CANADIAN STANDARDS ASSOCIATION

S16-09

Design of steel structures

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Preface

This is the seventh edition of CSA S16, *Design of steel structures.* It supersedes the previous limit states editions published in 2001, 1994, 1989, 1984, 1978, and 1974. These seven limit states design editions were preceded by seven working stress design editions published in 1969, 1965, 1961, 1954, 1940, 1930, and 1924. The 1969 working stress design edition was withdrawn in 1984, from which point the design of steel structures in Canada has been carried out using limit states design principles.

This Standard is appropriate for the design of a broad range of structures. It sets out minimum requirements and is expected to be used only by engineers competent in the design of steel structures.

The 2001 edition of this Standard and its interim revision in 2005 involved significant rewriting. The intent of the 2009 edition is to make less significant changes while updating the Standard with current research and practice. Some specific changes to this Standard include the following:

(a) Annex K has been added to provide guidance for design under fire conditions.
(b) To be in line with CAN/CSA-A23.3, the resistance factor, ϕ, for concrete has been increased from 0.6 to 0.65 and α factor has been introduced to modify the stress block intensity. These changes have a minor influence on the resistance of composite beams and columns.
(c) Resistance expressions have been added to the flexural buckling of singly symmetric sections (e.g., channels, Tees, and angles) and the flexural buckling of asymmetric sections (e.g., built-up angles).
(d) Clause 13.3.3 has been added to provide guidance on the design of single-angle braces in compression.
(e) The calculation of the coefficient, ω_2, for unsupported beams with a moment gradient has been updated to reflect current research.
(f) The shear design provisions for beams without web stiffeners have been separated from web-stiffened beams.
(g) Clause 13.4.1.3 has been added for shear resistance of tubular members.
(h) Block shear requirements have been expanded and revised to better reflect recent test results.
(i) Clause 13.14 has been added to provide the resistance for bolts and welds in combination.
(j) Clause 15 for trusses, Clause 16 for open-web steel joists, and Clause 20 for plate walls have been reviewed and modified for practical considerations.
(k) Bending and axial compression plus bending requirements for composite columns have been rewritten.
(l) Clause 27.8 has been added to cover buckling restrained brace frames under seismic loading. These braces contain an internal steel core that can yield under axial load but is restrained such that it does not buckle in compression by a larger diameter shaft that does not participate in the axial resistance. These braces have similar response in compression and tension.
(m) The height limits for conventional construction (R_d = 1.5) have been extended, provided a variety of conditions are satisfied. The restrictions are such that this extension would mostly apply to industrial buildings.
(n) The criteria used for seismic design are now required to be stated on drawings.
(o) The concept of the "protected zone" for seismic systems has been introduced. The provision of protected zones will assist in preventing local failures during rapidly reversing seismic loads.
(p) The factor, R_y, applied to the specified yield stress of steels, has been increased for HSS brace members to reflect test results of the actual yield of members containing these sections.
(q) Minimum cross-section slenderness requirements for columns both in and outside the braced frames and buckling restrained braced frames in seismic active regions are now specified. The aim is to provide a degree of ductility for those columns that might experience bending moments due to movements of the building under seismic loading. Columns in single and multi-storey brace bay buildings are no longer class 4.
(r) A number of improvements and additions have been made for ductile eccentric braced frames and ductile plate walls. New seismic requirements have been introduced for limited-ductility plate walls.
(s) Infill panels of ductile plate walls may now have perforations and corner cut-outs.

(t) The bolt edge distances for plates cut with plasma, laser, and water jet are now the same as those cut with gas.
(u) All column bases now require a minimum of four anchor rods unless special precautions are taken.
(v) Annex L has been added to provide designers with guidance to reduce the risk of brittle fracture.

A commentary on this Standard, prepared by the Canadian Institute of Steel Construction with contributions from many members of the Technical Committee, comprises Part 2 of the Institute's *Handbook of Steel Construction*.

This Standard is intended to be used with the provisions of the 2010 edition of the *National Building Code of Canada (NBCC)*, specifically Clause 7, which references the *NBCC* for load factors, load combinations, and other loading provisions.

This Standard was prepared by the Technical Committee on Steel Structures for Buildings, under the jurisdiction of the Strategic Steering Committee for Structures (Design), and has been formally approved by the Technical Committee. It will be submitted to the Standards Council of Canada for approval as a National Standard of Canada.

September 2009

Notes:

(1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

(2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

(3) *This publication was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this publication.*

(4) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee.*

(5) *All enquiries regarding this Standard, including requests for interpretation, should be addressed to Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6.*

Requests for interpretation should

(a) define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;
(b) provide an explanation of circumstances surrounding the actual field condition; and
(c) be phrased where possible to permit a specific "yes" or "no" answer.

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are published in CSA's periodical* Info Update*, which is available on the CSA Web site at www.csa.ca.*

S16-09
Design of steel structures

1 Scope and application

1.1 General

This Standard provides rules and requirements for the design, fabrication, and erection of steel structures. The design is based on limit states. The term "steel structures" refers to structural members and frames that consist primarily of structural steel components, including the detail parts, welds, bolts, or other fasteners required in fabrication and erection. This Standard also applies to structural steel components in structures framed in other materials. The clauses related to fabrication and erection, serve to show that design is inextricably a part of the design-fabrication-erection sequence and cannot be considered in isolation. For matters concerning standard practice pertinent to the fabrication and erection of structural steel not covered in this Standard, see Annex A.

1.2 Requirements

Requirements for steel structures such as bridges, antenna towers, offshore structures, and cold-formed steel structural members are given in other CSA Standards.

1.3 Application

This Standard applies unconditionally to steel structures, except that supplementary rules or requirements may be necessary for

(a) unusual types of construction;
(b) mixed systems of construction;
(c) steel structures that
    (i) have great height or spans;
    (ii) are required to be movable or be readily dismantled;
    (iii) are exposed to severe environmental conditions;
    (iv) are exposed to severe loads such as those resulting from vehicle impact or explosion;
    (v) are required to satisfy aesthetic, architectural, or other requirements of a non-structural nature;
    (vi) employ materials or products not listed in Clause 5; or
    (vii) have other special features that could affect the design, fabrication, or erection;
(d) tanks, stacks, other platework structures, poles, and piling; and
(e) crane-supporting structures.

1.4 Other standards

The use of other standards for the design of members or parts of steel structures is neither warranted nor acceptable except where specifically directed in this Standard. The formulas provided in this Standard may be supplemented by a rational design based on theory, analysis, and engineering practice acceptable to the regulatory authority, provided that nominal margins (or factors) of safety at least equal to those intended in the provisions of this Standard are maintained. (See Annex B.)

1.5 Terminology

In CSA Standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; "may" is used to express an option or that which is permissible within the limits of the standard; and "can" is used to express possibility or capability. Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is