TECHNICAL BULLETIN

Material Properties that Affect Steel Cladding Performance

Overview

Steel cladding covering the walls and roof of a structure is often a key element in the overall building design. Not only is the steel responsible for transferring loads to the framing (e.g., wind, snow) and providing framing stability, but it also forms an envelope that protects the interior of the structure from the outdoor elements. This technical bulletin will discuss important material parameters that affect a) the performance and qualities of steel cladding and b) the ability to fabricate the steel.

Discussion

Steel, fabricated using coil feedstock, is the most widely used metal for building cladding. The critical properties discussed here impact the overall performance of the steel and are specific details that the specifier must consider and identify.

Carbon Content

Steel is made from a combination of iron and several other components that change mechanical properties to more favorable states for performance and fabrication. The key element is carbon which, when added to the molten iron, changes the crystalline structure once the iron is solidified. The amount of carbon present and the cooling rate determine the microstructure of the steel. Generally, the higher the carbon percentage, the stronger the steel. However, carbon can have negative effects making the final product too brittle to allow forming. For this reason, sheet steel specifications designate steel material based on carbon content as well as the presence of other added metals or alloying agents.

Elongation, Yield and Tensile Strength

Steel is a ductile metal, which means that when placed under tension, the steel will deform significantly before breaking. *Yield strength* is defined as the force per unit area at which permanent deformation starts (stated in pounds per square inch, or psi). *Tensile strength* is the force per unit area at which fracture occurs (also stated in psi). *Elongation* is the increase in length under tension experienced by a material as it goes from zero stress through yield strength to tensile strength (stated as percentage). An interesting condition of steel is that when stretched past yield, the strength will again increase to a certain point before rupturing. This is called *strain hardening*.

Steel sheet used to make roof and wall cladding is generally 33 to 80 ksi material. This means that the minimum yield strength of the steel is between 33,000 and 80,000 psi. This minimum yield strength is also called the *grade* of the steel. In this case, Grade 33 and Grade 80 steel respectively. The tensile strength of steel used typically for cladding varies from 45 to 80 ksi or higher.

The yield strength of the steel is one factor in determining the spacing of the underlying support framing. Generally, the higher the yield strength the longer the allowable distance between supports. This being the case, one would think to just get the highest yield strength available; however, the higher the yield strength, the harder the material is to cut and bend (fabricate). This generally leads to higher overall cladding costs.

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Lower yield strength steel is ideal for creating sharp bends in metal without cracking or splitting the metal. This is important for trim applications and panels that have sharp creases or hemmed edges. While ease in fabrication may be an advantage, metals with lower yield strengths will dent or bend more easily during installation and also require more support points than metals with higher yield strengths. For this reason, most manufacturers use lower yield strength metals solely for trim that has hems and sharp bends or for thicker panels typically used for standing seam roofs with sharper bends.

Steel Designations

Coiled steel is available in many different designations. The ones most relevant to cladding are:

- SS – Structural Steel
- HSLAS – High Strength Low Alloy Steel
- CS – Commercial Steel

SS steels generally have a higher carbon content than other designations and are designed specifically for structural applications. HSLAS steels are also structural steels but have lower carbon contents. HSLAS steels achieve strength not just through the addition of carbon, but also through alloying agents added in very low concentrations. CS steels generally do not have any guaranteed yield strength, tensile strength, or elongation and as such are primarily used for non-structural applications such as trim and flashing or non-structural roof or wall panels.

Each designation is subdivided into grades and in some cases, further subdivided into classes. Each combination of grade and class has its own unique values for yield strength, tensile strength and elongation as shown in Table 1 (Galvanized) and Table 2 (Zn-Al Alloy or Galvalume™, SS only).

Coating Systems

Although steel is a strong and durable material, it is subject to corrosion and must be coated for use in exterior applications. Generally, there is a metallic coating applied directly to the steel followed by a paint layer (or layers) added for visual effect. Bare metallic coatings are also growing in popularity for their unique and cost-effective appearance.

Metallic Coatings

Steel is commonly protected by a rust-inhibitive zinc or zinc-based coating. These coatings can vary from high-quality zinc with the proper pretreatment (galvanized steel) to a coating consisting of a zinc-aluminum mixture. The choice of coating is often made based on the use, location, and performance requirements of the structure. Zinc (galvanized) coatings have been used successfully in applications across North America since 1837. Aluminum-zinc (Galvalume™) coatings were introduced in 1972 to offer enhanced durability, better performance in most environments, and to provide a cost competitive alternative to traditional zinc.

Each type of coating has a specific set of performance characteristics that provide value in certain locations or environmental conditions. A detailed explanation of coatings can be found on the MCA website in "Metal Roofing from (A) Aluminum to (Z) Zinc". The end user should consult this document to determine the required performance and then choose the most appropriate option.

Steel Thickness

Another very important parameter regarding steel coil/sheet is the thickness of the underlying steel. Another term often used in place of thickness is *gauge*. (a.k.a. "gage") Thickness has traditionally been expressed as a numerical value (e.g., XXX") whereas gauge is a designator number followed by the word "gauge" or "ga.". (e.g., 24 gauge).

Unfortunately, there are no universally accepted standards to define the relationship of thickness and gauge. Many sources cite a "U.S. Standard Gauge", which comes from Title 15, Chapter 6, Subchapter III of the U.S. Code of Federal Regulations. However, this guideline was created primarily for assessment of tariffs and deals only with approximate thicknesses. This document is NOT recognized by the metal roofing industry for determination of structural properties.

Nevertheless, thickness is a critical parameter in the performance of steel sheet and coil. According to a formula provided by US Steel[5], a 10% difference in thickness could result in as much as a 150% difference in impact resistance – a significant issue in the visual performance of metal in hail impact conditions. Metal thickness is also a key component in load transfer, resistance to buckling, and product durability. Metal of insufficient thickness will not be able to transfer the load to the structure as required which can lead to failure. Fortunately, Metal roofing manufacturers rigorously design and test these products to meet these performance requirements for the thicknesses used.

The bottom line is that material gauge thicknesses are specific to manufacturers. Table 3 gives thicknesses for various gauges and types of steel common in the industry, but it does not represent any consensus among the manufacturers or suppliers. Generally, metallic coatings are specified by the relevant steel specification using minimum mass per unit surface area, not thickness. Therefore, MCA recommends that the thickness of the coating not be included when specifying a steel thickness. However, total thicknesses including metallic coatings are shown in Table 3 for illustrative purposes. **What matters most is that the material used to fabricate wall and roof cladding has the same or greater uncoated base metal thickness as what was used in the testing regimen and/or section property calculations.**

It is also recognized that there is a production tolerance in the manufacture of any sheet steel. These tolerances are handled by panel manufacturers in one of two ways:

1. Order a minimum thickness directly with only positive tolerance allowed.
2. Order a nominal thickness and subtract half of the tolerance to get the minimum thickness as allowed by Note B of Table 4 of this technical bulletin.

Tolerances are defined by ASTM A 924 and are also shown in Table 4.

The American Iron and Steel Institute (AISI) states in the "North American Specification for the Design of Cold-Formed Steel Structural Members" (AISI S100)[4] that the delivered thickness of the uncoated (excluding paints and metallic coating) base material shall not be less than 95% of the uncoated thickness. Conversely, this means that calculation of section properties used in the design of metal panel systems should assume a metal thickness of 1/0.95 = 1.0526 times the minimum uncoated thickness. This value is called the *design thickness* and is stated by most manufacturers in published section properties.

Table 1

Mechanical Requirements (Longitudinal) for Galvanized Steels[1]

Designation	Grade	Yield Strength, min, ksi	Tensile Strength, min, ksi [A]	Elongation in 2 in., min, %[A]
SS	33	33	45	20
	37	37	52	18
	40	40	55	16
	50 Class 1	50	65	12
	50 Class 2	50	…	12
	50 Class 3	50	70	12
	50 Class 4	50	60	12
	55	55	70	11
	60	60	70	10[B]
	70	70	80	9[B]
	80 Class 1[C]	80[D]	82	…
	80 Class 2[C,E]	80[D]	82	…
	80 Class 3	80[D]	82	3[F]
HSLAS	40	40	50[G]	24
	50	50	60[G]	22
	55 Class 1	55	70[G]	18
	55 Class 2	55	65[G]	20
	60	60	70[G]	18
	70	70	80[G]	14
	80	80	90[G]	12
CS[H]	No Mandatory Requirements			

Notes:

A. Where an ellipsis (. . .) appears in this table there is no requirement.
B. For sheet thickness of 0.028 in. or thinner, the elongation requirement is reduced two percentage points for SS Grades 60 and 70.
C. For sheet thickness of 0.028 in. or thinner, no tension test is required if the hardness result in Rockwell B85 or higher.
D. As there is no discontinuous yield curve, the yield strength should be taken as the stress at 0.5% elongation under load or 0.2% offset.
E. SS Grade 80 Class 2 may exhibit different forming characteristics than Class 1, due to difference in chemistry.
F. The purchaser should consult with the producer when ordering SS Grade 80 Class 3 material in sheet thicknesses 0.028 in. or thinner regarding elongation and tension test requirements.
G. If a higher tensile strength is required, the user should consult the producer.
H. Commercial Steel (CS) should not be used for structural roofing or siding sheathing unless the mechanical properties can be proven to support the structural requirements for the project.

Table 2

Mechanical Requirements (Longitudinal) for Zn-Al Alloy Steels[2]

Grade	Yield Strength, min, ksi	Tensile Strength, min, ksi [A]	Elongation in 2 in., min, %
33	33	45	20
37	37	52	18
40	40	55	16
50 Class 1	50	65	12
50 Class 2	50	…	12
50 Class 4	50	60	12
60	60	70	10[B]
70	70	80	9[B]
80 Class 1[C]	80[D]	82	…
80 Class 2[C,E]	80[D]	82	…
80 Class 3	80[D]	82[F]	3

Notes:

A. Where an ellipsis (. . .) appears in this table there is no requirement.
B. For sheet thickness of 0.028 in. or thinner, the elongation requirement is reduced two percentage points for Grades 60 and 70.
C. For sheet thickness of 0.028 in. or thinner, no tension test is required if the hardness result in Rockwell B85 or higher.
D. As there is no discontinuous yield curve, the yield strength should be taken as the stress at 0.5% elongation under load or 0.2% offset.
E. Grade 80 Class 2 may exhibit different forming characteristics than Class 1, due to difference in chemistry.
F. The purchaser should consult with the producer when ordering Grade 80 Class 3 material in sheet thicknesses 0.028 in. or thinner regarding elongation and tension test requirements.

Table 3

Example Material Thickness by Gauge [A]

Gauge	Nominal Uncoated Thickness, in.	Bare G90 (Galvanized), in.[B]	Painted G90, in.[B,D]	Bare/Acrylic Coated 55% Al-Zn, 0.50 oz/ft^2 (AZ50), in.[C]	Bare/Acrylic Coated 55% Al-Zn, 0.55 oz/ft^2 (AZ55), in.[C]	Painted 55% Al-Zn, 0.50 oz/ft^2 (AZ50), in.[C,D]
22	**0.030**	0.031	0.032	0.031	0.031	0.033
24	**0.023**	0.025	0.026	0.025	0.025	0.027
26	**0.019**	0.020	0.022	0.020	0.020	0.022
29	**0.014**	0.015	0.017	0.015	0.016	0.017

Notes:

A. This table is only to provide an example of various material thickness and is not intended to be representative of all manufacturers. Consult your manufacturer for product-specific thicknesses.
B. G-90 coating thickness of 0.001512 in. from ASTM A 653 (Reference 1), Section 8.1.3.
C. AZ50 and AZ55 coating thicknesses of 0.00160 in. and 0.00176 in. respectively from ASTM A 792 (Reference 2), Section 8.1.2.
D. Paint thickness of 0.0010 in. (exterior) and 0.0004 in. (interior) based on manufacturer’s system specifications and can vary by manufacturer.

Table 4

Metallic Coated Steel Thickness Tolerances[3]

Specified Width, in.	**Specified Order Thickness, in.** [A]	
	0.023 and thinner	**Over 0.023 through 0.043**
Thickness Tolerances, Over, in., No Tolerance Under [B]		
Less than or equal to 72	0.003	0.004

Notes:

A. The specified thickness range captions apply independently of whether the ordered thickness is stated as a nominal or minimum.

B. The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance s divided equally over and under (tolerance over, tolerance under).

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Thickness Recommendations

By providing only a gauge identifier (i.e., 24 ga.), a specifier fails to make a traceable connection to the dictating design standard, which could lead to an under/over-design of the cladding system. Therefore, the Metal Construction Association recommends the following approach when specifying thickness of cladding systems using sheet steel:

- Gauge designations should not be used in building specifications to define thickness. Only decimal dimensions of the base steel should be used, without allowance for coating thickness.
- If gauge designations are used in architectural drawings for brevity, the accompanying notes or specifications should set the thickness in decimal inches for all gauges referenced.
- Decimal thicknesses should be specified using nominal dimensions to two significant digits with tolerances from the relevant ASTM specification applied 50% over/50% under. (See Table 3 values in **bold** text as an example)

When gauge is the only available method of specifying thickness, the following procedure will convert gauge to a nominal decimal thickness:

1. Select a basis of design manufacturer, consult the section properties for the desired system, and determine the design thickness.
2. Multiply the design thickness by 0.95. This is the minimum allowed uncoated thickness required by AISI S100.
3. Determine the tolerance for minimum allowed uncoated thickness and coil width combination using Table 4. If the coil width is not known, assume 48".
4. Divide the tolerance by 2.0 and add it to the minimum allowed uncoated thickness determined in Step 2.
5. Round the result to two significant digits to arrive at a nominal uncoated thickness.

Example

Determine the nominal uncoated thickness of a 24-gauge standing seam roof panel.

1. Pick a basis of design manufacturer and consult their panel section property tables to determine the AISI Design Thickness as 0.0223 in.
2. Determine the minimum uncoated thickness by taking 95% of the design thickness: 0.0223 x 0.95 = 0.0212
3. Determine the allowed tolerance using Table 4, which is 0.003 in.
4. Divide this the tolerance by 2.0 and add to the minimum uncoated thickness, giving 0.003/2.0 + 0.0212 = 0.0227 in.
5. Round the result of Step 4 to two significant digits, or 0.023 in.

Summary

Not all steel cladding systems are made or perform the same. Steel used in roof and wall applications is a highly engineered product. Buyers and end users should consider a variety of factors including the metal thickness, yield strength, metal coatings and finish systems when comparing sources of steel and determining the level of performance needed for the building location and end use.

References

1. American Society of Testing Materials; ASTM A 653-19a, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process (abridged).
2. American Society of Testing Materials; ASTM A 792-10 (2015), Standard Specification for Steel Sheet, 55 % Aluminum-Zinc Alloy-Coated by the Hot-Dip Process (abridged).
3. American Society of Testing Materials; ASTM A 924-19, Standard Specification for General

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Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process (abridged).
4. American Iron and Steel Institute; AISI S100, North American Specification for the Design of Cold-Formed Steel Structural Members, 2016 Edition with Supplement 1.
5. United Stated Steel Corporation (USS), Technical Bulletin Construction: Hail Damage on Coated Sheet Steel Roofing; Circa 2020 c4833252c2b90772c8fc2801203b38f7 (wsimg.com)

Founded in 1983, the Metal Construction Association brings together the diverse metal construction industry for the purpose of expanding the use of all metals used in construction. MCA promotes the benefits of metal in construction through:

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It is the responsibility of the end user to verify the applicability of this information with the local building and fire officials.

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