ENGINEERING STANDARD

FOR

STEEL STRUCTURES

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1. SCOPE

This Engineering Standard gives minimum requirements for the design of steel structures for buildings including those intended for use in oil refineries, petrochemical and gas plants and, where applicable, in exploration, production and other new ventures.

It covers requirements for the design and selection of materials for land based steel structures such as buildings, equipment-supporting or pipe-supporting structures, operating platforms, accessways, etc.

2. REFERENCES

In this Standard the following standards and codes have been referred to, and to the extent specified, form a part of this Standard.

AISC (AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC.)

Manual of Steel Construction, 9th Edition, 1989, Part 5 "Specifications and Codes"

ANSI (AMERICAN NATIONAL STANDARDS INSTITUTE, INC.)

A 58.1-82 "Minimum Design Loads for Building and Other Structures"

AWS (AMERICAN WELDING SOCIETY)

AWS D1.1-88 "Structural Welding Code-Steel"

ISIRI (INSTITUTE OF STANDARDS AND INDUSTRIAL RESEARCH OF IRAN)

ISIRI 519 "Minimum Required Loads for Buildings and Other Structures"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-CE-500 "Loads"
IPS-E-TP-270 "Protective Coating"

3. DEFINITIONS AND TERMINOLOGY

3.1 Technical Definitions

For the general listing of technical definitions related to this Standard refer to Part 5, pages 5-213 thru 5-220 of AISC Manual of Steel Construction, 9th Edition, 1989.

3.2 Legal and Contractual Words

- Shall and Should- the word "shall" is to be understood as mandatory and the word "should" as strongly recommended to comply with the requirements of this Standard.

- The Owner is the party which, initiates the project and ultimately pays for its design and construction. The Owner will generally specify the technical requirements. The Owner may also include an agent or consultant, authorized to act for the principal.

- AR designates the Authorized Representative of the Owner.

- The Consultant is the party which carries out all or part of the design, and sometimes, the supervision on behalf of the Owner.

- The Contractor is the party which carries out all or part of the design, engineering, procurement, construction and commissioning for the project. The Owner may sometimes undertake all or part of the duties of the Contractor.

- The Manufacturer/Supplier is the party which manufactures or supplies materials and/or equipment, and performs services or duties specified by the consultant or the Owner.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. SYMBOLS AND ABBREVIATIONS

For the designation of symbols used in this Standard refer to pages 5-201 thru 5-206, Part 5 of AISC Manual of Steel Construction, 9th Edition, 1989.

5.1 Conversion Factors

Formulas listed in Appendix 'A' of this Standard are in SI system, for which the following equivalents have been adopted for the conversion of FPS units used throughout the AISC Manual of Steel Construction:

UNITS UTILIZED

IN AISC MANUAL	IN THIS STANDARD
in^2	mm^2
ksi	MPa
in^4	mm^4
ft	m
in	mm
kip-ft	kN-m
kips	kN
in^3	mm^3

6. DESIGN CRITERIA

6.1 General

The design of a steel structure shall take into account not only the properties of the materials of construction and the calculated stresses for the members, but also the prevailing conditions of the local environment and the requirements at site, the details of construction, methods of erection and fabrication and their effect on cost, in order to achieve a safe and economic design.

In cases where it is necessary, the most stringent of the requirements of the national/local regulations applicable to the area concerned shall be taken and applied in such a way as to ensure a safe and economic design without overestimation.

To select the most economical type of structure for the application concerned, it is necessary to make an accurate estimate of the loads to be carried by the structure, and to design the details with reference to the ease of obtaining the materials, the cost of shipwreck, the cost of erection and the ease of access for maintenance. The aim should be for simplicity in design since this generally produces the most economical structure.

Where the design has been developed by the Owner, all loadings (dead loads, live loads, wind loads, etc.) and the main and detail dimensions shown on the relevant instruction drawing(s) forming part of the inquiry or purchase order shall be strictly adhered to. Deviations may be made only after approval in writing from the Owner. Where the supplier of the steel structure is to determine the dimensions of members from the loading specification provided by the Owner, he shall do so in accordance with this Engineering Standard.

6.2 Design Documents

6.2.1 Design drawings

The design drawings shall show a complete design with sizes, sections and relative locations of the various 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 Clause 6.3 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, design documents shall indicate the connection type (slip-critical, tension or bearing).

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

6.2.2 Shop drawings

Shop drawings giving complete information necessary for the fabrication of the component parts of the structure, including the location, type and size of all welds, bolts and rivets, shall be prepared in advance of the actual fabrication. These drawings shall clearly distinguish between shop and field welds and bolts and shall clearly identify type of high-strength bolted connection (snug-tight or fully-tightened bearing, or slip-critical).

Shop drawings shall be made in conformity with the best practice and with due regard to speed and economy in fabrication and erection.

6.2.3 Notation for welding

Notes shall be made in the design documents and on the shop drawings of those joints or groups of joints in which the welding sequence and technique of welding shall be carefully controlled to minimize distortion.

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

6.3 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 Rigid (or continuous) frames as used in indeterminate structural analysis.
Type 2 Simple ("pinned") framing. Connections are assumed to transmit no moment.
Type 3 Semirigid framing. Connections possess a known moment capacity.

6.4 Loads and Forces

The nominal loads shall be the minimum design loads stipulated by the applicable code under which the structure is designed or dictated by the conditions involved. The loads shall be those stipulated in IPS-E-CE-500.

6.4.1 Dead load and live load

The dead load to be assumed in design shall consist of the weight of steelwork and all materials permanently fastened thereto or supported thereby.

The live load, including snow load if any, shall be that stipulated by the applicable code under which the structure is being designed or that dictated by the conditions involved. Snow load shall be considered as applied either to the entire roof area or to a part of the roof area, and any probable arrangement of loads resulting in the highest stresses in the supporting members shall be used in the design.

6.4.2 Impact

For structures carrying live loads which induce impact, the assumed live load shall be increased sufficiently to provide for same. If not otherwise specified, the increase shall be not less than those specified in Clause 10.9 of IPS-E-CE-500 "Loads".

6.4.3 Wind and resistance to horizontal forces

Proper provision shall be made for stresses caused by wind, both during erection and after completion of the building.

6.4.3.1 General

a) When considering the effect of wind pressure on buildings, due allowance shall be made for the resistance and stiffening effects of floors, roofs and walls.

b) When the floors, roof and walls are incapable of transmitting the horizontal forces to the foundation, the necessary steel framework shall be provided to transmit the forces to the foundations. This framework may be in the form of triangulated bracing to members, portal construction or cantilevers which shall comprise all members necessary effectively to transmit the forces to the foundations.

Resistance to the wind forces on the sides and roof of a building shall be provided by horizontal or inclined bracing or beam systems designed to transmit the wind loads direct to the foundations or to intermediate transverse frames or to end frames, and those frames shall be designed to transmit the loads to the foundations.

Resistance to the wind forces on the ends and roof of a building shall likewise be provided by horizontal or inclined bracing or beam systems designed to transmit the wind loads to the side framing, and the side framing shall be braced to transmit these loads to the foundations, or, alternatively, the wind forces on the ends may be taken direct to the foundations by vertical cantilevers.

In buildings where high-speed travelling cranes are supported by the structure or where a building or structure may be otherwise subject to vibration or sway, triangulated bracing or especially rigid portal systems shall be provided to reduce the vibration or sway to a suitable minimum.

6.4.3.2 Stability

The stability of the structure as a whole, or of any part of it shall be investigated, and weight or anchorage shall be provided so that the least restoring moment, including anchorage, shall be not less than the sum of 1.4 times the maximum overturning moment due to dead loads and 1.6 times the maximum overturning moment due to imposed loads.

When considering wind loads, the restoring moment shall not be less than 1.4 times the overturning moment due to dead loads and wind loads, nor less than 1.2 times the overturning moment due to the combined effects of dead, imposed and wind loads.

To ensure stability at all times account shall be taken of probable variations in dead load during construction, repair or other temporary measures.

In complying with the requirements of this clause it is necessary to ascertain that the resulting pressures and shear forces to be communicated by the foundations to the supporting soil would not produce failure.

All parts of the structure which have been designed for their dead, imposed and wind loads to the allowable stresses in this Engineering Standard shall be deemed to be adequately covered for this margin of stability provided that no stress reversal takes place in the part when the loads contributing to the overturning moment are increased by the factors specified above whilst the loads contributing to the restoring moment remain unfactord.

6.4.3.3 Sway-stability

All structures including portions between expansion joints shall be adequately strong and stiff to resist sway. To ensure adequate strength in addition to designing for applied horizontal loads, a separate check shall be carried out for notional horizontal forces which can arise due to practical imperfections such as lack of verticality.

These notional horizontal forces shall be applied at each roof and floor level or their equivalent and shall be taken as equal to 0.5 percent of the sum of the dead and imposed gravity loads applied at that level, but not less than 1.0 percent of the dead load.

The notional horizontal forces shall be taken as acting simultaneously with the vertical loads. They shall be assumed to act in any one horizontal direction at a time.

Notional horizontal forces shall not be applied when:

Considering stability against overturning.
Applying wind loads or other horizontal loads.
Considering temperature effects.
Determining horizontal loads on foundations.

Whatever system is used to resist horizontal forces (see Sub-clause 6.4.3.1), reversal of loading shall be accommodated. Where floors, walls or roofs are used to provide sway stability, they shall have adequate strength and be so secured to the structural framework as to transmit all horizontal forces to points of sway resistance. Where such sway stability is to be provided by construction other than the steel framework, the need for such construction and the forces acting upon it shall be clearly stated.

6.4.4 Other forces

Structures in localities subject to earthquakes, hurricanes and other extraordinary conditions shall be designed with due regard for such conditions.

For seismic forces, reference is made to BHRC-Iranian Building Code Series, Publication No. 82: Iranian Code for Seismic Resistant Design of Buildings (also known as Standard No. 2800).

6.5 Design Basis

6.5.1 Load combination

Load combination for the design of structural steel shall be specified including design method. Unless otherwise specified, the allowable stress design method shall be adopted.

6.5.2 Allowable stresses

All structural members, connections and connectors shall be proportioned so that stresses due to the working loads do not exceed the allowable stresses specified in Clause 6.6. The allowable stresses specified in this clause do not apply to peak stresses in regions of connections (see also Sect. B9 of AISC), provided requirements of Appendix K4 of AISC Specifications are satisfied.

For provisions pertaining to plastic design, refer to Chapter N of AISC "Specification for Structural Steel Buildings".

6.5.3 Wind and seismic stresses

Allowable stresses may be increased 1/3 above the values otherwise provided when produced by wind or seismic loading, acting alone or in combination with the design dead and live loads, provided the required section computed on this basis is not less than that required for the design dead and live load and impact (if any) computed without the 1/3 stress increase, and further provided that stresses are not otherwise(1) required to be calculated on the basis of reduction factors applied to design loads in combinations. The above stress increase does not apply to allowable stress ranges provided in Appendix K4 of AISC Specifications.

Note:

(1) For example, see ANSI A58.1, Sect. 2.3.3.

6.5.4 Structural analysis

The stresses in members, connections and connectors shall be determined by structural analysis for the loads defined in Clause 6.4. Selection of the method of analysis is the prerogative of the responsible engineer.

6.5.5 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 of AISC Specifications.

6.6 Allowable Stresses

For allowable tensile, shear, compressive bending and combined stresses reference is made to relevant chapters of AISC Manuals Part 5 "Specifications and Codes", and for equivalents of equations in SI units refer to Appendix "A" of this Standard.

6.7 Deflection

To overall structure and the individual members shall be checked for deflection.

7. SHOP PAINTING

7.1 General Requirements

Unless otherwise specified, steelwork which will be concealed by interior building finish need to be painted; steelwork to be encased in concrete shall not be painted. Unless specifically exempted, all other steelwork shall be given one coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned, in accordance with the following paragraph, by brush, spray, roller coating, flow coating, or dipping, at the election of the fabricator.

After inspection and approval and before leaving the shop, all steelwork specified to be painted shall be cleaned by hand-wire brushing, or by other methods elected by the fabricator, of loose mill scale, loose rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by solvent.

Steelwork specified to have no shop paint shall, after fabrication, be cleaned of oil or grease by solvent cleaners and be cleaned of dirt and other foreign material by thorough sweeping with a fiber brush.

The shop coat of paint is intended to protect the steel for only a short period of exposure, even if it is a primer for subsequent painting to be performed in the field by others.

7.2 Inaccessible Surfaces

Surfaces inaccessible after assembly shall be treated in accordance with Clause 7.1 before assembly.

7.3 Contact Surfaces

Contact surfaces shall be cleaned in accordance with Clause 7.1 before assembly but shall not be painted.

7.4 Finished Surfaces

Machine finished surfaces shall be protected against corrosion by a rust-inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

7.5 Surfaces Adjacent to Field Welds

Unless otherwise provided, surfaces within 50 mm of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

7.6 Technical Protection

For further information regarding shop painting refer to "A Guide to Shop Painting of Structural Steel", published jointly by the Steel Structures Painting Council (SSPC) and the American Institute of Steel Construction.

Reference is also made to IPS-E-TP-270 "Protective Coating".

8. MATERIALS

Materials conforming to one of the following standard specifications is approved for use under this Standard.

- Structural Steel:

ASTM A36,
A242,
A441,
A709,
A529,
A572,
A588

- Steel Plate:

ASTM A514,
A852

- Steel Sheet and Strip:

ASTM A570 Gr. 40, 45 and 50
A607

- High Strength Friction Type Bolts:

ASTM A325

- Carbon Steel Bolts and Studs:

ASTM A307

- Hardened Steel Washers:

ASTM F436

- Carbon and Alloy Steel Nuts:

ASTM A563

- Cast Steel:

ASTM A27, Gr. 65-35

- Steel Forgings:

ASTM A668

- Electrodes:

AWS A5.1
AWS A5.17

- Steel Pipe, Black:

ASTM A53, Gr.B

- Structural Tubing:

ASTM A500
ASTM A501
ASTM A618

- Steel Structural Rivets:

ASTM A502, Gr. 1 or 2

APPENDICES

APPENDIX A
IMPORTANT DESIGN FORMULAS OF AISC SPECIFICATIONS IN SI UNITS

The following design equations have been extracted from relevant Chapters of Part 5 of the Manual of Steel Construction, 9th Edition and their appropriate conversions in SI Units have been taken from "Structural Steel Design Data Manual "edited by Joseph E. Bowles, copyright 1980 by McGraw-Hill, Inc.

CHAPTER & RELATION No.	FPS UNIT	SI UNIT
(F1-2)	$\frac{76\ b_f}{12\sqrt{F_y}}$ or $\frac{20,000}{(12)(d/A_f)F_y}$ (ft)	$\frac{0.20\ b_f}{\sqrt{F_y}}$ or $\frac{139000}{F_y(d/A_f)}$ (m)
(F1-6)	When $\sqrt{\frac{102\times10^3 C_b}{F_y}} \le \frac{l}{r_T} \le \sqrt{\frac{510\times10^3 C_b}{F_y}}$ $F_b = \left[\frac{2}{3} - \frac{F_y\left(l/r_T\right)^2}{1530\times10^3 C_b}\right]F_y \le 0.60\ F_y$	When $840\sqrt{C_b/F_y} \le \frac{l}{r_T} \le 1880\sqrt{C_b/F_y}$ $F_b = \left[\frac{2}{3} - \frac{F_y\left(l/r_T\right)^2}{10.6\times10^6 C_b}\right]F_y \le 0.60\ F_y$
(F1-7)	When $\frac{l}{r_T} \ge \sqrt{\frac{510\times10^3 C_b}{F_y}}$ $F_b = \frac{170\times10^3 C_b}{\left(l/r_T\right)^2} \le 0.60\ F_y$	When $\frac{l}{r_T} \ge 1880\sqrt{C_b/F_y}$ $F_b = \frac{1.170\times10^6 C_b}{\left(l/r_T\right)^2}$
(F1-8)	For any value of l/r_T, $F_b = \frac{12\times10^3 C_b}{ld/A_f} \le 0.60F_y$	For any value of l/r_T, $F_b = \frac{82700\ C_b}{ld/A_f} \le 0.60\ F_y$

(to be continued)

APPENDIX A (continued)

CHAPTER & RELATION No.	FPS UNIT	SI UNIT
(F4-2)	$F_v = \frac{F_y}{2.89}(C_v) \le 0.40 F_y$ Where $C_v = \frac{45{,}000 k_v}{F_y (h/t_w)^2}$, When $C_v < 0.8$ $= \frac{190}{h/t_w}\sqrt{\frac{k_v}{F_y}}$, when $C_v > 0.8$ and $k_v = 4.00 + \frac{5.34}{(a/h)^2}$ when $a/h < 1.0$ $= 5.34 + \frac{4.00}{(a/h)^2}$ when $a/h > 1.0$	$F_v = \frac{F_y}{2.89}(C_v) \le 0.40 F_y$ Where $C_v = \frac{312{,}500 k_v}{F_y \left(h/t_w \right)^2}$, when $C_v < 0.8$ $= \frac{500}{h/t_w}\sqrt{k_v/F_y}$, when $C_v > 0.8$ value of k_v same as for FPS units
(G1-1)	$\frac{h}{t_w} \le \frac{14{,}000}{\sqrt{F_{yf}(F_{yf} + 16.5)}}$	$\frac{h}{t_w} \le \frac{97{,}100}{\sqrt{F_{yf}(F_{yf} + 114)}}$
(G1-2)	$\frac{h}{t_w} \le \frac{2{,}000}{\sqrt{F_{yf}}}$	$\frac{h}{t_w} \le \frac{5270}{\sqrt{F_{yf}}}$
(G2-1)	When $\frac{h}{t_w} > \frac{760}{\sqrt{F_b}}$ use $R_{PG} = F_b\left[1 - 0.0005\frac{A_w}{A_f}\left(\frac{h}{t} - \frac{760}{\sqrt{F_b}}\right)\right] \le 1.0$	When $\frac{h}{t_w} > \frac{2000}{\sqrt{F_b}}$ use $R_{PG} = F_b\left[1 - 0.0005\frac{A_w}{A_f}\left(\frac{h}{t} - \frac{2000}{\sqrt{F_b}}\right)\right] \le 1.0$
(G4-3)	$f_{vs} = h\sqrt{\left(\frac{F_y}{340}\right)^3}$ (kips/in)	$f_{vs} = h\sqrt{\left(\frac{F_y}{6.51}\right)^3}$ (kN/m)

(to be continued)

APPENDIX A (continued)

CHAPTER & RELATION No.	FPS UNIT	SI UNIT
APPENDIX B	for single angles:	
(A-B5-1)	When $76.0/\sqrt{F_y} < b/t < 155/\sqrt{F_y}$ reduction factor: $Q_s = 1.340 - 0.00447\,(b/t)\sqrt{F_y}$	When $200/\sqrt{F_y} < b/t < 409/\sqrt{F_y}$ $Q_s = 1.340 - 0.0017\,(b/t)\sqrt{F_y}$
(A-B5-2)	When $b/t \geq 155/\sqrt{F_y}$ $Q_s = 15{,}500/\left[F_y\,(b/t)^2\right]$	When $b/t \geq 409/\sqrt{F_y}$ $Q_s = 107600/\left[F_y\,(b/t)^2\right]$
	for angles or plates projecting from columns or other compression members:	
(A-B5-3) k_c=1.0	When $95.0/\sqrt{F_y} < b/t < 176/\sqrt{F_y}$ $Q_s = 1.415 - 0.00437\,(b/t)\sqrt{F_y}$	When $250/\sqrt{F_y} < b/t < 465/\sqrt{F_y}$ $Q_s = 1.415 - 0.00166\,(b/t)\sqrt{F_y}$
(A-B5-4) k_c=1.0	When $b/t > 176/\sqrt{F_y}$ $Q_s = 20000/\left[F_y\,(b/t)^2\right]$	When $b/t > 465/\sqrt{F_y}$ $Q_s = 139000/\left[F_y\,(b/t)^2\right]$
	for stems of tees:	
(A-B5-5)	When $127/\sqrt{F_y} < b/t < 176/\sqrt{F_y}$ $Q_s = 1.908 - 0.00715\,(b/t)\sqrt{F_y}$	When $335/\sqrt{F_y} < b/t < 176/\sqrt{F_y}$ $Q_s = 1.908 - 0.00271\,(b/t)\sqrt{F_y}$
(A-B5-6)	When $b/t \geq 176/\sqrt{F_y}$ $Q_s = 20000/\left[F_y\,(b/t)^2\right]$	When $b/t \geq 465/\sqrt{F_y}$ $Q_s = 833000/\left[F_y\,(b/t)^2\right]$
	for flanges of square and rectangular sections of uniform thickness:	
(A-B5-7)	reduced width, $b_e = \frac{253t}{\sqrt{f}}\left[1 - \frac{50.3}{(b/t)\sqrt{f}}\right] \leq b$	$b_e = \frac{670t}{\sqrt{f}}\left[1 - \frac{133}{(b/t)\sqrt{f}}\right] \leq b$
	for other uniformly compressed elements:	
(A-B5-8)	$b_e = \frac{253t}{\sqrt{f}}\left[1 - \frac{44.3}{(b/t)\sqrt{f}}\right] \leq b$	$b_e = \frac{670t}{\sqrt{f}}\left[1 - \frac{117}{(b/t)\sqrt{f}}\right] \leq b$