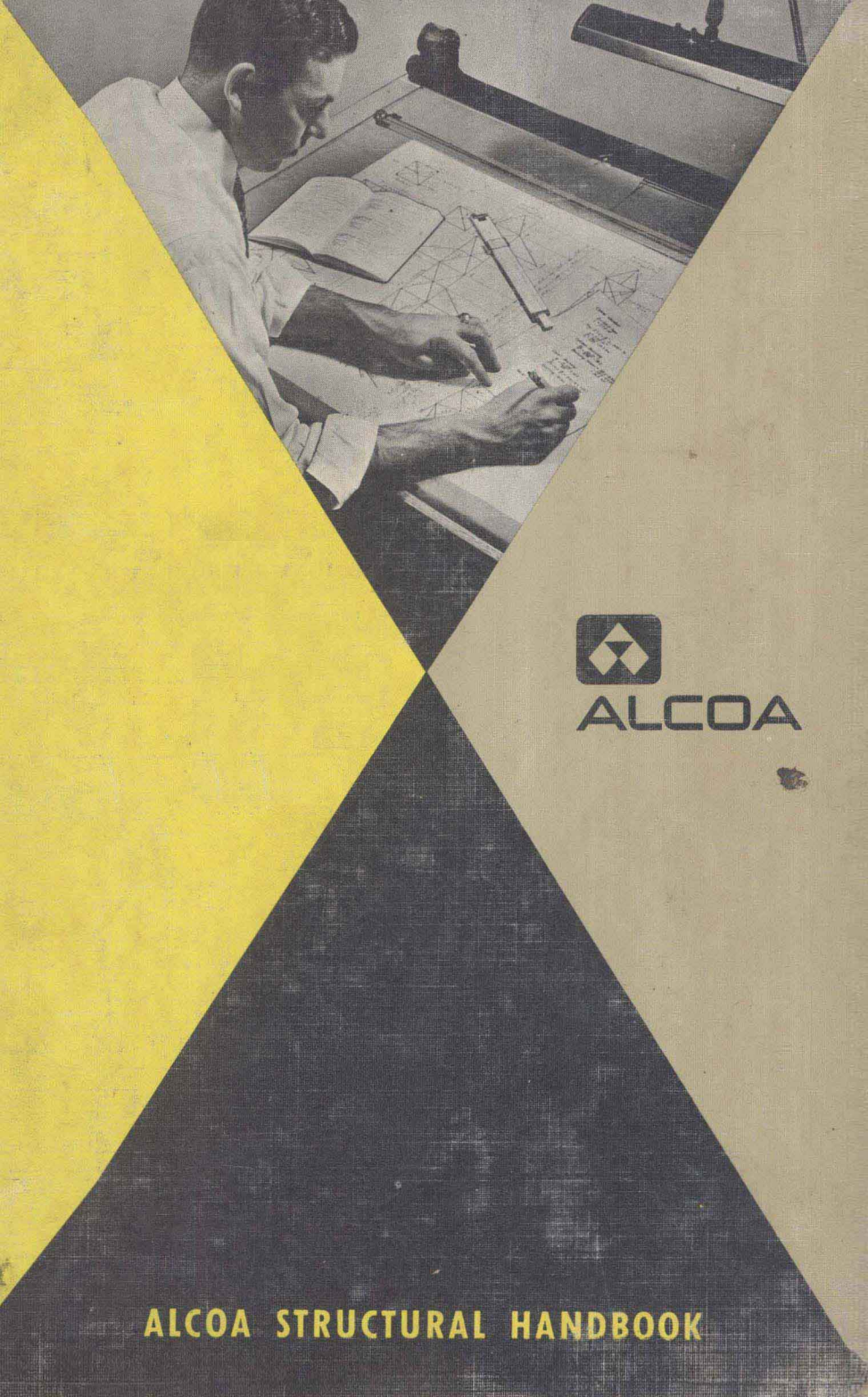

ALCOA

# ALCOA STRUCTURAL HANDBOOK

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# STRUCTURAL HANDBOOK

**A DESIGN MANUAL FOR ALUMINUM**

ALUMINUM COMPANY OF AMERICA

PITTSBURGH, PENNSYLVANIA

## NOTICE

Some of the materials or their uses, the alloys or their processes of fabrication or casting, their heat treatment or the products of one or more of these operations mentioned in this handbook are covered by United States patents.

# Foreword

**The diversity of form,** characteristics and uses of aluminum alloy products emphasizes the need for a broad approach to the design of aluminum alloy strength members. This revised edition of the ALCOA STRUCTURAL HANDBOOK presents such an approach. The information is presented by means of formulas, discussion, examples and tables, and is based on laboratory investigations, analytical studies, field tests and extensive practical experience.

Recent improvements in Alcoa aluminum alloy products, together with advances in design methods, are reflected in the revision of all sections of the handbook.

The calculations involved in the preparation of this book are based upon the nominal cross sections as shown in the tables. It should be noted, however, that in practice these sections vary according to the commercial tolerances shown in the tables. The principal mechanical property tables list minimum properties rather than typical properties. These mechanical properties are given in units of kips per square inch (1 kip=1,000 lb).

The services of the research and development facilities of Aluminum Company of America are available to customers who desire assistance in the application of aluminum to their products. Recommendations on alloy, temper, product, design and fabrication are furnished without cost.

Aluminum Company of America assumes responsibility for the quality of its products but does not assume responsibility for customers' designs or for the performance of structures or parts made in accordance therewith.

The extent of responsibility assumed by Aluminum Company of America is set forth in detail in the Company's formal warranty clause, which appears on all acknowledgments of its orders and which is quoted in full on page 335 of this book.

# CHARACTERISTICS, MANUFACTURE AND FABRICATION OF ALUMINUM ALLOY PRODUCTS

# SUPPLEMENT

**A Reprint of ASCE Proceedings Papers—Nos. 3341 and 3342**

**Paper No. 3341**

## SUGGESTED SPECIFICATIONS FOR STRUCTURES OF ALUMINUM ALLOYS 6061-T6 and 6062-T6

Report of the Task Committee on Lightweight Alloys, Committee on Metals, Structural Division

**Paper No. 3342**

## SUGGESTED SPECIFICATIONS FOR STRUCTURES OF ALUMINUM ALLOY 6053-T5 and 6063-T6

Report of the Task Committee on Lightweight Alloys, Committee on Metals, Structural Division

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**AMERICAN SOCIETY OF CIVIL ENGINEERS**

Journal of the
STRUCTURAL DIVISION
Proceedings of the American Society of Civil Engineers

# SUGGESTED SPECIFICATIONS FOR STRUCTURES OF ALUMINUM ALLOYS 6061-T6 AND 6062-T6

Report of the Task Committee on Lightweight Alloys
Committee on Metals, Structural Division

## COMMITTEE REPORT

The Task Committee on Lightweight Alloys (formerly the Committee on Design in Lightweight Structural Alloys) has prepared two suggested specifications for the design of structures of aluminum alloys. The first of these is for 6061-T6 and 6062-T6 alloys (Proc. Paper 3341) and supersedes the previous specifications (1), (a).[1] The second specification is for alloy 6063-T5 and 6063-T6 (Proc. Paper 3342). The task committee hopes that those who have constructive comments on, or criticism of, the suggested specifications will submit them to the Society.

## POLICY OF THE STRUCTURAL DIVISION, ASCE, RELATIVE TO STRUCTURAL SPECIFICATIONS

(Adopted by the Executive Committee, Structural Division, on May 26, 1962)

No specification shall be issued in the name of, nor be endorsed by, the Structural Division of ASCE.

Specifications may be prepared by Task Committees of the Structural Division, ASCE, working alone or jointly with other groups. Such specifications may be submitted as committee reports, through the Executive Committee of the Division, for publication in the Structural Division Journal.

Note.—Discussion open until May 1, 1963. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. This paper is part of the copyrighted Journal of the Structural Division, Proceedings of the American Society of Civil Engineers, Vol. 88, No. ST6, December, 1962.

[1] Numerals in parentheses refer to corresponding items in Appendix I.

The Structural Division Executive Committee requests that any committee report that takes the form of a specification, and is written in the usual terse specification style, be accompanied by a commentary or discussion supporting and explaining the specification. The Executive Committee will submit such a report for publication, after the necessary review and approval.

It is the desire and intent of the Structural Division Executive Committee that the best interests of the members of ASCE and the engineering profession be served. Where this is best accomplished by publication and open discussion of design specifications in the Division Journal, this will be done. The Committee feels that no useful purpose will be served by ASCE endorsement of specifications; however, constructive criticism and discussion will add materially to the understanding and improvement of specifications.

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## FOREWORD

These specifications supersede two previous sets of specifications for structures of aluminum alloy 6061-T6, prepared by this committee (1),(2).

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## SYNOPSIS

These specifications cover allowable stresses, design rules, and fabrication procedures for structures built of the aluminum alloys known commercially as 6061-T6 and 6062-T6. Alloy 6061-T6 is available in the form of sheet, plate, shapes, tubes, rods, bars, rivets and forgings. Alloy 6062-T6 is available in the form of shapes and tubes. The two alloys have the same mechanical properties and may be used interchangeably. Two sets of allowable stresses are provided; one for bridges and other structures to which allowable stresses for bridges are normally applied; the other for buildings and other structures to which allowable stresses for buildings are normally applied. The basic allowable stresses are 17 ksi for bridge structures and 19 ksi for building structures, based on a minimum yield strength of 35 ksi and a minimum tensile strength of 38 ksi.

## PART I.—GENERAL

*Introduction.*— These specifications cover the allowable stresses, the design rules, and the fabrication procedures for two aluminum alloys commonly used for structural purposes where a high degree of resistance to corrosion is de-

sired. In the preparation of these specifications the Committee has made use of the available theoretical and experimental work relating to this subject and particularly to the Committee's previously published specifications.

These specifications are confined to allowable stresses, design rules, and fabrication. No attempt has been made to cover the loading, erection, inspection, or nontechnical provisions included in many specifications, because such provisions are fairly well established in current good structural practice. It is intended, of course, that structures built under these specifications will be designed, constructed, and erected by following current good practice for metal structures.

It is believed that the designer can make more effective use of a set of specifications if he knows the basis for its various provisions. For this reason the section, "Explanation of Specifications," has been added. That section contains background information and references concerning those paragraphs of the specifications for which some explanation seems required.

When the abbreviation "ksi" is used in these specifications it denotes "kips per square inch" or "thousands of pounds per square inch."

*Material.*—The principal materials considered in these specifications are aluminum alloys having the following nominal chemical compositions:

| | Percentage by weight | |
|---|---|---|
| Composition | 6061-T6 | 6062-T6 |
| Copper | 0.25 | 0.25 |
| Silicon | 0.6 | 0.6 |
| Magnesium | 1.0 | 1.0 |
| Chromium | 0.25 | 0.06 |
| Aluminum | 97.9 | 98.09 |
| Total | 100.0 | 100.0 |

These materials are covered by the following American Society for Testing and Materials (ASTM) specifications:

| Product | ASTM Specification No. |
|---|---|
| Sheet and Plate | B209-62 (6061-T6) |
| Drawn Seamless Tubes | B210-62 (6061-T6 and 6062-T6) |
| Bars, Rods and Wire | B211-62 (6061-T6) |
| Extruded Bars, Rods and Shapes | B221-62 (6061-T6 and 6062-T6) |
| Drawn Seamless Tubes for Condensers and Heat Exchangers | B234-62 (6061-T6 and 6062-T6) |
| Extruded Tubes | B235-62 (6061-T6 and 6062-T6) |
| Pipe | B241-62 (6061-T6 and 6062-T6) |
| Forgings | B247-62 (6061-T6) |
| Standard Structural Shapes | B308-62 (6061-T6 and 6062-T6) |

For products that are available in both alloys, the two alloys may be used interchangeably.

The specified minimum tensile strength of these materials is 42 ksi for sheet and plate, drawn tubes, and bars, rods and wire; and 38 ksi for all other products. The specified minimum yield strength for all products is 35 ksi. The minimum mechanical properties that have been used as a basis for the selection of allowable stresses in these specifications are listed in Table 1.

TABLE 1.—BASIC STRENGTH DATA[a]

| | Unaffected Parent Material | Material Affected by Heat of Welding | |
|---|---|---|---|
| | | All material welded with 5356 or 5556 filler alloy and material 3/8-in. or less in thickness welded with 4043 filler alloy | Material more than 3/8-in. thick welded with 4043 filler alloy |
| Tensile strength | 38 | 24[b] | 24[b] |
| Tensile yield strength | 35 | 20[c] | 15[c] |
| Compressive yield strength | 35 | 20[c] | 15[c] |
| Shear strength | 24 | 15 | 15 |
| Shear yield strength | 20 | 12 | 9 |
| Bearing strength | 80 | 50 | 50 |
| Bearing yield strength | 56 | 30 | 22 |

[a] Minimum strength values for Alloys 6061-T6 and 6062-T6, ksi.
[b] ASME weld qualification test value for tensile strength across a butt weld.
[c] These are expected minimum values of the yield strength across a butt weld, corresponding to 0.2% offset on a 10-in. gage length.

Materials for rivets, bolts, nuts, washers, and welding rods and electrodes are covered by the ASTM specifications listed in Table 2. Following are typical values of other physical properties of these alloys:

| | |
|---|---|
| Modulus of elasticity, ksi | 10,000 |
| Modulus of elasticity in shear, ksi | 3,800 |
| Poisson's ratio | 1/3 |
| Coefficient of expansion, per degree Fahrenheit | 0.000012 |
| Weight, in pounds per cubic inch | 0.098 |

Alloys 6061-T6 and 6062-T6 are the ones principally considered in the preparation of these specifications and the ones to which the allowable stresses for parts other than bolts apply. However, these specifications may be applied to structures built of other suitable aluminum alloys, provided such alloys meet the specified strengths and elongations listed in the ASTM specifications mentioned in the first paragraph of this section. Whether or not such other alloys need paint protection will depend on whether they are as resistant to corrosion as 6061-T6 and 6062-T6. The sections of this specification dealing

TABLE 2.—PERTINENT ASTM SPECIFICATIONS

| Product | Alloy | ASTM Specification for Material from Which Product is Made |
|---|---|---|
| Rivets | 6061-T6 or 6061-T4(a) | B316-62 - Rivet and Cold Heading Wire and Rods(b) |
| Bolts | 2024-T4 | B316-62 - Rivet and Cold Heading Wire and Rods(b) |
| Nuts | 6061-T6 or 6262-T9 | B211-62 - Bars, Rods and Wire, or B316-62 - Rivet and Cold Heading Wire and Rods(b) |
| Washers | Alclad 2024-T3 or -T4 | B209-62 - Sheet and Plate |
| Welding Rods and Electrodes | ER4043, ER5356 or ER5556 | B285-62T - Welding Rods and Bare Electrodes |

(a) ASTM B316-61 includes mechanical property specifications for 6061-T6 but not 6061-T4. The heat treatment for the latter is the same as the former except that the artificial aging is omitted.

(b) ASTM B316-62 covers rods up to 0.615 in. in diameter. Rods with diameters from 0.615 to 1.000 in. are supplied with the same mechanical property limits and tolerances on diameter (+0.003 in., -0.001 in.) that apply to 0.615-in. rod in ASTM B316-62.

TABLE 3.—ALLOYS TO BE USED FOR RIVETS

| Designation before driving | Driving procedure | Designation after driving | Typical shear strength[a] |
|---|---|---|---|
| 6061-T6 | Cold, as received | 6061-T6 | 30 |
| 6061-T4 | Hot, 990°F to 1,050°F | 6061-T43 | 24 |

[a] Typical ultimate shear strength of the driven rivet, ksi.

with welding should not be applied to other alloys unless it has been clearly demonstrated that such alloys are suitable for welding.

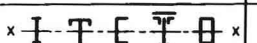
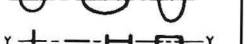
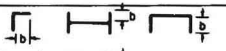
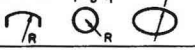
Rivets used in fabricating structures designed in accordance with these specifications shall be of aluminum alloy and may be either cold driven or hot driven. The alloy used is indicated in Table 3.

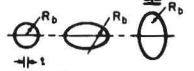
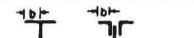
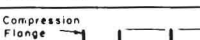
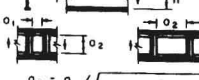
Aluminum bolts used in structures designed in accordance with these specifications shall be of alloy 2024-T4. Such bolts have expected minimum tensile and shear strengths of 62 ksi and 37 ksi, respectively.

## PART II.—SPECIFICATIONS FOR RIVETED AND BOLTED STRUCTURES

*Section A: Summary of Allowable Stresses.*—The allowable stresses to be used in proportioning the parts of a structure shall be determined from Tables

TABLE 4a.—ALLOWABLE STRESSES IN RIVETED OR BOLTED STRUCTURES IN WELDED STRUCTURES AT LOCATIONS FARTHER THAN 1.0 INCH FROM ANY WELD (6061-T6 AND 6062-T6 BRIDGE STRUCTURES NONWELDED)

| Type of Stress | | Specification No. | Type of Member or Component | Allowable Stress, ksi | | | | |
|---|---|---|---|---|---|---|---|---|
| TENSION, axial, net section | | A-1a | Any tension member | 17 | | | | |
| TENSION in extreme fibers of beams, net section | | A-2a | Structural shapes, rectangular tubes, built-up members bent about X-axis  | 17 | | | | |
| | | A-3a | Round or oval tubes | 21 | | | | |
| | | A-4a | Rectangular bars and plates, and outstanding flanges of shapes bent about Y-axis  | 23 | | | | |
| BEARING | | A-5a | On rivets and bolts | 30 (a) | | | | |
| | | A-6a | On milled surfaces and pins | 20 | | | | |
| | | | | Allowable Stress for Slenderness Less Than $S_1$, ksi | Slenderness Limit, $S_1$ | Allowable Stress for Slenderness Between $S_1$ and $S_2$ ksi | Slenderness Limit, $S_2$ | Allowable Stress for Slenderness Greater Than $S_2$, ksi |
| COMPRESSION in Columns Subjected to Axial Load, Gross Section | COMPRESSION, gross section (Also see Specs. A-8a to A-10a) | A-7a | Columns | 17 | $\frac{L}{r} = 9.2$ | $18.1 - 0.120 \frac{L}{r}$ | $\frac{L}{r} = 67$ | $\frac{45,000}{(L/r)^2}$ |
| | COMPRESSION in components of columns (Also see Spec. A-7a) | A-8a | Outstanding flanges and legs  | 17 | $\frac{b}{t} = 5.2$ | $21.0 - 0.77 \frac{b}{t}$ | $\frac{b}{t} = 12$ | $\frac{1,720}{(b/t)^2}$ |
| | | A-9a | Flat plates with both edges supported  | 17 | $\frac{b}{t} = 17$ | $21.0 - 0.24 \frac{b}{t}$ | $\frac{b}{t} = 38$ | $\frac{17,000}{(b/t)^2}$ |
| | | A-10a | Curved plates supported on both edges and walls of round or oval tubes  | 17 | $\frac{R}{t} = 20$ | $20.0 - 0.68 \sqrt{\frac{R}{t}}$ | $\frac{R}{t} = 125$ | - - - - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | COMPRESSION in extreme fibers of beams, gross section (Also see Specs. A-15a to A-19a) | A-11a | Single-web structural shapes and built-up sections bent about X-axis |  | 17 | $\frac{L_b}{r_y} = 11$ | $18.1 - 0.100\,\frac{L_b}{r_y}$ | $\frac{L_b}{r_y} = 80$ | $\frac{65,000}{(L_b/r_y)^2}$ |
| | | A-12a | Round or oval tubes |  | 21 | $\frac{R_b}{t} = 21$ | $25.0 - 0.19\,\frac{R_b}{t}$ | $\frac{R_b}{t} = 60$ | - - - - |
| | | A-13a | Solid rectangular beams bent about X-axis |  | 23 | $\frac{d}{t}\sqrt{\frac{L_b}{d}} = 12$ | $31.0 - 0.70\,\frac{d}{t}\sqrt{\frac{L_b}{d}}$ | $\frac{d}{t}\sqrt{\frac{L_b}{d}} = 27$ | $\frac{8,800}{(\frac{d}{t})^2(\frac{L_b}{d})}$ |
| | | A-14a | Rectangular tubes and box sections |  | 17 | $\frac{L_b S_c}{I_y} = 33$ | $18.1 - 0.192\sqrt{\frac{L_b S_c}{I_y}}$ | $\frac{L_b S_c}{I_y} = 1760$ | $\frac{17,700}{L_b S_c / I_y}$ |
| COMPRESSION in Members Subjected to Bending, Gross Section | COMPRESSION in components of beams, where component is under uniform compression (Also see Specs. A-11a to A-14a) | A-15a | Flat plates with one edge free and one edge supported |  | 17 | $\frac{b}{t} = 6.0$ | $21.0 - 0.67\,\frac{b}{t}$ | $\frac{b}{t} = 14$ | $\frac{2,240}{(b/t)^2}$ |
| | | A-16a | Flat plates with both edges supported |  | 17 | $\frac{b}{t} = 17$ | $21.0 - 0.24\,\frac{b}{t}$ | $\frac{b}{t} = 38$ | $\frac{17,000}{(b/t)^2}$ |
| | COMPRESSION in components of beams where component is under bending in its own plane, (Also see Specs. A-11a to A-14a) | A-17a | Flat plates with compression edge free and tension edge supported, bent about X-axis |  | 23 | $\frac{b}{t} = 7.3$ | $31.0 - 1.1\,\frac{b}{t}$ | $\frac{b}{t} = 19$ | $\frac{3,700}{(b/t)^2}$ |
| | | A-18a | Flat plates with both edges supported, bent about X-axis |  | 17 | - - - - | 17 | $\frac{h}{t} = 110$ | $\frac{205,000}{(h/t)^2}$ |
| | | A-19a | Flat plates with both edges supported, bent about X-axis with horizontal stiffener |  | 17 | - - - - | 17 | $\frac{h}{t} = 227$ | $\frac{880,000}{(h/t)^2}$ |
| SHEAR in webs of beams, and also in members subjected to torsion, gross section | | A-20a | Unstiffened flat webs |  | 11 | $\frac{h}{t} = 13$ | $12.1 - 0.082\,\frac{h}{t}$ | $\frac{h}{t} = 66$ | $\frac{29,000}{(h/t)^2}$ |
| | | A-21a | Stiffened flat webs |  | 11 | - - - - | 11 | $\frac{a_e}{t} = 65$ | $\frac{47,000}{(a_e/t)^2}$ |

(a) This value applies for a ratio of edge distance to rivet or bolt diameter of 2 or greater. For smaller ratios, multiply this allowable stress by the ratio, (edge distance)/(twice the rivet or bolt diameter).

4a to 7a and 4b to 7b. The allowable stresses in Tables 4a through 7a are intended for application to bridge structures and other structures to which specifications similar to the AASHO (3) and AREA (4) specifications for steel bridges are applied. These specifications for bridge structures are designated by the numbers A-1a to A-25a and I-1a to I-24a.

The allowable stresses in Tables 4b through 7b, which appear in Appendix II, are intended for application to building structures and other structures to which specifications similar to the AISC specifications for steel buildings are applied. These specifications for building structures are designated by the numbers A-1b to A-25b and I-1b to I-24b. In subsequent sections of these specifications, when reference is made to a specification number such as "A-1," this number is intended to apply to either "A-1a" or "A-1b."

In applications where it is conventional practice to increase allowable stresses for certain types of loads, such as wind loads, the allowable stresses

TABLE 5a.—ALLOWABLE STRESSES IN RIVETS AND BOLTS (BRIDGE STRUCTURES)

| Specification Number | Description of Rivet or Bolt | Allowable Stress, ksi | |
|---|---|---|---|
| | | Shear on effective shear Area | Tension on root area |
| A-22a | 6061-T6 rivets, cold driven | 10 | -- |
| A-23a | 6061-T43 rivets, driven at temperatures of from 990°F to 1,050°F | 8 | -- |
| A-24a | 2024-T4 bolts | 14[a] | 23 |
| A-25a | 6061-T6 pins | 10 | -- |

[a] This allowable shear stress applies to either turned bolts in reamed holes or unfinished bolts in 1/16-in. oversize holes.

in these specifications should be increased in the same proportion as are the allowable stresses in accepted specifications for steel structures.

The terms appearing in the formulas in Tables 4a, 4b, 6a and 6b are defined as follows:

$a_1$ = shorter span of rectangular shear panel, in inches;

$a_2$ = longer span of rectangular shear panel, in inches;

$a_e$ = equivalent span of rectangular shear panel, in inches;

b = clear width of outstanding flange or of flat plate supported on both unloaded edges, in inches;

d = depth of beam, in inches;

$d_1$ = distance from toe of compression flange to neutral axis, in inches;

$h$ = clear height of shear web, in inches;

$I_y$ = moment of inertia of a beam (about axis parallel to web), in.$^4$;

$L$ = length of compression member between points of lateral support or twice the length of a cantilever column (except where analysis shows that a shorter length can be used), in inches;

$L_b$ = length of beam between points at which the compression flange is supported against lateral movement or length of cantilever beam from free end to point at which the compression flange is supported against lateral movement, in inches;

$R$ = outside radius of round tube or maximum outside radius for an oval tube, in inches;

$R_b$ = outside radius of a round tube in bending or outside radius at the location of the critical compressive stress for an oval tube in bending, in inches. (The location of the critical compressive stress is at the extreme fiber for an oval tube bent about the major axis. For an oval tube bent about the minor axis, the location of the critical stress can be determined by calculating the allowable stress at several points using the formulas of Specification A-12, with $R_b$ equal to the outside radius at each point. Bending moments corresponding to the allowable stresses at the various points are calculated, and the point resulting in the smallest bending moment is the location of the critical compressive stress.);

$r$ = least radius of gyration of a column, in inches;

$r_y$ = radius of gyration of a beam about axis parallel to web, in inches. (For beams that are unsymmetrical about the horizontal axis, $r_y$ should be calculated as though both flanges were the same as the compression flange.);

$S_c$ = section modulus of a beam (compression side), in cubic inches; and

$t$ = thickness of flange, plate, web or tube, in inches. (For tapered flanges, t is the average thickness.)

*Section B: Column Design.*

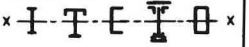
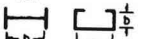
B-1: Allowable Compressive Stress in Columns.—The allowable compressive stress on the gross section of axially loaded columns shall be determined from the formulas in Specification A-7.

Columns having cross sections involving webs and outstanding legs of such proportions that local buckling may control the design shall be checked by Specifications A-8 to A-10 or by the method outlined in Part IV, Section M.

Open section members that are unsymmetrical about one or both principal axes may be subject to failure by combined torsion and flexure. For single or double angles and tee sections, Specification A-8 provides an adequate factor of safety against this type of failure. Other unsymmetrical, open shapes, such as channels, lipped angles or hat shapes should not be used as columns unless a special analysis is made of the resistance to buckling by combined torsion and flexure (17), (43).

B-2: Columns with Slenderness Ratio Exceeding 120.—Because long columns are relatively flexible, they may be appreciably weakened by the presence

TABLE 6a.—ALLOWABLE STRESSES ON SECTIONS WITHIN 1.0 INCH OF A WELD (6061-T6 AND 6062-T6 BRIDGE STRUCTURES WELDED)

| Type of Stress | | Specification No. | Type of Member or Component | Allowable Stress, ksi | | | | |
|---|---|---|---|---|---|---|---|---|
| TENSION, axial, net section | | I-1a | Any tension member | 10(b) | | | | |
| TENSION in extreme fibers of beams, net section | | I-2a | Structural shapes, rectangular tubes, built-up members bent about X-axis  | 10(b) | | | | |
| | | I-3a | Round or oval tubes  | 12(b) | | | | |
| | | I-4a | Rectangular bars and plates, and outstanding flanges of shapes bent about Y-axis  | 12(b) | | | | |
| BEARING | | I-5a | On rivets and bolts | 16(b)(d) | | | | |
| | | I-6a | On milled surfaces and pins | 11(b) | | | | |
| | | | | Allowable Stress for Slenderness Less Than $S_1$ ksi | Slenderness Limit, $S_1$ | Allowable Stress for Slenderness Between $S_1$ and $S_2$ ksi | Slenderness Limit, $S_2$ | Allowable Stress for Slenderness Greater Than $S_2$, ksi |
| COMPRESSION in Columns Subjected to Axial Load, Gross Section | COMPRESSION,(a) gross section (Also see Specs. I-8a to I-10a) | I-7a | Columns(a) | 10(b) | - - - - | 10(b) | $\frac{L}{r} = 67$(c) | $\frac{45,000}{(L/r)^2}$ |
| | COMPRESSION in components of columns (Also see Spec. I-7a) | I-8a | Outstanding flanges and legs  | 10(b) | $\frac{b}{t} = 4.7$(c) | $\frac{21.6}{\sqrt{b/t}}$ | $\frac{b}{t} = 19$ | $\frac{1,720}{(b/t)^2}$ |
| | | I-9a | Flat plates with both edges supported  | 10(b) | - - - - | 10(b) | $\frac{b}{t} = 41$(c) | $\frac{17,000}{(b/t)^2}$ |
| | | I-10a | Curved plates supported on both edges and walls of round or oval tubes  | 10(b) | $\frac{R}{t} = 13$(c) | $\frac{18.9}{(R/t)^{1/4}}$ | $\frac{R}{t} = 200$ | - - - - |
| COMPRESSION in Members Subjected | COMPRESSION(a) in extreme fibers of beams, gross section (Also see Specs. I-15a to I-19a) | I-11a | Single-web structural shapes and built-up sections bent about X-axis(a)  | 10(b) | - - - - | 10(b) | $\frac{L_b}{r_y} = 81$(c) | $\frac{65,000}{(L_b/r_y)^2}$ |
| | | I-12a | Round or oval tubes  | 12(b) | $\frac{R_b}{t} = 11$(c) | $\frac{21.9}{(R_b/t)^{1/4}}$ | $\frac{R_b}{t} = 135$ | - - - - |
| | | I-13a | Solid rectangular beams bent about X-axis  | 12(b) | $\frac{d}{t}\sqrt{\frac{L_b}{d}} = 9.8$(c) | $\frac{37.5}{[(d/t)^2 L_b/d]^{1/4}}$ | $\frac{d}{t}\sqrt{\frac{L_b}{d}} = 38$ | $\frac{8,800}{(\frac{d}{t})^2 \frac{L_b}{d}}$ |
| | | I-14a | Rectangular tubes and box sections(a)  | 10(b) | - - - - | 10(b) | $\frac{L_b S_c}{I_y} = 1770$(c) | $\frac{17,700}{L_b S_c / I_y}$ |