Aluminum Structures
Frequently Asked Questions

What is the seismic response modification factor *R* for aluminum seismic force resisting systems?
As noted in the 2020 *Aluminum Design Manual* Part II Commentary Section B.2.1, ASCE 7-16 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* does not provide seismic response modification factors (*R*) for aluminum seismic force resisting systems. If *R* is taken as 1, seismic loads are conservatively assumed to be resisted elastically, without utilizing the potential benefit of inelastic behavior.

The inelastic response of aluminum structures to seismic loads was investigated by Meimand, V., et al. in "Incremental Dynamic Analysis and Seismic Performance Evaluation of an Aluminum Framed Building Compared with Steel", presented at the *Eighth International Conference on Steel and Aluminium Structures*, in Hong Kong, China, December 7 – 9, 2016. They used the FEMA P695 procedure to compare seismic response modification factors, *R*, for two geometrically identical frames, one of steel and the other of 6061-T6 aluminum extrusions. These one-story structures used a three-span ordinary moment frame as the lateral force resisting system. The structure was found to satisfy the P695 criteria for an aluminum design with *R* = 3. The procedure was validated by showing that the steel frame met FEMA P695 requirements with *R* = 3.5, the factor prescribed by ASCE 7 for a steel ordinary moment frame. The study was limited to one frame and ignored fracture limit states, but the models included local buckling, local-global buckling interaction, and yielding.

Is there a *Code of Standard Practice* for aluminum structures?
The 2020 *Aluminum Design Manual* includes Part IX, the *Code of Standard Practice for Fabricating and Erecting Structural Aluminum*. It addresses issues similar to those in the AISC *Code of Standard Practice for Steel Buildings and Bridges*.

Is there software that calculates the available strengths given in the *Specification for Aluminum Structures*?
The Aluminum Association does not offer software to calculate the available strengths of aluminum members or connections. Software provided by other parties and applicable to many materials, including aluminum, is available to determine section properties and required strengths.

Where can I find minimum mechanical properties for aluminum alloy-tempers not listed in the *Specification for Aluminum Structures*?
Only alloy-tempers that are included in *Aluminum Standards and Data* published by the Aluminum Association are addressed by and included in the *Specification for Aluminum Structures*. The Aluminum Association publishes a list of other alloy-tempers registered by the Association in *Tempers for Aluminum and Aluminum-Alloy Products*, also called the Yellow Sheets, which is available on the Aluminum Association's web site www.aluminum.org.

What is the minimum bend radius for an aluminum part?
The bend radius large enough to avoid cracking is a function of the alloy, temper, thickness, bend orientation with respect to grain, and angle of bend. The 2020 *Aluminum Design Manual* Part VI Table 3-1 provides recommended minimum bend radii for various alloy-tempers and thicknesses of sheet and plate for 90 degree bends; Table 3-2 provides recommended inside radii for 180 degree cold bends of wire and rod; and Table 3-3 provides sheet thickness for 180 degree cold bending of metal to metal. Painted material may require larger radii to avoid damaging the paint. For various sheet and plate alloy-

tempers and thicknesses, ASTM B209 provides the diameter of a pin around which the product may be wrapped 180 degrees without cracking.

To minimize cracking, heat-treatable alloys are bent perpendicular to the grain (the longitudinal direction of the product) and non-heat treatable alloys are bent parallel to the grain. Dye penetrant inspection of the outside surface of the bent product is useful in detecting cracks.

Does the *Specification for Aluminum Structures* address welded tubular connections?
The *Specification for Aluminum Structures* has no provisions (such as Chapter K in the AISC *Specification for Structural Steel Buildings*) addressing additional requirements for tubular connections.

What materials are acceptable for fasteners used to connect aluminum parts?
The selection of material for fasteners connecting aluminum parts is a function of required strength, service conditions, need for removability, and intended service life. The 2020 *Specification for Aluminum Structures* does not prescribe fastener materials other than aluminum. Regarding contact between aluminum and metal, *Specification* Section M.7.1 states:

> "Where 1) aluminum contacts other metals except 300 series stainless steel, zinc, or cadmium and 2) the faying surfaces are exposed to moisture, the other metal shall be painted or coated with zinc, cadmium, or aluminum. Uncoated aluminum shall not be exposed to moisture or runoff that has come in contact with other uncoated metals except 300 series stainless steel, zinc, or cadmium.
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> Steel fasteners with a specified minimum tensile ultimate strength greater than 120 ksi in the load bearing portion of the shank shall not be used in contact with aluminum."

The Commentary to Section M.7 reads, in part:

> "The electrical potential difference between aluminum and zinc and cadmium in salt water is small, so galvanic corrosion usually will not occur when aluminum is in contact with these metals. Doyle and Wright (1988) conducted tests showing that zinc-coated steel is especially effective in resisting atmospheric exposure galvanic corrosion when in contact with aluminum. Coating the steel is usually more effective than coating the aluminum to prevent galvanic corrosion between aluminum and steel."

The Commentary to Section A.4.5 reads, in part:

> "Steel fasteners with a specified minimum tensile strength greater than 120 ksi (those with a Rockwell hardness greater than or equal to C35) may suffer hydrogen-assisted stress corrosion cracking (HASCC) when exposed to certain dissimilar materials (including aluminum), moisture, and tensile stress due to installation or loading. Examples of fasteners that are not to be used in contact with aluminum are A490 bolts and Grade 8 (SAE J429) bolts or screws, all of which have a specified minimum tensile strength of 150 ksi. Each of the maximum hardness values (C38 for A490 and C39 for Grade 8) exceeds C34."

Is it acceptable to place aluminum in contact with concrete?
The 2020 *Specification for Aluminum Structures* Section M.7.3 states:

“Aluminum surfaces shall be painted if they are to be placed in contact with concrete or masonry unless the concrete or masonry remains dry after curing and no corrosive additives such as chlorides are used. Aluminum shall not be embedded in concrete with corrosive additives such as chlorides if the aluminum is electrically connected to steel.”

The Commentary to Section M.7.3 reads:

“To avoid staining and surface corrosion, mill finished aluminum and anodized aluminum should be protected from uncured concrete, mortar, and similar alkaline substances and muriatic acid used in cleaning concrete and masonry.

Masonry products designed to remain at a relatively low pH during and after curing (such as magnesium phosphate grout, which does not exceed a pH of 8.5) do not corrode aluminum.”

Where can I find errata for the *Aluminum Design Manual*?
Errata for the 2010, 2015, and 2020 ADMs are posted at http://www.aluminum.org/errata.

Is there a certification program for aluminum fabricators or erectors?
The Aluminum Association does not maintain a certification program for aluminum fabricators or erectors. Industry associations for specific structure types may have such programs.

Does the *Aluminum Design Manual* address prying action for aluminum connected parts?
No, but prying action behavior in aluminum is similar to such behavior in steel, addressed by the American Institute of Steel Construction’s *Steel Construction Manual*.

Are there prequalified welding procedure specifications (WPSs) for aluminum?
The 2020 *Specification for Aluminum Structures* Section M.9 requires that aluminum welding comply with AWS D1.2, *Structural Welding Code – Aluminum*. AWS D1.2-2014 states, “Only WPSs with previous qualifications accepted by the Engineer or qualified in conformance with Part C of this clause shall be recognized as approved WPSs.”

How are the welded yield strengths of aluminum alloys determined?
a) Non-Heat Treatable Alloys: For non-heat treatable alloys the welded strengths are the same as the annealed strengths. This is because welding brings the base metal temperature to the melting point, which is above the 650^{o}F annealing temperature for most non-heat treatable alloys. For example, the tensile yield strength for annealed 5086 (that is, 5086-O) given in ASTM B209 is 14 ksi, and the tensile yield strength for welded 5086 given in the *Aluminum Design Manual* Part I Table A.4.3 is 14 ksi.

b) Heat Treatable Alloys: For heat treatable alloys the welded strengths are not the same as the annealed strengths. This is because welding brings the base metal temperature to the melting point, but annealing heat treatable alloys typically requires bringing the material to 775^{o}F for 2 to 3 hours. The strength of most weld-affected heat treatable alloys has been determined from tests to be slightly less than the solution heat treated (T4) strength. For example, the tensile yield strength for welded 6061 is 15 ksi, and the tensile yield strength for 6061-T4 is 16 ksi.

Welded yield strengths given in the Aluminum Design Manual editions before 2005 were not based on these principles, but rather on tests of 10” gauge length transversely welded specimens. Because only about 1” to either side of the weld was in the heat affected zone, these tests included the yield strength of 8” of unwelded base metal and 2” of weld affected base metal, and thus were not indicative of all-welded base metal. The welded strengths were changed in 2005 to be more representative of the weld affected zone by using the annealed yield strength as the welded yield strength for non-heat treatable alloys, and on tests of all-weld affected material for heat treatable alloys.