

Design of steel structures



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Contents

Technical Committee on Steel Structures for Buildings *xiii*

Preface *xv*

1 Scope and application 1

- 1.1 General 1
- 1.2 Requirements 1
- 1.3 Application 1
- 1.4 Other standards 1
- 1.5 Terminology 1

2 Definitions and symbols 2

- 2.1 Definitions 2
- 2.2 Symbols 4
- 2.3 Units 10

3 Reference publications 11

4 Structural documents 14

- 4.1 General 14
- 4.2 Structural design documents 14
- 4.3 Fabrication and erection documents 15
 - 4.3.1 Connection design details 15
 - 4.3.2 Shop details 15
 - 4.3.3 Erection diagrams 15
 - 4.3.4 Erection procedures 16
 - 4.3.5 Fieldwork details 16

5 Material — Standards and identification 16

- 5.1 Standards 16
 - 5.1.1 General 16
 - 5.1.2 Strength levels 16
 - 5.1.3 Structural steel 16
 - 5.1.4 Sheet steel 16
 - 5.1.5 Cast steel 16
 - 5.1.6 Forged steel 16
 - 5.1.7 Bolts and bolt assemblies 17
 - 5.1.8 Welding electrodes 17
 - 5.1.9 Studs 17
 - 5.1.10 Anchor bolts 17
- 5.2 Identification 17
 - 5.2.1 Methods 17
 - 5.2.2 Unidentified structural steel 17
 - 5.2.3 Tests to establish identification 17
 - 5.2.3.1 Affidavit 17

6 Design requirements 17

- 6.1 General 17
 - 6.1.1 Limit states 17
 - 6.1.2 Structural integrity 18
- 6.2 Loads 18

- 6.2.1 Specified loads 18
- 6.2.2 Importance factors based on use and occupancy 18
- 6.3 Requirements under specified loads 18
 - 6.3.1 Deflection 18
 - 6.3.2 Camber 18
 - 6.3.3 Dynamic effects 19
 - 6.3.4 Resistance to fatigue 19
- 6.4 Requirements under factored loads 19
 - 6.4.1 Strength 19
 - 6.4.2 Overturning 19
- 6.5 Expansion and contraction 19
- 6.6 Corrosion protection 19
- 6.7 Requirements under fire conditions 20
- 6.8 Brittle fracture 20

7 Factored loads and safety criterion 20

- 7.1 Safety during erection and construction 20
- 7.2 Safety criterion and effect of factored loads for the ultimate limit states 20

8 Analysis of structure 21

- 8.1 General 21
- 8.2 Types of construction 21
 - 8.2.1 General 21
 - 8.2.2 Rigidly connected and continuous construction 21
 - 8.2.3 Simple construction 21
 - 8.2.4 Semi-rigid (partially restrained) construction 21
- 8.3 Analysis methods 22
 - 8.3.1 Elastic analysis 22
 - 8.3.2 Plastic analysis 22
- 8.4 Stability effects 22

9 Stability of structures and members 23

- 9.1 Stability of structures 23
- 9.2 Stability of members 23
 - 9.2.1 Initial misalignment at brace points 23
 - 9.2.2 Displacement of bracing systems 23
 - 9.2.3 Function of bracing 23
 - 9.2.4 Twisting and lateral displacements 23
 - 9.2.5 Simplified analysis 23
 - 9.2.6 Detailed analysis 23
 - 9.2.7 Slabs or decks 24
 - 9.2.8 Accumulation of forces 24
 - 9.2.9 Torsion 24

10 Design lengths and slenderness ratios 25

- 10.1 Simple span flexural members 25
- 10.2 Continuous span flexural members 25
- 10.3 Members in compression 25
 - 10.3.1 General 25
 - 10.3.2 Failure mode involving bending in-plane 25
 - 10.3.3 Failure mode involving buckling 25
- 10.4 Slenderness ratios 25
 - 10.4.1 General 25
 - 10.4.2 Maximum slenderness ratio 26

11 Width (or diameter)-to-thickness — Elements in compression 26

- 11.1 Classification of sections 26
- 11.2 Maximum width (or diameter)-to-thickness ratios of elements subject to compression 26
- 11.3 Width and thickness 27

12 Gross and net areas 27

- 12.1 Application 27
- 12.2 Gross area 27
- 12.3 Net area 27
 - 12.3.1 General 27
 - 12.3.2 Allowance for bolt holes 28
 - 12.3.3 Effective net area — Shear lag 28
 - 12.3.4 Angles 29
 - 12.3.5 Plug or slot welds 29
- 12.4 Pin-connected members in tension 29

13 Member and connection resistance 30

- 13.1 Resistance factors 30
- 13.2 Axial tension 30
- 13.3 Axial compression 30
 - 13.3.1 Flexural buckling of doubly symmetric shapes 30
 - 13.3.2 Flexural, torsional, or flexural-torsional buckling 31
 - 13.3.3 Single-angle members in compression 32
 - 13.3.4 Segmented members in compression 33
 - 13.3.5 Members in compression subjected to elastic local buckling 33
- 13.4 Shear 34
 - 13.4.1 Webs of flexural members with two flanges 34
 - 13.4.2 Plastic analysis 35
 - 13.4.3 Webs of flexural members not having two flanges 35
 - 13.4.4 Pins 36
 - 13.4.5 Gusset plates and coped beams 36
- 13.5 Bending — Laterally supported members 36
- 13.6 Bending — Laterally unsupported members 37
- 13.7 Lateral bracing for members in structures analyzed plastically 39
- 13.8 Axial compression and bending 40
 - 13.8.1 General 40
 - 13.8.2 Member strength and stability — Class 1 and Class 2 sections of I-shaped members 40
 - 13.8.3 Member strength and stability — All classes of sections except Class 1 and Class 2 sections of I-shaped members 40
 - 13.8.4 Value of U_1 41
 - 13.8.5 Values of ω_1 41
- 13.9 Axial tension and bending 42
- 13.10 Load bearing 42
- 13.11 Block shear — Tension member, beam, and plate connections 42
- 13.12 Bolts and local connection resistance 43
 - 13.12.1 Bolts in bearing-type connections 43
 - 13.12.2 Bolts in slip-critical connections 44
- 13.13 Welds 45
 - 13.13.1 General 45
 - 13.13.2 Shear 45
 - 13.13.3 Tension normal to axis of weld 46
 - 13.13.4 Compression normal to axis of weld 47
- 13.14 Welds and high-strength bolts in combination 47

14 Beams and girders 47

- 14.1 Proportioning 47
- 14.2 Flanges 48
- 14.3 Webs 48
 - 14.3.1 Maximum slenderness 48
 - 14.3.2 Web crippling and yielding 49
 - 14.3.3 Openings 49
 - 14.3.4 Effect of thin webs on moment resistance 50
- 14.4 Bearing stiffeners 50
- 14.5 Intermediate transverse stiffeners 50
- 14.6 Combined shear and moment 51
- 14.7 Rotational restraint at points of support 52
- 14.8 Copes 52
- 14.9 Lateral forces 52
- 14.10 Torsion 52

15 Trusses 53

- 15.1 Analysis 53
 - 15.1.1 Simplified method 53
 - 15.1.2 Detailed method 53
- 15.2 General requirements 53
 - 15.2.1 Effective lengths of compression members 53
 - 15.2.2 Joint eccentricities 53
 - 15.2.3 Stability 53
 - 15.2.4 Chord members 53
 - 15.2.5 Web members 53
 - 15.2.6 Compression chord supports 53
 - 15.2.7 Maximum slenderness ratio of tension chords 54
 - 15.2.8 Deflection and camber 54
- 15.3 Composite trusses 54

16 Open-web steel joists 54

- 16.1 Scope 54
- 16.2 General 54
- 16.3 Materials 54
- 16.4 Design documents 54
 - 16.4.1 Building structural design documents 54
 - 16.4.2 Joist design documents 55
- 16.5 Design 55
 - 16.5.1 Loading for open-web steel joists 55
 - 16.5.2 Design assumptions 55
 - 16.5.3 Verification of joist manufacturer's design 56
 - 16.5.4 Member and connection resistance 56
 - 16.5.5 Width-to-thickness ratios 56
 - 16.5.6 Bottom chord 56
 - 16.5.7 Top chord 56
 - 16.5.8 Webs 57
 - 16.5.9 Spacers and battens 58
 - 16.5.10 Connections and splices 58
 - 16.5.11 Bearings 59
 - 16.5.12 Anchorage 59
 - 16.5.13 Deflection 60
 - 16.5.14 Camber 60
 - 16.5.15 Vibration 60

16.5.16	Welding	60
16.6	Stability during construction	60
16.7	Bridging	60
16.7.1	General	60
16.7.2	Installation	60
16.7.3	Types	60
16.7.4	Diagonal bridging	60
16.7.5	Horizontal bridging	61
16.7.6	Attachment of bridging	61
16.7.7	Anchorage of bridging	61
16.7.8	Bridging systems	61
16.7.9	Spacing of bridging	61
16.8	Decking	61
16.8.1	Decking to provide lateral support	61
16.8.2	Deck attachments	61
16.8.3	Diaphragm action	62
16.8.4	Cast-in-place slabs	62
16.8.5	Installation of steel deck	62
16.9	Shop coating	62
16.10	Manufacturing tolerances	62
16.11	Inspection and quality control	63
16.11.1	Inspection	63
16.11.2	Identification and control of steel	63
16.11.3	Quality control	63
16.12	Handling and erection	63
16.12.1	General	63
16.12.2	Erection tolerances	64
17	Composite beams, trusses, and joists	64
17.1	Application	64
17.2	Definitions	64
17.3	General	65
17.3.1	Deflections	65
17.3.2	Vertical shear	66
17.3.3	End connections	66
17.4	Design effective width of concrete	66
17.5	Slab reinforcement	67
17.5.1	General	67
17.5.2	Parallel reinforcement	67
17.5.3	Transverse reinforcement — Concrete slab on metal deck	67
17.5.4	Transverse reinforcement — Ribbed slabs	67
17.6	Interconnection	67
17.7	Shear connectors	68
17.7.1	General	68
17.7.2	End-welded studs	68
17.7.3	Channel connectors	69
17.8	Ties	69
17.9	Design of composite beams with shear connectors	70
17.10	Design of composite beams without shear connectors	72
17.11	Unshored beams	72
17.12	Beams during construction	72
18	Composite columns	73
18.1	Resistance prior to composite action	73

18.2	Concrete-filled hollow structural sections	73
18.2.1	General	73
18.2.2	Compressive resistance	73
18.2.3	Bending resistance	74
18.2.4	Axial compression and bending	75
18.3	Partially encased composite columns	75
18.3.1	General	76
18.3.2	Compressive resistance	76
18.3.3	Bending resistance	77
18.3.4	Axial compression and bending	77
18.3.5	Special reinforcement for seismic zones	77
18.4	Encased composite columns	78
18.4.1	General	78
18.4.2	Compressive resistance	78
18.4.3	Reinforcement	78
18.4.4	Columns with multiple steel shapes	78
18.4.5	Load transfer	79
18.4.6	Bending resistance	79
19	Built-up members	79
19.1	Members in compression	79
19.2	Members in tension	81
19.3	Open box-type beams and grillages	82
20	Plate walls	82
20.1	General	82
20.1.1	Definition	82
20.1.2	Lateral resistance	82
20.2	Seismic applications	82
20.3	Analysis	82
20.4	Angle of inclination	83
20.5	Limits on column and beam flexibilities	83
20.6	Infill plates	84
20.7	Beams	84
20.8	Columns	84
20.9	Anchorage of infill plates	84
20.10	Infill plate connections	84
21	Connections	84
21.1	Alignment of members	84
21.2	Unrestrained members	84
21.3	Restrained members	84
21.4	Connections of tension or compression members	85
21.5	Bearing joints in compression members	85
21.6	Lamellar tearing	85
21.7	Placement of fasteners and welds	86
21.8	Fillers	86
21.8.1	Fillers in bolted connections	86
21.8.2	Fillers in welded connections	86
21.9	Welds in combination	86
21.10	Fasteners and welds in combination	87
21.10.1	New connections	87
21.10.2	Existing connections	87
21.11	High-strength bolts (in slip-critical joints) and rivets in combination	87

22 Design and detailing of bolted connections 87

- 22.1 General 87
- 22.2 Design of bolted connections 87
 - 22.2.1 Use of snug-tightened high-strength bolts 87
 - 22.2.2 Use of pretensioned high-strength bolts 87
 - 22.2.3 Joints subject to fatigue loading 87
 - 22.2.4 Effective bearing area 87
 - 22.2.5 Fastener components 88
- 22.3 Detailing of bolted connections 88
 - 22.3.1 Minimum pitch 88
 - 22.3.2 Minimum edge distance 88
 - 22.3.3 Maximum edge distance 88
 - 22.3.4 Minimum end distance 88
 - 22.3.5 Bolt holes 88

23 Installation and inspection of bolted joints 89

- 23.1 ASTM A 307 bolts 89
- 23.2 Connection fit-up 89
- 23.3 Surface conditions for slip-critical connections 90
- 23.4 Minimum bolt length 90
- 23.5 Use of washers 90
- 23.6 Storage of fastener components for pretensioned bolt assemblies 90
- 23.7 Snug-tightened high-strength bolts 91
- 23.8 Pretensioned high-strength bolts 91
 - 23.8.1 Installation procedure 91
 - 23.8.2 Turn-of-nut method 91
 - 23.8.3 Use of ASTM F 959 washers 91
 - 23.8.4 Use of ASTM F 1852 and ASTM F 2280 bolts 91
- 23.9 Inspection procedures 92

24 Welding 92

- 24.1 Arc welding 92
- 24.2 Resistance welding 92
- 24.3 Fabricator and erector qualification 92
- 24.4 Joint surface conditions 92

25 Column bases and anchor rods 93

- 25.1 Loads 93
- 25.2 Minimum number of anchor rods 93
- 25.3 Resistance 93
 - 25.3.1 Concrete in compression 93
 - 25.3.2 Tension 93
 - 25.3.3 Shear 93
 - 25.3.4 Anchor rods in shear and tension 94
 - 25.3.5 Anchor rods in tension and bending 94
 - 25.3.6 Moment on column base 94
- 25.4 Fabrication and erection 94
 - 25.4.1 Fabrication 94
 - 25.4.2 Erection 95

26 Fatigue 95

- 26.1 General 95
- 26.2 Proportioning 95
- 26.3 Live-load-induced fatigue 95

- 26.3.1 Calculation of stress range 95
- 26.3.2 Design criteria 95
- 26.3.3 Cumulative fatigue damage 96
- 26.3.4 Fatigue constants and detail categories 96
- 26.3.5 Limited number of cycles 96
- 26.4 Distortion-induced fatigue 96
- 26.5 High-strength bolts 97
- 27 Seismic design 97**
 - 27.1 General 97
 - 27.1.1 Scope 97
 - 27.1.2 Capacity design 97
 - 27.1.3 Seismic load path 98
 - 27.1.4 Members and connections supporting gravity loads 98
 - 27.1.5 Material requirements 98
 - 27.1.6 Bolted connections 98
 - 27.1.7 Probable yield stress 99
 - 27.1.8 Stability effects 99
 - 27.1.9 Protected zones 99
 - 27.2 Type D (ductile) moment-resisting frames, $R_d = 5.0$, $R_o = 1.5$ 99
 - 27.2.1 General 99
 - 27.2.2 Beams 100
 - 27.2.3 Columns 100
 - 27.2.4 Column joint panel zone 101
 - 27.2.5 Beam-to-column joints and connections 102
 - 27.2.6 Bracing 102
 - 27.2.7 Fasteners 103
 - 27.2.8 Protected zones 103
 - 27.3 Type MD (moderately ductile) moment-resisting frames, $R_d = 3.5$, $R_o = 1.5$ 103
 - 27.4 Type LD (limited-ductility) moment-resisting frames, $R_d = 2.0$, $R_o = 1.3$ 103
 - 27.4.1 General 103
 - 27.4.2 Beams and columns 103
 - 27.4.3 Column joint panel zone 104
 - 27.4.4 Beam-to-column connections 104
 - 27.5 Type MD (moderately ductile) concentrically braced frames, $R_d = 3.0$, $R_o = 1.3$ 104
 - 27.5.1 General 104
 - 27.5.2 Bracing systems 105
 - 27.5.3 Diagonal bracing members 106
 - 27.5.4 Brace connections 107
 - 27.5.5 Columns, beams, and connections other than brace connections 107
 - 27.5.6 Protected zones 108
 - 27.6 Type LD (limited-ductility) concentrically braced frames, $R_d = 2.0$, $R_o = 1.3$ 108
 - 27.6.1 General 108
 - 27.6.2 Bracing systems 108
 - 27.6.3 Diagonal bracing members 108
 - 27.6.4 Bracing connections 109
 - 27.6.5 Columns, beams, and other connections 109
 - 27.6.6 Columns with braces intersecting between floors 109
 - 27.7 Type D (ductile) eccentrically braced frames, $R_d = 4.0$, $R_o = 1.5$ 109
 - 27.7.1 General 109
 - 27.7.2 Link beam 109
 - 27.7.3 Link resistance 110
 - 27.7.4 Link length 110
 - 27.7.5 Link rotation 111

- 27.7.6 Link stiffeners 111
- 27.7.7 Lateral support for link 112
- 27.7.8 Link beam-to-column connection 112
- 27.7.9 Beam outside the link 112
- 27.7.10 Diagonal braces 113
- 27.7.11 Brace-to-beam connection 113
- 27.7.12 Columns 113
- 27.7.13 Protected zone 113
- 27.8 Type D (ductile) buckling restrained braced frames, $R_d = 4.0$, $R_o = 1.2$ 114
 - 27.8.1 General 114
 - 27.8.2 Bracing systems 114
 - 27.8.3 Bracing members 114
 - 27.8.4 Brace connections 115
 - 27.8.5 Beams, columns, and connections other than brace connections 115
 - 27.8.6 Testing 115
 - 27.8.7 Protected zone 115
- 27.9 Type D (ductile) plate walls, $R_d = 5.0$, $R_o = 1.6$ 116
 - 27.9.1 General 116
 - 27.9.2 Infill plates 116
 - 27.9.3 Beams 116
 - 27.9.4 Columns 117
 - 27.9.5 Column joint panel zones 117
 - 27.9.6 Beam-to-column joints and connections 117
 - 27.9.7 Protected zones 117
- 27.10 Type LD (limited-ductility) plate walls, $R_d = 2.0$, $R_o = 1.5$ 118
- 27.11 Conventional construction, $R_d = 1.5$, $R_o = 1.3$ 118
- 27.12 Special seismic construction 119

28 Shop and field fabrication and coating 119

- 28.1 Cambering, curving, and straightening 119
- 28.2 Thermal cutting 119
- 28.3 Sheared or thermally cut edge finish 119
- 28.4 Fastener holes 120
 - 28.4.1 Drilled and punched holes 120
 - 28.4.2 Holes at plastic hinges 120
 - 28.4.3 Thermally cut holes 120
 - 28.4.4 Alignment 120
- 28.5 Joints in contact bearing 120
- 28.6 Member tolerances 120
- 28.7 Cleaning, surface preparation, and shop coating 121
 - 28.7.1 General 121
 - 28.7.2 Uncoated steel 121
 - 28.7.3 Coated steel 121
 - 28.7.4 Special surfaces 122
 - 28.7.5 Metallic zinc coatings 122

29 Erection 123

- 29.1 Temporary conditions 123
 - 29.1.1 General 123
 - 29.1.2 Temporary loads 123
 - 29.1.3 Temporary bracing 123
 - 29.1.4 Adequacy of temporary connections 123
- 29.2 Alignment 123
- 29.3 Erection tolerances 123

- 29.3.1 General 123
- 29.3.2 Elevation of base plates 123
- 29.3.3 Plumbness of columns 124
- 29.3.4 Horizontal alignment of members 124
- 29.3.5 Elevations of members 124
- 29.3.6 Crane runway beams 124
- 29.3.7 Alignment of braced members 124
- 29.3.8 Members with adjustable connections 125
- 29.3.9 Column splices 125
- 29.3.10 Welded joint fit-up 125
- 29.3.11 Bolted joint fit-up 125

30 Inspection 125

- 30.1 General 125
- 30.2 Co-operation 125
- 30.3 Rejection 125
- 30.4 Inspection of high-strength bolted joints 125
- 30.5 Third-party welding inspection 125
- 30.6 Identification of steel by marking 126

Annexes

- A** (informative) — Standard practice for structural steel 141
- B** (informative) — Margins of safety 142
- C** (normative) — Crane-supporting structures 144
- D** (informative) — Recommended maximum values for deflections for specified design live, snow, and wind loads 145
- E** (informative) — Floor vibrations 147
- F** (informative) — Effective lengths of columns 148
- G** (informative) — Criteria for estimating effective column lengths in continuous frames 150
- H** (informative) — Deflections of composite beams, joists, and trusses due to shrinkage of concrete 153
- I** (informative) — Arbitration procedure for pretensioning connections 157
- J** (informative) — Ductile moment-resisting connections 158
- K** (normative) — Structural design for fire conditions 159
- L** (informative) — Design to prevent brittle fracture 169

Tables

- 1** — Maximum width (or diameter)-to-thickness ratios: Elements in axial compression 126
- 2** — Maximum width (or diameter)-to-thickness ratios: Elements in flexural compression 127
- 3** — Values of k_s and c_1 128
- 4** — Matching electrode ultimate tensile strengths for CSA G40.21 steels 128
- 5** — Maximum intermediate transverse stiffener spacing 129
- 6** — Minimum edge distance for bolt holes, mm 129
- 7** — Minimum bolt tension, kN 130
- 8** — Nut rotation from snug-tight condition 131
- 9** — Detail categories for load-induced fatigue 132
- 10** — Fatigue constants for detail categories 136

Figures

- 1** — Fatigue constants for detail categories 136
- 2** — Illustrative examples of detail categories 137

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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