STRUCTURAL STEELS

General

Canadian structural steels are covered by two standards prepared by the Canadian Standards Association Technical Committee on Structural Steel, G40. These are CSA G40.20 and CSA G40.21. The information provided in this section is based on the current 2004 editions of both standards, and on the SI metric values, in keeping with Canadian design standards for steel structures.

CSA G40.20, "General Requirements for Rolled or Welded Structural Quality Steel" sets out the general requirements governing the delivery of structural quality steels. These requirements include: Definitions, Chemical Composition, Variations in dimensions, Methods of Testing, Frequency of Testing, Heat Treatment, Repairs of defects, Marking, etc.

CSA G40.21, "Structural Quality Steel" governs the chemical and mechanical properties of 7 types and 8 strength levels of structural steels for general construction and engineering purposes. All strength levels are not available in all types, and selection of the proper grade (type and strength level) is important for a particular application. CSA G40.21 350A and CSA G40.21 350AT are atmospheric corrosion-resistant steels normally used in bridge construction. For HSS sections, 350W is the normal grade used when produced to CSA G40.21.

The 7 types covered in CSA G40.21 are:

(a) **Type W – Weldable Steel.** Steels of this type meet specified strength requirements and are suitable for general welded construction where notch toughness at low temperatures is not a design requirement. Applications include buildings, compression members of bridges, etc.

(b) **Type WT – Weldable Notch-Tough Steel.** Steels of this type meet specified strength and Charpy V-notch impact requirements and are suitable for welded construction where notch toughness at low temperature is a design requirement. The purchaser, in addition to specifying the grade, specifies the required category of steel that establishes the Charpy V-notch test temperature and energy level. Applications include primary tension members in bridges and similar elements.

(c) **Type R – Atmospheric Corrosion-Resistant Steel.** Steels of this type meet specified strength requirements. The atmospheric corrosion resistance of these steels in most environments is substantially better than that of carbon structural steels with or without a copper addition*. These steels are welded readily up to the maximum thickness covered by the G40.21 standard. Applications include unpainted siding, unpainted light structural members, etc., where notch toughness at low temperature is not a design requirement.

(d) **Type A – Atmospheric Corrosion-Resistant Weldable Steel.** Steels of this type meet specified strength requirements. The atmospheric corrosion resistance of these steels in most environments is substantially better than that of carbon structural steels with or without a copper addition*. These steels are suitable for welded construction where notch toughness at low temperature is not a design requirement. Applications include those similar to type W steel.

(e) **Type AT – Atmospheric Corrosion-Resistant Weldable Notch-Tough Steel.** Steels of this type meet specified strength and Charpy V-notch impact requirements. The atmospheric corrosion resistance of these steels in most environments is substantially better than that of carbon structural steels with or without a copper addition*. These steels are suitable for welded construction where notch toughness at low temperature is a design

requirement. The purchaser, in addition to specifying the grade, specifies the required category of steel that establishes the Charpy V-notch test temperature and energy level. Applications include primary tension members in bridges and similar elements.

(f) **Type Q – Quenched and Tempered Low-Alloy Steel Plate.** Steels of this type meet specified strength requirements. While these steels are weldable, the welding and fabrication techniques are of fundamental importance to the properties of the plate, especially the heat-affected zone. Applications include bridges and similar structures.

(g) **Type QT – Quenched and Tempered Low-Alloy Notch-Tough Steel Plate.** Steels of this type meet specified strength and Charpy V-Notch impact requirements. They provide good resistance to brittle fracture and are suitable for structures where notch toughness at low temperature is a design requirement. The purchaser, in addition to specifying the grade, specifies the required category of steel that establishes the Charpy V-notch test temperature and energy level. While these steels are weldable, the welding and fabrication techniques are of fundamental importance to the properties of the plate, especially the heat-affected zone. Applications include primary tension members in bridges and similar elements.

* *For methods of estimating the atmospheric corrosion resistance of low-alloy steels, see CSA G40.21 Clause 7.6. When properly exposed to the atmosphere, these steels can be used bare (unpainted) for many applications.*

Tables

Table 6-1, "Grades, Types, Strength Levels", gives the grade designation of the various types and strength levels of structural steels according to the requirements of CSA G40.21.

Availability of any grade and shape combination should be kept in mind when designing to ensure overall economy, since a specified product may not always be available in the tonnage and time frame contemplated. Local availability should always be checked.

Table 6-2, "Shape Size Groupings for Tensile Property Classification", summarizes the size groupings for SLB, C, MC and L shapes. Table 6-3, "Mechanical Properties Summary", provides a summary of the various grades, tensile strengths and yield strengths for plates, bars, welded shapes, rolled shapes, sheet piling, and hollow structural sections based on CSA G40.21.

Table 6-4, "Chemical Composition", summarizes the chemical requirements of various grades of steel covered by CSA G40.21.

The particular standards, CSA G40.20 and CSA G40.21, should be consulted for more details. Similar information about steel covered by ASTM standards should be consulted when appropriate.

Historical Remarks

When confronted with an unidentified structural steel, Clause 5.2.2 of CSA-S16-01 requires that F_y be taken as 210 MPa and F_u as 380 MPa. This provides a minimum in the place of more precise information, such as coupon testing. The following tables list selected dates of publication and data from various CSA and ASTM structural steel standards and specifications, many of which preceded current standards.

For more information on ASTM specifications and properties and dimensions of iron and steel beams previously produced in the U.S.A., consult the "AISC Rehabilitation and Retrofit Guide: A Reference for Historic Shapes and Specifications" published by the American Institute of Steel Construction. In that publication, the first date listed for both ASTM A7

and A9 is the year 1900. Between 1900 and 1909, medium steel in A7 and A9 had a tensile strength 5 ksi higher than that adopted in 1914. For CSA standards, consult original documents.

Historical Listing of Selected Structural Steels

CSA Standards

Designation	Date Published	Yield Strength		Tensile Strength (F_u)	
		ksi	MPa	ksi	MPa
A16	1924	½ F_u	½ F_u	55-65	380-450
S39	1935	30	210	55-65	380-450
S40	1935	33	230	60-72	410-500
G40.4	1950	33	230	60-72	410-500
G40.5	1950	33	230	60-72	410-500
G40.6	1950	45[1]	310	80-95	550-650
G40.8	1960	40[3]	280	65-85	450-590
G40.12	1964*	44[2]	300	65	450
G40.21	1973**	Replaced all previous Standards, see CISC Handbook			

* Introduced in May 1962 by the Algoma Steel Corporation as 'Algoma 44'
** In May 1997, grade 350W became the only grade for W and HP shapes produced by Algoma Steel Inc.
[1] Silicon steel
[2] Yield reduces when thickness exceeds 1½ inches (40 mm).
[3] Yield reduces when thickness exceeds ⅝ inches (16 mm).

Rivet Steel

Designation	Date Published	Yield Strength		Tensile Strength (F_u)	
		ksi	MPa	ksi	MPa
G40.2	1950	28	190	52 - 62	360 - 430

ASTM Specifications

Designation	Date Published	Yield Strength		Tensile Strength (F_u)	
		ksi	MPa	ksi	MPa
A7 (bridges) A9 (buildings)	1914*	½ F_u	½ F_u	55-65	380-450
	1924	½ F_u ≥ 30	½ F_u ≥ 210	55-65	380-450
	1934	½ F_u ≥ 33	½ F_u ≥ 230	60-72	410-500
A373	1954	32	220	58-75	400-520
A242	1955	50[1]	350	70[1]	480
A36	1960	36	250	60-80	410-550
A440	1959	50[1]	350	70[1]	480
A441	1960	50[1]	350	70[1]	480
A572 grade 50	1966	50	345	65	450
A588	1968	50[1]	345	70[1]	485
A992	1998	50 min. to 65 max.	345 min. to 450 max.	65	450

* See text, Historical Remarks, above.
[1] Reduces with increasing thickness

GRADES, TYPES, STRENGTH LEVELS* Table 6-1

Type	Yield Strength, MPa							
	260	300	350	380	400	480	550	700
W	260W	300W	350W	380W**	400W	480W	550W	—
WT	260WT	300WT	350WT	380WT***	400WT	480WT	550WT	—
R	—	—	350R	—	—	—	—	—
A	—	—	350A	—	400A	480A	550A	—
AT	—	—	350AT	—	400AT	480AT	550AT	—
Q	—	—	—	—	—	—	—	700Q
QT	—	—	—	—	—	—	—	700QT

* See CSA-G40.20/G40.21

** This grade is available in Hollow Structural Sections, angles and bars only.

*** This grade is available in Hollow Structural Sections only.

SHAPE SIZE GROUPINGS FOR TENSILE PROPERTY CLASSIFICATION* Table 6-2

Shape Type	Group 1	Group 2	Group 3
Super-Light Beams (SLB)	To 28.1 kg/m	—	—
C Shapes	To 30.8 kg/m	Over 30.8 kg/m	—
MC Shapes	To 42.4 kg/m	Over 42.4 kg/m	—
L Shapes	To 13 mm	Over 13 to 19 mm	Over 19 mm

* See CSA-G40.20/G40.21

Table 6-3 MECHANICAL PROPERTIES SUMMARY

CSA G40.21*		Tensile Strength F_u (MPa)	Plates, Floor Plates, Bars, Sheet and Welded Shapes		Rolled Shapes and Sheet Piling		Hollow Structural Sections
			F_y (MPa) min.		Common Available Shape Size Group	F_y (MPa) min.	F_y (MPa) min.
Type	Grade		Thickness $t \leq 65$ mm	Thickness[4] $t > 65$ mm		Groups 1 to 3	
W	260W	410-590	260	250	3	260	
	300W	450-620[1]	300	280	3	300	300
	350W	450-650[2]	350	320	2	350	350
	380W	480-650	380		2[3]	380	380
	400W	520-690	400		1	400	400
	480W	590-790	480		1	480	480
	550W	620-860	550				550
WT	260WT	410-590	260	250	3	260	
	300WT	450-620	300	280	3	300	
	350WT	480-650[2]	350	320	3	350	350
	380WT	480-650					380
	400WT	520-690	400		2	400	400
	480WT	590-790	480		1	480	480
	550WT	620-860	550				550
R	350R	480-650	350		1	350	
A	350A	480-650	350	350	3	350	350
	400A	520-690	400		2	400	400
	480A	590-790	480				480
	550A	620-860	550				550
AT	350AT	480-650	350	350	3	350	350
	400AT	520-690	400		2	400	400
	480AT	590-790	480				480
	550AT	620-860	550				550
Q	700Q	760-895	700	620			
QT	700QT	760-895	700	620			

[1] 410-590 MPa for HSS
[2] 450-620 MPa for HSS
[3] For angles only
[4] For thickness t > 100 mm, see CSA G40.21
* See CSA G40.20/G40.21

CHEMICAL COMPOSITION[1]

Table 6-4

CSA G40.21 Grade	Chemical Composition (Heat Analysis) Percent[2]								
	All percentages are maxima unless otherwise indicated.								
	C	Mn[3]	P	S	Si[4,5]	Other[6]	Cr	Ni	Cu[7]
260W	0.20[10]	0.50-1.50	0.04	0.05	0.40	0.10	—	—	—
300W[8]	0.22[10]	0.50-1.50	0.04	0.05	0.40	0.10	—	—	—
350W	0.23	0.50-1.50	0.04	0.05	0.40	0.10	—	—	—
380W[9]	0.23	0.50-1.50	0.04	0.05	0.40	0.10	—	—	—
400W	0.23[11]	0.50-1.50	0.04	0.05	0.40	0.10	—	—	—
480W	0.26[11]	0.50-1.50	0.04	0.05	0.40	0.10[15]	—	—	—
550W	0.15	1.75[12]	0.04	0.05	0.40	0.15	—	—	—
260WT	0.20[10]	0.80-1.50	0.03	0.04	0.15-0.40	0.10	—	—	—
300WT	0.22[10]	0.80-1.50	0.03	0.04	0.15-0.40	0.10	—	—	—
350WT	0.22[10]	0.80-1.50[12]	0.03	0.04	0.15-0.40	0.10[16]	—	—	—
380WT[9]	0.22	0.80-1.50	0.03	0.04	0.15-0.40	0.10	—	—	—
400WT	0.22[11]	0.80-1.50[12]	0.03	0.04[14]	0.15-0.40	0.10[16]	—	—	—
480WT	0.26[11]	0.80-1.50[12]	0.03	0.04[14]	0.15-0.40	0.10[15,16]	—	—	—
550WT	0.15	1.75[12]	0.03	0.04[14]	0.15-0.40	0.15	—	—	—
350R	0.16	0.75	0.05-0.15	0.04	0.75	0.10	0.30-1.25[17]	0.90[17]	0.20-0.60[17]
350A	0.20	0.75-1.35[12]	0.03	0.04	0.15-0.50	0.10	0.70[18]	0.90[18]	0.20-0.60
400A	0.20	0.75-1.35[12]	0.03	0.04[14]	0.15-0.50	0.10	0.70[18]	0.90[18]	0.20-0.60
480A	0.20	1.00-1.60	0.025[13]	0.035[14]	0.15-0.50	0.12	0.70[18]	0.25-0.50[18]	0.20-0.60
550A	0.15	1.75[12]	0.025[13]	0.035[14]	0.15-0.50	0.15	0.70[18]	0.25-0.50[18]	0.20-0.60
350AT	0.20	0.75-1.35[12]	0.03	0.04	0.15-0.50	0.10	0.70[18]	0.90[18]	0.20-0.60
400AT	0.20	0.75-1.35[12]	0.03	0.04[14]	0.15-0.50	0.10	0.70[18]	0.90[18]	0.20-0.60
480AT	0.20	1.00-1.60	0.025[13]	0.035[14]	0.15-0.50	0.12	0.70[18]	0.25-0.50[18]	0.20-0.60
550AT	0.15	1.75[12]	0.025[13]	0.035[14]	0.15-0.50	0.15	0.70[18]	0.25-0.50[18]	0.20-0.60
700Q	0.20	1.50	0.03	0.04	0.15-0.40	—	Boron 0.0005-0.005		—
700QT	0.20	1.50	0.03	0.04	0.15-0.40	—	Boron 0.0005-0.005		—

Notes:

1. For full details, consult CSA Standard G40.20/G40.21. Usual deoxidation for all grades is fully killed.
2. Additional alloying elements may be used when approved.
3. For HSS Mn 0.50 - 1.50% for 350WT and 380WT, 1.65% for 400 yield, 1.75% for 480 yield and 1.85% for 550 yield steels. For HSS mininum limit for Mn shall be 0.30% provided that the ratio of Mn to C is not less than 2 to 1 and the ratio of Mn to S is not less than 20 to 1.
4. Si content of 0.15% to 0.40% is required for type W steel over 40 mm thickness, HSS of A or AT steel, or bar diameter except as required by Note 5.
5. By purchaser's request or producer's option, no minimum Si content is required provided that 0.015% acid-soluble Al or 0.02% total Al is used.
6. Includes grain-refining elements Cb, V, Al. Elements Cb and V may be used singly or in combination. See G40.20/G40.21 for qualifications. Al, when used, is not included in the summation.
7. Copper content of 0.20% minimum may be specified.
8. For HSS 0.26% C and 0.30-1.20% Mn.
9. Only angles, bars, and HSS in 380W grade, and only HSS in 380WT grade.
10. For thicknesses over 100 mm, C may be 0.22% for 260W and 260WT grades, and 0.23% for 300W, 300WT and 350WT grades.
11. For HSS 0.20% C.
12. Mn may be increased. See G40.20/G40.21 for qualifications.
13. For HSS 0.03% P.
14. For HSS 0.03% S.
15. For HSS 0.12%
16. 0.01-0.02% N may be used but N ≤ ¼ V.
17. Cr + Ni + Cu ≥ 1.00%
18. Cr + Ni ≥ 0.40% and for HSS, 0.90% Ni max.

Table 6-5 STEEL MARKING COLOUR CODE

Steel Grade	Primary Colour	Secondary Colour
260W	White	Green
300W	Green	Green
350W	Blue	Green
380W	Brown	Green
400W	Black	Green
480W	Yellow	Green
550W	Pink	Green
260WT	White	White
300WT	Green	White
350WT	Blue	White
380WT	Brown	White
400WT	Black	White
480WT	Yellow	White
550WT	Pink	White
350R	Blue	Blue
350A	Blue	Yellow
400A	Black	Yellow
480A	Yellow	Yellow
550A	Pink	Yellow
350AT	Blue	Brown
400AT	Black	Brown
480AT	Yellow	Brown
550AT	Pink	Brown
700Q	Red	Red
700QT	Red	Purple

In this Code, the following colour system applies:

Strength Level	Primary Colour	Type	Secondary Colour
260	White	W	Green
300	Green	WT	White
350	Blue	R	Blue
380	Brown	A	Yellow
400	Black	AT	Brown
480	Yellow	Q	Red
550	Pink	QT	Purple
700	Red		

STANDARD IMPACT ENERGY AND TEST TEMPERATURE FOR SPECIFIED TYPE, GRADE AND CATEGORY

Type	Grade	Category				
		1	2	3	4	5
WT	260, 300	20 J, 0° C	20 J, -20° C	20 J, -30° C	20 J, -45° C	Both energy and test temperature are specified by the purchaser.
	350, 380, 400, 480, 550	27 J, 0° C	27 J, -20° C	27 J, -30° C	27 J, -45° C	
AT	350, 400, 480, 550	27 J, 0° C	27 J, -20° C	27 J, -30° C	27 J, -45° C	
QT	700	34 J, 0° C	34 J, -20° C	34 J, -30° C	34 J, -45° C	

Note: Charpy V-Notch, longitudinal specimens. See CSA G40.21-04 Clause 8.2.2.

Units: Impact energy in Joules (1 J ≈ 0.738 ft·lb) and test temperature in degrees Celsius.