New HSS Specification
ASTM A1085

Brad Fletcher, S.E.
Atlas Tube – Market Leader

- **Largest size range in North America**
  - 1”–16” square, up to 5/8” wall
  - 1.25” – 20” round, up to 5/8” wall
  - Now offering Jumbo HSS

- **Shortest rolling cycle in the industry**
  - 2 – 3 weeks for common sizes

- **Able to roll custom lengths to minimize cost, waste, column splices**
  - Rolled lengths up to 135 ft. for rounds, up to 85 ft. for sq. & rect.

- **Four production facilities in North America**

- **Metallurgists and Structural Engineer on staff to assist with technical and product questions**

- **Products stocked by service centers across North America**
Through a partnership with NSMP & Mitsui, Atlas is now offering large HSS

- 10” & 12” sq. x .750”
- 14” & 16” sq. x .750”, .875”
- 18” & 20” sq. x .5”, .625”, .750”, .875”
- 22” sq. x .750”
- 20” x 12” x .750”
- 24” x 12” x .5”, .625”, .750”

Material stocked and readily available
Large quantities can be mill ordered
Available as A500 or CSA G40
Also available in new ASTM A1085
Jumbo HSS listed on AISC website as available through Atlas

November 2011 *Modern Steel Construction* article

Column Design Tables in AISC format available to download for free from AISC website

- [www.atlastube.com/jumbo-hss](http://www.atlastube.com/jumbo-hss)
- [www.aisc.org/hss](http://www.aisc.org/hss)
Hollow Structural Sections

The use of HSS is growing in popularity in the building industry.

~15% of the U.S. structural steel market
~30% of the market in Europe, Canada and Japan
~10 times more HSS per capita used in Canada than US

Popular structural uses include:
- Columns
- Trusses
- Bracing
- AESS applications
## Common HSS Specifications

<table>
<thead>
<tr>
<th>Round or Square?</th>
<th>wall thickness</th>
<th>material</th>
<th>designation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t ≤ 0.625”</td>
<td>ASTM A500 Gr. B Fy = 42 ksi Gr. C Fy = 46 ksi</td>
<td>HSS 5.500x0.258</td>
</tr>
<tr>
<td></td>
<td>any thickness</td>
<td>ASTM A53 Gr. B “Pipe” Fy = 35 ksi</td>
<td>PXX5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM A500 Gr. B Fy = 46 ksi Gr. C Fy = 50 ksi</td>
<td>HSS 5x3x3/8</td>
</tr>
</tbody>
</table>
ASTM A500

Designation: A500/A500M – 10a

Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

Note 1—Products manufactured to this specification may not be suitable for those applications such as dynamically loaded elements in welded structures, etc., where low-temperature notch-toughness properties may be important.
AISC HSS Committee

- Formed in 2007
- The mission of the committee is to promote the use of structural steel and HSS through education, research and marketing.
- The committee is comprised of member HSS producers, professors, researchers and HSS users.
- Development of new specification to address “bad press” from poor quality of imported HSS and poor performance of HSS in emerging seismic research.
US Design Codes
Codes have evolved over the years demanding a higher level of performance, especially in seismic regions.

Design firms look for high performance products for buildings, bridges and dynamically loaded structures

Critical Structures

What’s Missing?

Engineering Firms
Elevating safety factors in all aspects of design
US Design Codes
Codes have evolved over the years demanding a higher level of performance, especially in seismic regions.
Design firms look for high performance products for buildings, bridges and dynamically loaded structures.

Engineering Firms
Elevating safety factors in all aspects of design
Ready to meet / exceed future demands today

Critical Structures

High Performance HSS
Seismic Applications

- About half of the buildings designed and constructed in North America have some level of seismic design requirements.
- Seismic design has evolved.
- In North America, HSS are commonly used as bracing members in braced frames in seismic zones.
- In Europe & Asia, HSS commonly used as columns and bracing in seismic zones.
- Researchers are looking for more innovative ways to utilize the advantages of HSS in building and bridge design.
Seismic Design Has Evolved
Seismic Design Has Evolved
Seismic Design Has Evolved
Seismic Design Has Evolved

- 1994 Northridge, CA earthquake
  - Spurred 10 years of research
  - ASTM A992 was developed in response to observed connection failures

- Capacity Design – members and connections designed for member capacity

- Seismic designs now take into account variability of material properties.

- Over-strength factors (based on that variability) are applied to ensure ductile failures.
Seismic Design Has Evolved

Required strength of members and connections is based on the expected yield and expected tensile stress:

\[ \begin{align*}
R_y \cdot F_y \\
R_t \cdot F_u
\end{align*} \]

ASTM A992  \( R_y = 1.1 \)  \( R_t = 1.1 \)
ASTM A500  \( R_y = 1.4 \)  \( R_t = 1.3 \)
ASTM A53   \( R_y = 1.6 \)  \( R_t = 1.2 \)

Impact: Higher design force leads to larger, more expensive connections and to increased sizes of column and beam sections in steel frame. This leads to more cost associated with using HSS bracing members versus other types of steel sections.

Up to 40% increase of design force for A500 HSS
# HSS Mechanical Properties

- Current HSS and pipe specs only specify minimum yield strength
- Maximum yield strength is required to lessen variability of material strength and lower overstrength factors (Ry & Rt)

<table>
<thead>
<tr>
<th></th>
<th>Square, Rect &amp; Round HSS - CSA G40</th>
<th>Square &amp; Rect HSS - ASTM A500</th>
<th>Round HSS - ASTM A500</th>
<th>Round Pipe - ASTM A53</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade 50W</td>
<td>Grade B</td>
<td>Grade C</td>
<td>Grade B</td>
</tr>
<tr>
<td>Yield Strength, min (ksi)</td>
<td>50</td>
<td>46</td>
<td>46</td>
<td>35</td>
</tr>
<tr>
<td>Tensile Strength (ksi)</td>
<td>65 - 90</td>
<td>58</td>
<td>62</td>
<td>60</td>
</tr>
<tr>
<td>Elongation in 2 in, min %</td>
<td>22</td>
<td>23</td>
<td>21</td>
<td>Varies</td>
</tr>
</tbody>
</table>
"Design Implications of Recent Research on SCBF”
by Uriz, Sabelli and Mahin

“Square and rectangular HSS have limited ductility capacity as buckling braces of moderate slenderness. The ability of such braces to withstand buckling without premature fracture resulting from local buckling may be significantly less than that implied by current design provisions. These findings are consistent with past research and as witnessed in earthquake reconnaissance (For example see AIJ 1995; Bonneville and Bartoletti 1996; Goel and Tang 1987; Lee and Goel 1987; Shaback and Brown 2003; Tang 1987).”

“Recommendation: For braces subject to inelastic buckling the use of round HSS, angle(s), wide flange shapes, or other sections as braces in lieu of square and rectangular HSS is recommended”.
Cold-formed square hollow sections have a real $F_y / F_u$ ratio which is sometimes very high (0.85 to 0.95), even in the flats, and square hollow sections are prone to fracture in the corners after local buckling, even with low b/t ratios.
Bridge Applications

- Vehicle and pedestrian bridges are governed by AASHTO.
- ASTM A709 has Charpy requirements
- HSS becoming more popular for bridges in US
New Bridge Construction

- ASCE Infrastructure Report Card – US bridges have a C rating
- ASCE recommends $930 Billion of spending to improve US Roads & Bridges
- The AWS (American Welding Society) has recently formed a Tubular Task Group to develop a document for tubular bridge connections that is suitable for use by AASHTO. Provisions are to be tailored for use in welded tubular bridges.
- Huge potential for HSS usage in bridges if material properties are improved
Tubular bridges are becoming more popular
CVN – Charpy V-Notch
- High strain rate test
- Measures amount of absorbed energy during fracture
- Indicates material’s toughness
- Tool to study material’s temperature-dependent ductile-brittle transition

AASHTO requires CVN of 25 ft-lb @ 40°F

Some DOT design manuals do not allow A500 to be used, unless the min CVN requirements are met

CVN’s are also required for seismic design
Tolerances

ASTM A500 Wall Tolerances
- +/- 10% on nominal thickness

AISC 360 Specification for Structural Steel Buildings
- Requires design thickness for A500 HSS to be 0.93*nominal wall thickness

CISC Handbook of Steel Construction
- Requires design thickness for A500 HSS to be 0.90*nominal wall thickness

Net result: Not able to fully utilize cross-sectional properties of A500 material, which diminishes economy of HSS
**Corner Radii**

ASTM A500
- Outside corner radius not to exceed 3t
- No lower limit

Too tight of radius can lead to micro-cracking in the corners.

Cracking can lead to explosive release of residual stresses during operations such as welding or galvanizing.
Architectural Feature?
How can a new HSS Specification make design easier?

- Design with full nominal section
- Increased suitability in fatigue applications
- Seismic overstrength control
- Better control of galvanizing
- Better control of corner radii
## ASTM A1085

<table>
<thead>
<tr>
<th></th>
<th>ASTM A500</th>
<th>Grade B</th>
<th>Grade C</th>
<th>ASTM A1085</th>
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</thead>
<tbody>
<tr>
<td><strong>Yield Stress</strong></td>
<td>Round</td>
<td>42 ksi min</td>
<td>46 ksi min</td>
<td>50 ksi min</td>
</tr>
<tr>
<td></td>
<td>Sq/Rect</td>
<td>46 ksi min</td>
<td>50 ksi min</td>
<td>70 ksi max</td>
</tr>
<tr>
<td><strong>Tensile Stress</strong></td>
<td>Round</td>
<td>58 ksi min</td>
<td>62 ksi min</td>
<td>65 ksi min</td>
</tr>
<tr>
<td></td>
<td>Sq/Rect</td>
<td>58 ksi min</td>
<td>62 ksi min</td>
<td></td>
</tr>
</tbody>
</table>
### ASTM A1085

<table>
<thead>
<tr>
<th></th>
<th>ASTM A500</th>
<th>ASTM A1085</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall thickness</td>
<td>-10%</td>
<td>-5%</td>
</tr>
<tr>
<td>Mass tolerance</td>
<td>N/A</td>
<td>-3.5%</td>
</tr>
</tbody>
</table>
## ASTM A1085

<table>
<thead>
<tr>
<th>Corner radii</th>
<th>ASTM A500</th>
<th>ASTM A1085</th>
</tr>
</thead>
<tbody>
<tr>
<td>r &lt; 3t</td>
<td>t ≤ 0.400”</td>
<td>1.6t to 3.0t</td>
</tr>
<tr>
<td>t &gt; 0.400”</td>
<td>1.8t to 3.0t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASTM A500</td>
<td>ASTM A1085</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td>CVN</td>
<td>N/A</td>
<td>25 ft-lbs@40F</td>
</tr>
<tr>
<td>Supplemental Requirements</td>
<td>N/A</td>
<td>Optional heat-treating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optional varying CVN</td>
</tr>
</tbody>
</table>
## ASTM A1085

<table>
<thead>
<tr>
<th></th>
<th>ASTM A500</th>
<th>ASTM A1085</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbon, max</strong></td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td><strong>Manganese, max</strong></td>
<td>1.35</td>
<td>1.35</td>
</tr>
<tr>
<td><strong>Phosphorous, max</strong></td>
<td>0.035</td>
<td>0.035</td>
</tr>
<tr>
<td><strong>Sulfur, max</strong></td>
<td>0.035</td>
<td>0.035</td>
</tr>
<tr>
<td><strong>Aluminum, min</strong></td>
<td>N/A</td>
<td>0.15/0.20</td>
</tr>
<tr>
<td><strong>Copper, min</strong></td>
<td>0.20</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Silicon, max</strong></td>
<td>N/A</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*Maximum carbon equivalent of 0.45 is also specified*

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Minimum Al content specified

- .020% min total Al content
- Guarantees use of fully-killed, fine-grained steel
- This is current typical practice, but spec now mandates it.

Maximum Si content specified

- .04% max
- Helps avoid Sandelin Effect
- Aids galvanizing process
<table>
<thead>
<tr>
<th>Material</th>
<th>Yield Strength ksi, min</th>
<th>Tensile Strength ksi, min</th>
<th>Elongation %, min</th>
<th>CVN</th>
<th>Tolerance (Wall Thickness)</th>
<th>Tolerance (Mass)</th>
<th>Corner Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>A500 Grade B</td>
<td>Rnd 42 Sq/Rec 46 No Max</td>
<td>58 No Max</td>
<td>23</td>
<td>NA</td>
<td>-10% +10%</td>
<td>NA</td>
<td>3t Max</td>
</tr>
<tr>
<td>A500 Grade C</td>
<td>Rnd 46 Sq/Rec 50 No Max</td>
<td>62 No Max</td>
<td>21</td>
<td>NA</td>
<td>-10% +10%</td>
<td>NA</td>
<td>3t Max</td>
</tr>
<tr>
<td>CSA G40 50W</td>
<td>50 No Max</td>
<td>65 – 90</td>
<td>22</td>
<td></td>
<td>Cat 1: 20 ft-lb @ 32°F</td>
<td>-5% +10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cat 2: 20 ft-lb @ 0°F</td>
<td>-3.5% +10%</td>
<td></td>
</tr>
<tr>
<td>A53 Grade B</td>
<td>35 No Max</td>
<td>60</td>
<td>-</td>
<td>NA</td>
<td>-12.5%</td>
<td>-10%</td>
<td>NA</td>
</tr>
<tr>
<td>API 5L PSL X52N</td>
<td>52 No Max</td>
<td>67</td>
<td>-</td>
<td></td>
<td>20 ft-lb @ 32°F</td>
<td>-10%</td>
<td>-3.5% regular plain end</td>
</tr>
<tr>
<td>EN10210 S355J2H</td>
<td>51.5 for t&lt;5/8'' No Max</td>
<td>68</td>
<td>22</td>
<td></td>
<td>20 ft-lb @ 0°F</td>
<td>-10%</td>
<td>3t Max</td>
</tr>
<tr>
<td>EN10219 S355J2H</td>
<td>51.5 for t&lt;5/8'' No Max</td>
<td>68</td>
<td>20</td>
<td></td>
<td>20 ft-lb @ 0°F</td>
<td>-10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>t&lt;1/4'' 1.6t-2.4t</td>
<td>-6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1/4''&lt;t&lt;3/8'' 2t-3t</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>t&gt;3/8'' 2.4t-3.6t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASTM A1085</td>
<td>50 - 70</td>
<td>65</td>
<td>21</td>
<td></td>
<td>25 ft-lb @ 40°F</td>
<td>-5% +10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-3.5% +10%</td>
<td>t &lt; .4” 1.6t - 3.0t</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>t &gt; .4”</td>
</tr>
</tbody>
</table>
ASTM A1085 and the Codes

- Proposed: Added to approved materials list in AISC 360, Chapter A3

- Proposed: Added language to AISC 360, Chapter B4 that allows the full nominal wall thickness to be used as the design wall thickness for HSS produced to ASTM A1085. A500 HSS will still need to be reduced by the 0.93 factor.

- Proposed: Added to Group II of Table 3.1 in AWS D1.1. Added to Group II because of the higher Fy over A500 material.
A1085 & Welding

- Chemistry of A1085 is essentially the same as A500.
- A1085 will be an AWS Group II material.
- Currently, A1085 is not a prequalified material so a Procedure Qualification Record (PQR) will need to be performed.
- To avoid the need to do qualification, ask for material to be dual certified to A1085 & A500, Grade C.
- Once the next AWS is published, A1085 should be a prequalified material.
### Design Comparison

<table>
<thead>
<tr>
<th></th>
<th>ASTM A500 Gr. B</th>
<th>ASTM A1085</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Wall thickness, $t$ (in.)</td>
<td>0.465</td>
<td>0.500</td>
</tr>
<tr>
<td>Nominal Wt. (lb/ft)</td>
<td>48.85</td>
<td>48.85</td>
</tr>
<tr>
<td>Area, $A$ (in.$^2$)</td>
<td>13.5</td>
<td>14.4</td>
</tr>
<tr>
<td>$I$, (in.$^4$)</td>
<td>125</td>
<td>131</td>
</tr>
<tr>
<td>$S$, (in.$^3$)</td>
<td>31.2</td>
<td>32.8</td>
</tr>
<tr>
<td>$r$, (in.)</td>
<td>3.04</td>
<td>3.02</td>
</tr>
<tr>
<td>$Z$, (in.$^3$)</td>
<td>37.5</td>
<td>39.7</td>
</tr>
</tbody>
</table>
Design Comparison

HSS 8x8x1/2 Column, KL = 15 ft, LRFD

ASTM A500 Gr. B $\Rightarrow$ $\Phi P_n = 441$ kips

ASTM A1085 $\Rightarrow$ $\Phi P_n = 500$ kips

$\Rightarrow$ Increase of 13%
Design Comparison

8” HSS Column, Pu = 380 kips, KL = 15 ft, LRFD

A500 Gr. B:
HSS 8x8x1/2 (48.85 plf) \( \Phi P_n = 441 \) kips
HSS 8x8x3/8 (37.69 plf) \( \Phi P_n = 343 \) kips

A1085:
HSS 8x8x3/8 (37.69 plf) \( \Phi P_n = 390 \) kips

\( \Rightarrow \) Weight savings of 23%
Benefits of New Spec

**Minimum and Maximum values for Yield Stress**

- Expected for seismic design.
- Will hopefully result in lower $R_y$, which will make HSS more economical choice for bracing members.
- If the upper yield stress is not controlled then it makes it difficult to pick HSS for energy-dissipating elements.
- New Specification will be only one in the world to cap yield stress.
**Minimum Charpy Notch Toughness**

- Expected for all dynamically loaded structures.
- The minimum requirements of AASHTO will be met.
**Benefits of New Spec**

**Tighter thickness and mass tolerances**

- This will enable the 0.93t design thickness in the US and .90t in Canada to be abolished.
- Using nominal thickness as design thickness will increase HSS column capacity.
Benefits of New Spec

**Revised Corner Radii**
- Help limit corner cracking

**Revised Chemistry**
- Guarantees fully-killed, fine grained steel
- Aids in galvanizing process
Have You Heard?
New HSS Spec Makes Design Easier!

In the 2nd quarter of 2019, a new ASTM specification will result in the production of an improved Hollow Structural Sections (HSS). This new specification provides improved performance that makes HSS design easier and provides more opportunities for the client.

Some of the benefits of the new specification are:

- Tighter material tolerances and a single minimum yield stress of 50 ksi
- More stringent weld tolerances and the addition of a mass tolerance mean the full nominal wall thickness can be used for design of HSS. This means no longer needing to reduce the nominal wall thickness by 0.03 as prescribed in the AISC Steel Construction Manual for both member selection and connection design.
- More area available for design and a higher min yield means that HSS are more economical and more efficient.

Maximum specified yield stress of 70 ksi
- The maximum yield will result in a lower expected yield strength and reduced capacity design requirements and column required strength in seismic design.
- This is the only specification used in North America or Europe that limits the maximum yield stress in HSS.

Standard requirement for Charpy notch toughness
- New specification will require all HSS to meet a minimum CVN value of 25 ft-lb @ 4°F, which corresponds to AISC E20 Zone 2.
- Having the minimum CVN required makes HSS more suitable for use in dynamically loaded structures.

Inquire with domestic HSS producers and your local service center about price and availability. For more information, log on to www.aisc.org/hss.