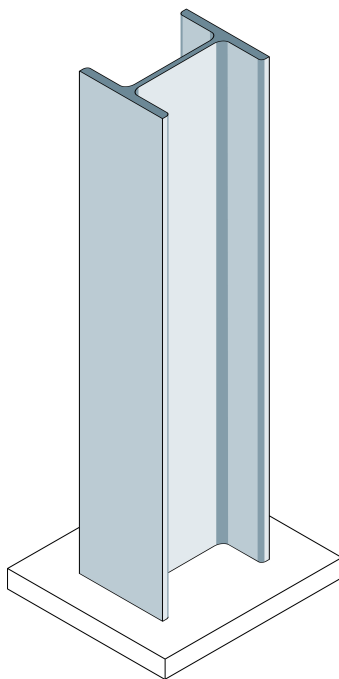


# *CISC Steel Design Series*

## **Module 3** **ASTM A913 Grade 70 Columns**



**SDS-3**  
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## MODULE 3

### ASTM A913 GRADE 70 COLUMNS

#### General

ASTM A913 steels are currently produced as quenched and self-tempered W-shapes in three yield strength levels: Grade 50 (345 MPa), Grade 65 (450 MPa) and Grade 70 (485 MPa). ArcelorMittal International produces these three grades, whereas Nucor Yamato Steel has announced its intended schedule to start producing Grade 65 in the summer of 2017 and to start producing Grades 50 and 70 shortly after.

The ASTM A913/A913M specification provides tight controls on chemical compositions and mandatory notch-toughness requirements. Currently produced to A913 are large and medium sections in the depth ranges of W610-W1100 and W250-W360. Grades 65 and 70 offer the greatest advantages when used as columns in high-rise buildings and as long-span truss members.

A913 is explicitly referenced in CSA S16-14, and column design tables for A913 Grade 65 steel are provided in the 11<sup>th</sup> edition of the CISC Handbook of Steel Construction. Yield strength, tensile strength and chemical properties of A913 grade steels can be found in Tables 6-7 and 6-9 in the Handbook.

#### Design Tables

Design tables for A913 Grade 70 steel on the following pages extend the Handbook data presently found in Part 4 on *Compression Members*:

- Table 1 provides *Factored Axial Compressive Resistances* for heavy W360 column sections produced to A913 Grade 70 with  $F_y = 485$  MPa.
- Table 2 indicates the *Class of Sections* for W360 members in combined axial compression and major-axis bending.
- Table 3 provides *Factored Moment Resistances* for bending about the major axis and various unsupported lengths.

#### Design Example

A solved example is presented to illustrate the design of a gravity column.

## DESIGN EXAMPLE

### Given:

Design the concentrically loaded gravity steel column as shown on Figure 1:  $C_f = 8\,450$  kN and  $KL_y = 4\,200$  mm. The steel grade is ASTM A913 Grade 70 ( $F_y = 485$  MPa).

### Solution:

Try a W360x196 column.

For  $KL = 4\,000$  mm, Table 1 indicates a factored resistance of  $C_r = 8\,870$  kN, and for  $KL = 4\,500$  mm, a resistance of  $C_r = 8\,310$  kN. By linear interpolation, we obtain:

$$C_r = 8\,650 \text{ kN} > 8\,450 \text{ kN}.$$

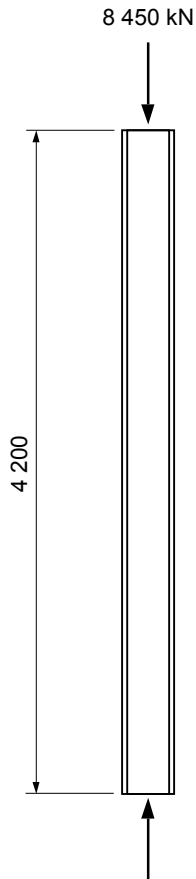
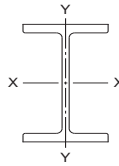


Figure 1

# W COLUMNS

## Factored Axial Compressive Resistances, $C_r$ (kN)

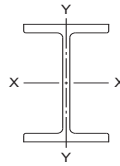


## TABLE 1 ASTM A913 Grade 70 $F_y = 485 \text{ MPa}$

Designation		W360					
Mass (kg/m)		1299	1202	1086	990	900	818
Effective length (KL) in millimetres with respect to the least radius of gyration	0	72 200	66 800	60 500	55 100	50 200	45 500
	2 500	69 900	64 500	58 300	53 000	48 200	43 700
	3 000	68 500	63 200	57 000	51 800	47 100	42 600
	3 500	66 700	61 500	55 400	50 300	45 700	41 300
	4 000	64 600	59 500	53 500	48 500	44 000	39 700
	4 500	62 200	57 200	51 300	46 400	42 100	38 000
	5 000	59 600	54 800	49 000	44 300	40 100	36 100
	5 500	56 900	52 100	46 500	42 000	38 000	34 100
	6 000	54 000	49 400	44 000	39 600	35 800	32 100
	6 500	51 100	46 700	41 400	37 200	33 700	30 100
	7 000	48 200	44 000	38 900	34 900	31 500	28 200
	7 500	45 300	41 300	36 500	32 700	29 500	26 300
	8 000	42 600	38 700	34 200	30 600	27 600	24 500
	8 500	39 900	36 300	31 900	28 500	25 700	22 900
	9 000	37 400	34 000	29 800	26 600	24 000	21 300
	9 500	35 100	31 800	27 900	24 800	22 400	19 800
	10 000	32 900	29 700	26 000	23 200	20 900	18 500
	10 500	30 800	27 800	24 300	21 700	19 500	17 200
	11 000	28 900	26 100	22 800	20 200	18 200	16 100
	11 500	27 100	24 400	21 300	18 900	17 000	15 000
12 000	25 400	22 900	20 000	17 700	15 900	14 100	
12 500	23 900	21 500	18 700	16 600	14 900	13 200	
13 000	22 500	20 200	17 600	15 600	14 000	12 400	
13 500	21 100	19 000	16 600	14 700	13 200	11 600	
14 000	19 900	17 900	15 600	13 800	12 400	10 900	
15 000	17 800	16 000	13 900	12 300	11 000	9 690	
16 000	15 900	14 300	12 400	11 000	9 820	8 640	
17 000	14 300	12 800	11 100	9 830	8 810	7 750	
18 000	12 900	11 600	10 000	8 860	7 940	6 980	
19 000	11 700	10 500	9 080	8 020	7 190	6 320	
20 000	10 600	9 550	8 260	7 290	6 530	5 740	
PROPERTIES AND DESIGN DATA							
Area (mm <sup>2</sup> )	165 000	153 000	139 000	126 000	115 000	105 000	
t (mm)	140	130	125	115	106	97.0	
r <sub>x</sub> (mm)	214	208	207	203	198	194	
r <sub>y</sub> (mm)	124	122	119	117	116	114	
r <sub>x</sub> / r <sub>y</sub>	1.73	1.70	1.74	1.74	1.71	1.70	
M <sub>rx</sub> (kN·m) (L < L <sub>u</sub> )	14 500	13 100	11 900	10 600	9 430	8 420	
L <sub>u</sub> (mm)	17 600	16 600	15 100	14 000	13 100	12 100	
M <sub>ry</sub> (kN·m)	7 290	6 630	5 850	5 240	4 670	4 170	
(b <sub>ei</sub> /t) <sub>√485</sub>	37.4	39.9	40.0	42.9	45.9	49.6	
(h/w) <sub>√485</sub>	70.5	74.2	90.1	98.0	107	116	
IMPERIAL SIZE AND WEIGHT							
Weight (lb/ft)	873	808	730	665	605	550	
Depth x Width (in.)	23 <sup>5</sup> / <sub>8</sub> x 18 <sup>3</sup> / <sub>4</sub>	22 <sup>1</sup> / <sub>2</sub> x 18 <sup>1</sup> / <sub>2</sub>	22 <sup>3</sup> / <sub>8</sub> x 17 <sup>1</sup> / <sub>2</sub>	21 <sup>1</sup> / <sub>2</sub> x 17 <sup>3</sup> / <sub>8</sub>	20 <sup>7</sup> / <sub>8</sub> x 17 <sup>3</sup> / <sub>8</sub>	20 <sup>1</sup> / <sub>4</sub> x 17 <sup>1</sup> / <sub>4</sub>	

# W COLUMNS

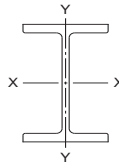
## Factored Axial Compressive Resistances, $C_r$ (kN)



## TABLE 1 ASTM A913 Grade 70 $F_y = 485 \text{ MPa}$

Designation		W360						
Mass (kg/m)		744	677	634	592	551	509	463
Effective length (KL) in millimetres with respect to the least radius of gyration	0	41 400	37 700	35 300	33 000	30 600	28 300	25 700
	2 500	39 600	36 000	33 700	31 400	29 200	27 000	24 500
	3 000	38 600	35 100	32 800	30 600	28 400	26 200	23 800
	3 500	37 300	33 900	31 700	29 500	27 400	25 300	22 900
	4 000	35 900	32 600	30 400	28 300	26 200	24 200	21 900
	4 500	34 200	31 000	28 900	26 900	24 900	23 000	20 800
	5 000	32 500	29 400	27 400	25 500	23 500	21 800	19 700
	5 500	30 600	27 700	25 800	24 000	22 100	20 500	18 500
	6 000	28 800	26 000	24 200	22 400	20 700	19 100	17 300
	6 500	27 000	24 400	22 600	21 000	19 300	17 900	16 100
	7 000	25 200	22 700	21 100	19 500	18 000	16 600	15 000
	7 500	23 500	21 200	19 600	18 100	16 700	15 400	13 900
	8 000	21 800	19 700	18 200	16 900	15 500	14 300	12 900
	8 500	20 300	18 300	16 900	15 600	14 400	13 300	11 900
	9 000	18 900	17 000	15 700	14 500	13 300	12 300	11 100
	9 500	17 600	15 800	14 600	13 500	12 400	11 500	10 300
	10 000	16 400	14 700	13 600	12 500	11 500	10 600	9 540
	10 500	15 300	13 700	12 700	11 700	10 700	9 900	8 860
	11 000	14 200	12 800	11 800	10 900	9 960	9 210	8 250
	11 500	13 300	11 900	11 000	10 100	9 290	8 590	7 690
12 000	12 400	11 200	10 300	9 470	8 670	8 020	7 180	
12 500	11 600	10 400	9 620	8 860	8 110	7 500	6 710	
13 000	10 900	9 780	9 020	8 300	7 590	7 020	6 280	
13 500	10 200	9 180	8 460	7 780	7 120	6 580	5 890	
14 000	9 620	8 630	7 950	7 310	6 680	6 180	5 530	
15 000	8 530	7 650	7 040	6 480	5 920	5 480	4 890	
16 000	7 610	6 820	6 280	5 770	5 270	4 880	4 360	
17 000	6 820	6 110	5 620	5 170	4 720	4 370	3 900	
18 000	6 140	5 500	5 060	4 650	4 250	3 930	3 510	
19 000	5 550	4 970	4 580	4 200	3 840	3 550	3 170	
20 000	5 050	4 520	4 160	3 820	3 480	3 220	2 880	
PROPERTIES AND DESIGN DATA								
Area (mm <sup>2</sup> )	94 800	86 500	80 600	75 500	70 300	65 200	59 000	
t (mm)	88.9	81.5	77.1	72.3	67.6	62.7	57.4	
$r_x$ (mm)	190	186	184	182	180	178	175	
$r_y$ (mm)	112	111	110	109	108	108	107	
$r_x / r_y$	1.70	1.68	1.67	1.67	1.67	1.65	1.64	
$M_{rx}$ (kN·m) ( $L < L_u$ )	7 510	6 680	6 200	5 720	5 280	4 800	4 310	
$L_u$ (mm)	11 300	10 600	10 100	9 550	8 990	8 550	7 980	
$M_{ry}$ (kN·m)	3 730	3 350	3 110	2 870	2 640	2 420	2 170	
$(b_{ei}/t)\sqrt{485}$	53.5	57.8	60.6	64.1	68.1	73.1	79.0	
$(h/w)\sqrt{485}$	127	138	148	157	168	181	197	
IMPERIAL SIZE AND WEIGHT								
Weight (lb/ft)	500	455	426	398	370	342	311	
Depth x Width (in.)	19% x 17	19 x 16%	18% x 16%	18% x 16%	17% x 16½	17½ x 16%	17% x 16%	

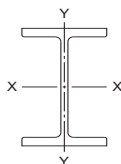
**W COLUMNS**  
**Factored Axial Compressive**  
**Resistances,  $C_r$  (kN)**



**TABLE 1**  
**ASTM A913 Grade 70**  
 **$F_y = 485 \text{ MPa}$**

Designation		W360					
Mass (kg/m)		421	382	347	314	287	262
Effective length (KL) in millimetres with respect to the least radius of gyration	0	23 400	21 300	19 300	17 400	16 000	14 600
	2 500	22 300	20 200	18 300	16 500	15 100	13 800
	3 000	21 600	19 600	17 700	16 000	14 700	13 400
	3 500	20 800	18 800	17 000	15 400	14 100	12 800
	4 000	19 900	18 000	16 300	14 600	13 400	12 200
	4 500	18 900	17 000	15 400	13 800	12 700	11 500
	5 000	17 800	16 100	14 500	13 000	11 900	10 800
	5 500	16 700	15 000	13 600	12 200	11 200	10 100
	6 000	15 600	14 000	12 600	11 300	10 400	9 400
	6 500	14 500	13 100	11 700	10 500	9 630	8 720
	7 000	13 500	12 100	10 900	9 720	8 920	8 070
	7 500	12 500	11 200	10 100	8 990	8 250	7 450
	8 000	11 600	10 400	9 320	8 320	7 630	6 890
	8 500	10 700	9 620	8 620	7 690	7 050	6 360
	9 000	9 950	8 910	7 980	7 110	6 520	5 880
	9 500	9 230	8 260	7 390	6 580	6 040	5 440
	10 000	8 570	7 660	6 850	6 100	5 600	5 040
	10 500	7 960	7 110	6 360	5 660	5 190	4 670
	11 000	7 410	6 620	5 910	5 260	4 830	4 340
	11 500	6 900	6 160	5 510	4 890	4 490	4 040
12 000	6 440	5 750	5 130	4 560	4 190	3 760	
12 500	6 020	5 370	4 790	4 260	3 910	3 510	
13 000	5 630	5 020	4 480	3 980	3 650	3 280	
13 500	5 280	4 710	4 200	3 730	3 420	3 070	
14 000	4 950	4 420	3 940	3 500	3 210	2 880	
15 000	4 380	3 910	3 490	3 090	2 840	2 550	
16 000	3 900	3 480	3 100	2 750	2 530	2 270	
17 000	3 490	3 110	2 770	2 460	2 260	2 030	
18 000	3 140	2 800	2 490	2 210	2 030	1 820	
19 000	2 840	2 530	2 250	2 000	1 830	1 640	
20 000	2 580	2 290	2 040	1 810	1 660	1 490	
<b>PROPERTIES AND DESIGN DATA</b>							
Area (mm <sup>2</sup> )	53 700	48 800	44 200	40 000	36 600	33 400	
t (mm)	52.6	48.0	43.7	39.6	36.6	33.3	
$r_x$ (mm)	172	170	168	166	165	163	
$r_y$ (mm)	106	105	104	103	103	102	
$r_x / r_y$	1.62	1.62	1.62	1.61	1.60	1.60	
$M_{rx}$ (kN·m) ( $L < L_u$ )	3 880	3 470	3 120	2 780	2 540	2 300	
$L_u$ (mm)	7 510	7 070	6 700	6 340	6 090	5 840	
$M_{ry}$ (kN·m)	1 960	1 760	1 580	1 410	1 290	1 170	
$(b_{ei}/t)\sqrt{485}$	85.6	93.1	102	112	120	132	
$(h/w)\sqrt{485}$	215	236	259	283	312	334	
<b>IMPERIAL SIZE AND WEIGHT</b>							
Weight (lb/ft)	283	257	233	211	193	176	
Depth x Width (in.)	16 <sup>3</sup> / <sub>4</sub> x 16 <sup>3</sup> / <sub>8</sub>	16 <sup>3</sup> / <sub>8</sub> x 16	16 x 15 <sup>7</sup> / <sub>8</sub>	15 <sup>3</sup> / <sub>4</sub> x 15 <sup>3</sup> / <sub>4</sub>	15 <sup>1</sup> / <sub>2</sub> x 15 <sup>3</sup> / <sub>4</sub>	15 <sup>1</sup> / <sub>2</sub> x 15 <sup>3</sup> / <sub>8</sub>	

**W COLUMNS**  
**Factored Axial Compressive**  
**Resistances,  $C_r$  (kN)**



**TABLE 1**  
**ASTM A913 Grade 70**  
 **$F_y = 485 \text{ MPa}$**

Designation		W360		W360		
Mass (kg/m)		237	216	196	†† 179	†† 162
Effective length (KL) in millimetres with respect to the least radius of gyration	0	13 100	12 000	10 900	9 960	9 010
	500	13 100	12 000	10 900	9 950	9 000
	1 000	13 100	12 000	10 900	9 900	8 950
	1 500	12 900	11 800	10 700	9 790	8 850
	2 000	12 700	11 600	10 500	9 600	8 670
	2 500	12 400	11 400	10 200	9 330	8 420
	3 000	12 000	11 000	9 850	8 970	8 100
	3 500	11 500	10 500	9 390	8 550	7 710
	4 000	11 000	10 000	8 870	8 070	7 280
	4 500	10 400	9 450	8 310	7 560	6 820
	5 000	9 740	8 860	7 740	7 040	6 340
	5 500	9 090	8 260	7 170	6 520	5 870
	6 000	8 450	7 670	6 620	6 010	5 420
	6 500	7 840	7 110	6 100	5 530	4 980
	7 000	7 250	6 570	5 600	5 080	4 580
	7 500	6 700	6 070	5 150	4 670	4 200
	8 000	6 190	5 600	4 730	4 290	3 860
	8 500	5 720	5 170	4 350	3 940	3 550
	9 000	5 290	4 770	4 010	3 630	3 270
	9 500	4 890	4 410	3 690	3 350	3 010
10 000	4 530	4 090	3 410	3 090	2 780	
10 500	4 200	3 790	3 150	2 860	2 570	
11 000	3 900	3 520	2 920	2 650	2 380	
11 500	3 630	3 270	2 710	2 450	2 210	
12 000	3 380	3 050	2 520	2 280	2 050	
12 500	3 160	2 840	2 350	2 130	1 910	
13 000	2 950	2 660	2 190	1 980	1 780	
13 500	2 760	2 490	2 050	1 860	1 670	
14 000	2 590	2 330	1 920	1 740	1 560	
15 000	2 290	2 060	1 690	1 530	1 380	
16 000	2 040	1 830	1 500	1 360	1 220	
PROPERTIES AND DESIGN DATA						
Area (mm <sup>2</sup> )	30 100	27 500	25 000	22 800	20 600	
t (mm)	30.2	27.7	26.2	23.9	21.8	
$r_x$ (mm)	162	161	159	159	158	
$r_y$ (mm)	102	101	95.6	95.2	94.9	
$r_x / r_y$	1.59	1.59	1.66	1.67	1.66	
$M_{rx}$ (kN·m) ( $L < L_u$ )	2 050	1 860	1 680	1 360	1 240	
$L_u$ (mm)	5 610	5 460	5 090	5 310	5 160	
$M_{ry}$ (kN·m)	1 040	952	812	485	437	
$(b_{el}/t)\sqrt{485}$	144	157	157	172	187	
$(h/w)\sqrt{485}$	372	407	429	470	531	
IMPERIAL SIZE AND WEIGHT						
Weight (lb/ft)	159	145	132	120	109	
Depth x Width (in.)	15 x 15 $\frac{5}{8}$	14 $\frac{3}{4}$ x 15 $\frac{1}{2}$	14 $\frac{3}{4}$ x 14 $\frac{3}{4}$	14 $\frac{1}{2}$ x 14 $\frac{3}{4}$	14 $\frac{3}{4}$ x 14 $\frac{3}{4}$	

†† Class 3 in bending about both axes



**CLASS OF SECTIONS**  
**Combined Axial Compression**  
**and Major-Axis Bending**

**TABLE 2**  
**ASTM A913 Grade 70**  
 **$F_y = 485 \text{ MPa}$**

Designation	Web			Flange	Designation	Web			Flange
	1 $C_f/\phi C_y \leq$	2 $C_f/\phi C_y \leq$	3 $C_f/\phi C_y \leq$			1 $C_f/\phi C_y \leq$	2 $C_f/\phi C_y \leq$	3 $C_f/\phi C_y \leq$	
W360x1299	1.0	—	—	1					
x1202	1.0	—	—	1	x382	1.0	—	—	1
x1086	1.0	—	—	1	x347	1.0	—	—	1
x990	1.0	—	—	1	x314	1.0	—	—	1
x900	1.0	—	—	1	x287	1.0	—	—	1
x818	1.0	—	—	1	x262	1.0	—	—	1
x744	1.0	—	—	1	x237	1.0	—	—	1
x677	1.0	—	—	1	x216	1.0	—	—	2
x634	1.0	—	—	1					
x592	1.0	—	—	1	W360x196	1.0	—	—	2
x551	1.0	—	—	1	x179	1.0	—	—	3
x509	1.0	—	—	1	x162	1.0	—	—	3
x463	1.0	—	—	1					
x421	1.0	—	—	1					
— Indicates web is never that class.									

**FACTORED MOMENT RESISTANCES**  
**OF COLUMNS,  $M_{rx}$  and  $M'_{rx}$  (kN·m)**

**TABLE 3**  
**ASTM A913 Grade 70**  
 **$F_y = 485 \text{ MPa}$**

Designation	$M_{rx}$	$M'_{rx}$ for the following unsupported lengths in millimetres									
		6 000	8 000	10 000	12 000	14 000	16 000	18 000	20 000	24 000	28 000
W360x1299	14 500	—	—	—	—	—	—	14 400	14 200	13 700	13 200
W360x1202	13 100	—	—	—	—	—	—	12 900	12 700	12 200	11 700
W360x1086	11 900	—	—	—	—	—	11 800	11 500	11 300	10 800	10 300
W360x990	10 600	—	—	—	—	—	10 400	10 100	9 920	9 460	9 000
W360x900	9 430	—	—	—	—	9 330	9 110	8 890	8 670	8 230	7 790
W360x818	8 420	—	—	—	—	8 230	8 010	7 800	7 580	7 160	6 730
W360x744	7 510	—	—	—	7 430	7 230	7 020	6 810	6 610	6 200	5 790
W360x677	6 680	—	—	—	6 530	6 340	6 140	5 940	5 740	5 350	4 960
W360x634	6 200	—	—	—	6 010	5 810	5 620	5 420	5 230	4 840	4 460
W360x592	5 720	—	—	5 670	5 480	5 290	5 100	4 910	4 720	4 350	3 970
W360x551	5 280	—	—	5 180	4 990	4 800	4 620	4 430	4 240	3 870	3 480
W360x509	4 800	—	—	4 670	4 480	4 300	4 110	3 930	3 750	3 390	2 980
W360x463	4 310	—	4 310	4 130	3 940	3 760	3 580	3 410	3 230	2 870	2 450
W360x421	3 880	—	3 830	3 650	3 470	3 300	3 120	2 950	2 780	2 390	2 040
W360x382	3 470	—	3 390	3 210	3 040	2 870	2 690	2 520	2 350	1 960	1 680
W360x347	3 120	—	3 000	2 830	2 660	2 490	2 320	2 150	1 960	1 620	1 380
W360x314	2 780	—	2 640	2 470	2 300	2 130	1 960	1 780	1 590	1 320	1 130
W360x287	2 540	—	2 370	2 200	2 040	1 870	1 710	1 510	1 350	1 120	953
W360x262	2 300	2 280	2 110	1 940	1 780	1 610	1 430	1 260	1 120	927	790
W360x237	2 050	2 020	1 850	1 680	1 520	1 350	1 170	1 030	916	755	643
W360x216	1 860	1 820	1 650	1 490	1 330	1 150	988	867	773	637	542
W360x196	1 680	1 600	1 440	1 280	1 110	931	800	702	626	516	439
† W360x179	1 360	1 320	1 190	1 060	931	783	671	588	524	430	366
† W360x162	1 240	1 180	1 060	927	788	653	558	488	434	356	302

Note: Moment resistances are based on class of section for X-X axis of bending only,  $\omega_2 = 1.0$ .

† Class 3