steelwise

ARE YOU PROPERLY SPECIFYING MATERIALS?

Keeping tabs on current ASTM specifications will help you make the right choices when designing and building your projects.

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THE MATERIALS AND PRODUCTS used in building design and construction are almost universally designated by reference to an appropriate ASTM specification. This simplifies the design and construction process because you can define all the characteristics of a specified product. However, with dozens of ASTM specifications applicable in steel building construction alone, it can be a challenge to keep the standard designations used in contracts current.

This article provides a summary of the common ASTM specifications used in steel building design and construction, including structural shapes, plate products, fastening products and other products. This information is based upon similar and more extensive information in the 14th Edition AISC *Steel Construction Manual*. You may also find it convenient to use the AISC publication *Selected ASTM Standards for Steel Construction*, a compilation of more than 60 steel-related ASTM standards. (Both the AISC *Manual* and *Selected ASTM Standards* are available for purchase online at **www.aisc.org/bookstore**.)

Note that ASTM standards routinely include a section on ordering requirements that lists the variables in each standard that should be specified in a complete order or specification for the material. This is routine for the purchasing department at the local fabrication company and may be of great interest to others as well.

This Article Covers Buildings, but for Bridges...

Another possibility for structural shapes and plates is ASTM A709, which is an "umbrella" standard that assembles ASTM A36, A572, A992, A588 and three high-performance steel (HPS) grades into a convenient single standard for bridge designers and fabricators. The HPS grades are available in plate form only. Grade 50S is available in shapes. The other grades are available in plates form and as shapes, though availability should be confirmed prior to specification.

ASTM A709 provides toughness levels for three exposures and two uses. Much material supplied to A709 meets one of those toughness levels. Material furnished to ASTM A709 grades are acceptable for use where the corresponding parent standard is specified.

STRUCTURAL SHAPES

See Summary in Table 1 (page 18).

W-Shapes

The preferred material specification for W-shapes is ASTM A992 (F_y = 50 ksi, F_u = 65 ksi). The availability and cost effectiveness of W-shapes in grades other than ASTM A992 should be confirmed prior to their specification. W-shapes with higher yield and tensile strength can be obtained by specifying ASTM A529 Grade 55, ASTM A572 Grades 55, 60 or 65, or ASTM A913 Grades 60, 65 or 70.

W-shapes with atmospheric corrosion resistance (weathering characteristics) can be obtained by specifying ASTM A588 Grade 50. These and other material specifications applicable to W-shapes are shown in Table 1.

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Table 1

Table 2-4														
Applicable ASTM Specifications for Various Structural Shapes														
Steel Type	ASTM Designation		F_y Yield Stress[a] (ksi)	F_u Tensile Stress[a] (ksi)	Applicable Shape Series									
					W	M	S	HP	C	MC	L	HSS		Pipe
												Rect.	Round	
Carbon	A36		36	58-80[b]										
	A53 Gr B		35	60										
	A500	Gr. B	42	58										
			46	58										
		Gr. C	46	62										
			50	62										
	A501	Gr. A	36	58										
		Gr. B	50	70										
	A529[c]	Gr. 50	50	65-100										
		Gr. 55	55	70-100										
	A709	36	36	58-80[b]										
	A1043[d]	36	36-52	58										
		50	50-65	65										
High-Strength Low-Alloy	A572	Gr. 42	42	60										
		Gr. 50	50	65										
		Gr. 55	55	70										
		Gr. 60[e]	60	75										
		Gr. 65[e]	65	80										
	A618[f]	Gr. Ia, Ib & II	50[g]	70[g]										
		Gr. III	50	65										
	A709	50	50	65										
		50S	50-65	65										
		50W	50	70										
	A913	50	50[h]	65[h]										
		60	60	75										
		65	65	80										
		70	70	90										
	A992		50[i]	65[i]										
Corrosion Resistant High-Strength Low-Alloy	A588		50	70										
	A847		50	70										

= Preferred material specification.
= Other applicable material specification, the availability of which should be confirmed prior to specification.
= Material specification does not apply.

a Minimum unless a range is shown.
b For wide-flange shapes with flange thickness over 3 in., only the minimum of 58 ksi applies.
c For shapes with a flange or leg thickness less than or equal to 1½ in. only. To improve weldability, a maximum carbon equivalent can be specified (per ASTM Supplementary Requirement S78). If desired, maximum tensile stress of 90 ksi can be specified (per ASTM Supplementary Requirement S79).
d For shape profiles with a flange width of 6 in. or greater.
e For shapes with a flange thickness less than or equal to 2 in. only.
f ASTM A618 can also be specified as corrosion-resistant; see ASTM A618.
g Minimum applies for walls nominally ¾-in. thick and under. For wall thickness over ¾-in., F_y = 46 ksi and F_u = 67 ksi.
h If desired, maximum yield stress of 65 ksi and maximum yield-to-tensile strength ratio of 0.85 can be specified (per ASTM Supplementary Requirement S75).
i A maximum yield-to-tensile ratio of 0.85 and carbon equivalent formula are included as mandatory, and some variation is allowed including for shapes tested with coupons cut from the web; see ASTM A992.

M-Shapes and S-Shapes

The preferred material specification for these shapes is in transition. Use of ASTM A36 (F_y = 36 ksi, F_u = 58 ksi) is now only slightly more common than use of a 50-ksi grade like ASTM A572 Grade 50, ASTM A529 Grade 50, or ASTM A992; each of these 50-ksi grades has F_y = 50 ksi and F_u = 65 ksi for these shapes. The availability and cost effectiveness of M-shapes and S-shapes in grades other than these should be confirmed prior to their specification.

M-shapes and S-shapes with a higher yield and tensile strength can be obtained by specifying ASTM A572 Grades 55, 60 and 65, ASTM A529 Grade 55 or ASTM A913 Grades 60, 65 or 70. Atmospheric corrosion resistance (weathering characteristics) can be obtained by specifying ASTM A588 Grade 50. These and other material specifications applicable to M-shapes and S-shapes are shown in Table 1.

Channels

The preceding comments for M-shapes and S-shapes apply equally to channels.

HP-Shapes

The preferred material specification for HP shapes is ASTM A572 Grade 50 (F_y = 50 ksi, F_u = 65 ksi); the availability and cost effectiveness of other grades should be confirmed prior to specification.

HP-shapes with atmospheric corrosion resistance (weathering characteristics) can be obtained by specifying ASTM A588 Grade 50. These and other material specifications applicable to HP-shapes are shown in Table 1.

Angles

The preceding comments for M-shapes and S-shapes apply equally to angles.

Structural Tees

Structural tees are split from W-, M- and S-shapes to make WT-, MT- and ST-shapes, respectively. For the preferred material specifications, as well as other suitable material specifications for structural tees, refer to the preceding sections on W-, M- or S-shapes, as appropriate.

Rectangular (and Square) HSS

The preferred material specification for rectangular hollow structural sections (HSS) is ASTM A500 Grade C (F_y = 50 ksi, F_u = 62 ksi). Note that a new standard, ASTM A1085 (see sidebar "New (and Recently New) Things"), seeks to replace it. The availability and cost effectiveness of rectangular HSS in grades other than ASTM A500 Grade C should be confirmed prior to their specification.

Rectangular HSS with atmospheric resistance (weathering characteristics) can be obtained by specifying ASTM A847. These and other material specifications applicable to rectangular HSS are shown in Table 1.

Round HSS

The preferred material specification for round HSS is ASTM A500 Grade C (F_y = 46 ksi, F_u = 62 ksi). Note that a new standard, ASTM A1085 (see sidebar "New (and Recently New) Things"), seeks to replace it. The availability and cost effectiveness of round HSS in grades other than ASTM A500 Grade C should be confirmed prior to specification.

Generally speaking, only round HSS with the same cross-sectional dimensions as steel pipe are stocked and available. See the sidebar "12 Tidbits" for further information.

Round HSS with atmospheric corrosion resistance (weathering characteristics) can be obtained by specifying ASTM A847. These and other material specifications applicable to round HSS are shown in Table 1.

New (and Recently New) Things

- *A Channel Especially for Stair Stringers*: The MC12×14.3 that recently was added to ASTM A6 was conceived as a stair stringer. It has a 2⅛-in. flange width, which is wide enough to accept the common handrail pipe size and fillet weld around it. No more crimping the pipe or goobering the weld!
- *Bigger HP-shapes*: The HP18- and HP16-series shapes that recently were added to ASTM A6 provide for even higher pile strengths. They, like all HP shapes, also have thicker webs ($t_w = t_f$) and may help eliminate the need for stiffeners and doublers when used as columns.
- *Larger HSS*: Until recently ASTM A500 HSS was limited to ⅝-in. thickness and 64-in. perimeter. It now permits HSS to ⅞-in. thickness and 88-in. perimeter. While the standards permit these larger sizes, they are not currently made in the U.S.; availability should be checked. HSS with sizes that exceed ASTM A500's 88-in. periphery limit can also be obtained and are discussed in an article titled "Larger Hollow Structural Sections" in the November 2011 issue of *Modern Steel*. This includes a discussion of ASTM A1065, which covers these shapes produced by forming two channels and welding the channels together.
- *ASTM A1085 for HSS*: Formalized in April 2013, this new standard offers tighter tolerances on wall thickness and corner radii, shape perimeters of up to 88 inches, minimum yield strength of 50 ksi, minimum tensile strength of 70 ksi *and* a maximum yield of 70ksi, standard CVN of 25 ft-lb at 40 °F with the option to request a custom CVN through a supplementary requirement. For additional information on ASTM A1085, see **www.aisc.org/A1085** and "Hollow Product, Solid Benefit" in the September 2013 issue of *Modern Steel*.
- *Simpler Bolting*: ASTM recently approved ASTM F3125, an umbrella specification that covers what is now in ASTM A325, A490, F1852 and F2280. The beauty of this standard is that these previously separate standards have been unified, coordinated and made consistent with each other (kudos to Chad Larson, president of LeJeune Bolt Company, for leading the effort to create this significant improvement). In future editions of RCSC and AISC standards, we expect you will see ASTM F3125 referenced instead of the currently separate list of standards. The names of the current standards are used as the names of the grades in the new standard, so you will still be able to order A325, A490, F1852 and F2280 bolts, and you will still be able to identify them by the marks on the head. Stay tuned!
- *Two other materials to mention*: ASTM A283 covers low-yield carbon steel plate material in four grades. ASTM A1043 covers plates and shapes and is most commonly used as core material in the manufacture of buckling-restrained braces. These two newer products are shown in Tables 1 and 2.
- *Very High Strength Bolting:* ASTM also just approved ASTM F3111 and F3043, which are 200-ksi structural bolts available in heavy hex and TC versions, respectively. These bolts have strict environmental requirements that are discussed in the standards, but essentially they must always remain dry and free from contact with corrosive chemicals. These bolts are proprietary and not produced domestically ask the steel fabricator to make sure you can obtain these bolts; if so, they may be helpful, especially in large connections.

Steel Pipe

The material specification for steel pipe used in structural frames is ASTM A53 Grade B (F_y = 35 ksi, F_u = 60 ksi). In some regions, ASTM A53 material is more readily available than ASTM A500 for round cross sections. See the sidebar "12 Tidbits" for further information.

PLATE PRODUCTS

See Summary in Table 2.

Structural Plates

The preferred material specification for structural plates is in transition. Use of ASTM A36 (F_y = 36 ksi for plate thickness equal to or less than 8 in., F_y = 32 ksi otherwise; F_u = 58 ksi) is as common as use of ASTM A572 Grade 50 (F_y = 50 ksi, F_u = 65 ksi for plate thickness equal to or less than 4 in.). The availability and cost effectiveness of structural plates in grades other than these should be confirmed prior to their specification. Note also the thickness ranges are different for other grades as shown in Table 2-2.

Structural plates with higher yield and tensile strength can be obtained by specifying ASTM A572 Grade 55, 60 or 65, ASTM A529 Grade 55, ASTM A514 Grade 90 or 100 or ASTM A852. Structural plates with atmospheric corrosion resistance (weathering characteristics) can be obtained by specifying ASTM A588 Grade 42, 46 or 50. These and other material specifications applicable to structural plates are shown in Table 2.

Structural Bars

The preceding comments for structural plates apply equally to structural bars, except ASTM A514 is not applicable.

Raised-Pattern Floor Plates

ASTM A786 is the standard specification for rolled steel floor plates. As floor-plate design is seldom controlled by strength considerations, ASTM A786 "commercial grade" is commonly specified. If so, per ASTM A786 Section 5.1.3, "the product will be supplied with 0.33 percent maximum carbon…and without specified

Table 2

Table 2-5

Applicable ASTM Specifications for Plates and Bars

Steel Type	ASTM Designation		F_y Yield Stress[a] (ksi)	F_u Tensile Stress[a] (ksi)	Plates and Bars, in.									
					to 0.75 incl.	over 0.75 to 1.25 incl.	over 1.25 to 1.5 incl.	over 1.5 to 2 incl.	over 2 to 2.5 incl.	over 2.5 to 4 incl.	over 4 to 5 incl.	over 5 to 6 incl.	over 6 to 8 incl.	over 8
Carbon	A36		32	58-80										
			36	58-80										
	A283	Gr. C	30	55-75					d					
		Gr. D	33	60-80					d					
	A529	Gr. 50	50	70-100		b	b	b	b	b				
		Gr. 55	55	70-100		c	c	c	c	c				
	A709	Gr. 36	36	58-80										
High-Strength Low-Alloy	A572	Gr. 42	42	60										
		Gr. 50	50	65										
		Gr. 55	55	70										
		Gr. 60	60	75										
		Gr. 65	65	80										
	A709	Gr. 50	50	65										
	A1043	Gr. 36	36-52	58										
		Gr. 50	50-65	65										
Corrosion Resistant High-Strength Low-Alloy	A242		42	63										
			46	67										
			50	70										
	A588		42	63										
			46	67										
			50	70										
Quenched and Tempered Alloy	A514		90	100-130										
			100	110-130										
Corrosion Resistant Quenched and Tempered Low-Alloy	A709	Gr. 50W	50	70										
		Gr. HPS 50W	50	70										
		Gr. HPS 70W	70	85-110										
		Gr. HPS 100W	90	100-130										
			100	110-130										

= Preferred material specification.
= Other applicable material specification, the availability of which should be confirmed prior to specification.
= Material specification does not apply.

a Minimum unless a range is shown.
b Applicable for plates to 1-inch thickness and bars to 3½-inch thickness.
c Applicable for plates to 1-inch thickness and bars to 3-inch thickness.
d Thickness is not limited to 2 in. in ASTM A283 and thicker plates may be obtained but availability should be confirmed.

mechanical properties." Alternatively, if a defined strength level is desired, ASTM A786 raised-pattern floor plate can be ordered to a specific plate material specification, such as ASTM A36, A572 or A588; see ASTM A786 Sections 5.1.3, and Section 7.

Sheet and Strip

Sheet and strip products, which generally are thinner than structural plate and bar products, are produced to such ASTM specifications as A606, A1008 or A1011. These are "umbrella" standards with many types and grades; the structural steel type is designated "SS" and the standards provide for grades from 25 or 30 to 80. Availability should be checked before specifying the grade.

FASTENING PRODUCTS

See Summary in Table 3.

Conventional Bolts

The preferred material specification for conventional (heavy hex) high-strength bolts in steel-to-steel connections is ASTM A325, although ASTM A490 is equally available and can be specified when higher strength is desired. In either case, Type 1 is the most commonly specified (medium-carbon steel). When atmospheric corrosion resistance is desired, Type 3 can be specified. While still formally permitted in the AISC *Specification*, the use of other material specifications in steel-to-steel bolting applications has become quite uncommon.

Twist-Off-Type Tension-Control Bolt Assemblies

There are two preferred material specifications for twist-off-type tension-control bolt assemblies; ASTM F1852, which offers a strength equivalent to that of ASTM A325 bolts, and ASTM F2280, which offers a strength equivalent to that of ASTM A490 bolts.

Nuts

The preferred material specification for heavy-hex nuts is ASTM A563. The appropriate grade and finish is specified per ASTM A563 Table X1.1 according to the bolt or threaded part with which the nut will be used. For steel-to-steel structural bolting applications, the appropriate grade and finish is summarized in Section 2.4 of the RCSC *Specification*. If its availability can be confirmed prior to specification, ASTM A194 Grade 2H nuts are permitted as an alternative, as indicated in Table 2.1 in the RCSC *Specification*.

Washers for Structural Bolts

The preferred material specification for hardened steel washers is ASTM F436. This specification provides for both flat and beveled washers. Recently, an "extra thick" option was added to provide for the cases in RCSC *Specification* Table 6.1 that require a special 5/16-in. thickness (when oversized or slotted holes are used in the outer ply of a steel-to-steel structural joint).

Washers for Anchor Rods

In anchor rod and other embedment applications, hole sizes generally are larger than those for steel-to-steel structural bolting applications; see Table 14-2 in the AISC *Steel Construction Manual*. Accordingly, washers used in such applications generally are larger and might require design consideration for proper force transfer, particularly when the anchorage is subject to tension. Such anchor-rod washers generally are made from plate or bar material. When anchor rods are used in holes that are smaller (5/16-in. larger than rod diameters up to 1 in.; ½-in. larger than rod diameters over 1 in. to 2 in.; and 1 in. larger than rod diameters over 2 in.) ASTM F844 washers can be used. Note that they can be ordered with a larger diameter than ASTM F436 washers.

Compressible-Washer-Type Direct-Tension Indicators

When bolted joints are specified as pretensioned or slip-critical and the direct-tension-indicator pretensioning method is used, ASTM F959 compressible-washer-type direct-tension indicators are specified. Type 325 is used with ASTM A325 high-strength bolts and type 490 is used with ASTM A490 high-strength bolts. The use of these devices must conform to the requirements in the RCSC *Specification*, which provides detailed requirements for pre-installation verification (Section 7), installation (Section 8) and inspection (Section 9). The RCSC *Specification* also permits alternative washer-type indicating devices subject to the provision in Section 2.6.2.

Anchor Rods

The preferred material specification for anchor rods is ASTM F1554, which covers hooked, headed, threaded and nutted anchor rods in three strength grades: 36, 55 and 105. ASTM F1554 Grade 55 is most commonly specified, although grades 36 and 105 are normally available. Note that, per Section 4.1 in ASTM F1554, when grade 36 is ordered the supplier may substitute weldable grade 55 at their option.

ASTM F1554 Grade 36 may be welded, while Grade 55 may be welded if it is ordered with Supplement S1. Grade 105 may not be welded, as the heat will detrimentally affect performance.

Several other ASTM specifications also may be used. For applications involving rods that are not headed, ASTM A36, A193, A307, A354, A449, A572, A588 and A687 can be specified; note that the ASTM A307 Grade C "anchor bolt" has been deleted from ASTM A307 and replaced by ASTM F1554 Grade 36. For applications involving headed rods, A354 and A449 can be specified.

Threaded Rods

The preferred material specification for threaded rods, whether provided with plain or upset ends, is ASTM A36. Other material specifications that can be specified include ASTM A193, A307, A354, A449, A572, A588 and A687. Note that ASTM A354 Grade BC and A449 are permitted to be used for bolts when the size required is outside the range of ASTM A325.

Table 3

Table 2-6

Applicable ASTM Specifications for Various Types of Structural Fasteners

ASTM Designation		F_y Yield Stress[a] (ksi)	F_u Tensile Stress[a] (ksi)	Diameter Range (in.)	Bolts: High Strength: Conventional	Bolts: High Strength: Twist-Off-Type Tension Control	Bolts: Common	Nuts	Washers: Hardened	Washers: Plain	Washers: Direct-Tension Indicator	Threaded Rods	Anchor Rods: Hooked	Anchor Rods: Headed	Anchor Rods: Threaded & Nutted
A325	Type 1	–	105	1.125 to 1.5, incl.	■										
		–	120	0.5 to 1, incl.	■										
	Type 3	–	105	1.125 to 1.5, incl.	■										
		–	120	0.5 to 1, incl.	■										
A490	Type 1	–	150	0.5 to 1.5	■										
	Type 3	–	150	0.5 to 1.5	■										
F1852	Type 1	–	105	1.125		■									
		–	120	0.5 to 1, incl.		■									
	Type 3	–	105	1.125		■									
		–	120	0.5 to 1, incl.		■									
F2280	Type 1	–	150	0.5 to 1.125		■									
	Type 3	–	150	0.5 to 1.125		■									
A194 Gr. 2H		–	–	0.25 to 4				▒							
A563		–	–	0.25 to 4				■							
F436		–	–	0.25 to 4[b]					■						
F844		–	–	any						■					
F959		–	–	0.5 to 1.5							■				
A36		36	58-80	to 10								■	▒	▒	▒
A193 Gr. B7		75	100	over 4 to 7	▒							▒	▒	▒	▒
		95	115	over 2.5 to 4	▒							▒	▒	▒	▒
		105	125	2.5 and under	▒							▒	▒	▒	▒
A307 Gr. A		–	60	0.25 to 4			■					▒	▒	▒	▒
A354	Gr. BC	109	125	0.25 to 2.5, incl.								▒	▒	▒	▒
		99	115	over 2.5 to 4, incl.								▒	▒	▒	▒
	Gr. BD	115	140	2.5 to 4 incl.								▒	▒	▒	▒
		130	150	0.25 to 2.5, incl.								▒	▒	▒	▒
A449	Type 1	58	90	over 1.5 to 3 incl.								▒	▒	▒	▒
		81	105	over 1 to 1.5 incl.								▒	▒	▒	▒
	Type 3	92	120	0.25 to 1 incl.								▒	▒	▒	▒
A572	Gr. 42	42	60	to 6								▒	▒		▒
	Gr. 50	50	65	to 4[c]								▒	▒		▒
	Gr. 55	55	70	to 2								▒	▒		▒
	Gr. 60	60	75	to 3.5								▒	▒		▒
	Gr. 65	65	80	to 1.25								▒	▒		▒
A588		42	63	over 5 to 8, incl.								▒	▒		▒
		46	67	over 4 to 5, incl.								▒	▒		▒
		50	70	4 and under								▒	▒		▒
F1554	Gr. 36	36	58-80	0.25 to 4								▒	■	■	■
	Gr. 55	55	75-95	0.25 to 4								▒	■	■	■
	Gr. 105	105	125-150	0.25 to 3								▒	▒	▒	▒

■ = Preferred material specification.
▒ = Other applicable material specification, the availability of which should be confirmed prior to specification.
□ = Material specification does not apply.

– Indicates that a value is not specified in the material specification.
a Minimum unless a range is shown or maximum (max.) is indicated.
b Diameter range is ½ in. to 1½ in. for beveled and extra thick washers.
c ASTM A572 permits larger rod diameters, but practicality of threading should be confirmed before specification.

12 Important Tidbits for 2015

1. When in doubt, check it out. Have questions about availability? Call a fabricator or contact the AISC Steel Solutions Center (**solutions@aisc.org**; 866.ASK.AISC). Either one can keep you swimming in available steel. Also visit **www.aisc.org/availability**.
2. Times change. ASTM A992 originally was introduced covering only W-shapes. A later revision to this ASTM standard expanded its scope to include other hot-rolled structural cross sections (channels, angles, M-shapes, etc.), allowing them to be made to ASTM A992. Nevertheless, A992 still is not common in shapes other than W-shapes.
3. Round HSS ≠ steel pipe. Know the difference between ASTM A500 and ASTM A53. ASTM A500 is for HSS (F_y = 46 ksi for Grade C, 42 ksi for Grade B). ASTM A53 is for steel pipe (F_y = 35 ksi).
4. Round HSS are similar to steel pipe. Know the similarity between available round HSS (ASTM A500) and steel pipe (ASTM A53). Generally speaking, only round HSS with the same cross-sectional dimensions as steel pipe are stocked and available. So, avoid specifying a round HSS with a cross section that does not match up to one of the steel pipe cross sections. This is a lot easier than it sounds; just use round HSS with non-zero numbers after the decimal point. For example, HSS5.563×0.258 has the same cross-section as a Pipe 5 Std. And it will generally be available, while HSS5.000×0.250 is an HSS-only product and will require a mill-order quantity to obtain.
5. Properly designate your HSS. A round HSS is designated by nominal diameter and wall thickness, each expressed to three decimal places—for example, HSS5.563×0.258. A square or rectangular HSS is designated by nominal outside dimensions and wall thickness, each in rational numbers—for example, HSS5×3×⅜.
6. Properly designate your steel pipes. Use nominal pipe size (NPS) designation through NPS 12—for example, Pipe 5 Std., Pipe 5 x-strong or Pipe 5 xx-strong. Note that this notation has commonly been abbreviated as follows for the examples given: P5, PX5 and PXX5 respectively. Above NPS 12, use the format "Pipe" followed by nominal diameter × nominal wall thickness, each expressed to three decimal places—for example, NPS 14 Standard is designated Pipe 14.000×0.375. The latter format also applies to any steel pipe size smaller than NPS 12 that does not have an NPS size.
7. Don't confuse anchor rods with structural bolts. Do not specify your anchor rods as ASTM A325 or A490. The ASTM A325 and A490 standards cover headed bolts, with limited thread length, generally available only up to 8 in. in length, and governed by provisions for steel-to-steel structural joints only. You say you've always specified your anchorage devices this way and it's never been a problem? Well, the reality is that your fabricator has been awfully nice to not embarrass you by pointing out that you've specified a product that does not come in the length you likely specified—or as a hooked or longer-threaded rod. Use ASTM F1554, which covers hooked, headed and threaded/nutted rods in three strength grades.
8. Have all the information at your fingertips. More extensive information can be found in the 14th Edition AISC *Steel Construction Manual* and the AISC publication *Selected ASTM Standards for Steel Construction*, which are available at **www.aisc.org/bookstore**.
9. Remember to specify the alternate core location CVN requirement when you have heavy shapes or plates with CJP groove welds and subject to tension; see AISC *Specification* Sections A3.1c and A3.1d for further information.
10. When specifying weathering steel, think ASTM A588 first. ASTM A242 is increasingly less common.
11. Use the MC12×14.3 for stair stringers. The handrail pipe sizes will fit—as will the fillet welds used to connect them on this new channel with a wider flange.
12. When in doubt, check it out and ask your fabricator. Oh wait, this is number 1. Well, it is important.

ASTM A354 Grade BD is permitted when the size required is outside the range of ASTM A490. These standards are material standards, not bolt standards, so the desired dimensions have to be specified as per ANSI ASME B18.2.6 heavy hex class 2A.

Shear Stud Connectors

Shear studs are specified as given in AWS D1.1 Clause 7, with material as required in Clause 7.2.6. Type B is usual and the corresponding mechanical requirements are stated in AWS D1.1 Table 7.1 (F_y = 51 ksi, F_u = 65 ksi).

Forged Steel Structural Hardware

Forged steel structural hardware products, such as clevises, turnbuckles, eye nuts and sleeve nuts are occasionally used in building design and construction. These products are generally provided to AISI material specifications. AISI C-1035 is commonly used in the manufacture of clevises and turnbuckles. AISI C-1030 is commonly used in the manufacture of steel eye nuts and steel eye bolts. AISI C-1018 Grade 2 is commonly used in the manufacture of sleeve nuts. Other products, such as steel rod ends, steel yoke ends and pins, cotter pins and coupling nuts are provided generically as "carbon steel." The dimensional and strength characteristics of these devices are described in the literature provided by their manufacturer. Note that such information may be provided as a safe working load and based upon a factor of safety as high as 5, assuming that the product will be used in rigging or similar applications subject to dynamic loading. If so, the tabular value might be overly conservative for permanent installations and similar applications subject to static loading only. In these applications, a factor of safety of 3 is more common.

Filler Metal

Filler metals permitted for use with prequalified welding procedure specifications are shown associated with the base metals for which they are considered "matching" in AWS D1.1 Table 3.1. A tensile strength of 70 is considered matching for base metals up to 70 ksi minimum tensile strength.

OTHER PRODUCTS

Steel Castings and Forgings

Steel castings can be produced in a wide variety of chemical compositions and mechanical properties; most are heat treated. Two standards useful in steel structures are ASTM A216 Grade WCB with Supplementary Requirement S11 and A958A958M Grade SC8620 class 80/50. Steel forgings are specified as ASTM A668.

Crane Rails

Crane rails are furnished to ASTM A759, ASTM A1 and/or manufacturer's specifications and tolerances. Rail is designated by unit weight in units of pounds per yard. Dimensions of common rail are shown in the AISC 14th Edition *Manual* Table 1-21; other rail profiles also exist and may be available.

Most manufacturers chamfer the top and sides of the crane rail head at the ends unless specified otherwise to reduce chipping of the running surfaces. Often crane rails are ordered as end-hardened, which improves the crane rail ends' resistance to impact from contact with the moving wheel during crane operation. Alternatively, the entire rail can be ordered as heat-treated. When maximum wheel loading or controlled cooling is needed, refer to manufacturer catalogs. Purchase orders for crane rails should be noted "for crane service."

Light 40-lb rails are available in 30-ft lengths, standard rails in 33-ft or 39-ft lengths, and crane rails up to 80 ft. Consult manufacturer for availability of other lengths.

Rails should be arranged so that joints on opposite sides of the crane runway will be staggered with respect to each other and with due consideration to the wheelbase of the crane. Rail joints should not occur at crane girder splices. Odd lengths that must be included to complete a run or obtain the necessary stagger should be not less than 10 ft long. Rails are furnished with standard drilling for splice bars in both standard and odd lengths unless stipulated otherwise on the order. ■