DESIGNER

HANDBOOK

with Directory of
Stainless Steel
Structural Producers

STAINLESS STEEL FOR STRUCTURAL APPLICATIONS

TABLE OF CONTENTS

INTRODUCTION

Stainless steel is not a single alloy, but rather the name applies to a group of iron based alloys containing a minimum 10.5% chromium. Other elements are added and the chromium content increased to improve the corrosion resistance, improve heat resisting properties, enhance mechanical properties, and/or to improve fabricating characteristics. There are over 50 stainless steel grades that were originally recognized by the American Iron and Steel Institute (AISI). Three general classifications are used to identify stainless steel. They are: 1. Metallurgical structure. 2. The AISI numbering system (200, 300 and 400 series numbers). 3. The Unified Numbering System, which was developed by the American Society for Testing Materials (ASTM) and the Society of Automotive Engineers (SAE) to apply to all commercial metals and alloys.

The various types of stainless steel are detailed in a designer handbook, “Design Guidelines for the Selection and Use of Stainless Steel” available from the Specialty Steel Industry of North America (SSINA). Several other publications are also available, including: “Stainless Steel Fabrication,” “Stainless Steel Fasteners,” “Stainless Steel Finishes,” “Stainless Steel Specifications,” and “Stainless Steel Architectural Facts,” to mention a few.

GENERAL INFORMATION ON STAINLESS STEEL

ALLOYS

The following grades of stainless steel are often used in structural applications:

304 has an austenitic metallurgical structure. It is the basic "18-8" alloy (18% chromium, 8% nickel UNS S30400), is the most readily available grade, and is often specified for "all-purpose" applications. It has excellent corrosion resistance and unusually good formability.

316 is basically a 304 grade with the addition of 2 to 3% molybdenum. It has greater corrosion resistance than 304 and is usually preferred for long term service in aggressive industrial, chemical and seacoast atmospheres.

409 has a ferritic metallurgical structure. It is a straight chrome alloy (11 to 12% chromium UNS S40900). It has good ductility and corrosion resistance. It is mainly used for internal applications.

410-3 is a dual phase alloy (UNS S41003) with micro alloy element control that permits welding in up to 1 1/4 inches (30mm).

2205 has a duplex structure which is typically about equal parts of austenite and ferrite (21% chromium, 4.5% nickel, 2.5% molybdenum UNS 32304). It has excellent corrosion resistance and exhibits about twice the yield strength as conventional grades.

CONDITION

Stainless steel is usually available in the "Hot Rolled and Annealed" condition and has a yield strength of about 42 ksi. The austenitic grades can be hardened by cold working the material. 301, a modification of 304, (with the chromium and nickel lowered slightly to increase the work hardening rate), can be supplied in various "tempers" up to full hard with a yield strength of 140 ksi.

The American Society of Civil Engineers (ASCE) has a standard ANSI/ASCE -8 -90 "Specifications for the Design of Cold Formed Stainless Steel Structural Members,"[1] which details the design information on "cold formed" stainless steel.

Table 1 **CLASSIFICATION OF STAINLESS STEEL PRODUCT FORMS***

Item	Description	Dimensions		
		Thickness	Width	Diameter or Size
Sheet	Coils and cut lengths: Hot Rolled No. 1	under 0.1875" (4.76mm)	24.000" (609.6mm) and over	—
	Cold Rolled No. 2D, 2B, Bright Annealed, TR	under 0.1875" (4.76mm)	24.000" (609.6mm) and over	
	Polished No. 3, 4, 6, 7 & 8	under 0.1875" (4.76mm)	24.000" (609.6mm) and over	
Strip	Coils and cut lengths: Hot Rolled No. 1	under 0.1875" (4.76mm)	under 24.000" (609.6mm)	—
	Cold Rolled No. 2D, 2B, Bright Annealed, TR	under 0.1875" (4.76mm)	under 24.000" (609.6mm)	
	Polished No. 3, 4, 6, 7 & 8	under 0.1875" (4.76mm)	under 24.000" (609.6mm)	
Plate	Coils and cut lengths: Hot Rolled, annealed & pickled	0.1875" (4.76mm) and over	over 10.000" (254mm)	—
	Polished available for special applications	0.1875" (4.76mm) and over	over 10.000" (254mm)	
Bar	Straight lengths: Hot finished rounds, squares, octagons and hexagons	—	—	0.250" (6.35mm) and over
	Hot finished flats	0.125" (3.18mm) and over	0.250" (6.35mm) to 10.000" (254mm)	—
	Cold finished rounds, squares, octagons and hexagons	—	—	0.062" (1.59mm) and over
	Cold finished flats	—	0.375" (9.53mm) and over	—
Rod	Hot Rolled coils may be annealed and/or descaled	—	—	0.200" (5.54mm) and over
Wire	Cold finishes only: Rounds, squares, octagons and hexagons	—	—	0.500" (12.7mm) and under
	Flat wire (coils only)	0.010" (0.254mm) to under 0.185" (4.76mm)	0.062" (1.59mm) to under 0.375" (9.35mm)	
Pipe & Tube	Several different classifications with differing specifications are available. For more information on standard sizes, consult your local Steel Service Center or the SSINA.			
Extrusions	Not considered "standard" shapes, but available. Currently limited in size to approximately 6.50" (165.1 mm) diameter circle, or structurals to 5.00" (127 mm) diameter.			

**Ingots, Slabs, Hot Bands, Angles and Rolled Shapes are also available.*

PRODUCT FORMS

The forms of stainless steel used in structural applications are: plate and sheet (often fabricated into structural shapes), extrusions, forgings, preformed products (tubes and angles), bar and rod, wire, and castings.

Plate:

Plate is defined as material that has a thickness of 3/16" or greater (Table 1). It is usually available in widths of 48, 60, 72 and 96". It can be supplied as individual flat plates or in "coil" form (some limits on thickness and width). Many structural shapes are produced by fabricating the plate into beams, angles and other components. For information, contact the "Steel Plate Fabricators Association" (708-298-0880).

Sheet:

Sheet is defined as material that has a thickness of less than 3/16" (Table 1), and is usually supplied in either 48 or 60" wide coils.

Extrusions:

Stainless steel can be extruded into several complex shapes as detailed in the Designer Handbook "The Selection and Use of Stainless Steel."

Also contact: Al Tech Specialty Steel Corporation (716-366-1000), Plymouth Tube Company (1-800-323-9506).

Forging:

Stainless steel forging are also available in several shapes. For information, contact the "Forging Industry Association" (216-781-0102).

Preformed Products:

Angles are available as a hot rolled product. Contact Slater Steel Corporation (219-432-2561).

- **Hot rolled and cold rolled shapes**, as well as **cold-drawn "shapes"** can also be made from stainless steel as detailed in the Designer Handbook "The Selection and Use of Stainless Steel."
- **Tubular products** are commonly used for structural applications either in round or square sections. Further information is available for the Specialty Tubing Group (202-342-8400).
- **Bar and Rod:** Bar is defined as hot finished or cold finished rounds, square, octagons and hexagons and flats (Table 1).

Wire:

Wire is cold finished only, produced in coils, as round, square, octagon, hexagon, and flat wire (Table 1).

Castings:

Stainless steel casting can be produced for structural applications. For information, contact the "Steel Founders' Society of America" (847-299-9160).

STAINLESS STEEL STRUCTURES

Fabrication:

Stainless steel can be fabricated by methods similar to those used for carbon steel. However, other considerations must be taken into account because of the difference in material properties, such as yield strength and rate of work hardening. The SSINA Designer Handbook "Stainless Steel Fabrication,"[2] has several suggestions on techniques for cutting, bending, forming and finishing the austenitic and ferritic stainless steels. For example, 304 requires 50% more power to bend it than carbon steel.

Duplex grades like 2205 have roughly twice the yield strength of 304 or 316. Once the yield strength is exceeded, the plastic deformation takes place just as easily as with the austenitic material.

Heavy gauge material (over 3/16") is usually fabricated into structural components such as "I" beams and angles. Tubular products are available in round tubes or square hollows.

Table 2 shows the relative fabrication characteristics of the various grades of stainless steel.

Connections:

Stainless steel structures must be connected by using stainless steel fasteners. The SSINA has a Designer Handbook "Stainless Steel Fasteners A Systematic Approach to Their Selection" which details a method of selecting stainless steel fasteners.

Stainless steel is also readily "welded," although the welding rods and techniques are different from that of mild steel. The American Welding Society (800-443-WELD) and the Nickel Development Institute (416-591-7999) have information available on welding stainless steels.

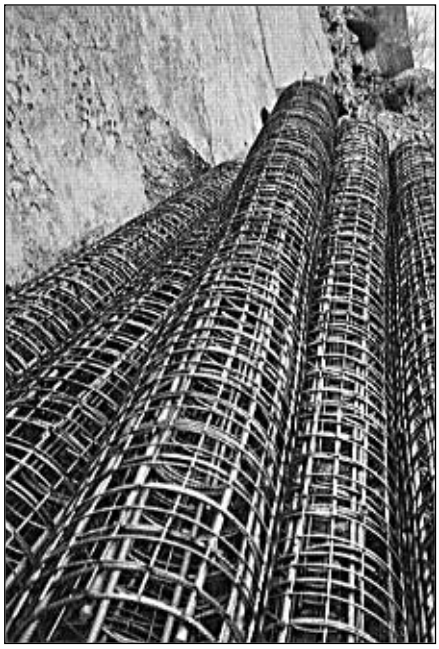
Table 2

Characteristic	Austenitic 304	Austenitic 316	Ferritic 409	Dual Phase 410-3	Duplex 2205
Bending	E	E	G	G	G
Deep Drawing	E	E	E	E	P
Hot Forming	G	G	G	G	G
Cold Forming	G	G	G	G	F
Punching	F	F	F	F	F
Shearing	F	F	F	F	F
Welding	E	E	F	G	G
Machining	F	F	G	G	P

Code: E = Excellent G = Good F = Fair P = Poor

CONCRETE REINFORCEMENT

Stainless steel rebars being installed in a bridge on highway 407 in Ontario, Canada



Preformed rebars for columns

Applications for Rebars:

- Supports for reinforced concrete (i.e., bridge decks)
- Marine construction, piers and wharfs
- Balconies and frames for front-elevation units
- Anchorages and any kind of joints
- Off-shore platforms
- Framers and anchorages for damp environments, tunnels, underpasses and subways
- Bridges, viaducts, overpasses
- Cement frameworks with amagnetic characteristics
- Frameworks which are prone to breaking up due to frost or because of low temperatures
- Concrete slabs for drainage in environments with corrosive agents
- Supports/restoration for statues, monuments, cement, stone and marble works

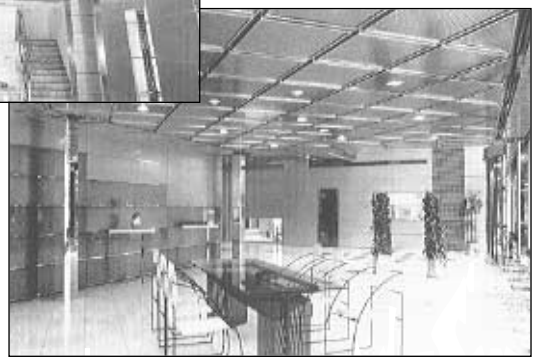
FABRICATED COMPONENTS

Stainless steel is becoming the material of choice for concrete reinforcement. It has a high resistance to corrosion particularly in chloride bearing concrete (from de-icing salts or seacoast exposure). Significant reductions in maintenance and repair will result in applications where the structure is subject to adverse corrosion.

An article, published in the May 1995 issue of "Concrete International,"[3] by D. B. McDonald; M. R. Sherman; D. W. Pfeifer, and Y. P. Virmani, concludes that both "field and laboratory data have shown that stainless steel rebars are capable of maintaining excellent corrosion resistance in severe chloride environments," and that "the chloride tolerance for stainless steel was shown to be significantly greater than that of mild steel." This article also concludes that the "use of stainless steel may be warranted when guaranteed long-term corrosion resistance is required. The

Ladders and walkways and rails fabricated by ENERFAB a Bishopric Company

Entrance hall of an all-stainless steel building in Japan[4]



A showroom of an all-stainless steel building in Japan

Arches, strut light covers and traffic signal poles (not in photo) were fabricated from 316L Stainless steel by the Offenhauser Company. The project is in the Galleria area in Houston.

Applications for Fabricated Components:

- Columns and Pillars
- Walkways, Railings and Ladders
- Arches
- Storage Units
- Processing Vessels
- Structural Supports
- Wall and Ceiling Panels

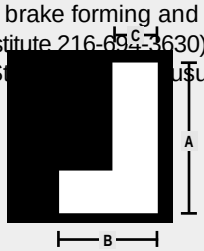
overall cost increase due to the use of stainless steel reinforcing bars is considered to be reasonably low."

Stainless angles were used to construct a Bar Screen (Series 1000 from Envirex, INC) for a water treatment application.

Stainless steel can be fabricated into several structural components from sheet, plate, bars or strip. There are many fabrication shops that are experienced in fabricating stainless steel (for more information contact the Steel Plate Fabricators Association 708-562-8750). Steel service centers also can perform some fabrication services such as brake forming and cutting custom shapes and sizes (contact the Steel Service Center Institute 216-694-3630).

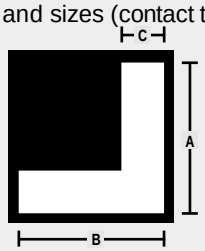
St usually the material

Unequal Leg Angles



A	B	C	Approx. Wt. Lbs. per Ft.
2	1-1/2	3/16	2.12
2-1/2	2	3/16	2.75
3	2	3/16	3.07
1-1/2	1	1/4	1.92
2	1	1/4	2.34
2	1-1/2	1/4	2.77
2-1/2	1-1/4	1/4	2.85
2-1/2	1-1/2	1/4	3.19
2-1/2	2	1/4	3.62
3	1-1/2	1/4	3.51
3	2	1/4	4.10
3	2-1/2	1/4	4.50
3-1/2	2-1/2	1/4	4.90
3-1/2	3	1/4	5.40
4	3	1/4	5.80
3	2	5/16	5.00
3-1/2	2-1/2	5/16	6.10
4	3	5/16	7.20
2-1/2	1-1/2	3/8	4.70
2-1/2	2	3/8	5.30
3	1-1/2	3/8	5.30
3	2	3/8	5.90
3-1/2	2-1/2	3/8	7.20
3-1/2	3	3/8	7.90
4	3	3/8	8.50
5	3	3/8	9.80
3	1	1/2	6.01
3	1-1/2	1/2	6.85
3	2	1/2	7.70
3-1/2	1-1/2	1/2	7.64
3-1/2	3	1/2	10.20
4	3	1/2	11.10
5	3	1/2	12.80

Equal Leg Angles



A	B	C	Approx. Wt. Lbs. per Ft.
1-1/2	1-1/2	3/16	1.80
1-3/4	1-3/4	3/16	2.12
2	2	3/16	2.44
2-1/2	2-1/2	3/16	3.07
3	3	3/16	3.71
1-1/4	1-1/4	1/4	1.92
1-1/2	1-1/4	1/2	2.34
1-3/4	1-3/4	1/4	2.75
2	2	1/4	3.19
2-1/2	2-1/2	1/4	4.10
3	3	1/4	4.90
3-1/2	3-1/2	1/4	5.80
4	4	1/4	6.60
2	2	5/16	3.92
2-1/2	2-1/2	5/16	5.00
3	3	5/16	6.10
3-1/2	3-1/2	5/16	7.05
4	4	5/16	8.20
2	2	3/8	4.70
2-1/2	2-1/2	3/8	5.90
3	3	3/8	7.20
3-1/2	3-1/2	3/8	8.50
4	4	3/8	9.80
2-1/2	2-1/2	1/2	7.70
3	3	1/2	9.40
3-1/2	3-1/2	1/2	11.10
4	4	1/2	12.80

of choice in the food, beverage, pharmaceutical and chemical industries, but is often specified where long life and attractive appearance are desired in other applications. For example, stainless steel is often used as a column "cover" where the outer skin is stainless; however, it can also be used as the load bearing member.

TUBULAR COMPONENTS

Stainless steel angles are produced by hot rolling, annealing, blast cleaning and chemical passivation. Angles can be formed from sheet and plate or rolled from billets creating various structural components. A popular use involves bending the angle into a ring and welding the ends together for use as an outer strengthening component in

Tubular sections form the La Grande Arch structure in Paris.

Stainless steel trusses (20 meters) for bracing and end frames for skylight supports.

Structural tubes, filled with water, used as an external fire prevention system.

Applications for Tubular Components:

- Space frames
- Trusses
- Bracing and end frames
- Lattices
- Load bearing member
- Light poles
- Overhead signs

cyclindrical structures. Typical sizes are listed in Table 3.

(photo, above)
Stainless steel was used to support a lightweight PTFE coated glass fiber woven fabric roof (not yet installed).

(photo, left)
Stainless steel tie rods linked to stainless steel tubular columns to maintain the roof membrane in tension.

The Minnesota Department of Transportation replaced conventional low alloy steel with stainless steel hinge pins and hangers on the Blatnik Bridge in Duluth, Minnesota.

A continuous reinforced concrete slab supported by 44 stainless steel rods provides pedestrians and cyclists a bridge over the Humber River in Toronto.

Applications for Bars and Rods:

- Structural members in tension
- Load transfer devices
- Tie rods
- Bridge pins

FRAMES

Stainless steel has been specified in bus and rail cars for internal frames and for the entire structure.

Rail coal carriers fabricated from stainless steel.

Truck mirror frame.

Tubular supports for the roof structure of the Canadian Archives Building.

INVESTMENT CASTING

Table 3 **ANGLES**

Slater is able to produce the following sizes of angles in the Hot Rolled, Annealed and Descaled condition:

1 x 1 x 1/8	2 x 2 x 1/4
1 x 1 x 3/16	2 x 2 x 5/16
1 x 1 x 1/4	2 x 2-3/8
1-1/4 x 1-1/4 x 1/8	2-1/2 x 2-1/2 x 3/16
1-1/4 x 1-1/4 x 3/16	2-1/2 x 2-1/2 x 1/4
1-1/4 x 1-1/4 x 1/4	2-1/2 x 2-1/2 x 5/16
1-1/2 x 1-1/2 x 1/8	2-1/2 x 2-1/2 x 3/8
1-1/2 x 1-1/2 x 3/16	3 x 3 x 1/4

Complex stainless steel investment casting connecting the tubular structure with the glass wall.

Applications for Frames:

- Bus and transit frames
- Coal cars
- Space frames
- Mirror mount frames

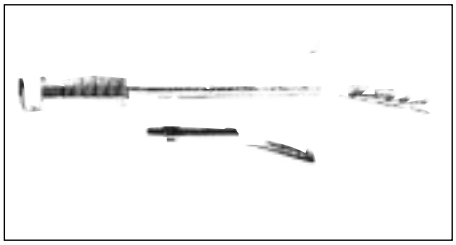
Applications for Castings:

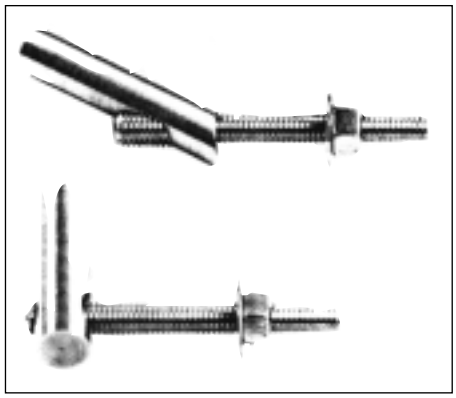
- Anchors
- Support housings
- Joints

WALL TIES AND ANCHORS

1-1/2 x 1-1/2 x 1/4 3 x 3 x 5/16
2 x 2 x 1/8 3 x 3 x 3/8
2 x 2 x 3/16

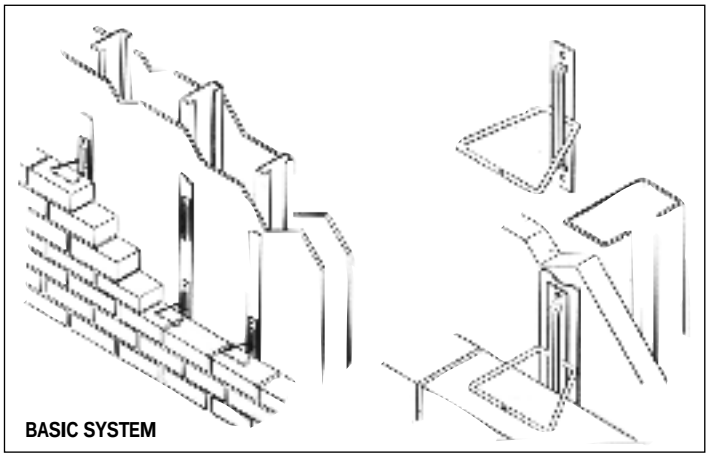
Tolerance information is as follows:
Leg Tolerance (length)....+1/8"
Weight Tolerance.....+7-1/2%
Right Angle Tolerance.....+2°
Straightness or Camber...1/8" in 5 feet



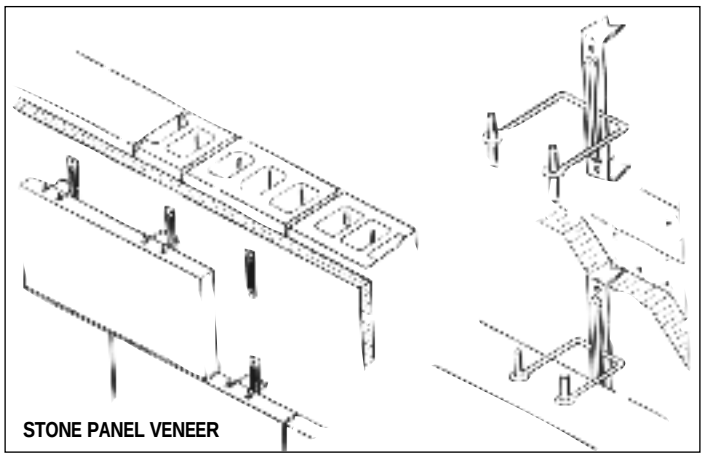


Lewis bolts (top) and threaded inserts for hanging stone (bottom) show variety of stainless steel fastening devices used in stone and concrete anchoring systems.

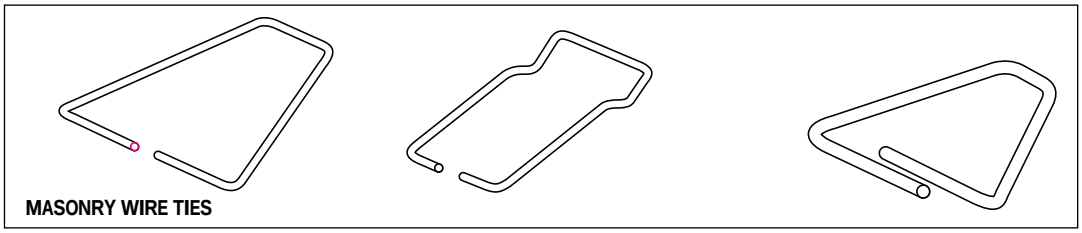
Stainless steel tie bar.



BASIC SYSTEM

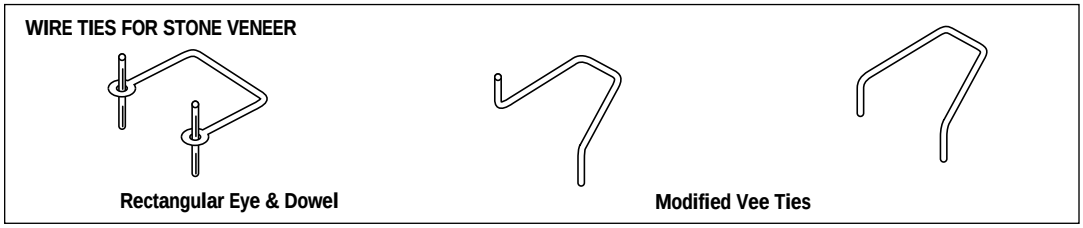


STONE PANEL VENEER



MASONRY WIRE TIES

WIRE TIES FOR STONE VENEER



Rectangular Eye & Dowel

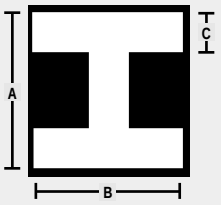
Modified Vee Ties

EXTRUSIONS

Stainless steel can be extruded in many shapes including angles. Angles are produced with parallel surfaces on the legs. Typical sizes are listed in Table 4.

Table 4

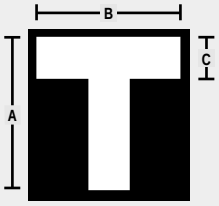
Beams



A	B	C	Approx. Lbs. per Ft.
1-1/2	1	3/16	2.02
1-1/2	1	1/4	2.64
2	1-1/4	1/4	3.43
2-1/2	1-1/2	1/4	4.22
3 (T)	2-3/8	1/4	6.60
4 (T)	2-3/4	1/4	8.44

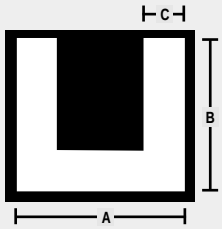
(T) standard tapered sections

Tees



A	B	C	Approx. Wt. Lbs. per Ft.
1-1/4	2	3/16	1.94
1-1/2	1-1/2	3/16	1.65
1-1/2	2	3/16	2.09
1-1/2	2-3/8	3/16	2.37
2	2	3/16	2.44
1	1-1/4	1/4	1.69
1-1/2	1-1/2	1/4	2.34
1-1/2	2	1/4	2.75
2	1-1/4	1/4	2.57
2	2	1/4	3.19
2-1/2	1-1/2	1/4	3.19
2-1/2	2-1/2	1/4	4.10
3	3	1/4	4.91
1-1/2	1-1/2	3/8	3.60
2	2	3/8	4.70
2-1/2	2	3/8	5.29
2-1/2	2-1/2	3/8	5.90
2-1/2	3	3/8	6.70
2	2	1/2	6.38

Channels



A	B	C	Approx. Wt. Lbs. per Ft.
1-1/2	3/4	3/16	1.75
2 (T)	9/16	3/16	1.85
2	3/4	3/16	2.02
2 (T)	1	3/16	2.60
2-1/2 (T)	5/8	3/16	2.40
3 (T)	1-3/8	3/16	4.19
1-1/4	1	1/4	2.33
1-1/2	1	1/4	2.57
2	5/8	1/4	2.37
2	1	1/4	3.15
2-1/2	1	1/4	3.57
3	1-1/2	1/4	4.75
4 (T)	1-3/4	1/4	6.69
5 (T)	1-7/8	3/8	10.43

(T) standard tapered sections

Specifications:

The following specifications can be applied to structural products:

ASTM A276 QQS-763
ASTM A479

Grades:

304 316 304L 316L

Other grades available upon request. Not all sizes available in all grades.

REFERENCES:

[1] American Society of Civil Engineers: ANSI/ASCE 8-90: "Specification for the Design of Cold Formed Stainless Steel Structural Members"

[2] Specialty Steel Industry of North America: Designer Handbook Series: "Stainless Steel Fabrication"

[3] Concrete International: May 1995: "Stainless Steel Reinforcing as Corrosion Protection": D.B.McDonald; M.R.Sherman; D.W. Pfeifer, and Y.P.Virmani.

[4] Steel Today & Tomorrow: News of Japanese Steel Jan.-Mar. 1996: Page 9 "A New Steel Structure — Stainless steel Buildings"

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Ontario Ministry of Transportation:
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