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CSA S16:19
National Standard of Canada

Design of steel structures

Standards Council of Canada
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REVISED DECEMBER 2019

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Revision History

CSA S16:19, Design of steel structures

Errata — December 2019	**Revision symbol (in margin)**
Technical Committee Clauses 5.1.3, 8.4.3.2, 12.4.2, 13.3.1.1, 13.3.1.2, 13.6.1, 13.11, 14.4.1, 17.9.3, 21.3, J.1.2, J.3, L.2.2.1, L.2.3, L.2.5, L.3.1, and L.3.2	Δ

Standards Update Service

CSA S16:19
September 2019

Title: *Design of steel structures*

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Standards Council of Canada
Conseil canadien des normes

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National Standard of Canada

CSA S16:19
Design of steel structures

Published in September 2019 by CSA Group
A not-for-profit private sector organization
178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3

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ICS 91.080.10
ISBN 978-1-4883-1548-0

Contents

Preface

This is the ninth edition of CSA S16, *Design of steel structures*. It supersedes the previous limit states editions published in 2014, 2009, 2001, 1994, 1989, 1984, 1978, and 1974. These 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 The 1969 working stress design edition was withdrawn in 1984, from which point the design of steel structures in Canada has been carried out using limit states design principles.

The following are the major changes to this edition:

a) Minor changes were made to the Scope to bring it into line with the Terms of Reference for CSA Technical Committee on Design of Steel Structures (A263).
b) Defined terms were unified and others added to improve clarity in interpreting the intent of the Standard. The consistent term “engineer” replaces occurrences of “designer”, “structural engineer”, “structural designer”, and “building designer” when intended to have the same meaning. The term “structural documents” is clarified and expanded to include models.
c) High-strength bolts are referenced using ASTM F3125/F3125M.
d) A more consistent distinction is made between specified (unfactored) and service (for assessing serviceability limit states) loads.
e) Inelastic analysis has been included as a defined analytical method with reference to new Annex O, which provides guidance for advanced structural analysis techniques.
f) Additional guidance is provided for stability analysis and design, also with a link to Annex O.
g) The factor U_2, accounting for P-Δ effects in frames, is expanded to account for load in columns of moment frames.
h) Width-to thickness class criteria have been added for multi-sided hollow sections and singly-symmetric I-sections. Wording in Tables 1 and 2 has been clarified.
i) The provisions for designing doubly-symmetric compression members have been restructured and condensed, in part to emphasise that torsional buckling should be considered, but there is no resulting change to the intent.
j) Provisions have been added for designing single angles as beams.
k) Wording has been improved pertaining to lateral-torsional buckling of doubly-symmetric beams with top flange loading.
l) Limits have been placed on the approximate equation for the parameter β_x used in the design of laterally unsupported singly-symmetric beams, notably to exclude T-sections.
m) Provisions have been added for designing built-in cantilevers, and general guidance is now included for the Gerber (cantilever and suspended span) roof system.
n) Use of HSS members as beam-columns is now explicitly supported.
o) The provisions for members in combined tension and bending have been expanded to include instances of biaxial bending and benefits for ductile behaviour.
p) Slip parameters are provided for hot-dip galvanized and metalized surfaces in Table 3 to reflect new test data.
q) Some modifications to the design provisions for fillet welds have been included to better address the effects of weld groups with welds in multiple orientations and welds for HSS.
r) The Standard now better accounts for the effects on flexural capacity of fastener holes in beams.
s) Provisions for accounting for the effect of thin webs on moment resistance and that of combined shear and moment have been improved.
t) Minor modifications have been made to the provisions for the design of plate walls for non-seismic loads.

u) A minimum design force has been specified for moment-connection stiffeners to reflect new research recommendations.
v) An interaction equation based on plasticity theory has been added for compact connection elements subjected to combined loads to reflect new research recommendations.
w) A detailed list of potential limit states has been included specifically for HSS connections.
x) The various types of bolt holes for imperial and metric bolts have been clarified using Table 5, which has also incorporated larger hole sizes for larger bolts, in part to accommodate ASTM upper diameter tolerances.
y) Provisions have been added related to fatigue resistance of stud shear connectors.
z) Seismic design has been addressed by the new standard for two new systems: moderately-ductile plate walls (Clause 27.10) and moderately-ductile truss moment-resisting frames (Annex L).
aa) Seismic design "triggers" requiring more ductile detailing where the seismic loads are greater have been defined by a series of five seismic categories based on the worst condition of short and long period cases. Throughout Clause 27 the detailing requirements now relate to these seismic categories rather than $I_E F_a S_a(0.2)$.
ab) Additional guidance is provided on multi-tiered bracing in which braces stack but do not have a diaphragm at the top and bottom of each bracing level.
ac) The Standard now requires that when using ASTM A500 material in seismic braces the nominal section properties be used for determining probable resistance, as using the reduced wall thickness might underestimate the forces on adjacent elements in the system.
ad) Additional guidance is provided for determining the seismic foundation rotations in accordance with *NBC* and CSA A23.3 and the concept and definitions for nominal overturning resistance are introduced.
ae) Additional guidance and clarity have been included for special seismic design to address systems not explicitly included as part of the NBC and Clause 27, with reference to Annex O for advanced analysis.
af) Material has been added pertaining to responsibilities and quality control for welding inspection.
ag) Provisions for control of brittle fracture have been moved in their entirety from an annex to the main body of the standard and updated to reflect current knowledge. Tables 11 to 15 have been added to provide Charpy V-notch impact energy and other related requirements.
ah) Annex K has been updated to reflect current knowledge on design for fire conditions, notably pertaining to utilization of membrane action and performance evaluation of individual members at elevated temperatures.
ai) Annex N has been developed considerably from the previous edition to bring the design of storage racks into compliance with the remainder of the Standard. Provisions for the design of selective-type storage racks consisting of concentrically braced frames in the down-aisle direction, racks with recessed legs, rack column splices, and welded wire rack decking, are included. Displacement-based seismic analysis and design is now explicitly permitted in the cross-aisle direction. Documentation and certification requirements for rack structures have been expanded.
aj) A new Annex P on third-party inspection has been included to provide guidance on what are deemed to be effective, yet reasonable, inspection requirements for steel structures.

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 2020 edition of the *National Building Code of Canada (NBC)*, specifically Clause 7, which references the *NBC* 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 Construction and Civil Infrastructure, and has been formally approved by the Technical Committee.

This Standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

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 Standard 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 Standard.*
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   c) *wording of the proposed change; and*
   d) *rationale for the change.*

CSA S16:19
Design of steel structures

1 Scope and application

1.1 General

This Standard provides rules and requirements for the design, fabrication, and erection of a broad range of steel structures based on limit states design approach. The term “steel structures” refers to structural members and frames that consist primarily of structural steel components, including structural steel acting compositely with concrete, and 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 sets out minimum requirements and is expected to be used only by engineers competent in the design of steel structures. It applies unconditionally to steel structures, except that supplementary rules or requirements might 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, fabrication, erection, and/or inspection of members or parts of steel structures is neither warranted nor acceptable except where specifically directed in this Standard. The design 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 are at least equal to those intended in the provisions of this

Standard. The substitution of other standards or criteria for fabrication, erection, and/or inspection is expressly prohibited unless specifically directed in this Standard.

1.5 Terminology

In this Standard, “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; and “may” is used to express an option or that which is permissible within the limits of the Standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA Group

A23.1/A23.2-14
Concrete materials and methods of concrete construction/Test methods and standard practices for concrete

A23.3:19
Design of concrete structures

A344-17
User guide for steel storage racks

A660-10 (R2014)
Certification of manufacturers of steel building systems

B95-1962 (withdrawn)
Surface Texture (Roughness, Waviness, and Lay)

B335-15
Safety standard for lift trucks

G40.20-13/G40.21-13 (R2018)
General requirements for rolled or welded structural quality steel/Structural quality steel

CAN/CSA-G164-M92 (withdrawn)
Hot Dip Galvanizing of Irregularly Shaped Articles

