CSA GROUP™

S16-14
(reaffirmed 2019)

Design of steel structures

REVISED DECEMBER 2016

Legal Notice for Standards

Canadian Standards Association (operating as "CSA Group") develops standards through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA Group administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document's fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party's intellectual property rights. CSA Group does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA Group makes no representations or warranties regarding this document's compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA GROUP, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA GROUP HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA Group is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA Group accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA Group is a private not-for-profit company that publishes voluntary standards and related documents. CSA Group has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA Group and the users of this document (whether it be in printed or electronic form), CSA Group is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA Group's and/or others' intellectual property and may give rise to a right in CSA Group and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by licence or by law, CSA Group reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA Group shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA Group for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:

- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF format.

Limited copies of this document in printed or paper form may be distributed only to persons who are authorized by CSA Group to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to

- alter this document in any way or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA Group; or
- make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents thereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.

Revision History

S16-14, Design of steel structures

Update No. 1 — December 2016	**Revision symbol (in margin)**
Working Group on Design and Construction of Steel Storage Racks Preface Preface Clauses 2, 6.7, 8.3.2, 8.4.2, 13.2, 13.6, 13.12.2.3, 13.13.2.2, 15.2.1, 18.3.2, 18.3.5.1, 18.4.2, 20.2, 20.3, 20.7, 22.3.5.2, 23.4.2, 25.3.3.1, 26.1, 26.3.3, 27.1.6, 27.2.1.1, 27.2.2, 27.2.3.2, 27.2.4, 27.2.4.1, 27.4.4.2, 27.5.2.5, 27.5.3.2, 27.6.2.1, 27.6.2.2, 27.6.5, 27.7.2.4, 27.7.4.1, 27.7.6.2.2, 27.10.4, and 30.5 Annex N Table 2	①

Errata — October 2015	**Revision symbol (in margin)**
Clauses 3.1, 5.1.3, 5.1.6, 5.1.7, 7.2.1, 13.2, 13.3.3.1, 13.12.1.2, 14.5.3, 16.5.5.1, 16.5.5.2, 17.2, 17.7.2.3, 17.9.3, 18.2.2, 22.2.5.1, 23.2, and 25.3.4 Table 3	Δ

Standards Update Service

S16-14
June 2014

Title: *Design of steel structures*

To register for e-mail notification about any updates to this publication
- go to **store.csagroup.org**
- click on **CSA Update Service**

The **List ID** that you will need to register for updates to this publication is **24227**.

If you require assistance, please e-mail **techsupport@csagroup.org** or call 416-747-2233.

Visit CSA Group's policy on privacy at **www.csagroup.org/legal** to find out how we protect your personal information.

S16-14
Design of steel structures

Published in June 2014 by CSA Group
A not-for-profit private sector organization
178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3

*To purchase standards and related publications, visit our Online Store at **store.csagroup.org***
or call toll-free 1-800-463-6727 or 416-747-4044.

ISBN 978-1-77139-355-3

Contents

Technical Committee on Steel Structures for Buildings

R.B. Vincent	Vinmar Surface Coatings Inc, Westmount, Québec *Representing General Interest*	*Chair*
M.I. Gilmor	Cast Connex Corporation, Toronto, Ontario *Representing Producer Interest*	*Vice-Chair*
P.C. Birkemoe	University of Toronto, Toronto, Ontario *Representing General Interest*	
R. Bjorhovde	The Bjorhovde Group, Tucson, Arizona, USA	*Associate*
S. Boulanger	Supermétal, Saint-Laurent, Québec *Representing Producer Interest*	
M. Bruneau	University at Buffalo, Buffalo, New York, USA *Representing General Interest*	
L. Callele	Waiward Engineering, Edmonton, Alberta *Representing Producer Interest*	
B.D. Charnish	Entuitive Corporation, Toronto, Ontario *Representing User Interest*	
C. Christopoulos	University of Toronto, Toronto, Ontario	*Associate*
D. Clapp	Frazier Industrial Co., Long Valley, New Jersey, USA	*Associate*
M.P. Comeau	Campbell Comeau Engineering Limited, Halifax, Nova Scotia *Representing User Interest*	

R.G. Driver	University of Alberta, Edmonton, Alberta *Representing General Interest*	
J. Ferrari	Konstant Inc, Oakville, Ontario	*Associate*
R.B. Fletcher	Atlas Tube, Chicago, Illinois, USA *Representing Producer Interest*	
G. Frater	Canadian Steel Construction Council, Markham, Ontario	*Associate*
G. Grondin	AECOM, Edmonton, Alberta *Representing User Interest*	
C. Hanson-Carbonneau	ADF Group Inc, Terrebonne, Québec *Representing Producer Interest*	
P.S. Higgins	Peter S. Higgins & Associates, Malibu, California, USA	*Associate*
M. Hrabok	University of Saskatchewan, Saskatoon, Saskatchewan *Representing General Interest*	
M. Lasby	Fluor Canada Ltd, Calgary, Alberta *Representing User Interest*	
F. Legeron	Université de Sherbrooke, Sherbrooke, Québec	*Associate*
E.S. Lévesque	Structal Ponts, Québec, Québec	*Associate*
D.H. MacKinnon	Canadian Institute of Steel Construction, Markham, Ontario	*Associate*
I. MacPhedran	University of Saskatchewan, Saskatoon, Saskatchewan	*Associate*

J.R. Mark	Mississauga, Ontario *Representing General Interest*	
J.C. Martin	CWB Group, Milton, Ontario *Representing General Interest*	
A.W. Metten	Bush, Bohlman & Partners, Vancouver, British Columbia *Representing User Interest*	
C.J. Montgomery	DIALOG, Edmonton, Alberta *Representing User Interest*	
T. Mulholland	Rack-Net-Works, Mississauga, Ontario *Representing User Interest*	
P.K. Ostrowski	Ontario Power Generation Inc., Bowmanville, Ontario *Representing User Interest*	
J.A. Packer	University of Toronto, Toronto, Ontario	*Associate*
C. Rogers	McGill University, Montréal, Québec *Representing General Interest*	
R.M. Schuster	University of Waterloo, Waterloo, Ontario	*Associate*
C.R. Taraschuk	National Research Council Canada, Ottawa, Ontario *Representing Government and/or Regulatory Authority*	
A. Tiruneh	Alberta Municipal Affairs, Edmonton, Alberta *Representing Government and/or Regulatory Authority*	
R. Tremblay	Ecole Polytechnique de Montréal, Montréal, Québec *Representing General Interest*	

T. Verhey	Walters Incorporated, Hamilton, Ontario *Representing Producer Interest*	
E.J. Whalen	Canadian Institute of Steel Construction, Markham, Ontario	*Associate*
A.F. Wong	Canadian Institute of Steel Construction, Markham, Ontario *Representing Producer Interest*	
P.R. Zinn	Arpac Storage Systems Corporation, Delta, British Columbia	*Associate*
M. Braiter	CSA Group, Mississauga, Ontario	
L. Jula Zadeh	CSA Group, Mississauga, Ontario	

① *Working Group on Design and Construction of Steel Storage Racks*

J. Ferrari	Konstant Inc, Oakville, Ontario	*Chair*
D. Clapp	Frazier Industrial Co., Long Valley, New Jersey, USA	
P.S. Higgins	Peter S. Higgins & Associates, Malibu, California, USA	
J. Hirst	North American Storage, Nisku, Alberta	
E. Jacobsen	Polytechnique Montréal, Montréal, Québec	
A.W. Metten	Bush, Bohlman & Partners, Vancouver, British Columbia	
T. Mulholland	Rack-Net-Works, Mississauga, Ontario	
R. Tremblay	Polytechnique Montréal, Montréal, Québec	
L. Xu	University of Waterloo, Waterloo, Ontario	
P.R. Zinn	Arpac Storage Systems Corporation, Delta, British Columbia	
M. Braiter	CSA Group, Toronto, Ontario	*Project Manager*

① Preface

This is the eighth edition of CSA S16, *Design of steel structures*. It supersedes the previous limit states editions published in 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.

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 following is a list of some of the more important changes made in this edition:

a) Clause 1.4 specifically prohibits the use of other standards for fabrication, erection and inspection.
b) The definition of "snug-tightness" has been clarified.
c) Information required on design documents has been augmented.
d) ASTM grades A500/A500M, A1085 and A913/A913M have been added as permissible steel grades for design.
e) The fire endurance design requirements have been restated to be in compliance with the *NBCC*.
f) Requirements under impulse loading have been added.
g) The initial misalignment of members at brace points has been clarified.
h) A calculation for the net area of a slotted HSS member has been given.
i) The minimum b/t for bearing stiffeners has been added.
j) The clause permitting a joist manufacturer to determine the joist resistance by testing has been removed.
k) Provisions for column stiffeners opposite a rigidly connected beam by bolting have been provided.
l) Requirements for zinc-aluminum coated assemblies have been incorporated.
m) The use of plate washers in lieu of hardened washers is permitted in oversize or slotted holes.
n) The use of non-matching electrodes is permitted with reference to W59 for locations where this is permitted.
o) Clause 24 that referred to joint surface conditions for field welding in the previous edition has been removed and is now covered in CSA W47.1.
p) The factored resistance of anchor rods in bearing has been referred to CSA A23.3 to be consistent with other Canadian design standards.
q) A clarification on fatigue calculations has been made to include bending moments due to joint eccentricities.
r) An upper limit on the design force of single-storey buildings' roof diaphragms has been provided.
s) A minimum Charpy V-notch value has been specified for weld of primary members and connections.
t) A maximum sulfur content for ASTM A913 used in seismic-resisting systems is specified.
u) Additional criteria for joint connections have been added to ductile moment-resisting frames, limited ductility moment-resisting frames, and moderately ductile concentrically braced frames.
v) The design of link beams for ductile eccentrically braced frames has been expanded.
w) Detailing information for limited ductility plate walls has been given.
x) Annex K Structural design for fire conditions has been updated.
y) The clauses related to pin-connected members have been revised to clarify the net section and resistance requirements.

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 2015 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 Construction and Civil Infrastructure, and has been formally approved by the Technical Committee. Annex N was prepared by the Working Group on Design and Construction of Steel Storage Racks.

This edition of the CSA S16 is dedicated to the memories of Laurie Kennedy, André Picard, and Richard Redwood, three distinguished designers, researchers, and devoted educators committed to the advancement of steel standards.

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.*
4) *To submit a request for interpretation of this Standard, please send the following information to* ***inquiries@csagroup.org*** *and include "Request for interpretation" in the subject line:*
   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) *where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.*

   Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are available on the Current Standards Activities page at standardsactivities.csa.ca.
5) *This Standard is subject to review five years from the date of publication. Suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to* ***inquiries@csagroup.org*** *and include "Proposal for change" in the subject line:*
   a) *Standard designation (number);*
   b) *relevant clause, table, and/or figure number;*
   c) *wording of the proposed change; and*
   d) *rationale for the change.*

S16-14
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 Group Standards.

1.3 Application

This Standard 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.