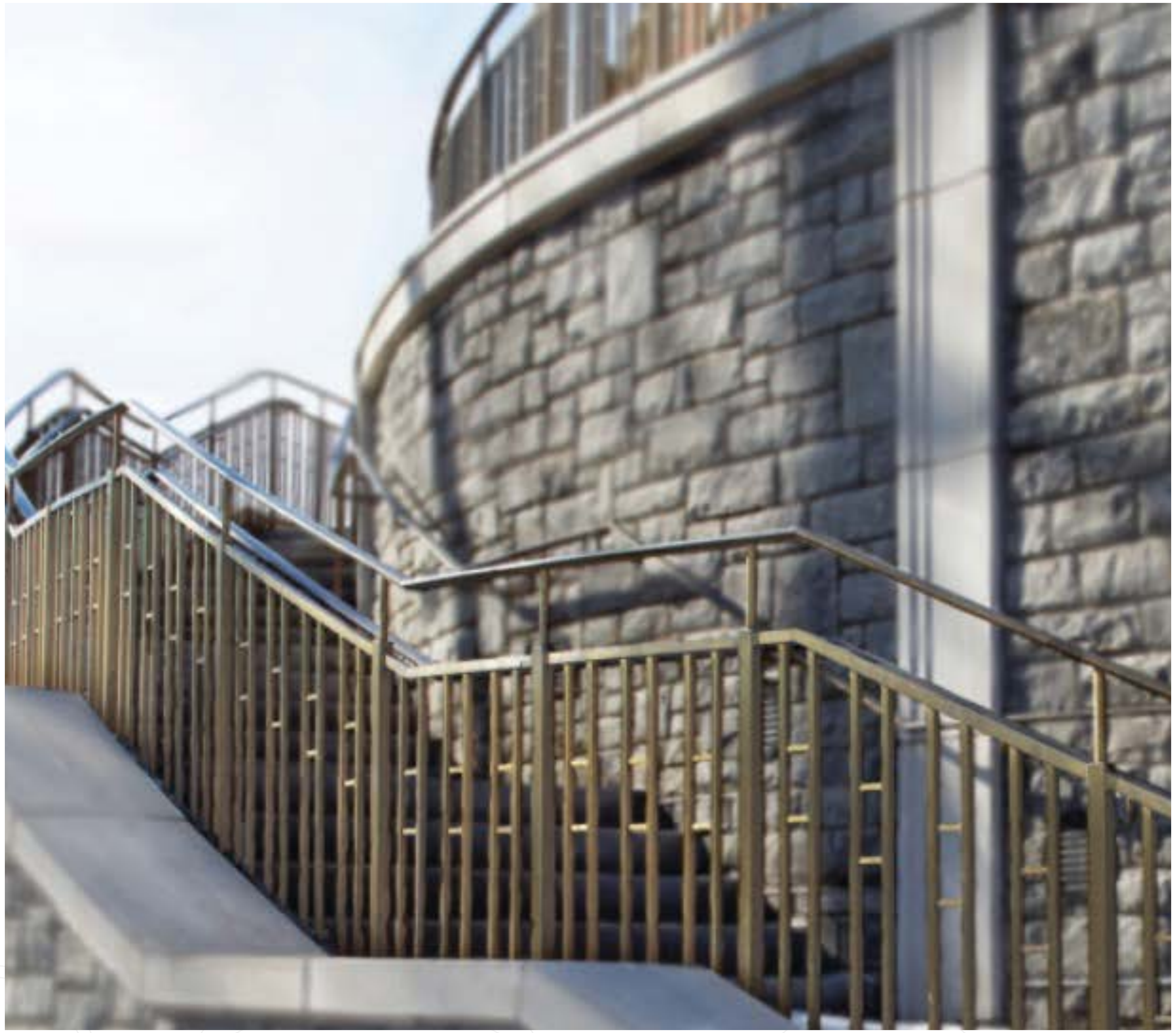
Single and Double Speed Saddles

Vertical Mounting Brackets

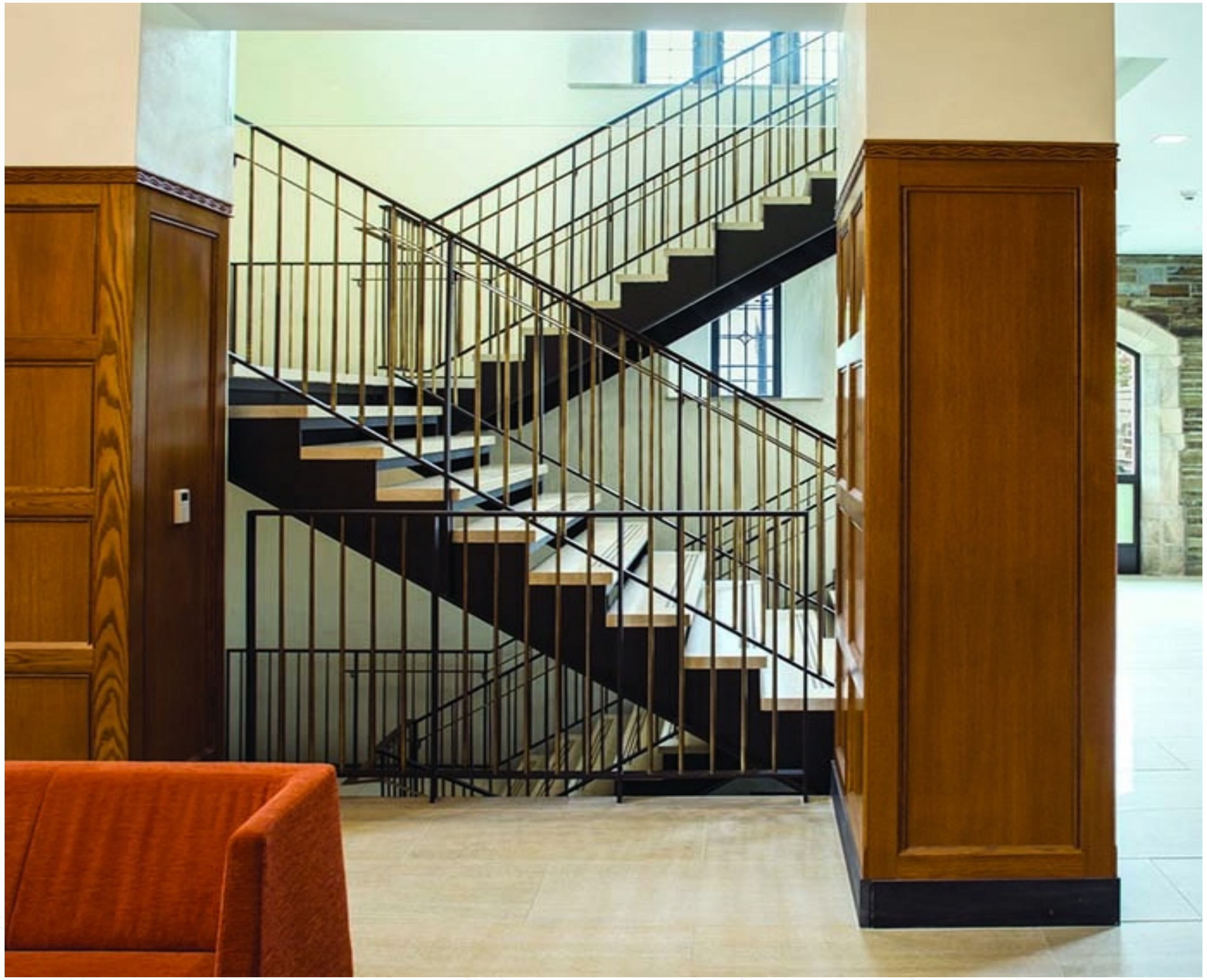
Part Four
Job Photos and System Applications

Glass Railing System

Tubing Bars and Shapes



Traditional Railing



Glass Railing System and Components

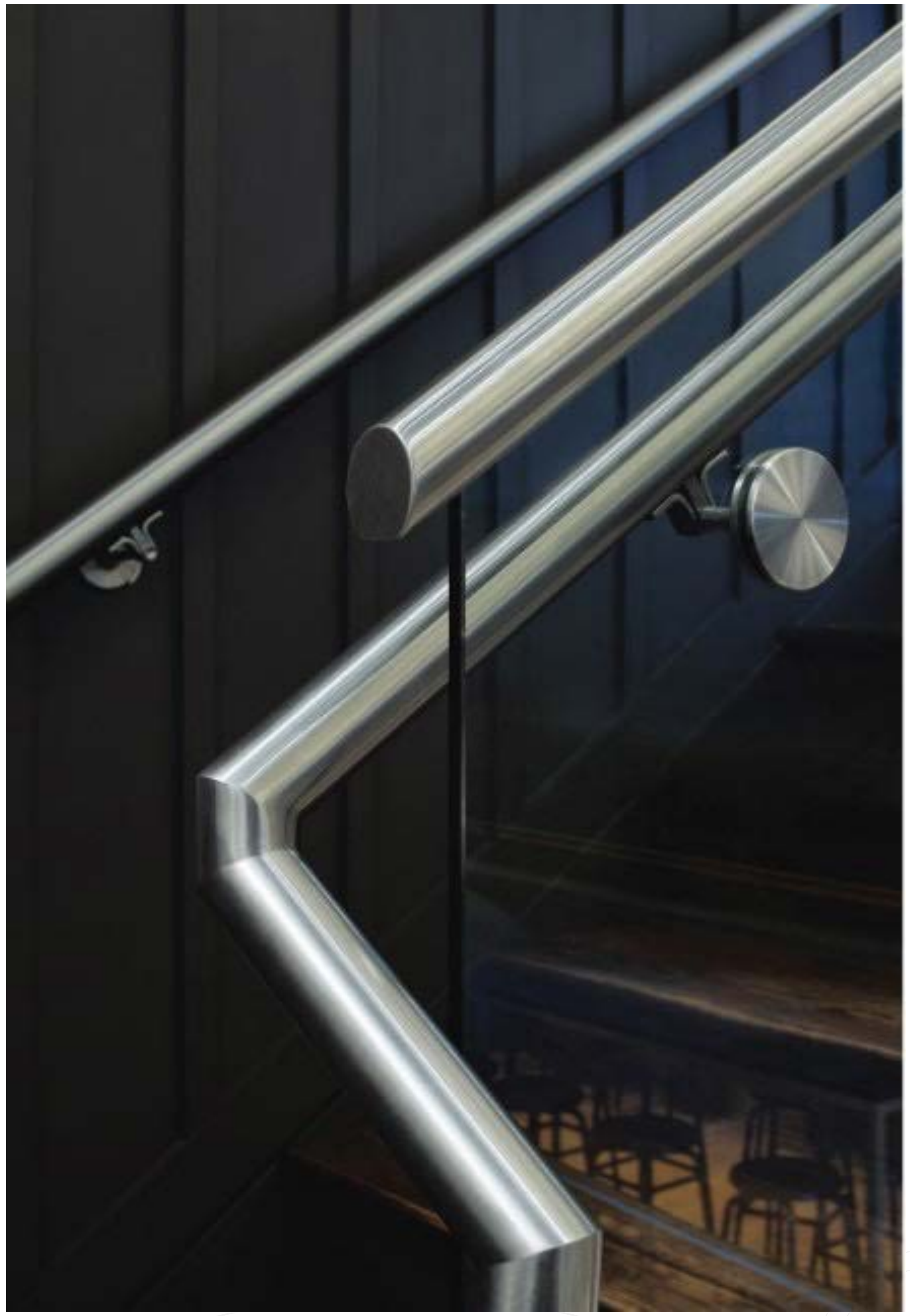
Chronicle Books, San Francisco, CA.

Stainless Steel: Alloy 304

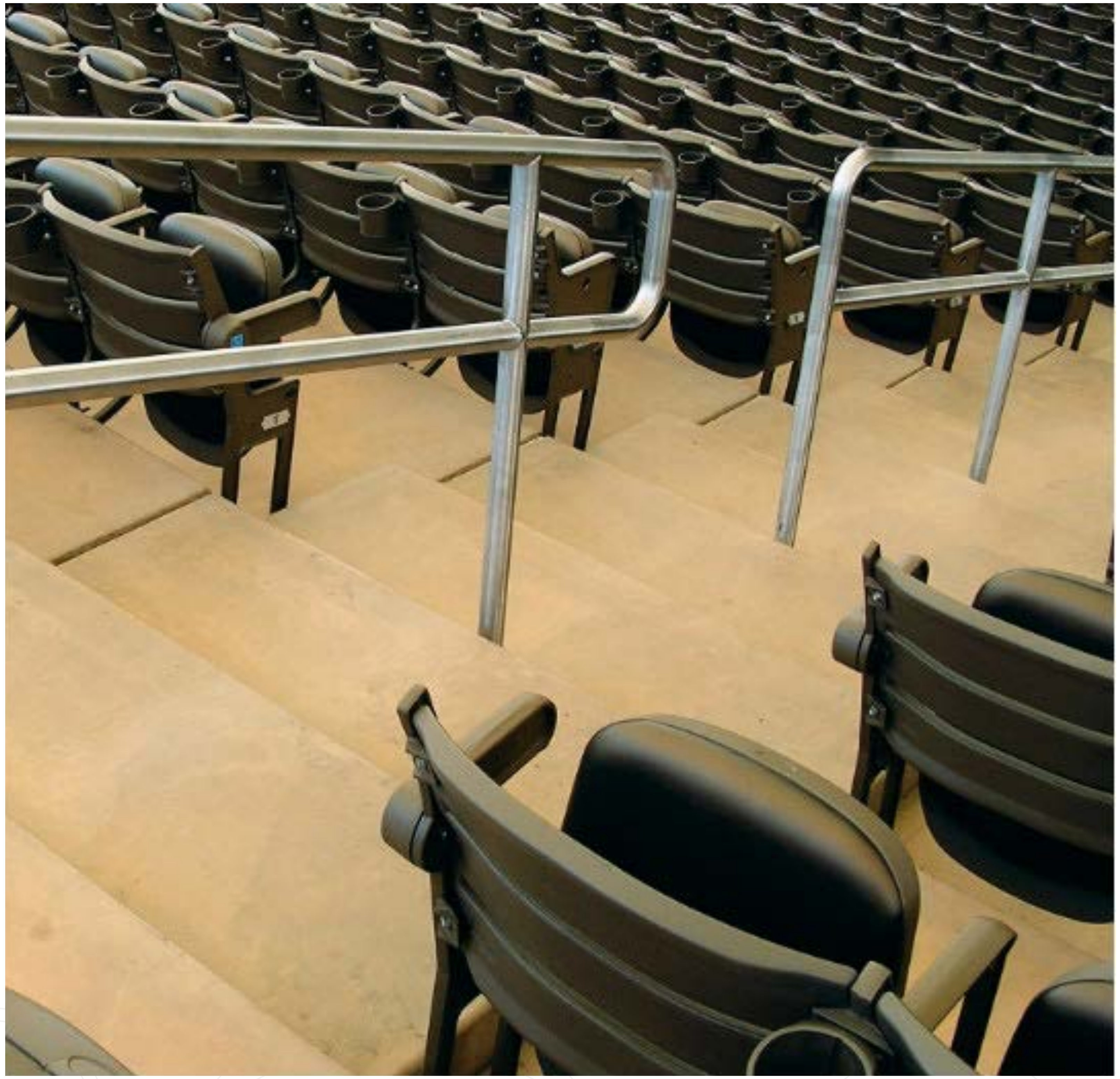
American Girl, Natick, MA.

Stainless Steel: Alloy 304

Glass Railing System and Components



Pipe Railing System



Pipe Railing System

Weld-Free Post and Panel Railing System

Summary

Attributes of a Material Supplier

Choose a supplier who can provide what your project needs most:

- A selection of railing systems for different applications and styles
- Metals for many applications
- Strong knowledge of the architectural metal industry
- Structural loading criteria
- Engineering and product strength testing

Learning Objectives Recap

Now design professionals will be able to:

- Discuss the benefits of utilizing stock components for architectural metal work, such as sustainability and durability, as well as compare metal alloys and finishes.
- List the five major engineering considerations for component systems to ensure products are specified and installed correctly for safe use.
- Evaluate different profiles of stock components in order to select the best component for each project's needs based on design and durability.
- Illustrate the different ways architectural metal work can be utilized in a wide variety of applications by analyzing case studies.

Thank you!

bluminfo@juliusblum.com

800-526-6293

www.juliusblum.com

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