steelwise

ARE YOU PROPERLY SPECIFYING MATERIALS?

As material specifications change and improve, so too can your steel-framed buildings.

BY JONATHAN TAVAREZ

WE WOULD HOPE THAT your answer to the important question masquerading as the title of this month's SteelWise is a resounding "Yes!"

We recognize that your answer might be a less confident "Yes," an "I *think* so," an "I'm not sure," a "Maybe" or even a "Please help!" Wherever you are on the spectrum, rest assured we're here to help clarify any confusion.

As we know, ASTM specifications undergo periodic revisions and new ones come into existence. The design and construction process is simplified greatly through the reference of appropriate ASTM specifications because they allow you to define all the relevant characteristics of a specified product. However, with dozens of ASTM specifications applicable to steel construction alone, it can be a challenge to keep the standard designations used in contracts current.

Here, we'll provide a summary of the most common ASTM specifications used in steel building design and construction, including standards for structural shapes, plate products, fastening products and more. This information is based on similar information in AISC's 15th Edition *Steel Construction Manual*. Another useful AISC publication is *Selected ASTM Standards for Steel Construction*, which provides a compilation of more than 60 steel-related ASTM standards. Both publications are available at **www.aisc.org/publications**. ASTM standards typically include a section on ordering requirements listing the variables in each standard that should be specified in a complete order or specification for the material. This is routine for fabricator purchasing departments at local fabrication companies.

Jonathan Tavarez (**tavarez@aisc.org**) is a staff engineer in AISC's Steel Solutions Center.

Structural Shapes

Let's start with structural shapes, which are summarized in Table 2-4.

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 of limited sizes 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. These and other material specifications applicable to W-shapes are shown in Table 2-4.

M-Shapes and S-Shapes. The preferred material specification for these shapes is in transition. ASTM A36 (F_y = 36 ksi, F_u = 58 ksi) is now only slightly more common than 50-ksi grades like ASTM A529 Grade 50, ASTM A572 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 those listed 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 A529 Grade 55, ASTM A572 Grades 55, 60 and 65 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 2-4.

Channels. The preceding comments for M-shapes and S-shapes apply equally to channels. However, note that channels are now most commonly available as ASTM A992 (F_y = 50 ksi, F_u = 65 ksi). Be sure to confirm material availability with your fabricator.

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 2-4.

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). Two material standards new to the 15th Edition *Manual* for HSS are A1065 and A1085. A1085 Grade A (F_y = 50 ksi, F_u = 65 ksi) provides tighter wall thickness and corner radii tolerances. Additional benefits include a maximum yield stress of 70 ksi and a defined standard for Charpy V-notch material toughness. The availability and cost-effectiveness of rectangular HSS in grades other than ASTM A500 Grade C should be confirmed prior to their specification. Because A500 Grade C meets the requirements of Grade B, it is likely that you will receive Grade C regardless of what you specify. It is therefore best to specify Grade C from the beginning and take advantage of the increased design strength. Rectangular HSS with atmospheric resistance (weathering characteristics) can be obtained by specifying ASTM A847 or A1065 Grade 50W. These and other material specifications applicable to rectangular HSS are shown in Table 2-4. Note that A1085 Grade A is hoped to supersede A500 relatively soon.

Round HSS. The preferred material specification for round HSS is ASTM A500 Grade C (F_y = 46 ksi, F_u = 62 ksi). Note that A1085 Grade A (F_y = 50 ksi, F_u = 65 ksi) may also be specified for round HSS members for tighter wall thickness—and again, is hoped to supersede A500 relatively soon. 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 "12 Tidbits" sidebar for further information). Round HSS with atmospheric corrosion resistance (weathering characteristics) can be obtained by specifying ASTM A847. These and other

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									
												HSS		
					W	M	S	HP	C	MC	L	Rect.	Round	Pipe
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,k]	36	36–52	58	■	□	□	□	□	□	□	□	□	□
		50	50–65	65	■	□	□	□	□	□	□	□	□	□
	A1085	Gr. A	50	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[k], 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]	■	■	■	■	■	■	■	□	□	□
	A1065[k]	Gr. 50[j]	50	60	□	□	□	□	□	□	□	■	□	□

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

Footnotes on facing page.

material specifications applicable to round HSS are shown in Table 2-4.

Steel Pipe. The *Manual* lists ASTM A53 Grade B (F_y = 35 ksi, F_u = 60 ksi) as the preferred material specification for steel pipe used in structural frames—however, the following considerations should be addressed first. Round ASTM A500 Grade C can be specified using pipe dimensions instead of A53 to take advantage of the increased strength. A53 pipes need to be pressure tested, which results in an unnecessarily increased overall cost for less strength than what could have been obtained if round A500 Grade C was specified. Additionally, regional availability may play a factor, so be sure to contact your fabricator. See the sidebar "12 Tidbits" for further information.

12 Important Tidbits

Here are a dozen points to keep in mind when specifying materials for your next project.

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/aisc-membership** to search for member providers.
2. Times change. When ASTM A992 was originally introduced, only W-shapes were covered. 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 and channels.
3. Round HSS ≠ steel pipe. Know the difference between ASTM A500 and ASTM A53. Remember that while ASTM A53 (F_y = 35 ksi) is the listed preferred material for pipes, ASTM A500 (F_y = 46 ksi for Grade C, 42 ksi for Grade B) can be specified instead of using pipe dimensions. See Tidbit 4 to learn how to specify pipe dimensions for round HSS.
4. 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 may require a mill-order quantity to obtain.
5. Properly designate your HSS. A round HSS is designated by outside diameter and wall thickness, each expressed to three decimal places—e.g., HSS5.563×0.258. A square or rectangular HSS is designated by nominal outside dimensions and wall thickness, each in rational numbers—e.g., HSS5×3×3/8. Rectangular HSS with even dimensions for sides—e.g., HSS6×4×5/16—is more readily available than odd-numbered dimensions—e.g., HSS5×3×3/8.
6. Properly designate your steel pipes. Use nominal pipe size (NPS) designation through NPS 12—e.g., 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—e.g., 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 F3125 Grade A325 or A490. The ASTM F3125 standard covers 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 and even has only slightly less tensile strength than A325 when specified as Grade 105. ASTM F3125 Grade A325 has a tensile strength of 120 ksi while ASTM F1554 Grade 105 has a tensile strength of 105 ksi.
8. Have all the information at your fingertips. More extensive information can be found in the 15th Edition AISC *Steel Construction Manual* and the AISC publication *Selected ASTM Standards for Steel Construction*, both available at **www.aisc.org/publications**.
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 plates or bars, 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 to 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 very important and warrants being the first and last consideration.

Plate Products

Next, let's take a look at plates, summarized in Table 2-5.

Structural Plates. For main member or weldment design, ASTM A36 and A572 Grade 50 should be readily available. For connection detail material, 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 the 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 that thickness ranges are different for other grades as shown in Table 2-5. 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 A1066 Grade 60, 65, 70 or 80; or ASTM A514 Grade 90 or 100. 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 2-5.

Structural Bars. The preceding comments for structural plates apply equally to structural bars, though note that ASTM A514 is not applicable. While frequently falling in the same size ranges as plates, bars are a separate classification and are generally available in widths up to 8 in. The terminology section in the ASTM A6 Standard (see *Selected ASTM Standards for Steel Construction*) provides thickness, width and length definitions to differentiate between steel plates and bars.

Raised-Pattern Floor Plates. ASTM A786 is the standard specification for rolled steel floor plates. As the floor-plate design is seldom controlled by strength considerations, ASTM A786 "commercial grade" is commonly specified. In those cases, per ASTM A786-15, Section 5.1.3, "The product will be supplied with 0.33% maximum carbon… and without specified mechanical properties." Alternatively, if a defined strength level is desired, ASTM A786 raised-pattern floor plate can be ordered to

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[e]	Gr. C	30	55–75	▒	▒	▒	▒	[d]					
		Gr. D	33	60–80	▒	▒	▒	▒	[d]					
	A529	Gr. 50	50	65–100	▒	[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[e]	Gr. 36	36–52	58	▒	▒	▒	▒	▒	▒	▒			
		Gr. 50	50–65	65	▒	▒	▒	▒	▒	▒	▒			
	A1066[e]	Gr. 50	50	65	▒	▒	▒	▒	▒	▒				
		Gr. 60	60	75	▒	▒	▒	▒	▒	▒				
		Gr. 65	65	80	▒	▒	▒	▒	▒	[f]				
		Gr. 70	70	85	▒	▒	▒	▒						
		Gr. 80	80	90	▒	[g]								
Corrosion Resistant High-Strength Low-Alloy	A242[e]		42	63				▒	▒	▒				
			46	67		▒	▒							
			50	70	▒									
	A588		42[e]	63								▒	▒	
			46[e]	67							▒			
			50	70	▒	▒	▒	▒	▒	▒				

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

Footnotes on facing page.

Table 2-6
Applicable ASTM Specifications for Various Types of Structural Fasteners

ASTM Designation		F_y Min. Yield Stress (ksi)	F_u Tensile Stress[a] (ksi)	Diameter Range (in.)	Bolts: High-Strength: Conventional	Bolts: High-Strength: Twist-Off-Type Tension-Control	Bolts: Common Bolts	Nuts	Washers: Hardened	Washers: Plain	Washers: Direct-Tension Indicator	Threaded Rods	Anchor Rods: Hooked	Anchor Rods: Headed	Anchor Rods: Threaded & Nutted
F3125	Gr. A325[d]	–	120	0.5 to 1.5	■	□	□	□	□	□	□	□	□	□	□
F3125	Gr. F1852[d]	–	120	0.5 to 1.25	□	■	□	□	□	□	□	□	□	□	□
F3125	Gr. A490[d]	–	150	0.5 to 1.5	■	□	□	□	□	□	□	□	□	□	□
F3125	Gr. F2280[d]	–	150	0.5 to 1.25	□	■	□	□	□	□	□	□	□	□	□
F3111		–	200	1 to 1.25 incl.	▒	□	□	□	□	□	□	□	□	□	□
F3043		–	200	1 to 1.25 incl.	□	▒	□	□	□	□	□	□	□	□	□
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		105	125	2.5 and under	□	□	□	□	□	□	□	▒	▒	▒	▒
A193 Gr. B7		95	115	over 2.5 to 4	□	□	□	□	□	□	□	▒	▒	▒	▒
A193 Gr. B7		75	100	over 4 to 7	□	□	□	□	□	□	□	▒	▒	▒	▒
A307 Gr. A		–	60	0.25 to 4	□	□	■	□	□	□	□	▒	▒	▒	▒
A354	Gr. BC	109	125	0.25 to 2.5 incl.	▒[e]	□	□	□	□	□	□	▒[e]	▒	▒	▒
A354	Gr. BC	99	115	over 2.5 to 4 incl.	▒[e]	□	□	□	□	□	□	▒[e]	▒	▒	▒
A354	Gr. BD	130	150	0.25 to 2.5 incl.	▒[e]	□	□	□	□	□	□	▒[e]	▒	▒	▒
A354	Gr. BD	115	140	2.5 to 4 incl.	▒[e]	□	□	□	□	□	□	▒[e]	▒	▒	▒
A449[d]		92	120	0.25 to 1 incl.	▒[e]	□	□	□	□	□	□	▒[e]	▒	▒	▒
A449[d]		81	105	over 1 to 1.5 incl.	▒[e]	□	□	□	□	□	□	▒[e]	▒	▒	▒
A449[d]		58	90	over 1.5 to 3 incl.	▒[e]	□	□	□	□	□	□	▒[e]	▒	▒	▒
A572	Gr. 42	42	60	to 6	□	□	□	□	□	□	□	▒	▒	□	▒
A572	Gr. 50	50	65	to 4[c]	□	□	□	□	□	□	□	▒	▒	□	▒
A572	Gr. 55	55	70	to 2	□	□	□	□	□	□	□	▒	▒	□	▒
A572	Gr. 60	60	75	to 3.5	□	□	□	□	□	□	□	▒	▒	□	▒
A572	Gr. 65	65	80	to 1.25	□	□	□	□	□	□	□	▒	▒	□	▒
A588		50	70	4 and under	□	□	□	□	□	□	□	▒	▒	□	▒
A588		46	67	over 4 to 5 incl.	□	□	□	□	□	□	□	▒	▒	□	▒
A588		42	63	over 5 to 8 incl.	□	□	□	□	□	□	□	▒	▒	□	▒
F1554	Gr. 36	36	58–80	0.25 to 4	□	□	□	□	□	□	□	▒	■	■	■
F1554	Gr. 55	55	75–95	0.25 to 4	□	□	□	□	□	□	□	▒	■	■	■
F1554	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.
[b] Diameter range is 2 in. to 12 in. for beveled and extra thick washers.
[c] ASTM A572 permits rod diameters up to 11 in., but practicality of threading should be confirmed before specification.
[d] When atmospheric corrosion resistance is desired, Type 3 can be specified.
[e] See AISC *Specification* Section J3.1 for limitations on use of ASTM A449, A354 Gr. BC and A354 Gr. BD.

a specific plate material specification, such as ASTM A36, A572 or A588; see ASTM A786 Sections 5.1.3, 7.1 and 8.

Sheet and Strip. Sheet and strip products, which are generally thinner than structural plate and bar products, are produced to such ASTM specifications as A606, A1008 or A1011. This is an "umbrella" standard with many types and grades; the structural steel type is designated "SS" and the standards provide for grades from 25 or 30 to 80. High-strength low-alloy and high-strength low-alloy with improved formability are designated as HSLAS and HSLAS-F, respectively, and may also be specified if needed. When using shims and similar products, note that 3/16 in. is the minimum thickness to specify and receive a mill test report conforming to an ASTM standard material. Availability should be checked before specifying the grade.

Fastening Products

Next, let's explore fasteners, summarized in Table 2-6.

Conventional Bolts. The new bolt standard ASTM F3125 now includes grades that are made under similar manufacturing requirements by consolidating and replacing the ASTM A325, A325M, A490 and A490M standards for conventional high-strength bolts in steel-to-steel connections. Type 1 is the most commonly specified (medium-carbon steel). When atmospheric corrosion resistance is desired, Type 3 can be specified. A new bolt standard ASTM F3111, with a tensile strength of 200 ksi, has been introduced as an applicable material for conventional bolts. While it is still formally permitted by the AISC *Specification* to use other material specifications in steel-to-steel bolting applications, the use of materials besides those identified in this article is relatively rare.

Twist-Off-Type Tension-Control Bolt Assemblies. The bolt standard ASTM F3125 includes the two grades preferred for twist-off-type tension-control bolt assemblies: F1852 and F2280. Grade F1852 offers a strength equivalent to that of Grade A325, and F2280 offers a strength equivalent to A490. A new bolt standard ASTM F3043, with a tensile strength of 200 ksi, is introduced as an applicable material for twist-off-type tension-control bolts.

New Things

A list of recent developments to help guide your material specifications.

- The 15th Edition AISC *Steel Construction Manual* now includes design tables for W-shapes with A913 Grades 65 and 70 in Table 4-1. AISC Design Examples V15.0 now includes design tables for ASTM A1085 square, rectangular and round HSS members, with additional resources located online at **www.aisc.org/publications**.
- The new filler metal standard, AWS A5.36 has been added that supersedes A5.20 and 5.29. This classification combines both of the superseded materials into one specification that covers both carbon steel and low-alloy steel flux cored arc welding electrodes.
- A new bolt standard, ASTM F3148, is in development in conjunction with LeJeune Bolt Company and will be introduced to RCSC balloting for inclusion in the 2020 *RCSC Specification*. This standard is meant to provide a strength between that of F3125 Grade A325 and A490, with the hopes of superseding them both in the future.
- A channel especially for stair stringers. The MC12×14.3 that was recently 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. Like all HP shapes, they 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 the article "Larger Hollow Structural Sections" in the November 2011 issue of *Modern Steel Construction* (**www.modernsteel.com**). This includes a discussion of ASTM A1065 shapes, which are produced by forming two channels and welding them together.
- There are two other materials worth mentioning: ASTM A283 covers low-yield carbon steel plate material in four grades, and 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 2-4 and 2-5.

Nuts. The preferred material specification for heavy-hex nuts is ASTM A563. For steel-to-steel structural bolting applications, the appropriate grade and finish are summarized in Section 2.4 of the *RCSC Specification for Structural Joints Using High-Strength Bolts* (**www.aisc.org/specifications**). 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 of the *RCSC Specification*. While RCSC (Research Council on Structural Connections) is the authority of the use of nuts, Table 1 in the ASTM F3125 specification may have more up to date information and should be checked.

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 applications, hole sizes generally are larger than those for steel-to-steel structural bolting applications; see Table 14-2 in the AISC *Manual*. Accordingly, washers used in such applications generally are required to be larger and might require design consideration for proper force transfer, particularly when the anchorage is subject to tension. Such anchor rod washers are generally made from rectangular 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. Also note that the use of smaller holes will require more stringent placement of the anchors, and that misplaced anchors are a relatively common issue—hence why larger holes are recommended in the *Manual*.

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 can be specified. Type 325 is used with ASTM F3125 Grade A325 or F1852 assemblies, and Type 490 is used with ASTM F3125 Grade A490 or F2280 assemblies. 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 two strength grades: 36 and 55. 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 discretion.

ASTM F1554 Grade 36 may be welded as is, and Grade 55 may be welded if it is ordered with Supplement S1; this is the more common approach when welding is needed. Grade 105 may not be welded, as the heat will detrimentally affect performance.

Several other ASTM specifications may also 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 F1554. 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 F3125 Grade A325. ASTM A354 Grade BD is permitted when the size required is outside the range of ASTM F3125 Grade 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).

Filler Metal. AWS provides specifications for filler metals in the A5 series of specifications. Typically, there are two filler metal specifications for each process: carbon steel for strengths up to E70 and low alloy for higher strengths or other properties such as weathering. These specifications provide chemical composition requirements for the filler metals and tensile property and CVN toughness requirements for weld metal produced to specific classification test requirements. A recent change that will become evident to those procuring filler metals and writing weld procedure specifications is the release of standard A5.36 *Specification for Carbon And Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding*. Some of the fillers in A5.36 are identical to previous FCAW and GMAW fillers but are defined in a fashion that is more consistent and competitive with international standards.

Other Products

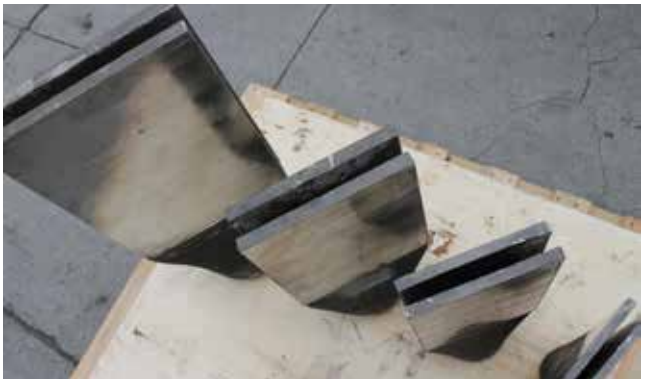
In addition to typical structural products, there are other related steel products to consider.

Steel Castings and Forgings. Steel castings can be produced in a wide variety of chemical compositions and mechanical properties; most are heat treated. Three standards useful in steel structures are ASTM A27 Grade 65-35, ASTM A216 Grade WCB with Supplementary Requirement S11 and A958/A958M 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 *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 in order 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 no 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.

Knowing the right specifications for your various steel shapes is one of the key methods for getting the most out of your framing system. ■



As for Bridges...

Another possibility for structural shapes and plates is ASTM A709, which is an "umbrella" standard that assembles ASTM A36, A572, A992, A588, A1010 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 plate form and as shapes, though availability should be confirmed prior to specification. ASTM A709 provides toughness levels for three exposures and two uses. Much of the 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.