Are You Properly Specifying Materials?

Part one in a three-part series: structural shapes

By Charles J. Carter, PE

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 all characteristics of the product specified are defined by simple reference to an approved standard. However, with dozens of ASTM specifications applicable in steel building construction alone and several new ones now available, it can be challenging to keep the standard designations in contract documents current.

This article (Part One) is a summary of the common ASTM specifications used for structural members in building design and construction. Parts Two and Three will focus on plate and fastening products, respectively.

The common structural shapes are either hot-rolled cross sections (such as W-shapes, channels and angles), steel pipe or hollow structural sections. The generally applicable ASTM specifications for each are given in Table 1.

Also included is a discussion of the usual and other applicable ASTM specifications for each type of structural shape. The usual ASTM specifications are summarized by product in Table 2.

W-SHAPES

The usual material specification for W-shapes is ASTM A572 grade 50 with special requirements per AISC Technical Bulletin #3, dated March 1997 (See box on page 50). A572 Grade 50 with special requirements is currently being phased in while both ASTM A36 and A572 grade 50 are being phased out (for wide-flange shapes only). This modified ASTM specification, which will eventually bear the simpler name ASTM A992, covers only W-shapes and has specified minimum values for F_y and F_u of 50 ksi and 65 ksi, respectively.

W-shapes with higher yield and tensile strength can be obtained by specifying ASTM A572 grade 60 (applicable to tensile group 1 and 2 W-shapes only), ASTM A572 grade 65 (applicable to tensile group 1 W-shapes only) 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. Other material specifications applicable to W-shapes include ASTM A529 grade 42 (tensile group 1 W-shapes only), A529 grade 50 (tensile groups 1 and 2 W-shapes only), A572 grade 42 and A913 grade 50. However, the availability of W-shapes in grades other than ASTM A572 grade 50 with special requirements per AISC Technical Bulletin #3, dated March 1997 should be confirmed prior to their specification.

Regardless of the material specification chosen, the cross-sectional dimensions and production tolerances for W-shapes are given in ASTM A6.

M-SHAPES

The usual material specification for M-shapes is ASTM A36 (F_y = 36 ksi; F_u = 58 ksi), although ASTM A572 grade 50 (F_y = 50 ksi; F_u = 65 ksi) is increasingly very common.

M-shapes with higher yield and tensile strength can be obtained by specifying ASTM A572 grade 42, 50, 60 or 65, or A529 grade 42 or 50. M-shapes with atmospheric corrosion resistance (weathering) characteristics can be obtained by specifying ASTM A588 grade 50. However, the availability of M-shapes in grades other than ASTM A36 should be confirmed prior to their specification.

Regardless of the material specification chosen, the cross-sectional dimensions and production tolerances for M-shapes are given in ASTM A6.

S-SHAPES

Also known as American Standard beams, the usual material specification for S-shapes is ASTM A36 (F_y = 36 ksi;

Table 1. ASTM specifications and their product-specific applicability

Product	Applicable ASTM specifications	Notes:
Hot-rolled structural shapes	A36, A529, A572, A588, A913, A992	1, 2, 3
Steel pipe	A53 grade B	--
HSS	A500, A501, A618, A847	--

Notes:

1. ASTM A992 is also known as "ASTM A572 grade 50 with special requirements per AISC Technical Bulletin #3, dated March 1997" and is only applicable to wide-flange shapes.
2. ASTM A529 is most commonly used as a specification in the metal building industry, but can be obtained in many smaller shape sizes (tensile groups 1 or 2) for hot-rolled structural shapes.
3. ASTM A913 is a relatively new product specification that covers hot-rolled structural shapes produced by the quenching and self-tempering process.

So what is "ASTM A572 grade 50 with special requirements per AISC Technical Bulletin #3, dated March 1997" anyway?

In the early 90s, wide-flange steel producers began a practice called dual-certification, targeting their production of wide-flange material for the window of overlap between the mechanical, chemical and other requirements in both ASTM A36 and A572 grade 50. Among other factors, the lack of an upper limit on yield strength in ASTM A36 made this possible.

Steel producers benefited because the resulting product could be stocked universally and sold as either A36 or A572 grade 50. The consumer benefited because price differentials between ASTM A572 grade 50 and A36 quickly eroded. Alas, there was often confusion about the product being supplied because it usually carried both names.

To eliminate confusion and facilitate the shift to a single grade material for wide-flange shapes, AISC proposed the material specification "ASTM A572 grade 50 with special requirements per AISC Technical Bulletin #3, dated March 1997" Since that time, it has been approved by ASTM as specification A992.

Note however, that ASTM A992 has not yet been incorporated into all industry documents, including AWS D1.1. Thus, to avoid the otherwise unnecessary project-specific qualification of ASTM A992 material for welding, call it by its longer name in this interim period until the codes catch up.

To get a copy of Technical Bulletin #3, please fax a request to Jeri Irwin at 312-670-5403.

F_u = 58 ksi), although ASTM A572 grade 50 (F_y = 50 ksi; F_u = 65 ksi) is increasingly very common.

S-shapes with higher yield and tensile strength can be obtained by specifying ASTM A572 grade 42, 50, 60 or 65 (tensile group 1 S-shapes only), A529 grade 42 (tensile group 1 S-shapes only) or 50. S-shapes with atmospheric corrosion resistance (weathering) characteristics can be obtained by specifying ASTM A588 grade 50. However, the availability of S-shapes in grades other than ASTM A36 should be confirmed prior to their specification.

Regardless of the material specification chosen, the cross-sectional dimensions and production tolerances for S-shapes are given in ASTM A6.

HP-shapes

Also known as bearing piles, the usual material specification for HP-shapes is ASTM A36 (F_y = 36 ksi; F_u = 58 ksi), although ASTM A572 grade 50 (F_y = 50 ksi; F_u = 65 ksi) is increasingly very common.

HP-shapes with higher yield and tensile strength can be obtained by specifying ASTM A572 grade 42, 50 or 60 (tensile group 2 HP-shapes only) or A529 grade 50 (tensile group 2 HP-shapes only). HP-shapes with atmospheric corrosion resistance (weathering) characteristics can be obtained by specifying ASTM A588 grade 50. However, the availability of HP-shapes in grades other than ASTM A36 should be confirmed prior to their specification.

Regardless of the material specification chosen, the cross-sectional dimensions and production tolerances for HP-shapes are given in ASTM A6.

Channels

The usual material specification for American Standard Channels (C-shapes) and miscellaneous channels (MC-shapes) is ASTM A36 (F_y = 36 ksi; F_u = 58 ksi), although ASTM A572 grade 50 (F_y = 50 ksi; F_u = 65 ksi) is increasingly very common.

Channels with higher yield and tensile strength can be obtained by specifying ASTM A572 grade 42, 50, 60 or 65 (tensile group 1 channels only) or A529 grade 42 (tensile group 1 channels only) or 50. Channels with atmospheric corrosion resistance (weathering) characteristics can be obtained by specifying ASTM A588 grade 50. However, the availability of channels in grades other than ASTM A36 should be confirmed prior to their specification.

Regardless of the material specification chosen, the cross-sectional dimensions and production tolerances for channels are given in ASTM A6.

Angles

The usual material specification for angles is ASTM A36 (F_y = 36 ksi; F_u = 58 ksi).

Angles with higher yield and tensile strength can be obtained by specifying ASTM A572 grade 42, 50, 60 (tensile groups 1 and 2 angles only) or 65 (tensile group 1 angles only) or A529 grade 42 (tensile group 1 angles only) or 50 (tensile groups 1 and 2 angles only). Angles with atmospheric corrosion resistance (weathering) characteristics can be obtained by specifying ASTM A588 grade 50. However, the availability of angles in grades other than ASTM A36 should be confirmed prior to their specification.

Regardless of the material specification chosen, the cross-sectional dimensions and production tolerances for angles are given in ASTM A6.

Structural Tees

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

Steel Pipe

The sole material specification for steel pipe is ASTM A53 grade B (F_y = 35 ksi; F_u = 60 ksi). Note that steel pipe as a product is different from round HSS. So it is also designated differently (see box). The cross-sectional dimensions and production tolerances for steel pipe are also given in ASTM A53.

Round HSS

The usual material specification for round HSS is ASTM A500 grade B (F_y = 42 ksi; F_u = 58 ksi), although ASTM A500 grade C (F_y = 46 ksi; F_u = 62 ksi) is increasingly more common.

Round HSS with atmospheric corrosion resistance (weathering) character-

Table 2. Structural shapes and their usual ASTM specifications

Structural Shapes	Usual ASTM Specification	Min. F_y (ksi)	Min. F_u (ksi)
W-shapes[1]	ASTM A572 grade 50 with special requirements per AISC Technical Bulletin #3, dated March 1997 (ASTM A992)	50	65
M-, S- and HP-shapes	A36 A572 grade 50	36 50	58 65
Channels	A36 A572 grade 50	36 50	58 65
Angles	A36	36	58
Steel pipe	A53 grade B	35	60
Round HSS	A500 grade B A500 grade C	42 46	58 62
Square and rectangular HSS	A500 grade B A500 grade C	46 50	58 62

Notes:1. "ASTM A572 grade 50 with special requirements per AISC Technical Bulletin #3, dated March 1997" is also known as ASTM A992.

istics can be obtained by specifying ASTM A847. Other material specifications applicable to round HSS include ASTM A501 and A618. However, the availability of round HSS in grades other than ASTM A500 grade B should be confirmed prior to their specification.

The cross-sectional dimensions and production tolerances for round HSS are also given in the selected material specification.

Square and Rectangular HSS

The usual material specification for square and rectangular HSS is ASTM A500 grade B (F_y = 46 ksi; F_u = 58 ksi), although ASTM A500 grade C (F_y = 50 ksi; F_u = 62 ksi) is increasingly more common.

Square and rectangular HSS with (weathering) atmospheric corrosion resistance characteristics can be obtained by specifying ASTM A847. However, the availability of square and rectangular HSS in grades other than ASTM A500 grade B should be confirmed prior to their specification.

The cross-sectional dimensions and production tolerances for square and rectangular HSS are also given in the selected material specification.

Designating Steel Pipe, Round HSS and Square and Rectangular HSS Properly.

Steel pipe is designated as follows:

1. By 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.
2. In the format "Pipe" followed by diameter x nominal wall thickness, each expressed three decimal places, to for NPS designations greater than NPS 12 and other non-NPS sizes (e.g., NPS 14 Standard is designated Pipe 14.000x0.375)

A round HSS is designated by nominal diameter and wall thickness, each expressed to three decimal places, e,g,, HSS 5.563x0.258

A square or rectangular HSS is designated by nominal outside dimensions and wall thickness, each in rational numbers, e.g., HSS 5x3x3/8

Charles J. Carter, PE, is Director of Manuals with the American Institute of Steel Construction, Inc. and an occasional contributor of articles to Modern Steel Construction.

TECHNICAL BULLETIN 3 **MARCH, 1997**

SHAPE MATERIAL
(ASTM A572 Gr 50 with special requirements)

As announced, effective May 1, 1997, structural steel shapes will be commercially available with special requirements. Please consult your steel supplier for specifics.

Steel shapes ordered to this technical bulletin shall conform to the following:

1. Meet all requirements of ASTM A572/A572M-94c *Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel* Grade 50;

2. The steel shall be made to a practice producing nitrogen not greater than 0.012% or steel shall be made to a practice producing nitrogen not greater than 0.015% and nitrogen binding elements shall be added;

3. Chemical Requirements:

   The heat analysis shall conform to the requirements in Table 1;
   Test reports shall include the chemical analysis for tin for information. When the amount of tin is less than 0.02%, the analysis may be reported as "<0.02%";
   The carbon equivalent (CE) shall not exceed 0.50% except steel shapes not included in Groups 4 or 5 shall be supplied with a maximum of 0.45% if the carbon content is greater than 0.12%. The carbon equivalent shall be calculated using the following formula:

   $$CE = C + (Mn + Si)/6 + (Cu + Ni)/15 + (Cr + Mo + V + Cb)/5$$

   TABLE 1 Chemical Requirements

Element	Composition, %
Carbon, max	Refer to ASTM A572
Manganese	0.50 - 1.50[a]
Silicon, max	Refer to ASTM A572
Vanadium[b]	Refer to ASTM A572
Columbium[b]	Refer to ASTM A572
Phosphorous, max	0.035
Sulfur, max	0.045

Element	Composition, %
Copper, max	0.60
Nickel, max	0.45
Chromium, max	0.35
Molybdenum, max	0.15

[a] Minimum manganese for Group 1 shapes is 0.30%. The ratio of manganese to sulfur shall not be less than 20 to 1.

[b] Columbium plus vanadium is not to exceed 0.15% maximum. Nitrogen when added as a supplement to vanadium shall be reported and the minimum ratio of vanadium to nitrogen shall be 4 to 1.

4. Tensile Requirements:

Yield Point, ksi [Mpa]	50 - 65 [345 - 450]
Yield to Tensile Ratio, max	0.85

SUPPLEMENTARY REQUIREMENTS

These requirements shall not apply unless specified in the order.

Standardized supplementary requirements for use at the option of the purchaser are listed in Specification A6/A6M. Those that are considered suitable for use with this specification are listed by title:

S1. Vacuum Treatment

S2. Product Analysis

S5. Charpy V-Notch Impact Test

S8. Ultrasonic Examination

S14. Bend Test

ADDED SUPPLEMENTARY REQUIREMENTS

In addition, the following optional supplementary requirements are also suitable for use with this specification.

S79. Maximum Tensile Strength
S79.1 The maximum tensile strength shall be 90 ksi [620 Mpa].

S91. Fine Austenitic Grain Size
S91.1 The steel shall be killed with a fine austenitic grain size.

SX3. Charpy V-Notch Impact Test for Group 4 and 5 Structural Shapes

SX3.1 When Group 4 and 5 structural shapes are used as members subject to primary tensile stress and when such members are spliced using full penetration welds, the steel shall be impact tested in accordance with Specification ASTM A6, supplementary requirement S5, modified in accordance with SX3.2.

SX3.2 Charpy V-Notch impact tests shall be conducted in accordance with Specification ASTM A673/A673M with the following exceptions for Group 4 and 5 rolled shapes:

The center longitudinal axis of the specimens shall be located as near as practical to midway between the inner flange surface and the center of the flange thickness at the intersection with the web mid-thickness (see Fig. 1).

SX3.3 The frequency of testing shall be Frequency P in Specification ASTM A673/A673M with the following exception for rolled shapes produced from ingots:

Tests shall be conducted from a location representing the top of each ingot or part of an ingot used to produce the product represented by these tests.

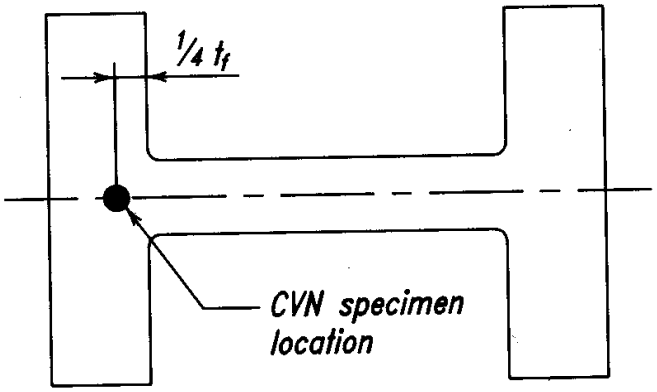

Fig. 1 Location from which Charpy impact specimen shall be taken for Group 4 and 5 structural shapes.

SX3.4 The test result shall meet a minimum average value of 20 ft-lb [27J] absorbed energy at +70°F [+21°C] if the steel is intended for ordinary use in buildings such as static loading. For unusual applications such as dynamic loading, highly restrained connections, low temperature or any combination of these conditions, the purchaser should consider more restrictive Charpy V-notch requirements for specification in the contract documents.