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Supplement No. 1 to the Specification for Structural Steel Buildings

Allowable Stress Design and Plastic Design
(June 1, 1989)

Approved by the
AISC Committee on Specifications and
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AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC.

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PREAMBLE TO
Supplement No. 1 to the *Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design* (June 1, 1989)

Since 1923, the American Institute of Steel Construction has published and maintained the Specification for Structural Steel Buildings based on the Allowable Stress Design (ASD) method. In 1989, the Institute published its ninth and latest edition of the ASD Specification. The Institute introduced the first edition of the *Load and Resistance Factor Design Specification* (LRFD) in 1986, based on the latest steel design and construction research and technology. Subsequently, there has been a 2nd and 3rd edition of that specification in 1993 and 1999, respectively. The 1989 ASD Specification has remained in effect as an alternative design method to LRFD.

In 2000, the Board of Directors of the American Institute of Steel Construction directed the AISC Committee on Specifications to unify ASD and LRFD into a single specification in order to provide a more efficient and cost effective design, fabrication, and construction methodology for the steel industry in the United States.

Supplement No. 1 to the *Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design* (ASD Specification), (dated June 1, 1989) is a limited supplement in anticipation of a complete integration of ASD with LRFD criteria within a single AISC Specification in the near future. For provisions that have evolved since 1989 for all aspects of the design of structural steel buildings, such as shear lag, stability bracing, flanges and webs under concentrated forces, evaluation of existing structures, and fatigue criteria see the 1999 *Load and Resistance Factor Design Specification for Structural Steel Buildings*. Note that the two design methods are not intended to be used simultaneously in the design of the same structure.

This Supplement includes the following: updated code and specification references, such as the current AISC provisions for seismic design, the RCSC Specification, ASCE 7, AWS D1.1, ASTM A913 and A992; new filler metal toughness and shape material toughness criteria for certain conditions; and expanded structural analysis requirements that are all consistent with prevailing steel design requirements. This supplement is not intended to provide a complete metric conversion. Metric standards are only included when designated as such by other organizations such as ASTM or AWS.

This Supplement also deletes all explicit loading requirements, other than by reference to the governing building code and ASCE 7, and removes the separate 1/3 stress increase allowance. The latter effect is more properly included within the current service load combination requirements of ASCE 7.

Supplement No. 1 to the Specification For Structural Steel Buildings,

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I. Chapter A

Replace Chapter A with the following:

CHAPTER A

GENERAL PROVISIONS

A1. SCOPE

The *Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design* is intended as an alternate to the *Load and Resistance Factor Design Specification for Structural Steel Buildings*.

This Specification includes the list of symbols, the glossary, and the appendices. The tables of numerical values are provided for design convenience.

Seismic design of buildings shall comply with the AISC *Seismic Provisions for Structural Steel Buildings, Seismic Provisions Supplement No. 2,* and with this Specification.

Single angle members shall comply with the *Specification for Allowable Stress Design of Single-Angle Members* and with this Specification.

Design of nuclear structures shall comply with the *Specification for the Design, Fabrication and Erection of Steel Safety Related Structures for Nuclear Facilities* and with this Specification.

Design of structural joints shall comply with the *Specification for Structural Joints Using ASTM A325 or A490 Bolts* (Research Council on Structural Connections) and the *Structural Welding Code-Steel* (AWS D1.1) and with this Specification.

As used in this Specification, the term *structural steel* refers to the steel elements of the structural steel frame essential to the support of the design loads. Such elements are enumerated in Section 2.1 of the AISC *Code of Standard Practice for Steel Buildings and Bridges*. For the design of cold-formed steel structural members, whose profiles contain rounded corners and slender flat elements, the provisions of the American Iron and Steel Institute *Specification for the Design of Cold-Formed Steel Structural Members* are recommended.

A2. TYPES OF CONSTRUCTION

Three basic types of construction and associated design assumptions are permissible under the respective conditions stated herein, and each will govern in a specific manner the size of members and the types and strength of their connections:

Type 1, commonly designated as “rigid-frame” (continuous frame), assumes that beam-to-column connections have sufficient rigidity to hold virtually unchanged the original angles between intersecting members.

Type 2, commonly designated as “simple framing” (unrestrained, free-ended) assumes that, insofar as gravity loading is concerned, ends of beams and girders are connected for shear only and are free to rotate under gravity load.

Type 3, commonly designated as “semi-rigid framing” (partially restrained), assumes that the connections of beams and girders possess a dependable and known moment capacity intermediate in degree between the rigidity of Type 1 and the flexibility of Type 2.

The design of all connections shall be consistent with the assumptions as to type of construction called for on the design drawings.

Type 1 construction is unconditionally permitted under this Specification. Two different methods of design are recognized. Within the limitations laid down in Sect. N1, members of continuous frames or continuous portions of frames may be proportioned, on the basis of their maximum predictable strength, to resist the specified design loads multiplied by the prescribed load factors. Otherwise, Type 1 construction shall be designed, within the limitations of Chapters A through M, to resist the stresses produced by the specified design loads, assuming moment distribution in accordance with elastic theory.

Type 2 construction is permitted under this Specification, subject to the stipulations of the following paragraph, wherever applicable.

In buildings designed as Type 2 construction (i.e., with beam-to-column connections other than wind connections assumed flexible under gravity loading) the wind moments may be distributed among selected joints of the frame, provided:

1. Connections and connected members have adequate capacity to resist wind moments.
2. Girders are adequate to carry full gravity load as "simple beams."
3. Connections have adequate inelastic rotation capacity to avoid overstress of the fasteners or welds under combined gravity and wind loading.

Type 3 (semi-rigid) construction is permitted upon evidence the connections to be used are capable of furnishing, as a minimum, a predictable proportion of full end restraint. The proportioning of main members joined by such connections shall be predicated upon no greater degree of end restraint than this minimum.

Types 2 and 3 construction may necessitate some inelastic, but self-limiting, deformation of a structural steel part.

A 3. MATERIAL

1. Structural Steel

a. ASTM Designations

Material conforming to one of the following standard specifications is approved for use under this Specification:

Carbon Structural Steel, ASTM A36/A36M
Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless Steel Pipe, ASTM A53/A53M, Gr. B
High-Strength Low-Alloy Structural Steel, ASTM A242/A242M
Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes, ASTM A500
Hot-Formed Welded and Seamless Carbon Steel Structural Tubing, ASTM A501
High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding, ASTM A514/A514M
High-Strength Carbon-Manganese Steel of Structural Quality, ASTM A529/A529M
High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, ASTM A572/A572M
High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4-in. (100 mm) Thick, ASTM A588/A588M
Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance, ASTM A606
Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing, ASTM A618
Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates and Bars and Quenched-and-Tempered Alloy Structural Steel Plates for Bridges, ASTM A709/A709M
Quenched and Tempered Low-Alloy Structural Steel Plate with 70 ksi (485 MPa) Minimum Yield Strength to 4 in. (100 mm) Thick, ASTM A852/A852M
High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST), ASTM A913/A913M
Steel for Structural Shapes for Use in Building Framing, ASTM A992/ A992M
Structural Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, ASTM A1011

Certified mill test reports or certified reports of tests made by the fabricator or a testing laboratory in accordance with ASTM A6/A6M, *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling* or A568/A568M, *Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for* as applicable, and the governing specification shall constitute sufficient evidence of conformity with one of the above ASTM standards. Additionally, the fabricator shall, if requested, provide an affidavit stating the structural steel furnished meets the requirements of the grade specified.

b. Unidentified Steel

Unidentified steel, if surface conditions are acceptable according to criteria contained in ASTM A6/A6M, is permitted to be used for unimportant members or details, where the precise physical properties and weldability of the steel would not affect the strength of the structure.

c. Heavy Shapes

For ASTM A6/A6M Group 4 and 5 rolled shapes to be used as members subject to primary tensile stresses due to tension or flexure, toughness need not be specified if splices are made by bolting. If such members are spliced using complete-joint-penetration groove welds, the steel shall be specified in the contract documents to be supplied with Charpy V-Notch (CVN) impact testing in accordance with ASTM A6/A6M, Supplementary Requirement S5. The impact test shall meet a minimum average value of 20 ft-lbs. absorbed energy at +70°F and shall be conducted by the producer in accordance with ASTM A673/A673M, with the following exceptions:

(1) 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.

(2) For shapes produced from ingots, tests shall be conducted on material selected from a location representing the top of each ingot or part of an ingot used to produce the product represented by these tests.

For plates exceeding 2-in. thick used for built-up cross-sections with bolted splices and subject to primary tensile stresses due to tension or flexure, material toughness need not be specified. If such cross-sections are spliced using complete-joint-penetration welds, the steel shall be specified in the contract documents to be supplied with Charpy V-Notch testing in accordance with ASTM A6/A6M, Supplementary Requirement S5 for the Charpy V-Notch Impact Test for Structural Shapes: Alternate Core Location. The impact test shall be conducted by the producer in accordance with ASTM A673/A673M, Frequency P, and shall meet a minimum average value of 20 ft-lbs. absorbed energy at +70°F.

The above supplementary toughness requirements shall also apply when complete-joint-penetration welded joints through the thickness of ASTM A6/A6M Group 4 and 5 shapes and built-up cross sections with thickness exceeding 2 in. are used in connections subjected to primary tensile stress due to tension or flexure of such members. The requirements need not apply to ASTM A6/A6M Group 4 and 5 shapes and built-up members with thickness exceeding two in. to which members other than ASTM A6/A6M Group 4 and 5 shapes and built-up members are connected by complete-joint-penetration welded joints through the thickness of the thinner material to the face of the heavy material.

Additional requirements for joints in heavy rolled and built-up members are given in Sections J1.7, J1.8, J2.6, J2.7 and M2.2.

d. Design Wall Thickness of Hollow Structural Sections

The design wall thickness t shall be used in calculations involving the wall thickness of hollow structural sections. The design wall thickness, t, shall be taken equal to 0.93 times the nominal wall thickness for electric-resistance-welded (ERW) HSS and equal to the nominal thickness for submerged-arc-welded (SAW) HSS.

2. Steel Castings and Forgings

Cast steel shall conform to one of the following standard specifications:

Steel Castings, Carbon, for General Application, ASTM A27/A27M, Gr. 65-35 (450-240)
Steel Castings, High Strength, for Structural Purposes, ASTM A148/148M Gr. 80-50 (550-345)

Steel forgings shall conform to the following standard specification:

Steel Forgings Carbon and Alloy, for General Industrial Use, ASTM A668/A668M

Certified test reports shall constitute sufficient evidence of conformity with standards.

Allowable stresses shall be the same as those provided for other steels, where applicable.

3. Bolts, Washers, and Nuts

Steel bolts, washers, and nuts shall conform to one of the following standard specifications:

Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both, ASTM A194/A194M
Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength, ASTM A307
Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength, ASTM A325
High-Strength Bolts for Structural Steel Joints [Metric], ASTM A325M
Quenched and Tempered Steel Bolts and Studs, ASTM A449
Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength, ASTM A490
High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints [Metric], ASTM A490M
Carbon and Alloy Steel Nuts, ASTM A563
Hardened Steel Washers, ASTM F436
Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, ASTM F959
Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners [Metric], ASTM F959M
“Twist Off” Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength, ASTM F1852

ASTM A449 bolts are permitted only in connections requiring bolt diameters greater than 1½-in. and shall not be used in slip-critical connections.

Manufacturer’s certification shall constitute sufficient evidence of conformity with the standards.

4. Anchor Rods and Threaded Rods

Anchor rods and threaded rod steel shall conform to one of the following standard specifications:

Carbon Structural Steel, ASTM A36/A36M

Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service, ASTM A193/A193M

Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners, ASTM A354

High-Strength Low-Alloy Columbium-Vanadium Structural Steel, ASTM A572/A572M

High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4-in. [100 mm] Thick, ASTM A588/A588M

Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength, ASTM F1554

Threads on anchor rods and threaded rods shall conform to the Unified Standard Series of ASME B18.2.6 and shall have Class 2A tolerances.

Steel bolts conforming to other provisions of Section A3.3 are permitted as anchor rods.

Manufacturer's certification shall constitute sufficient evidence of conformity with the standards.

5. Filler Metal and Flux for Welding

Filler metals and fluxes shall conform to one of the following specifications of the American Welding Society:

Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding, AWS A5.1

Specification for Low-Alloy Steel Covered Arc Welding Electrodes for Shielded Metal Arc Welding, AWS A5.5

Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding, AWS A5.17/A5.17M

Specification for Carbon Steel Filler Metals for Gas Shielded Arc Welding, AWS A5.18

Specification for Carbon Steel Electrodes for Flux Cored Arc Welding, AWS A5.20

Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding, AWS A5.23/A5.23M

Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag Welding, AWS A5.25/A5.25M

Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding, AWS A5.26/A5.26M

Specification for Low-Alloy Steel Filler Metals for Gas Shielded Arc Welding, AWS A5.28

Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding, AWS A5.29
Specification for Welding Shielding Gases, AWS A5.32/A5.32M

Filler metals and fluxes that are suitable for the intended application shall be selected.

Filler metal with a specified Charpy V-Notch toughness with a minimum of 20 ft-lbs at 40°F shall be used in the following joints:

(a) Complete-joint-penetration groove welded T and corner joints with steel backing left in place subject to tension normal to the effective area.

If filler metal without the required toughness is used and the backing bar is left in place, the joint shall be sized for tension normal to the effective area using the allowable stress specified in Table J2.5 for a partial-joint-penetration groove weld.

(b) Complete-joint-penetration groove welded splices subject to tension normal to the effective area in Group 4 and Group 5 shapes and shapes built up by welding plates more than 2 in. thick.

Manufacturer's certification shall constitute sufficient evidence of conformity with the standards.

6. Stud Shear Connectors

Steel stud shear connectors shall conform to the requirements of *Structural Welding Code—Steel*, AWS D1.1.

Manufacturer's certification shall constitute sufficient evidence of conformity with the code.

A 4. LOADS AND LOAD COMBINATIONS

The nominal loads and load combinations shall be as stipulated by the applicable code under which the structure is designed or dictated by the conditions involved. In the absence of a code, the loads, including impact and crane loads, and load combinations, shall be those stipulated in ASCE 7. For design purposes, the loads stipulated by the applicable code or ASCE 7 shall be taken as nominal loads.

A 5. DESIGN BASIS

1. Allowable Stresses

Except as provided in Chapter N, all structural members, connections and connectors shall be proportioned so the stresses due to the load combinations stipulated in Section A4 do not exceed the allowable stresses specified in Chapters D through K. The allowable stresses specified in these chapters do not apply to peak stresses in regions of connections (see also Sect. B9) provided the requirements of Chapter K are satisfied.

For provisions pertaining to plastic design, refer to Chapter N.

2. Structural Analysis

The stresses in members, connections and connectors shall be determined by structural analysis for the loads stipulated in Sect. A4. Selection of the method of analysis is the prerogative of the responsible engineer.

a. Braced Frames

The vertical bracing system for a braced multistory frame shall be determined by structural analysis to be adequate to prevent buckling of the structure and to maintain the lateral stability of the structure, including the overturning effects of drift, under the load combinations stipulated in Section A4.

It is permitted that the vertical bracing system for a braced multistory frame be considered to function together with in-plane shear-resisting exterior and interior walls, floor slabs, and roof decks, that are properly secured to the structural frames. The columns, girders, beams, and diagonal members, when used as the vertical bracing system, are permitted to be considered to comprise a vertically cantilevered simply connected truss in the analyses for frame buckling and lateral stability. Axial deformation of all members in the vertical bracing system shall be included in the lateral stability analysis.

b. Unbraced Frames

The destabilizing effects of gravity loaded columns whose simple connections to the frame do not provide resistance to lateral loads shall be included in the design of the columns of unbraced frames. Stiffness reduction adjustment due to column inelasticity is permitted.

Second-order analysis of the stresses in unbraced multistory frames shall include the effects of frame instability and column axial deformation under the load combinations stipulated in Section A4 at ultimate strength levels.

3. Design for Serviceability and Other Considerations

The overall structure and the individual members, connections and connectors shall be checked for serviceability in accordance with Chapter L.

A6. REFERENCED CODES AND STANDARDS

Where codes and standards are referenced in this Specification, the editions of the following listed adoption dates are intended:

ACI International (ACI)
Building Code Requirements for Structural Concrete and Commentary, ACI 318-99
Metric Building Code Requirements for Structural Concrete and Commentary, ACI 318M-99

American Institute of Steel Construction, Inc. (AISC)
Code of Standard Practice for Steel Buildings and Bridges, 2000
Load and Resistance Factor Design Specification for Structural Steel Buildings, 1999
Seismic Provisions for Structural Steel Buildings, 1997
Seismic Provisions for Structural Steel Buildings Supplement No. 2, 2000
Specification for Allowable Stress Design of Single-Angle Members, 1993
Specification for the Design, Fabrication and Erection of Steel Safety Related Structures for Nuclear Facilities, 1994

American Iron and Steel Institute (AISI)
Specification for the Design of Cold-Formed Steel Structural Members, 1996, *including Supplement No. 1,* 1999

American Society of Civil Engineers (ASCE)
Minimum Design Loads for Buildings and Other Structures, ASCE 7-98

American Society of Mechanical Engineers (ASME)
Fasteners for Use in Structural Applications, ASME B18.2.6-96

Surface Texture, Surface Roughness, Waviness, and Lay, ASME B46.1-85

American Society for Testing and Materials (ASTM)

ASTM A6/A6M-01	ASTM A27/A27M-95 (2000)
ASTM A36/A36M-00a	ASTM A53/A53M-01
ASTM A148/A148M-01	ASTM A193/A193M-01a
ASTM A194/A194M-01	ASTM A242/A242M-00a
ASTM A307-00	ASTM A325-00
ASTM A325M-00	ASTM A354-01
ASTM A370-97a	ASTM A449-00
ASTM A490-00	ASTM A490M-00
ASTM A500-01	ASTM A501-01
ASTM A514/A514M-00a	ASTM A529/A529M-00
ASTM A563-00	ASTM A563M-00
ASTM A568/568M-00b	ASTM A572/A572M-00a
ASTM A588/A588M-00a	ASTM A606-98
ASTM A618- 01	ASTM A668/A668M-96e1
ASTM A673/A673M-95	ASTM A709/A709M-01
ASTM A751-96	ASTM A847-99a
ASTM A852/A852M-00a	ASTM A913/A913M-00a
ASTM A992/A992M-00	ASTM A1011/A1011M-01e1
ASTM C33-01	ASTM C330-00
ASTM F436-93(2000)	ASTM F436M-93(2000)
ASTM F606-00	ASTM F606M-93
ASTM F959-01	ASTM F959M-01
ASTM F1554-99	ASTM F1852-00

American Welding Society (AWS)

AWS D1.1: 2000	AWS A5.1-91
AWS A5.5-96	AWS A5.17/A5.17M-98
AWS A5.18-93	AWS A5.20-95
AWS A5.23/A5.23M-97	AWS A5.25/A5.25M-97
AWS A5.26/A5.26M-97	AWS A5.28-96
AWS A5.29-98	AWS A5.32/A5.32M-97

Research Council on Structural Connections (RCSC)
Specification for Structural Joints Using ASTM A325 or A490 Bolts, 2000

A7. DESIGN DOCUMENTS

The design drawings shall show a complete design with sizes, sections, and relative locations of all members. Floor levels, column centers and offsets shall be dimensioned. Drawings shall be drawn to a scale large enough to show the information clearly.

Design documents shall indicate the type or types of construction as defined in Section A2 and shall include the loads and design requirements necessary for preparation of shop drawings including shears, moments and axial forces to be resisted by all members and their connections.

Where joints are to be assembled with high-strength bolts, the design documents shall indicate the connection type (i.e., snug-tightened, pretensioned, or slip-critical).

Camber of trusses, beams, and girders, if required, shall be specified in the design documents. The requirements for stiffeners and bracing shall be shown on the design documents.

Welding and inspection symbols used on design and shop drawings shall be the American Welding Society symbols. Welding symbols for special requirements not covered by AWS are permitted to be used provided complete explanations thereof are shown in the design documents.

Weld lengths called for in the design documents and on the shop drawings shall be the net effective lengths.

II. Section I5.2

Add the following to Section I5.2:

"Where there is only a single stud placed in a rib oriented perpendicular to the steel beam, the reduction factor of Equation I5-1 shall be limited as follows:

$$\frac{0.85}{\sqrt{N_r}}\left(w_r / h_r\right)\left[\left(H_s / h_r\right) - 1.0\right] \leq 0.75 \qquad \text{(I5-1a)"}$$

III. Section J3.6

Revise Section J3.6 as follows:

"6. Combined Tension and Shear in Slip-critical Joints

For A325 and A490 bolts used in slip-critical connections, the maximum shear stress allowed by Table J3.2 shall be multiplied by the reduction factor $(1 - f_t A_b / T_b)$, where f_t is the average tensile stress due to a direct load applied to all of the bolts in a connection and T_b is the pretension load of the bolt specified in Table J3.7."

IV. Section K1.2

Revise the definition of P_{bf} to read as follows:

"P_{bf} = the computed force delivered by the flange or moment connection plate multiplied by 5/3, kips"

Delete the footnote corresponding to the old definition.

V. Commentary Chapter A

Replace Commentary Chapter A with the following:

CHAPTER A

GENERAL PROVISIONS

Supplement No. 1 to the *Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design* (ASD Specification), June 1, 1989 is a limited supplement intended to serve as a bridge to and in anticipation of a complete integration of ASD with LRFD criteria within a single AISC Specification in the near future. Other provisions in the existing 1989 ASD Specification have not been made fully consistent with the 1999 *Load and Resistance Factor Design Specification for Structural Steel Buildings*, which contains the latest provisions for all aspects of design of structural steel buildings, such as shear lag, stability bracing, flanges and webs under concentrated forces, evaluation of existing structures, and fatigue criteria. The bolting provisions have been updated simply by reference to the 2000 RCSC Specification in Section A1.

This Supplement includes the following: updated code and specification references, such as the current AISC provisions for seismic design and the design of hollow structural sections (HSS), the RCSC Specification, ASCE 7, AWS D1.1, ASTM A913 and A992; new filler metal toughness and shape material toughness criteria for certain conditions; and expanded structural analysis requirements that are all consistent with prevailing steel design requirements. This supplement is not intended to provide a complete metric conversion. Metric standards are only included when designated as such by other organizations such as ASTM or AWS.

This Supplement also deletes all explicit loading requirements, other than by reference to the governing building code and ASCE 7, and removes the separate 1/3 stress increase allowance. The latter effect is more properly included within the current service load combination requirements of ASCE 7.

A 2. TYPES OF CONSTRUCTION

In order that adequate instructions can be issued to fabrication and erection personnel, the basic assumptions underlying the design must be thoroughly understood by all concerned. These assumptions are classified under three separate but generally recognized types of construction.

A 3. MATERIAL

1. Structural Steel

a. ASTM Designations

The grades of structural steel approved for use under the Specification, covered by ASTM standard specifications, extend to a yield stress of 100 ksi. Some of these ASTM standards specify a minimum yield point, while others specify a minimum yield strength. The term “yield stress” is used in the Specification as a generic term to denote either the yield point or the yield strength.

Several new ASTM designations are included in this Supplement. In particular, ASTM A992 (formerly referred to as A572 with Special Requirements as per AISC Technical Bulletin #3) has been added to the list of structural steels. It is recommended that A992 Grade 50 be specified for W shapes in place of A572 Grade 50 or A36. A992 has a more specific material definition, in that it stipulates an upper limit on yield strength of 65 ksi, a minimum tensile strength of 65 ksi, a specified maximum yield-to-tensile ratio of 0.85, and a specified maximum carbon equivalent of 0.47 percent or 0.45 percent, depending on the shape Group.

It is important to be aware of limitations of availability that may exist for some combinations of strength and size. Not all structural section sizes are included in the various material specifications. For example, the 60-ksi yield strength steel in the A572/A572M specification includes plate only up to 1¼-in. in thickness. Another limitation on availability is that even when a product is included in the specifications, it may be infrequently produced by the mills. Specifying these products may result in procurement delays or require ordering large quantities directly from the producing mills. Consequently, it is prudent to check availability before completing the details of a design.

Provisions of the Specification are based on providing a factor of safety against reaching yield stress in primary connected material at allowable loads. The direction parallel to the direction of rolling is the direction of principal interest in the design of steel structures. Hence, yield stress as determined by the standard tensile test is the principal mechanical property recognized in the selection of the steels approved for use under the Specification. It must be recognized that other mechanical and physical properties of rolled steel, such as anisotropy, ductility, notch toughness, formability, and corrosion resistance may also be important to the satisfactory performance of a structure. In such situations, the user of the Specification is advised to make use of reference material contained in the literature on the specific properties of concern and to specify supplementary material production or quality requirements as provided for in ASTM material specifications. One such situation, for example, is the design of highly restrained welded connections (AISC, 1973). Rolled steel is anisotropic, especially insofar as ductility is concerned; therefore weld contraction strains in the region of highly restrained welded connections may exceed the capabilities of the material if special attention is not given to material selection, details, workmanship and inspection.

Another special situation is that of fracture control design for certain types of service conditions (Barsom and Rolfe, 1999). The relatively warm temperatures of steel in buildings, the essentially static strain rates, the stress intensity and the number of cycles of full allowable stress make the probability of fracture in building structures extremely remote. Good details, which incorporate joint geometry that avoids severe stress concentrations and good workmanship, are generally the most effective means to provide fracture-resistant construction. However, for especially demanding service conditions, such as low temperatures with impact loading, the specification of steels with adequate notch toughness should be specified.

For rotary-straightened W-shapes, an area of reduced notch toughness has been documented in a limited region of the web immediately adjacent to the flange as illustrated in Figure C-A3.2. Preliminary recommendations have been issued (AISC, 1997a) and AISC is currently exploring the associated implications for design and construction. More recently, the results of additional research have been published (Dexter, Prochnow, and Perez, 2001; Dexter, Hajjar, Prochnow, Graeser, Galambos, and Cotton, 2001).

c. Heavy Shapes

The web-to-flange intersection and the web center of heavy hot-rolled shapes, as well as the interior portions of heavy plates, may contain a coarser grain structure and/or lower toughness than other areas of these products. This is probably caused by segregation, as well as somewhat less deformation during hot rolling, higher finishing temperature and a slower cooling rate after rolling. This characteristic is not detrimental to suitability for service as compression members or non-welded members. However when heavy sections are fabricated using full-penetration welds, tensile strains induced by thermal cutting of the weld access hole and by weld shrinkage may result in cracking. For critical applications such as primary tension members, material should be produced to provide adequate toughness. Because of differences in the strain rate between the Charpy V-Notch (CVN) impact test and the strain rate experienced in actual structures, the CVN test is conducted at a temperature higher than the anticipated service temperature for the structure. The location of the CVN test is shown in Figure C-A3.1.

The toughness requirements of Section A3.1c are intended only to provide material of necessary toughness for ordinary service application. For unusual applications and/or low temperature service, more restrictive requirements and/or toughness requirements for other section sizes and thickness may be appropriate.

To minimize the potential for fracture, the notch toughness requirements of Section A3.1c must be used in conjunction with good design and fabrication procedures. Specific requirements are given in Sections J1.7, J1.8, J2.6, J2.7 and M2.2.

d. Design Wall Thickness of Hollow Structural Sections

The specification of a "design" wall thickness for hollow structural sections (HSS) originated in the *Specification for the Design of Hollow Structural Sections* (AISC, 1997b). ASTM A500 tolerances allow for a wall thickness that is not greater than plus/minus 10 percent of the nominal value. Because the plate and strip from which electric-resistance-welded (ERW) HSS are made is produced consistently to a wall thickness that is near the lower-bound wall thickness limit, AISC and the Steel Tube Institute of North America (STI) recommend that 0.93 times the nominal wall thickness should be used for calculations involving engineering design properties of ERW HSS. Submerged-arc-welded (SAW) HSS are produced with a wall thickness that is near the nominal thickness and require no such reduction. The design wall thickness and section properties based upon the reduced thickness have been tabulated in AISC and STI publications since 1997.

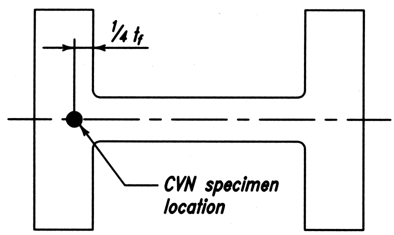

Fig. C-A3.1. Location from which Charpy impact specimen shall be taken.

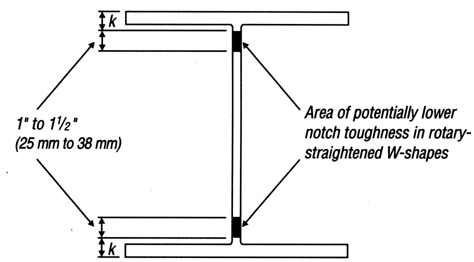

Fig. C-A3.2. "k-area."

5. Filler Metal and Flux for Welding

The filler metal specifications issued by the American Welding Society (AWS) are general specifications that include filler metals suitable for building construction, as well as consumables that would not be suitable for building construction. For example, some electrodes covered by the specifications are specifically limited to single pass applications, while others are restricted to sheet metal applications. Many of the filler metals listed are "low hydrogen," that is, they deposit filler metal with low levels of diffusible hydrogen. Other materials are not. Filler metals listed under the various AWS A5 specifications may or may not have required impact toughness, depending on the specific electrode classification. This supplement identifies certain welded joints where notch toughness of filler metal is needed in building construction. Applied stresses and residual stresses associated with notch effects and geometrical discontinuities from back-up bars contribute to the sensitivity of the weld to fracture. Some filler metals in combination with certain procedures result in welds with low notch toughness. The specification requires a minimum specified toughness in joints that are subject to primary applied stresses and may be sensitive to toughness demands. On structures subject to dynamic loading, filler metals may be required to deliver notch-tough weld deposits. Filler metals may be classified in either the as-welded or post weld heat-treated (stress-relieved) condition. Since most structural applications will not involve stress relief, it is important to utilize filler materials that are classified in conditions similar to those experienced by the actual structure.

When specifying filler metal and/or flux by AWS designation, the applicable standard specifications should be carefully reviewed to assure a complete understanding of the electrode designation. This is necessary because the AWS designation systems are not consistent. For example, in the case of electrodes for shielded metal arc welding (AWS A5.1), the first two or three digits indicate the nominal tensile strength classification, (in ksi) of the weld material and the final two digits indicate the type coating. However, in the case of carbon steel electrodes for submerged arc welding (AWS A5.17), the first one or two digits times 10 indicates the nominal tensile strength classification, and the final digit or digit times –10 indicates the testing temperature, in degrees F, for filler metal impact tests. In the case of low-alloy steel covered arc welding electrodes (AWS A5.5), certain portions of the designation indicate a requirement for stress relief, while others indicate no stress relief requirement.

A 4. LOADS AND LOAD COMBINATIONS

The specification does not presume to establish the loading requirements for which structures should be designed. In most cases these are adequately covered in the applicable local building codes. Where this is not the case, the generally recognized standards of ASCE 7 are recommended as the basis for design. The latest edition of the ASCE 7 standard on structural loads released in 1998 has adopted, in most aspects, the seismic design provisions from NEHRP (1997), as has the AISC *Seismic Provisions for Structural Steel Buildings* (AISC, 1997c). AISC *Seismic Provisions for Structural Steel Buildings Supplement No. 2* (AISC, 2000) has incorporated most aspects of the more recent NEHRP 2000 Provisions (NEHRP, 2000). The reader is referred to the commentaries to these documents for an expanded discussion on seismic loads, load factors, and seismic design of steel buildings.

A 5. DESIGN BASIS

The separate 1/3 stress increase allowance for wind and seismic loading has been removed. The nominal loads and load combinations shall be as stipulated in Section A4.

1. Allowable Stresses

The allowable stresses contained within the Specification are to be compared with stresses determined by analysis of the effects of the load combinations stipulated by the applicable building code upon the structure. The factor of safety inherent in the allowable stresses provide for the uncertainties that are associated with typical simplifying assumptions and the use of nominal or average calculated stresses as the basis for manual methods of analysis. It is not intended that highly localized peak stresses that may be determined by sophisticated computer-aided methods of analysis, and which may be blunted by confined yielding, must be less than the stipulated allowable stresses. The calculated stresses to be compared with the allowable stresses should be nominal stresses determined by appropriate analysis methods and not “hot spot” stresses which might be determined by finite element analysis using a mesh finer than approximately one foot (AWS, 2002). The exercise of engineering judgment is required.

In keeping with the inclusion of high strength low-allow steels, the Specification recognizes high strength steel castings. Allowable stresses are expressed in terms of the specified minimum yield stress for castings.

2. Structural Analysis

Certain issues that must be considered in the analysis of braced and unbraced frames are provided. The requirements for unbraced frame analysis stipulate the inclusion of second order effects due to gravity loading, which may not be fully captured in some cases by the strict interpretation of the traditional beam-column interaction equations of Chapter H. This so-called story buckling response needs to be properly assessed through appropriate analysis techniques and/or modified member sway amplification of first order analysis results (analogous to the B_2 factor in the AISC LRFD Specification (AISC, 1999)). For further discussion and information on such second order frame effects, see Geschwindner (2000).

VI. Commentary Section I5

Replace the seventh paragraph (beginning “Based upon all tests,…”) of Commentary Section I5 with the following:

“The strength of stud connectors installed in the ribs of concrete slabs on formed steel deck with the ribs oriented perpendicular to the steel beam is reasonably estimated by the strength of stud connectors in flat soffit composite slabs multiplied by values computed from Equation I5-1.

This Supplement includes a new upper limit of 0.75 on the reduction factor of Equation I5-1 for single studs located in deck ribs oriented perpendicular to the beam. This limit has been imposed as a temporary measure in response to a mounting set of test data (e.g., Easterling, Gibbings, and Murray, 1993; Kemp and Trinchero, 1997) that indicates that stud strengths calculated by the product of Equations I5-1 and the tabulated values in Table I4.1 may be unconservative when a single stud per rib is used. Research to further resolve this issue and to assess whether stud pairs are also affected is currently underway. Differences between recent test results and those originally used to develop Equation I5-1 for ribbed decks (Grant et al., 1977) appear to be due to the fact that (1) most of the earlier tests reported by Grant et al. were for beams with studs placed in pairs centered within the ribs, (2) stud strengths used to originally calibrate Equation I5-1 were back calculated from moment strengths of beam specimens which tend to mask variations in the stud strengths, and (3) differences in modern steel deck profiles that affect the placement of studs in the rib.”

VII. Commentary Section J3.6

Add the following to Commentary Section J3.6:

“This deletion is consistent with removal of the 1/3 stress increase allowance.”

VIII. Commentary Section K1.2

Add the following new Commentary Section K1.2:

“This change is consistent with the removal of the 1/3 stress increase allowance.”

IX. References

Add the following new References to the Commentary:

American Institute of Steel Construction, Inc. (AISC) (1997a), "k-area Advisory Statement," *Modern Steel Construction*, February.

American Institute of Steel Construction, Inc. (AISC) (1997b), *Specification for the Design of Hollow Structural Sections*, AISC, Chicago, IL, April 15.

American Institute of Steel Construction, Inc. (AISC) (1997c), *Seismic Provisions for Structural Steel Buildings,* AISC, Chicago, IL.

American Institute of Steel Construction, Inc. (AISC) (1999), *Load and Resistance Factor Design Specification for Structural Steel Buildings*, AISC, Chicago, IL, December 27.

American Institute of Steel Construction, Inc. (AISC) (2000), *Seismic Provisions for Structural Steel Buildings Supplement No. 2,* AISC, Chicago, IL, November 10.

American Welding Society (2002), *Structural Welding Code-Steel*, ANSI/AWS D1.1-2002, Miami, FL.

Barsom, J. M. and Rolfe, S. T. (1999), *Fracture and Fatigue Control in Structures*, 3rd Ed., Prentice-Hall, Inc., Englewood Cliffs, NJ.

Dexter, R. J., Hajjar, J. F., Prochnow, S. D., Graeser, M. D., Galambos, T. V., and Cotton, S. C. (2001), "Evaluation of the Design Requirements for Column Stiffeners and Doublers and the Variation in Material Properties," *Proceedings*, 2001 North American Steel Construction Conference, AISC, Chicago, IL.

Dexter, R. J., Prochnow, S. D., and Perez, M. I. (2001), "Constrained Through-thickness Strength of Column Flanges of Various Grades and Chemistries," *Engineering Journal*, 4th Quarter, AISC, Chicago, IL.

Easterling, W. S., Gibbings, D. R., and Murray, T. M. (1993), "Strength of Shear Studs in Steel Deck on Composite Beams and Joists," *Engineering Journal*, AISC, Vol. 30, No. 2, 2nd Quarter, pp. 44-55.

Federal Emergency Management Agency (2000), *NEHRP (National Earthquake Hazards Reduction Program) Recommended Provisions for Seismic Regulations for New Buildings,* FEMA, Washington, D.C.

Geschwindner (2000), "2000 T.R. Higgins Lecture: A Practical Look at Frame Analysis, Stability and Leaning Columns," *Proceedings*, 2000 North American Steel Construction Conference, American Institute of Steel Construction, Inc., Chicago, IL.

Kaufmann, E. J., Metrovich, B., Pense, A. W., and Fisher, J. W. (2001), "Effect of Manufacturing Process on k-Area Properties and Service Performance," *Proceedings,* 2001 North American Steel Construction Conference, American Institute of Steel Construction, Inc., Chicago, IL.

Kemp, A. R. and Trinchero, P. E. (1997), "Horizontal Shear Failures Around Connectors Used With Steel Decking," *Composite Construction in Steel and Concrete III,* ASCE, pp. 104-118.

Uang, C.-M. (2001), "Effect of Rotary-Straightening on Cyclic Behavior of k-Area in Steel Columns," *Proceedings,* 2001 North American Steel Construction Conference, American Institute of Steel Construction, Inc., Chicago, IL.

Delete the reference Rolfe and Barsom (1987).

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