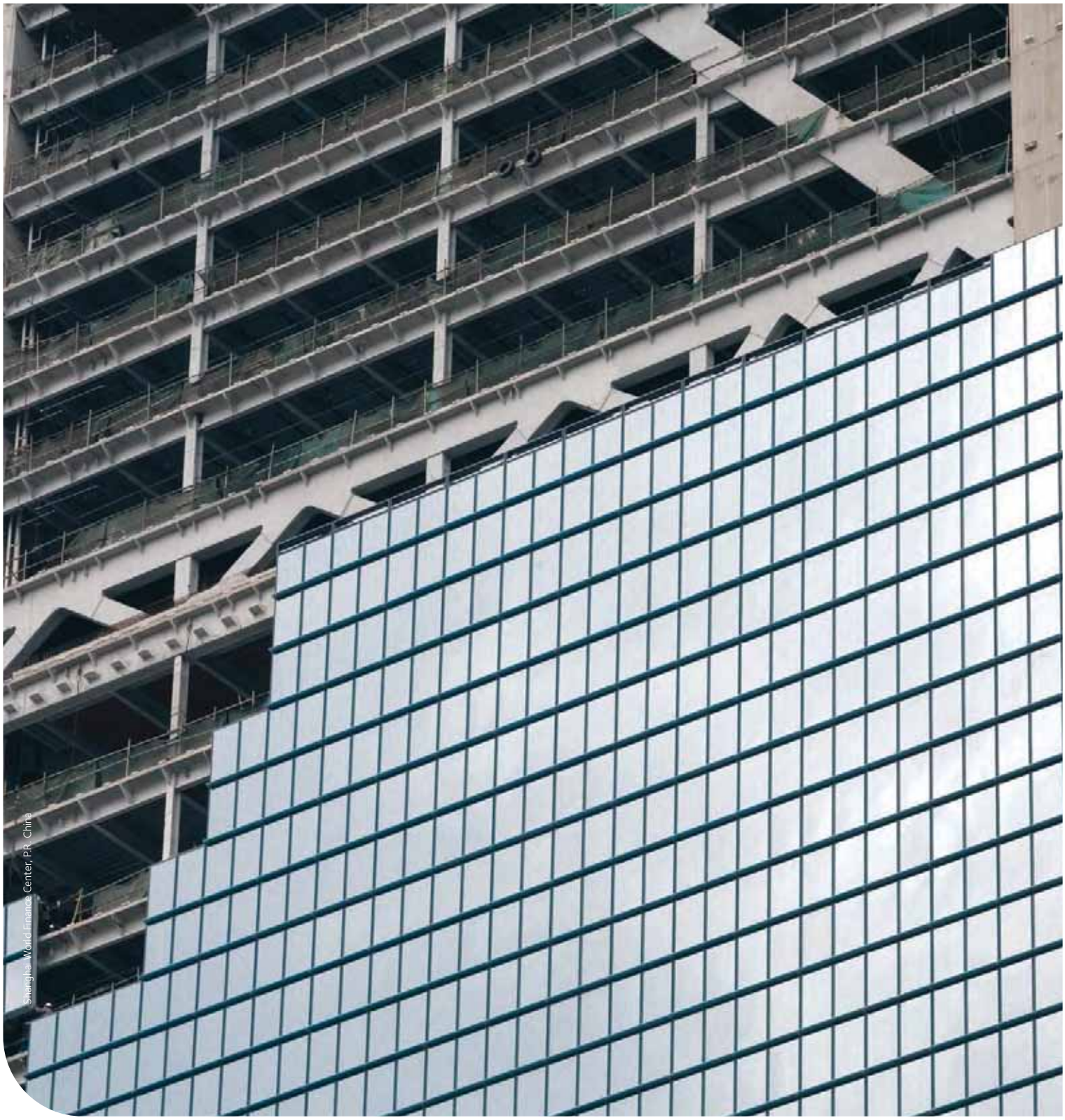
Long Carbon Europe
Sections and Merchant Bars

ArcelorMittal

HISTAR®

Innovative high strength steels for economical steel structures



Shanghai World Finance Center, P.R. China

Innovative high strength steels for economical steel structures

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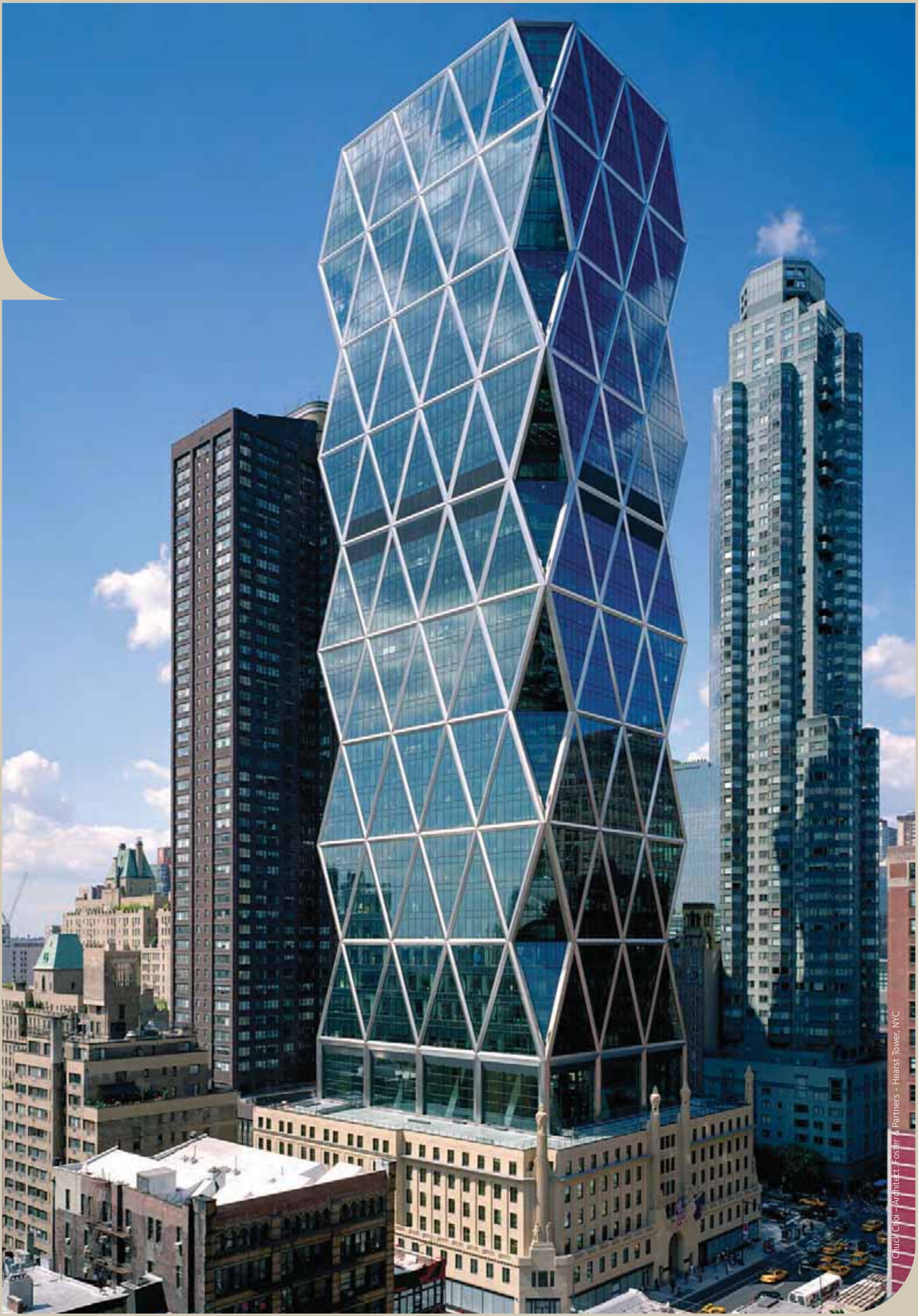


Chuck Choi - Architect: Foster & Partners - Hearst Tower, NYC

1. Introduction

With the development of the HISTAR steels, ArcelorMittal has succeeded in creating structural steels combining high yield strength with excellent toughness at low temperatures and outstanding weldability. These material properties were considered incompatible until now.

This development was made possible by the innovative "in line" Quenching and Self-Tempering (QST) process, developed by ArcelorMittal Long Carbon Europe in cooperation with the Centre de Recherches Métallurgiques in Liège.

The QST process enables the cost-effective production of high-strength steels. HISTAR steels are delivered in accordance with the European Technical Approval ETA-10/156. They are in full compliance with European and other national standards.

Hot rolled H-beams in HISTAR grades enable the construction of innovative and competitive structures. Engineers take full advantage of the excellent HISTAR properties when designing gravity columns of high-rise buildings, long-span trusses and offshore structures. Furthermore, the new steels are recommended in case of stress governed as well as seismic design.

With HISTAR, ArcelorMittal satisfies the needs of the designers for light and economical structures which fulfil at the same time the criteria of safety and sustainability.

Freedom Tower, NYC, on the site of the former World Trade Center. HISTAR 460.

2. Characteristics of HISTAR® steels

1. Product Description

HISTAR steels are structural grades with a low alloy content, combining high strength, good toughness and superior weldability. HISTAR grades are available with minimum yield strengths of 355 or 460 MPa.

When compared to standard structural steels, HISTAR grades feature improved guaranteed mechanical characteristics over the whole range of product thicknesses (Figure 1). In order to best suit the different applications, HISTAR grades are available with guaranteed toughnesses down to -20° C and down to -50° C.

HISTAR steels are delivered in the thermo-mechanically rolled condition in accordance with the European Technical Approval ETA-10/0156. They comply with the requirements of the European standards EN 10025-4:2004 for weldable fine grain structural steels and EN 10225:2009 for weldable structural steels for fixed offshore structures. They also comply with other national standards like ASTM A 913-11 and JIS G 3106:2008. Table 1 shows a comparison, based on yield strength, between HISTAR and other standard structural steel grades. HISTAR grades are compatible with the requirements of the Eurocodes for the design of steel structures and composite steel-concrete structures.

The HISTAR grades for offshore applications offer the following additional features:

- improved deformation properties in through thickness direction with respect to the resistance to lamellar tearing (Z qualities).
- notch impact properties in transverse direction.
- maximum ratio between yield strength and tensile strength.

Different HISTAR grades are available in the market:

for general construction:

HISTAR 355
fulfils the requirements of
1) ETA-10/0156 (t ≤ 125 mm)
2) EN 10025-4:2004 for S355M

HISTAR 355 L
fulfils the requirements of
1) ETA-10/0156 (t ≤ 82 mm)
2) EN 10025-4:2004 for S355ML

HISTAR 460
fulfils the requirements of
1) ETA-10/0156 (t ≤ 125 mm)
2) EN 10025-4:2004 for S460M

HISTAR 460 L
fulfils the requirements of
1) ETA-10/0156 (t ≤ 82 mm)
2) EN 10025-4:2004 for S460ML

for offshore applications:

HISTAR 355 TZ OS
fulfils the requirements of
EN 10225:2009 for S355G11+M

HISTAR 355 TZK OS
fulfils the requirements of
EN 10225:2009 for S355G12+M

HISTAR 460 TZ OS
fulfils the requirements of
EN 10225:2009 for S460G3+M

HISTAR 460 TZK OS
fulfils the requirements of
EN 102225:2009 for S460G4+M

Figure 1: Minimum yield strength of HISTAR steels and EN 10025-4:2004 steels according to the material thickness

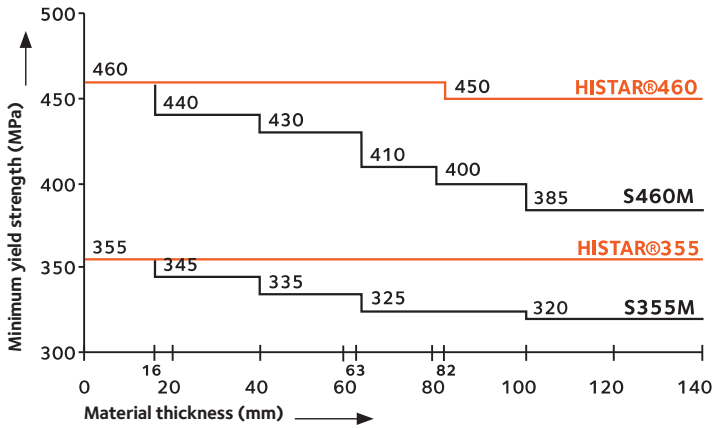


Table 1: Comparison table for HISTAR grades

HISTAR Yield strength (MPa)	Standards									
	European and national standards					Previous standards				
	EN 10025-4: 2004	EN 10025-2: 2004	EN 10225: 2009	ASTM A 913-11	JIS G 3106: 2008	NF A 35-504 NF A 36-201	NF A 35-501	DIN 17102	DIN 17100	BS 4360
355	S 355	S 355	S 355	Gr 50	SM 490 B/C/YB	E 355	E 36	St E 355	St 52-3	50 D
460	S 460	S 450	S 460	Gr 65	SM 570	E 460		St E 460		55 C
				Gr 70						

2. Chemical composition and mechanical properties

The chemical composition and the mechanical properties of the HISTAR grades are given in Table 3 and 4 for general construction and in Table 5 and 6 for offshore applications. (pages 6-7)

3. Types of sections

HISTAR grades are available in the following dimensions:

Table 2: Available sections

Parallel flange beams	IPE 550 on request IPE 600 - IPE 750
Wide flange beams	HE 260 - HE 280 on request HE 300 - HE 1000
Extra wide flange beams	HL 920 - HL 1100
Wide flange columns	HD 260 - HD 400
Wide flange bearing piles	HP 305 - HP 400

Equivalent shapes of ASTM A6, BS4 or other section series available. See Sales Programme of ArcelorMittal Long Carbon Europe, Sections and Merchant Bars for complete list and additional information.

The maximum flange thickness is:

- 140 mm for HISTAR 355 / 460
- 125 mm for HISTAR 355 / 460 according to ETA-10/0156
- 125 mm for HISTAR 355 L / 460 L
- 82 mm for HISTAR 355 L / 460 L according to ETA-10/0156
- 40 mm for HISTAR Offshore grades (sections with flange thickness > 40 mm are subject to agreement).

Table 3: Chemical composition of HISTAR steel grades for general applications

Grades	Chemical composition															
	Ladle analysis[4] [%]															
	C max.	Mn max.	Si [3] max.	P max.	S max.	Al [2] min.	Cr ≤	Ni ≤	Mo ≤	Nb max.	Ti max.	V max.	CEV[1] max. Nominal thickness [mm]			
													t ≤ 63	63 < t ≤ 82	82 < t ≤ 125	125 < t ≤ 140
HISTAR 355	0.12	1.60	0.50	0.035	0.030	0.02	0.30	0.30	0.20	0.05	0.05	0.10	0.39	0.39	0.39	0.39 [5]
HISTAR 355 L	0.12	1.60	0.50	0.030	0.025	0.02	0.30	0.30	0.20	0.05	0.05	0.10	0.39	0.39	0.39 [5]	-
HISTAR 460	0.12	1.70	0.60	0.035	0.030	0.02	0.30	0.70	0.20	0.05	0.05	0.12	0.41	0.43	0.43	0.43 [5]
HISTAR 460 L	0.12	1.70	0.60	0.030	0.025	0.02	0.30	0.70	0.20	0.05	0.05	0.12	0.41	0.43	0.43 [5]	-

(1) CEV = C + Mn/6 + (Cr + Mo + V)/5 + (Cu + Ni)/15
(2) If sufficient nitrogen binding elements are present, the minimum aluminium requirement does not apply.
(3) Upon agreement: Si = 0.14 - 0.25 % and P ≤ 0.035% max. for capability of forming a zinc layer during hot-dip galvanisation.
(4) Chemical elements not in present table are limited as per the provisions of ETA-10/0156.
(5) Upon agreement. Not included in ETA-10/0156

Table 4: Mechanical properties of HISTAR steel grades for general applications

Grades	Mechanical properties						
	Tensile test					Charpy V-notch impact test [1]	
	Min. yield strength R_e [MPa] Nominal thickness [mm]			Tensile strength R_m	Minimum elongation A $L_o=5.65\sqrt{S_o}$	Temperature	Min. absorbed energy
	t ≤ 82	82 < t ≤ 125	125 < t ≤ 140	[MPa]	[%]	[°C]	[J]
HISTAR 355	355	355	355 [2]	470 -630	22	-20	40
HISTAR 355 L	355	355 [2]	-	470-630	22	-20	47
						-50	27
HISTAR 460	460	450	450 [2]	540-720	17	-20	40
HISTAR 460 L	460	450 [2]	-	540-720	17	-20	47
						-50	27

(1) Mean value of three tests for full size specimens with no single value less than 70 % of the guaranteed average value. The provisions according to EN 10025:2004 are applicable.
(2) Upon agreement. Not included in ETA-10/0156

Table 5: Chemical composition of HISTAR steel grades for offshore applications

Grades	Chemical composition									
	Ladle analysis (4) [%]									
	C max.	Mn max.	Si (3) max.	P max.	S max.	Al (2) min.	Nb max.	Ti max.	V max.	CEV(1) max.
HISTAR 355 TZ OFFSHORE	0.12	1.60	0.30	0.025	0.010	0.02	0.04	0.025	0.06	0.38
HISTAR 355 TZK OFFSHORE	0.12	1.60	0.30	0.020	0.007	0.02	0.04	0.025	0.06	0.38
HISTAR 460 TZ OFFSHORE	0.12	1.70	0.30	0.025	0.010	0.02	0.05	0.025	0.06	0.39
HISTAR 460 TZK OFFSHORE	0.12	1.70	0.30	0.020	0.007	0.02	0.05	0.025	0.06	0.39

(1) CEV = C + Mn/6 + (Cr + Mo + V)/5 + (Cu + Ni)/15
(2) When other N-binding elements are used, the minimum Al value does not apply.
(3) Upon agreement: Si = 0.14 - 0.25 % and P ≤ 0.035% max. for capability of forming a zinc layer during hot-dip galvanisation.
(4) Chemical elements not in present table are limited as per the provisions of EN 10225:2009.

Table 6: Mechanical properties of HISTAR steel grades for offshore applications

Grades	Mechanical properties						
	Tensile test				Through thickness tensile test (1)	Charpy V-notch impact test (2)	
	Min. yield strength R_e [MPa]		Tensile strength R_m	Minimum elongation A $L_o=5.65\sqrt{S_o}$	Min. reduction of area Z_z	Longitudinal direction (4)	Transverse direction (3) (4)
	Nominal thickness (mm)		[MPa]	[%]	[%]		
	16	> 16 ≤ 40					
HISTAR 355 TZ OFFSHORE	355	355	460-620	22	25	-40° C KV ≥50 J	-40° C KV ≥27 J
HISTAR 355 TZK OFFSHORE	355	355	460-620	22	35	-40° C KV ≥50 J	-40° C KV ≥50 J
HISTAR 460 TZ OFFSHORE	460	460	530-720	17	25	-40° C KV ≥60 J	-40° C KV ≥27 J
HISTAR 460 TZK OFFSHORE	460	460	530-720	17	35	-40° C KV ≥60 J	-40° C KV ≥50 J

(1) Through thickness testing upon agreement. Mean value of 3 tests. Only for t >15mm.
(2) Mean value of three tests for full size specimens with no single value less than 70 % of the guaranteed average value. The provisions according to EN 10225: 2009 are applicable.
(3) Tested upon agreement.
(4) For thickness ≤ 25 mm, Charpy V test at -20°C

3. Weight reduction of steel structures through the use of HISTAR® steels

1. General

Due to the manufacturing process of quenching and self tempering (QST) HISTAR steels deviate from EN 10025-4:2004 with more severe requirements. The following rules and requirements are defined in the European Technical Approval ETA-10/0156 for HISTAR steel grades.

2. Design advantages

For thicknesses larger than 16mm the minimum yield strength R_{eH} and the ultimate strength R_m of HISTAR steels are greater than those specified in EN 10025-4 (Figure 1).

Lower imperfections of S460 high strength steels are reflected in EN 1993-1-1 in lower imperfection factors and more favorable buckling curves. The same applies to HISTAR 460 (Design example and tables given in Chapter 4. Column design tables).

3. Advantages in fabrication

The chemical analysis (Table 3) of HISTAR steels differs from the analysis specified in EN 10025-4. This results in a lower carbon equivalent value (CEV) and thus a better weldability of HISTAR steels compared to conventional steel grades (Figure 8). No or less preheating before welding is required for HISTAR steel grades (Details given in Chapter 5. Fabrication guidelines).

Additional rules for the design of fillet weld connections allow the use of more favorable correlation factors β_w for HISTAR steels deviating from EN 1993-1-8:

Table 7: Correlation factor β_w

Steel grade	correlation factor β_w for filet welds
HISTAR355/355L	0.85
HISTAR460/460L	0.80

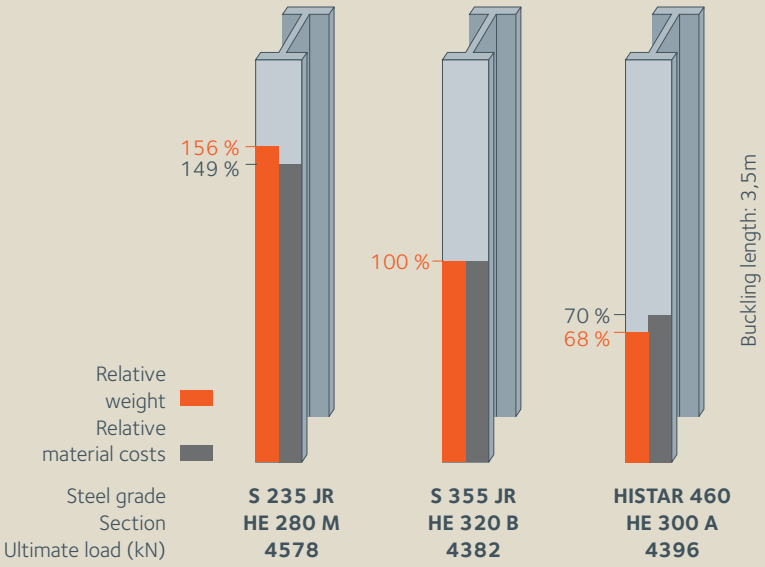
4. Material toughness

HISTAR steels rank in the same good toughness level than thermomechanical rolled steels according to EN10025-4. Consequently the following steel grades have the same maximum permissible flange thickness according to EN1993-1-10, Table 2.1:
HISTAR355 and S355M (idem S355K2)
HISTAR355L and S355ML
HISTAR460 and S460M
HISTAR460L and S460ML

Additionally, as web-to-flange connections of sections in HISTAR steels are hot-rolled and not welded, the thickness limitations given in the rules of EN1993-1-10 do not apply. Generally, if applicable and depending on the reference temperature and the reference stress level, HISTAR steel grades enable the use of heavy sections for safer and more reliable steel structures.

5. Application examples

Sections in HISTAR steel grade have economical advantages to sections in conventional steel grades under compression, tension and bending. Complicated and expensive built-up sections can be substituted by economical hot rolled beams. The reduced weight achieved with HISTAR steels compared to conventional steels leads to reduced cost for material, finishing and assembly.



High strength HISTAR grades allow, in comparison with conventional structural steels, to reduce the weight and material costs of steel structures, and to cut welding and assembly time (see Figures 2,3 and 4).

Figure 2: Economical use of HISTAR steel in columns

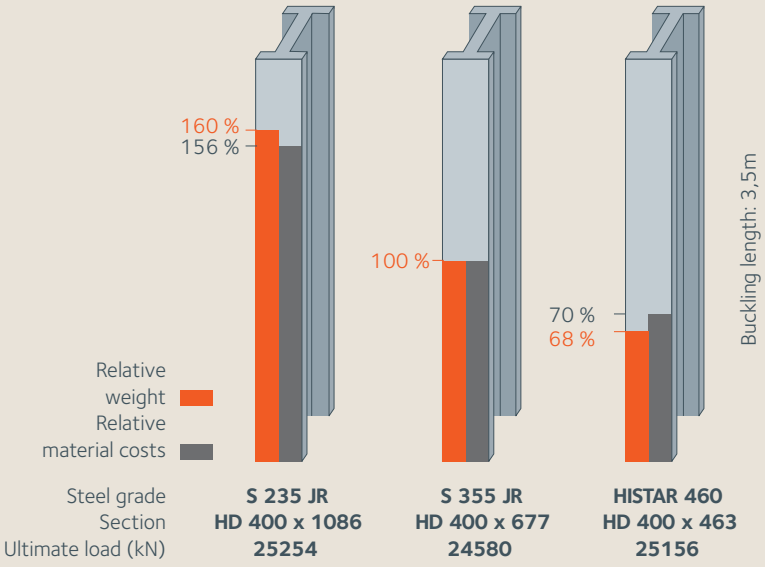


Figure 3: Economical use of HISTAR steel in heavy columns

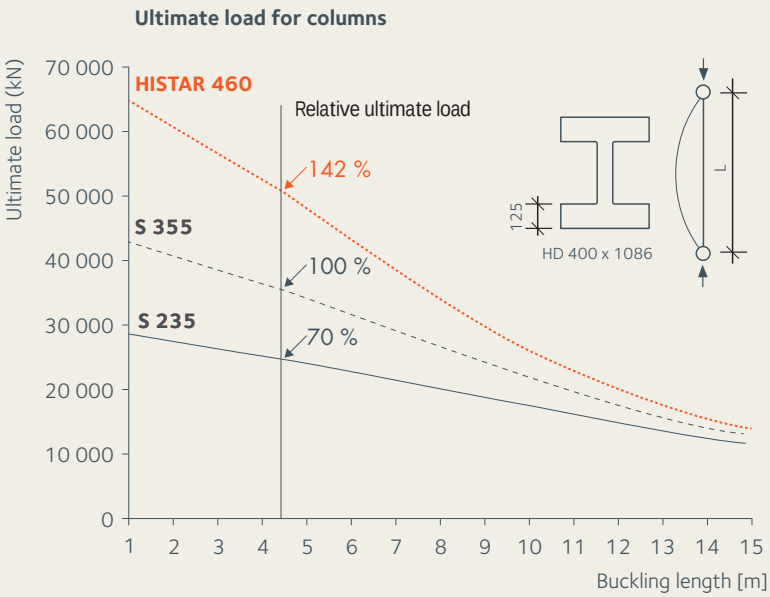


Figure 4: Influence of the slenderness on the load carrying capacity of the columns in HISTAR and conventional steels

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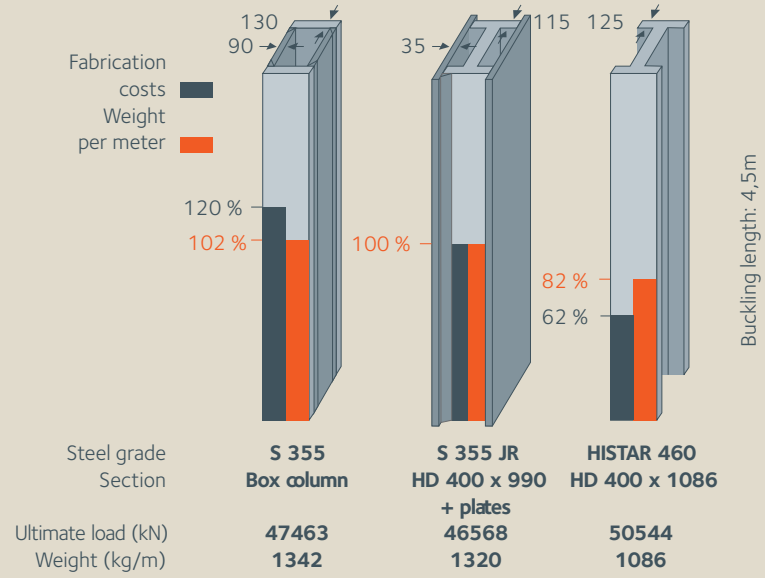
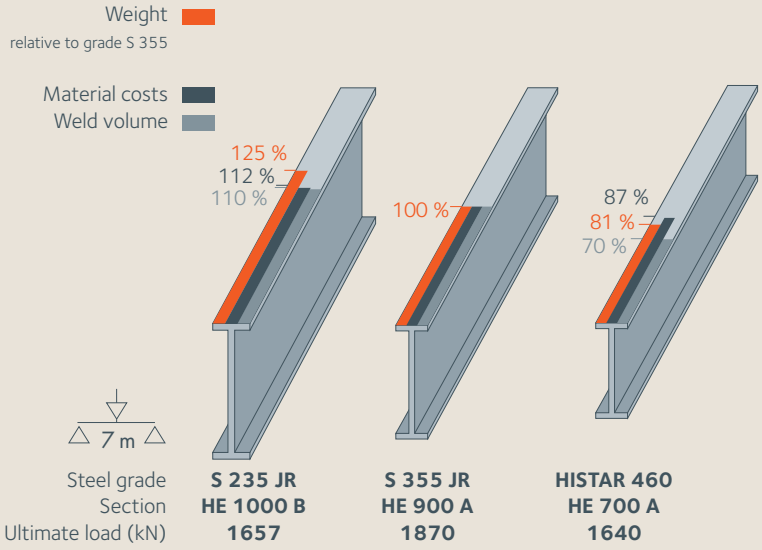


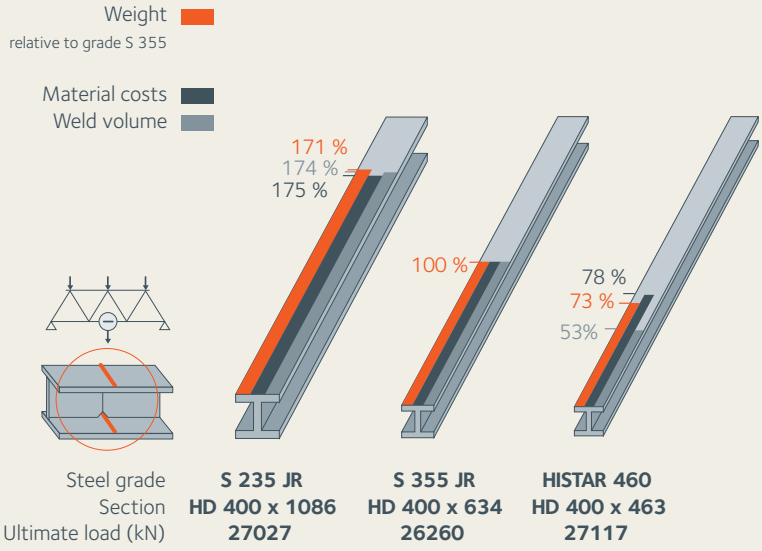
Due to the high yield strength of HISTAR beams, it is possible to substitute complicated and expensive built-up sections by economical hot rolled beams (see Figure 5).

Figure 5: Economical use of a HISTAR column compared to built-up sections



In case of bending, the required cross section and fabrication cost can be reduced by using beams in HISTAR grades (see Figure 6).

Figure 6: Economical use of HISTAR beams as girders



HISTAR grades develop their full potential in the design of tension members in trusses. Here, they not only allow to save material costs by taking full advantage of the high yield strength but the reduction of the dead load of the truss also leads to the design of even thinner sections, resulting in additional savings in fabrication costs (see Figure 7).

Figure 7: Economical use of HISTAR beams in truss Applications

4. Column design tables

Table 8: Design buckling resistance of strong and weak axis of HD column sections in HISTAR 355

Section designation	Axis	Compression resistance $N_{b,y,Rd}$, $N_{b,z,Rd}$ [kN] for buckling length L_b [m]												
		2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00
HD 400 x 1299	$N_{b,y,Rd}$	58 570	58 570	56 530	53 830	51 200	48 610	46 070	43 570	41 110	38 700	36 360	34 110	31 960
	$N_{b,z,Rd}$	58 070	53 380	48 900	44 540	40 300	36 240	32 430	28 930	25 790	23 010	20 570	18 440	16 590
HD 400 x 1202	$N_{b,y,Rd}$	54 310	54 310	52 140	49 580	47 080	44 630	42 220	39 840	37 510	35 240	33 040	30 920	28 910
	$N_{b,z,Rd}$	53 710	49 300	45 090	40 990	37 010	33 200	29 650	26 400	23 490	20 920	18 680	16 730	15 040
HD 400 x 1086	$N_{b,y,Rd}$	49 200	49 200	47 190	44 860	42 590	40 360	38 170	36 010	33 890	31 820	29 820	27 900	26 070
	$N_{b,z,Rd}$	48 430	44 340	40 430	36 620	32 940	29 430	26 180	23 230	20 610	18 310	16 310	14 580	13 080
HD 400 x 990	$N_{b,y,Rd}$	44 800	44 800	42 780	40 610	38 500	36 430	34 400	32 390	30 430	28 520	26 670	24 910	23 240
	$N_{b,z,Rd}$	43 980	40 210	36 600	33 090	29 700	26 480	23 500	20 810	18 430	16 350	14 550	12 990	11 650
HD 400 x 900	$N_{b,y,Rd}$	40 780	40 780	38 750	36 740	34 780	32 850	30 960	29 090	27 270	25 510	23 810	22 190	20 660
	$N_{b,z,Rd}$	39 930	36 460	33 130	29 890	26 770	23 810	21 090	18 640	16 480	14 600	12 980	11 580	10 380
HD 400 x 818	$N_{b,y,Rd}$	37 020	36 990	36 100	35 180	34 210	33 180	32 060	30 850	29 530	28 110	26 590	25 010	23 410
	$N_{b,z,Rd}$	36 460	34 290	32 040	29 640	27 080	24 420	21 780	19 280	17 000	14 980	13 230	11 730	10 440
HD 400 x 744	$N_{b,y,Rd}$	33 650	33 570	32 740	31 890	30 980	30 020	28 970	27 820	26 580	25 240	23 820	22 340	20 850
	$N_{b,z,Rd}$	33 090	31 090	29 010	26 790	24 420	21 970	19 550	17 260	15 190	13 370	11 790	10 440	9 290
HD 400 x 677	$N_{b,y,Rd}$	30 650	30 530	29 760	28 960	28 110	27 210	26 220	25 140	23 970	22 710	21 370	19 990	18 610
	$N_{b,z,Rd}$	30 100	28 250	26 330	24 280	22 100	19 840	17 620	15 530	13 640	11 990	10 570	9 350	8 310
HD 400 x 634	$N_{b,y,Rd}$	28 680	28 550	27 820	27 060	26 260	25 390	24 450	23 420	22 300	21 100	19 830	18 530	17 220
	$N_{b,z,Rd}$	28 130	26 390	24 580	22 630	20 570	18 430	16 340	14 380	12 620	11 080	9 760	8 630	7 670
HD 400 x 592	$N_{b,y,Rd}$	26 790	26 650	25 950	25 240	24 470	23 650	22 760	21 780	20 710	19 560	18 350	17 120	15 890
	$N_{b,z,Rd}$	26 260	24 610	22 900	21 060	19 110	17 100	15 130	13 290	11 650	10 220	9 000	7 950	7 060
HD 400 x 551	$N_{b,y,Rd}$	24 890	24 730	24 080	23 400	22 680	21 900	21 050	20 110	19 100	18 010	16 860	15 700	14 540
	$N_{b,z,Rd}$	24 370	22 830	21 220	19 500	17 670	15 780	13 940	12 240	10 720	9 390	8 260	7 300	6 480
HD 400 x 509	$N_{b,y,Rd}$	23 030	22 860	22 250	21 610	20 940	20 200	19 400	18 520	17 560	16 530	15 450	14 360	13 280
	$N_{b,z,Rd}$	22 530	21 100	19 600	17 990	16 280	14 530	12 820	11 240	9 830	8 610	7 570	6 690	5 930
HD 400 x 463	$N_{b,y,Rd}$	20 920	20 740	20 180	19 590	18 960	18 270	17 520	16 700	15 810	14 850	13 860	12 850	11 860
	$N_{b,z,Rd}$	20 440	19 120	17 740	16 260	14 690	13 080	11 520	10 080	8 800	7 700	6 770	5 970	5 300
HD 400 x 421	$N_{b,y,Rd}$	19 060	18 870	18 350	17 810	17 220	16 580	15 880	15 120	14 280	13 390	12 470	11 540	10 630
	$N_{b,z,Rd}$	18 600	17 390	16 120	14 760	13 310	11 830	10 400	9 090	7 930	6 940	6 090	5 370	4 760
HD 400 x 382	$N_{b,y,Rd}$	17 290	17 100	16 620	16 120	15 580	14 990	14 340	13 630	12 860	12 030	11 180	10 330	9 500
	$N_{b,z,Rd}$	16 850	15 750	14 580	13 330	12 000	10 650	9 350	8 160	7 120	6 220	5 450	4 810	4 260
HD 400 x 347	$N_{b,y,Rd}$	15 690	15 500	15 060	14 590	14 090	13 550	12 950	12 290	11 570	10 810	10 020	9 240	8 490
	$N_{b,z,Rd}$	15 280	14 270	13 210	12 060	10 850	9 620	8 430	7 350	6 400	5 590	4 900	4 320	3 830
HD 400 x 314	$N_{b,y,Rd}$	14 170	13 980	13 580	13 150	12 690	12 190	11 640	11 030	10 370	9 670	8 950	8 240	7 560
	$N_{b,z,Rd}$	13 780	12 860	11 890	10 840	9 730	8 610	7 540	6 560	5 710	4 980	4 360	3 840	3 400
HD 400 x 287	$N_{b,y,Rd}$	13 000	12 820	12 450	12 050	11 630	11 160	10 650	10 080	9 470	8 820	8 160	7 500	6 870
	$N_{b,z,Rd}$	12 640	11 790	10 890	9 930	8 910	7 870	6 880	5 990	5 210	4 540	3 980	3 500	3 100
HD 400 x 262	$N_{b,y,Rd}$	11 870	11 700	11 360	10 990	10 600	10 170	9 690	9 160	8 600	8 000	7 380	6 780	6 210
	$N_{b,z,Rd}$	11 540	10 760	9 930	9 040	8 100	7 150	6 250	5 430	4 720	4 110	3 600	3 170	2 800
HD 400 x 237	$N_{b,y,Rd}$	10 680	10 520	10 200	9 870	9 510	9 110	8 680	8 200	7 680	7 130	6 570	6 030	5 510
	$N_{b,z,Rd}$	10 360	9 660	8 910	8 100	7 250	6 390	5 570	4 840	4 200	3 660	3 200	2 810	2 490
HD 400 x 216	$N_{b,y,Rd}$	9 780	9 620	9 330	9 020	8 690	8 330	7 920	7 470	6 990	6 490	5 980	5 470	5 000
	$N_{b,z,Rd}$	9 480	8 830	8 150	7 410	6 620	5 830	5 090	4 410	3 830	3 330	2 920	2 560	2 270
HD 400 x 187	$N_{b,y,Rd}$	8 430	8 290	8 040	7 770	7 480	7 160	6 800	6 410	5 990	5 550	5 100	4 670	4 260
	$N_{b,z,Rd}$	8 170	7 600	7 000	6 360	5 670	4 990	4 340	3 760	3 260	2 830	2 480	2 180	1 930
HD 360 x 196	$N_{b,y,Rd}$	8 880	8 730	8 470	8 190	7 880	7 540	7 170	6 760	6 320	5 850	5 380	4 930	4 500
	$N_{b,z,Rd}$	8 550	7 920	7 240	6 520	5 760	5 010	4 320	3 710	3 200	2 770	2 410	2 120	1 870
HD 360 x 179	$N_{b,y,Rd}$	8 100	7 960	7 720	7 460	7 180	6 870	6 530	6 150	5 740	5 310	4 880	4 470	4 070
	$N_{b,z,Rd}$	7 790	7 210	6 600	5 930	5 230	4 550	3 920	3 370	2 900	2 510	2 190	1 920	1 690
HD 360 x 162	$N_{b,y,Rd}$	7 320	7 190	6 970	6 740	6 480	6 200	5 890	5 540	5 170	4 790	4 400	4 020	3 660
	$N_{b,z,Rd}$	7 040	6 510	5 950	5 350	4 720	4 100	3 530	3 030	2 610	2 260	1 970	1 720	1 520
HD 360 x 147	$N_{b,y,Rd}$	6 670	6 550	6 340	6 130	5 890	5 630	5 340	5 030	4 690	4 330	3 970	3 630	3 300
	$N_{b,z,Rd}$	6 400	5 920	5 410	4 860	4 280	3 710	3 190	2 740	2 360	2 040	1 770	1 550	1 370
HD 360 x 134	$N_{b,y,Rd}$	6 050	5 940	5 750	5 560	5 340	5 100	4 840	4 550	4 230	3 910	3 580	3 270	2 980
	$N_{b,z,Rd}$	5 810	5 370	4 900	4 400	3 870	3 360	2 880	2 470	2 130	1 840	1 600	1 400	1 240
HD 320 x 300	$N_{b,y,Rd}$	13 560	13 270	12 830	12 370	11 860	11 300	10 670	9 980	9 240	8 490	7 740	7 030	6 370
	$N_{b,z,Rd}$	12 690	11 510	10 220	8 840	7 490	6 270	5 240	4 410	3 730	3 190	2 760	2 400	2 110
HD 320 x 245	$N_{b,y,Rd}$	11 070	10 810	10 450	10 060	9 630	9 150	8 620	8 040	7 420	6 790	6 170	5 590	5 060
	$N_{b,z,Rd}$	10 340	9 370	8 300	7 170	6 050	5 060	4 220	3 540	3 000	2 570	2 210	1 930	1 690
HD 320 x 198	$N_{b,y,Rd}$	8 950	8 720	8 410	8 080	7 720	7 310	6 860	6 370	5 840	5 320	4 820	4 340	3 920
	$N_{b,z,Rd}$	8 330	7 530	6 640	5 700	4 790	3 980	3 320	2 780	2 350	2 000	1 730	1 500	1 320
HD 320 x 158	$N_{b,y,Rd}$	7 140	6 930	6 690	6 420	6 120	5 780	5 400	4 990	4 570	4 140	3 740	3 360	3 030
	$N_{b,z,Rd}$	6 620	5 970	5 250	4 490	3 750	3 110	2 580	2 160	1 830	1 560	1 340	1 170	1 020
HD 320 x 127	$N_{b,y,Rd}$	5 720	5 550	5 350	5 120	4 880	4 600	4 290	3 960	3 610	3 260	2 940	2 640	2 370
	$N_{b,z,Rd}$	5 300	4 760	4 170	3 550	2 960	2 450	2 030	1 700	1 430	1 220	1 050	910	800
HD 320 x 97,6*	$N_{b,y,Rd}$	4 410	4 270	4 110	3 930	3 740	3 520	3 270	3 010	2 730	2 460	2 210	1 980	1 780
	$N_{b,z,Rd}$	4 070	3 660	3 200	2 720	2 260	1 860	1 540	1 290	1 080	920	790	690	600
HD 320 x 74,2*	$N_{b,y,Rd}$	3 350	3 240	3 110	2 970	2 810	2 640	2 440	2 230	2 020	1 810	1 620	1 440	1 290
	$N_{b,z,Rd}$	3 080	2 750	2 380	2 000	1 650	1 350	1 110	920	780	660	570	490	430

* Steel grade S355M

Calculation of the design buckling resistance of a compression member according to EN 1993-1-1: 2005 (Design governed by buckling about weak axis z-z)

Steel Column; buckling length L_b = 4.00 m
HD 400 x 634, HISTAR 460 (f_y = 460 MPa, $t_f \leq 82$ mm)
A = 808 cm^2 I_z = 98250 cm^4 E = 210000 MPa

Partial safety factor (EN 1993-1-1: 2005, 6.1): $\gamma_{M1} = 1.00$

Elastic critical force: $N_{cr} = \frac{\pi^2 * E * I_z}{L_b^2}$

Non dimensional slenderness for class 1, 2 and 3 sections (EN 1993-1-1: 2005 (6.49)):

$$\bar{\lambda} = \sqrt{\frac{A * f_y}{N_{cr}}} = \frac{L_b}{\pi}\sqrt{\frac{A * f_y}{I_z * E}} = \frac{400\text{cm}}{\pi}\sqrt{\frac{808\text{cm}^2 * 460\text{MPa}}{98250\text{cm}^4 * 210000\text{MPa}}} = 0.5404$$

Determination of the buckling curve (EN 1993-1-1: 2005, Table 6.1, Table 6.2):
Rolled I–Section, Buckling of the weak axis z-z, h/b ≤ 1.20, $t_f \leq 100$ mm, S460:

- Table 6.2: Buckling curve a
- Table 6.1: Imperfection factor $\alpha = 0.21$

Buckling reduction factor χ (EN 1993-1-1: 2005 (6.49)):

$$\phi = 0.50 * \left[1 + \alpha * (\bar{\lambda} - 0.20) + \bar{\lambda}^2\right] = 0.50 * \left[1 + 0.21 * (0.5404 - 0.20) + 0.5404^2\right] = 0.6818$$

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} \leq 1.00 \qquad \chi = \frac{1}{0.6818 + \sqrt{0.6818^2 - 0.5404^2}} = 0.911$$

Design buckling resistance of a compression member for class 1, 2 and 3 sections (EN 1993-1-1: 2005 (6.47)):

$$N_{b,Rd} = \frac{\chi * A * f_y}{\gamma_{M1}} \qquad N_{b,z,Rd} = \frac{0.911 * 808\text{cm}^2 * 46\text{kN/cm}^2}{1.00} = 33860\text{kN}$$

Weight and cost reduction due to Design in HISTAR460:

HISTAR 460	S 355
HD 400 x 634 G = 634 kg/m	HD 400 x 1086 G = 1086 kg/m
h x b = 474 x 424 mm t_f = 77.1 mm; t_w = 47.6 mm A = 808.0 cm^2	h x b = 569 x 454 mm t_f = 125 mm; t_w = 78 mm A = 1386.0 cm^2
f_y = 460 MPa (ETA-10/0156)	f_y = 295 MPa (EN 10025-2: 2004)
Buckling length L_b = 4.00 m $\bar{\lambda} = 0.5404$ Buckling curve **a** $\chi = 0.911$	Buckling length L_b = 4.00 m $\bar{\lambda} = 0.4011$ Buckling curve **d** $\chi = 0.850$
$N_{b,Rd}$ = 33860 kN	**$N_{b,Rd}$ = 34740 kN**

Table 9: Design buckling resistance of strong and weak axis of HD column sections in HISTAR 460

Section designation	Axis	Compression resistance $N_{b,y,Rd}$, $N_{b,z,Rd}$ [kN] for buckling length L_b [m]												
		2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00
HD 400 x 1299	$N_{b,y,Rd}$	74 250	73 990	71 390	68 770	66 090	63 320	60 430	57 420	54 310	51 120	47 910	44 730	41 630
	$N_{b,z,Rd}$	72 830	68 330	63 630	58 600	53 250	47 730	42 310	37 230	32 680	28 700	25 270	22 350	19 860
HD 400 x 1202	$N_{b,y,Rd}$	68 850	68 410	65 940	63 440	60 880	58 220	55 440	52 550	49 570	46 520	43 470	40 460	37 550
	$N_{b,z,Rd}$	67 410	63 160	58 720	53 960	48 900	43 700	38 620	33 900	29 690	26 030	22 890	20 230	17 960
HD 400 x 1086	$N_{b,y,Rd}$	62 370	61 940	59 690	57 420	55 080	52 660	50 130	47 500	44 780	42 010	39 230	36 490	33 850
	$N_{b,z,Rd}$	60 850	56 890	52 730	48 270	43 520	38 680	34 010	29 720	25 930	22 670	19 900	17 550	15 560
HD 400 x 990	$N_{b,y,Rd}$	56 790	56 260	54 170	52 050	49 860	47 590	45 220	42 750	40 210	37 620	35 040	32 520	30 090
	$N_{b,z,Rd}$	55 300	51 640	47 780	43 630	39 230	34 760	30 470	26 560	23 130	20 190	17 700	15 600	13 820
HD 400 x 900	$N_{b,y,Rd}$	51 700	51 090	49 130	47 150	45 100	42 970	40 740	38 420	36 040	33 620	31 220	28 890	26 670
	$N_{b,z,Rd}$	50 250	46 860	43 280	39 430	35 360	31 230	27 300	23 740	20 640	17 990	15 750	13 870	12 280
HD 400 x 818	$N_{b,y,Rd}$	46 930	46 640	45 830	44 960	43 990	42 900	41 630	40 130	38 380	36 350	34 070	31 630	29 140
	$N_{b,z,Rd}$	46 320	44 860	43 120	40 900	37 980	34 290	30 110	25 970	22 260	19 110	16 500	14 340	12 550
HD 400 x 744	$N_{b,y,Rd}$	42 660	42 350	41 600	40 780	39 870	38 840	37 630	36 200	34 520	32 590	30 430	28 140	25 830
	$N_{b,z,Rd}$	42 070	40 720	39 100	37 020	34 280	30 820	26 950	23 170	19 820	16 990	14 650	12 730	11 140
HD 400 x 677	$N_{b,y,Rd}$	39 710	39 360	38 630	37 840	36 950	35 920	34 720	33 290	31 600	29 670	27 540	25 320	23 130
	$N_{b,z,Rd}$	39 110	37 820	36 250	34 220	31 520	28 150	24 460	20 920	17 830	15 250	13 130	11 400	9 970
HD 400 x 634	$N_{b,y,Rd}$	37 160	36 810	36 120	35 370	34 520	33 540	32 380	31 000	29 380	27 530	25 500	23 400	21 340
	$N_{b,z,Rd}$	36 580	35 360	33 860	31 920	29 340	26 130	22 640	19 320	16 450	14 060	12 100	10 490	9 170
HD 400 x 592	$N_{b,y,Rd}$	34 720	34 370	33 710	33 000	32 190	31 250	30 140	28 820	27 260	25 480	23 540	21 560	19 620
	$N_{b,z,Rd}$	34 160	33 000	31 580	29 730	27 270	24 210	20 920	17 820	15 150	12 940	11 130	9 650	8 430
HD 400 x 551	$N_{b,y,Rd}$	32 260	31 910	31 290	30 610	29 840	28 940	27 870	26 600	25 110	23 400	21 570	19 700	17 890
	$N_{b,z,Rd}$	31 720	30 630	29 300	27 540	25 210	22 330	19 250	16 370	13 900	11 860	10 200	8 840	7 720
HD 400 x 509	$N_{b,y,Rd}$	29 850	29 510	28 920	28 280	27 560	26 700	25 690	24 480	23 060	21 450	19 720	17 970	16 300
	$N_{b,z,Rd}$	29 340	28 320	27 070	25 430	23 240	20 540	17 670	15 010	12 730	10 860	9 330	8 090	7 070
HD 400 x 463	$N_{b,y,Rd}$	27 110	26 780	26 240	25 640	24 960	24 170	23 210	22 070	20 730	19 220	17 620	16 010	14 490
	$N_{b,z,Rd}$	26 630	25 690	24 530	23 000	20 960	18 460	15 830	13 420	11 370	9 690	8 320	7 210	6 290
HD 400 x 421	$N_{b,y,Rd}$	24 700	24 380	23 880	23 320	22 690	21 940	21 040	19 960	18 700	17 290	15 800	14 330	12 940
	$N_{b,z,Rd}$	24 250	23 390	22 310	20 890	18 990	16 680	14 270	12 070	10 220	8 700	7 470	6 470	5 650
HD 400 x 382	$N_{b,y,Rd}$	22 400	22 090	21 630	21 120	20 530	19 830	18 990	17 990	16 810	15 500	14 130	12 790	11 530
	$N_{b,z,Rd}$	21 980	21 190	20 200	18 880	17 130	15 000	12 800	10 810	9 140	7 780	6 680	5 780	5 050
HD 400 x 347	$N_{b,y,Rd}$	20 330	20 030	19 600	19 130	18 580	17 930	17 140	16 200	15 100	13 880	12 630	11 400	10 260
	$N_{b,z,Rd}$	19 940	19 210	18 310	17 090	15 480	13 530	11 530	9 730	8 220	6 990	6 000	5 190	4 530
HD 400 x 314	$N_{b,y,Rd}$	18 360	18 080	17 690	17 250	16 740	16 140	15 410	14 530	13 510	12 390	11 240	10 130	9 110
	$N_{b,z,Rd}$	17 990	17 330	16 500	15 380	13 880	12 100	10 280	8 650	7 300	6 210	5 320	4 600	4 020
HD 400 x 287	$N_{b,y,Rd}$	16 840	16 580	16 220	15 810	15 340	14 780	14 100	13 280	12 330	11 290	10 230	9 210	8 270
	$N_{b,z,Rd}$	16 510	15 890	15 120	14 090	12 700	11 050	9 380	7 890	6 660	5 650	4 850	4 190	3 660
HD 400 x 262	$N_{b,y,Rd}$	15 390	15 130	14 800	14 420	13 990	13 460	12 830	12 060	11 180	10 210	9 240	8 300	7 450
	$N_{b,z,Rd}$	15 070	14 510	13 790	12 830	11 550	10 030	8 500	7 140	6 020	5 110	4 380	3 790	3 310
HD 400 x 237	$N_{b,y,Rd}$	13 840	13 600	13 300	12 950	12 550	12 070	11 480	10 780	9 960	9 080	8 200	7 360	6 590
	$N_{b,z,Rd}$	13 550	13 030	12 380	11 500	10 330	8 950	7 570	6 350	5 350	4 540	3 890	3 360	2 930
HD 400 x 216	$N_{b,y,Rd}$	12 670	12 450	12 160	11 850	11 470	11 030	10 480	9 820	9 070	8 250	7 440	6 670	5 970
	$N_{b,z,Rd}$	12 400	11 930	11 330	10 520	9 440	8 170	6 900	5 790	4 870	4 130	3 540	3 060	2 670
HD 400 x 187	$N_{b,y,Rd}$	10 920	10 730	10 480	10 200	9 870	9 480	9 000	8 420	7 750	7 040	6 340	5 670	5 070
	$N_{b,z,Rd}$	10 690	10 270	9 750	9 030	8 080	6 970	5 870	4 920	4 140	3 510	3 000	2 600	2 260
HD 360 x 196	$N_{b,y,Rd}$	11 510	11 300	11 040	10 750	10 410	9 990	9 490	8 880	8 180	7 430	6 690	5 990	5 360
	$N_{b,z,Rd}$	11 220	10 750	10 140	9 290	8 170	6 930	5 760	4 790	4 010	3 390	2 900	2 500	2 180
HD 360 x 179	$N_{b,y,Rd}$	10 500	10 300	10 070	9 800	9 480	9 100	8 630	8 070	7 430	6 740	6 060	5 420	4 850
	$N_{b,z,Rd}$	10 230	9 800	9 230	8 450	7 430	6 290	5 220	4 340	3 630	3 070	2 620	2 260	1 970
HD 360 x 162	$N_{b,y,Rd}$	9 480	9 310	9 090	8 850	8 560	8 210	7 790	7 270	6 690	6 070	5 450	4 880	4 360
	$N_{b,z,Rd}$	9 240	8 850	8 340	7 620	6 690	5 650	4 700	3 900	3 260	2 760	2 350	2 030	1 770
HD 360 x 147	$N_{b,y,Rd}$	8 640	8 470	8 280	8 050	7 780	7 460	7 070	6 590	6 050	5 480	4 920	4 390	3 920
	$N_{b,z,Rd}$	8 410	8 050	7 580	6 920	6 060	5 110	4 240	3 520	2 940	2 480	2 120	1 830	1 590
HD 360 x 134	$N_{b,y,Rd}$	7 840	7 690	7 510	7 300	7 060	6 760	6 400	5 960	5 460	4 940	4 430	3 950	3 530
	$N_{b,z,Rd}$	7 630	7 310	6 880	6 270	5 490	4 620	3 830	3 180	2 650	2 240	1 910	1 650	1 440
HD 320 x 300	$N_{b,y,Rd}$	17 570	17 190	16 760	16 270	15 690	14 960	14 080	13 020	11 840	10 630	9 470	8 420	7 490
	$N_{b,z,Rd}$	16 870	15 910	14 530	12 560	10 300	8 270	6 650	5 420	4 490	3 760	3 200	2 750	2 390
HD 320 x 245	$N_{b,y,Rd}$	14 340	14 020	13 660	13 240	12 740	12 120	11 360	10 460	9 470	8 460	7 510	6 660	5 910
	$N_{b,z,Rd}$	13 760	12 970	11 810	10 170	8 310	6 650	5 340	4 350	3 600	3 020	2 570	2 210	1 920
HD 320 x 198	$N_{b,y,Rd}$	11 580	11 310	11 010	10 650	10 220	9 680	9 020	8 240	7 410	6 580	5 810	5 140	4 550
	$N_{b,z,Rd}$	11 110	10 440	9 450	8 070	6 540	5 210	4 170	3 390	2 800	2 350	2 000	1 720	1 490
HD 320 x 158	$N_{b,y,Rd}$	9 230	9 000	8 750	8 460	8 100	7 650	7 090	6 440	5 760	5 090	4 490	3 960	3 500
	$N_{b,z,Rd}$	8 840	8 290	7 480	6 340	5 110	4 050	3 240	2 630	2 170	1 820	1 550	1 330	1 150
HD 320 x 127	$N_{b,y,Rd}$	7 390	7 210	7 000	6 760	6 460	6 080	5 620	5 090	4 530	4 000	3 510	3 090	2 730
	$N_{b,z,Rd}$	7 080	6 620	5 950	5 020	4 020	3 180	2 540	2 060	1 700	1 420	1 210	1 040	900
HD 320 x 97,6 *	$N_{b,y,Rd}$	5 690	5 550	5 390	5 190	4 950	4 650	4 280	3 850	3 420	3 000	2 630	2 310	2 040
	$N_{b,z,Rd}$	5 450	5 100	4 560	3 830	3 050	2 410	1 920	1 560	1 280	1 080	910	780	680
HD 320 x 74,2 *	$N_{b,y,Rd}$	3 720	3 630	3 530	3 420	3 280	3 100	2 880	2 630	2 360	2 090	1 850	1 630	1 440
	$N_{b,z,Rd}$	3 570	3 360	3 040	2 600	2 110	1 680	1 350	1 100	900	760	640	550	480

* Steel grade S460M

Table 8: Design buckling resistance of strong and weak axis of HD column sections in HISTAR 355 (continued)

Section designation	Axis	Compression resistance $N_{b,y,Rd}$, $N_{b,z,Rd}$ [kN] for buckling length L_b [m]												
		2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00
HD 260 x 299	$N_{b,y,Rd}$	13 500	13 010	12 490	11 920	11 270	10 540	9 730	8 870	8 000	7 160	6 390	5 700	5 090
	$N_{b,z,Rd}$	12 380	11 040	9 560	8 030	6 610	5 420	4 460	3 710	3 120	2 650	2 280	1 980	1 730
HD 260 x 225	$N_{b,y,Rd}$	10 130	9 740	9 320	8 860	8 330	7 730	7 060	6 370	5 690	5 060	4 480	3 980	3 540
	$N_{b,z,Rd}$	9 260	8 210	7 050	5 870	4 790	3 900	3 200	2 650	2 220	1 890	1 620	1 410	1 230
HD 260 x 172	$N_{b,y,Rd}$	7 740	7 430	7 090	6 720	6 290	5 800	5 270	4 720	4 190	3 700	3 270	2 890	2 570
	$N_{b,z,Rd}$	7 070	6 260	5 360	4 440	3 610	2 940	2 400	1 990	1 670	1 420	1 220	1 050	920
HD 260 x 142	$N_{b,y,Rd}$	6 340	6 080	5 790	5 470	5 100	4 680	4 220	3 760	3 320	2 920	2 570	2 270	2 010
	$N_{b,z,Rd}$	5 780	5 090	4 340	3 570	2 890	2 340	1 910	1 580	1 320	1 120	960	830	730
HD 260 x 114	$N_{b,y,Rd}$	5 110	4 900	4 660	4 390	4 080	3 730	3 350	2 970	2 620	2 300	2 020	1 780	1 570
	$N_{b,z,Rd}$	4 650	4 090	3 460	2 840	2 290	1 850	1 510	1 240	1 040	880	750	650	570
HD 260 x 93,0	$N_{b,y,Rd}$	4 150	3 970	3 770	3 550	3 290	3 000	2 690	2 370	2 080	1 830	1 600	1 410	1 250
	$N_{b,z,Rd}$	3 770	3 310	2 790	2 280	1 830	1 480	1 200	990	830	700	600	520	450
HD 260 x 68,2*	$N_{b,y,Rd}$	3 030	2 900	2 750	2 580	2 380	2 160	1 920	1 690	1 480	1 290	1 130	990	880
	$N_{b,z,Rd}$	2 760	2 410	2 030	1 650	1 320	1 060	860	710	590	500	430	370	320
HD 260 x 54,1*	$N_{b,y,Rd}$	2 410	2 300	2 180	2 030	1 870	1 690	1 500	1 310	1 140	1 000	870	760	670
	$N_{b,z,Rd}$	2 180	1 890	1 580	1 280	1 020	810	660	540	450	380	330	280	250
HL 1100 R	$N_{b,y,Rd}$	21 550	21 550	21 550	21 550	21 550	21 550	21 340	21 130	20 900	20 680	20 450	20 220	19 980
	$N_{b,z,Rd}$	20 580	18 960	17 210	15 330	13 380	11 510	9 830	8 390	7 190	6 200	5 390	4 710	4 150
HL 1100 M	$N_{b,y,Rd}$	17 990	17 990	17 990	17 990	17 990	17 990	17 900	17 790	17 680	17 560	17 440	17 320	17 190
	$N_{b,z,Rd}$	17 460	16 480	15 360	14 020	12 480	10 850	9 290	7 920	6 760	5 800	5 010	4 370	3 830
HL 1100 B	$N_{b,y,Rd}$	15 840	15 840	15 840	15 840	15 840	15 840	15 760	15 670	15 570	15 470	15 360	15 260	15 150
	$N_{b,z,Rd}$	15 370	14 520	13 540	12 370	11 020	9 590	8 220	7 000	5 980	5 130	4 440	3 870	3 390
HL 1100 A	$N_{b,y,Rd}$	13 510	13 510	13 510	13 510	13 510	13 510	13 450	13 370	13 280	13 200	13 110	13 020	12 930
	$N_{b,z,Rd}$	13 120	12 400	11 560	10 570	9 430	8 220	7 050	6 010	5 140	4 410	3 810	3 320	2 920
HL 1000 x 976	$N_{b,y,Rd}$	44 120	44 120	44 120	44 120	44 120	43 950	43 480	43 000	42 520	42 030	41 530	41 010	40 480
	$N_{b,z,Rd}$	42 590	39 540	36 290	32 780	29 100	25 430	22 020	19 000	16 420	14 250	12 430	10 920	9 640
HL 1000 x 883	$N_{b,y,Rd}$	39 940	39 940	39 940	39 940	39 940	39 770	39 340	38 900	38 460	38 010	37 550	37 080	36 600
	$N_{b,z,Rd}$	38 500	35 700	32 720	29 500	26 120	22 780	19 680	16 960	14 630	12 690	11 060	9 710	8 570
HL 1000 x 748	$N_{b,y,Rd}$	33 840	33 840	33 840	33 840	33 840	33 660	33 290	32 920	32 540	32 150	31 760	31 350	30 930
	$N_{b,z,Rd}$	32 520	30 090	27 490	24 680	21 750	18 870	16 240	13 940	12 000	10 390	9 040	7 930	7 000
HL 1000 x 642	$N_{b,y,Rd}$	29 020	29 020	29 020	29 020	29 020	28 840	28 520	28 190	27 860	27 530	27 180	26 830	26 460
	$N_{b,z,Rd}$	27 810	25 680	23 390	20 920	18 360	15 870	13 600	11 650	10 010	8 650	7 520	6 590	5 810
HL 1000 x 591	$N_{b,y,Rd}$	26 720	26 720	26 720	26 720	26 720	26 550	26 250	25 950	25 650	25 340	25 020	24 690	24 350
	$N_{b,z,Rd}$	25 580	23 610	21 490	19 200	16 830	14 520	12 440	10 640	9 140	7 890	6 860	6 010	5 300
HL 1000 x 554	$N_{b,y,Rd}$	25 050	25 050	25 050	25 050	25 050	24 880	24 600	24 320	24 030	23 740	23 440	23 130	22 810
	$N_{b,z,Rd}$	23 950	22 090	20 080	17 920	15 670	13 510	11 550	9 870	8 470	7 310	6 350	5 560	4 900
HL 1000 x 539	$N_{b,y,Rd}$	24 390	24 390	24 390	24 390	24 390	24 230	23 950	23 680	23 400	23 110	22 820	22 520	22 210
	$N_{b,z,Rd}$	23 330	21 510	19 560	17 450	15 270	13 160	11 260	9 620	8 260	7 130	6 190	5 420	4 780
HL 1000 x 483	$N_{b,y,Rd}$	21 440	21 440	21 440	21 440	21 440	21 300	21 060	20 820	20 580	20 330	20 080	19 810	19 540
	$N_{b,z,Rd}$	20 510	18 910	17 200	15 350	13 430	11 580	9 900	8 460	7 260	6 270	5 450	4 770	4 200
HL 1000 x 443	$N_{b,y,Rd}$	19 340	19 340	19 340	19 340	19 340	19 220	19 010	18 790	18 570	18 350	18 120	17 880	17 640
	$N_{b,z,Rd}$	18 490	17 050	15 500	13 820	12 090	10 410	8 900	7 610	6 520	5 630	4 890	4 280	3 770
HL 1000 M	$N_{b,y,Rd}$	17 630	17 630	17 630	17 630	17 630	17 580	17 460	17 340	17 210	17 080	16 950	16 810	16 670
	$N_{b,z,Rd}$	17 130	16 190	15 100	13 820	12 330	10 750	9 220	7 870	6 730	5 780	5 000	4 350	3 820
HL 1000 B	$N_{b,y,Rd}$	15 530	15 530	15 530	15 530	15 530	15 490	15 380	15 280	15 170	15 050	14 940	14 820	14 690
	$N_{b,z,Rd}$	15 090	14 270	13 320	12 200	10 900	9 510	8 170	6 980	5 970	5 130	4 440	3 870	3 390
HL 1000 A	$N_{b,y,Rd}$	13 030	13 030	13 030	13 030	13 030	13 000	12 910	12 820	12 730	12 640	12 540	12 440	12 340
	$N_{b,z,Rd}$	12 680	11 990	11 210	10 290	9 220	8 070	6 950	5 950	5 090	4 380	3 790	3 310	2 910
HL 1000 AA	$N_{b,y,Rd}$	11 920	11 920	11 920	11 920	11 920	11 880	11 800	11 720	11 640	11 550	11 460	11 370	11 270
	$N_{b,z,Rd}$	11 570	10 930	10 190	9 310	8 290	7 220	6 180	5 270	4 500	3 860	3 340	2 910	2 550
HL 920 x 1377	$N_{b,y,Rd}$	62 260	62 260	62 260	62 260	62 260	61 270	59 760	58 280	56 820	55 380	53 950	52 540	51 140
	$N_{b,z,Rd}$	60 260	54 660	49 280	44 060	39 070	34 410	30 200	26 480	23 250	20 480	18 120	16 110	14 390
HL 920 x 1269	$N_{b,y,Rd}$	57 400	57 400	57 400	57 400	57 400	56 660	55 290	53 940	52 620	51 310	50 020	48 740	47 470
	$N_{b,z,Rd}$	55 540	50 380	45 410	40 600	36 000	31 700	27 820	24 390	21 410	18 860	16 690	14 830	13 250
HL 920 x 1194	$N_{b,y,Rd}$	54 030	54 030	54 030	54 030	54 030	53 270	51 970	50 700	49 450	48 210	46 980	45 770	44 570
	$N_{b,z,Rd}$	52 170	47 260	42 550	37 980	33 610	29 550	25 890	22 670	19 880	17 500	15 470	13 740	12 270
HL 920 x 1077	$N_{b,y,Rd}$	48 700	48 700	48 700	48 700	48 700	48 350	47 810	47 260	46 690	46 120	45 530	44 930	44 310
	$N_{b,z,Rd}$	47 510	44 410	41 160	37 660	33 950	30 160	26 510	23 160	20 200	17 660	15 500	13 660	12 110
HL 920 x 970	$N_{b,y,Rd}$	43 890	43 890	43 890	43 890	43 890	43 550	43 050	42 550	42 030	41 510	40 980	40 420	39 850
	$N_{b,z,Rd}$	42 740	39 910	36 930	33 720	30 310	26 860	23 540	20 520	17 870	15 600	13 670	12 050	10 670
HL 920 x 787	$N_{b,y,Rd}$	35 570	35 570	35 570	35 570	35 570	35 240	34 830	34 410	33 990	33 560	33 110	32 650	32 180
	$N_{b,z,Rd}$	34 520	32 160	29 670	26 980	24 140	21 280	18 570	16 120	13 990	12 180	10 660	9 380	8 300
HL 920 x 725	$N_{b,y,Rd}$	32 760	32 760	32 760	32 760	32 760	32 430	32 050	31 670	31 270	30 870	30 460	30 030	29 590
	$N_{b,z,Rd}$	31 750	29 550	27 230	24 720	22 070	19 410	16 900	14 650	12 700	11 050	9 660	8 500	7 520
HL 920 x 656	$N_{b,y,Rd}$	29 650	29 650	29 650	29 650	29 650	29 340	28 990	28 640	28 280	27 920	27 540	27 150	26 750
	$N_{b,z,Rd}$	28 710	26 700	24 570	22 280	19 860	17 440	15 160	13 120	11 370	9 880	8 640	7 590	6 710
HL 920 x 588	$N_{b,y,Rd}$	26 550	26 550	26 550	26 550	26 550	26 260	25 950	25 630	25 310	24 980	24 640	24 290	23 920
	$N_{b,z,Rd}$	25 670	23 850	21 920	19 840	17 640	15 460	13 410	11 590	10 020	8 700	7 600	6 680	5 900
HL 920 x 537	$N_{b,y,Rd}$	24 220	24 220	24 220	24 220	24 220	23 950	23 660	23 370	23 070	22 770	22 460	22 130	21 800
	$N_{b,z,Rd}$	23 400	21 730	19 950	18 030	16 020	14 010	12 140	10 480	9 060	7 860	6 860	6 030	5 330
HL 920 x 491	$N_{b,y,Rd}$	22 120	22 120	22 120	22 120	22 120	21 870	21 600	21 330	21 060	20 780	20 500	20 200	19 890
	$N_{b,z,Rd}$	21 350	19 810	18 170	16 400	14 550	12 710	10 990	9 480	8 190	7 100	6 200	5 440	4 800
HL 920 x 449	$N_{b,y,Rd}$	19 910	19 910	19 910	19 910	19 910	19 680	19 440	19 200	18 960	18 710	18 450	18 190	17 910
	$N_{b,z,Rd}$	19 230	17 860	16 400	14 830	13 170	11 530	9 990	8 620	7 460	6 470	5 650	4 960	4 380
HL 920 x 420	$N_{b,y,Rd}$	18 370	18 370	18 370	18 370	18 370	18 240	18 110	17 970	17 820	17 680	17 520	17 360	17 190
	$N_{b,z,Rd}$	17 940	17 020	15 970	14 750	13 320	11 770	10 220	8 800	7 570	6 540	5 670	4 950	4 360
HL 920 x 390	$N_{b,y,Rd}$	16 790	16 790	16 790	16 790	16 790	16 680	16 550	16 430	16 290	16 160	16 020	15 870	15 710
	$N_{b,z,Rd}$	16 390	15 540	14 580	13 450	12 140	10 710	9 290	7 990	6 870	5 920	5 140	4 490	3 940
HL 920 x 368	$N_{b,y,Rd}$	15 650	15 650	15 650	15 650	15 650	15 540	15 430	15 310	15 180	15 060	14 920	14 790	14 640
	$N_{b,z,Rd}$	15 270	14 480	13 580	12 530	11 300	9 970	8 640	7 440	6 390	5 510	4 780	4 170	3 670
HL 920 x 344	$N_{b,y,Rd}$	14 520	14 520	14 520	14 520	14 520	14 420	14 320	14 210	14 090	13 980	13 850	13 720	13 590
	$N_{b,z,Rd}$	14 170	13 440	12 600	11 620	10 480	9 240	8 010	6 890	5 920	5 110	4 430	3 870	3 400

* Steel grade S355M

Table 9: Design buckling resistance of strong and weak axis of HD column sections in HISTAR 460 (continued)

Section designation	Axis	Compression resistance $N_{b,y,Rd}$, $N_{b,z,Rd}$ [kN] for buckling length L_b [m]												
		2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00
HD 260 x 299	$N_{b,y,Rd}$	17 380	16 920	16 390	15 740	14 930	13 900	12 640	11 250	9 880	8 620	7 520	6 580	5 790
	$N_{b,z,Rd}$	16 610	15 440	13 650	11 240	8 840	6 920	5 500	4 450	3 670	3 070	2 600	2 230	1 940
HD 260 x 225	$N_{b,y,Rd}$	13 060	12 690	12 250	11 710	11 020	10 140	9 090	7 990	6 930	6 000	5 210	4 550	3 990
	$N_{b,z,Rd}$	12 460	11 520	10 060	8 150	6 340	4 940	3 910	3 160	2 600	2 170	1 840	1 580	1 370
HD 260 x 172	$N_{b,y,Rd}$	9 990	9 690	9 330	8 890	8 320	7 580	6 730	5 860	5 050	4 360	3 770	3 280	2 880
	$N_{b,z,Rd}$	9 530	8 790	7 640	6 160	4 770	3 710	2 930	2 370	1 950	1 630	1 380	1 180	1 030
HD 260 x 142	$N_{b,y,Rd}$	8 180	7 930	7 630	7 240	6 740	6 090	5 360	4 640	3 980	3 420	2 950	2 570	2 250
	$N_{b,z,Rd}$	7 810	7 170	6 180	4 930	3 790	2 940	2 320	1 870	1 540	1 280	1 090	930	810
HD 260 x 114	$N_{b,y,Rd}$	6 610	6 390	6 140	5 820	5 390	4 850	4 240	3 650	3 120	2 670	2 310	2 000	1 750
	$N_{b,z,Rd}$	6 290	5 760	4 940	3 900	2 990	2 310	1 820	1 470	1 210	1 010	850	730	630
HD 260 x 93,0	$N_{b,y,Rd}$	5 360	5 190	4 980	4 700	4 340	3 890	3 390	2 900	2 480	2 120	1 820	1 580	1 380
	$N_{b,z,Rd}$	5 110	4 670	3 970	3 130	2 390	1 840	1 450	1 170	960	800	680	580	500
HD 260 x 68,2 *	$N_{b,y,Rd}$	3 920	3 790	3 630	3 420	3 140	2 790	2 410	2 060	1 750	1 490	1 280	1 110	970
	$N_{b,z,Rd}$	3 740	3 400	2 880	2 250	1 710	1 320	1 040	840	690	570	480	410	360
HD 260 x 54,1 *	$N_{b,y,Rd}$	2 670	2 580	2 490	2 360	2 200	1 990	1 750	1 510	1 300	1 120	960	840	730
	$N_{b,z,Rd}$	2 550	2 350	2 040	1 640	1 270	990	780	630	520	430	360	310	270
HL 1100 R	$N_{b,y,Rd}$	27 050	27 050	27 050	27 050	27 050	26 920	26 730	26 530	26 330	26 130	25 910	25 680	25 450
	$N_{b,z,Rd}$	26 300	25 130	23 580	21 400	18 580	15 550	12 830	10 610	8 850	7 470	6 380	5 500	4 790
HL 1100 M	$N_{b,y,Rd}$	22 590	22 590	22 590	22 590	22 590	22 540	22 440	22 340	22 240	22 130	22 020	21 900	21 780
	$N_{b,z,Rd}$	22 220	21 610	20 740	19 360	17 200	14 480	11 890	9 760	8 090	6 790	5 770	4 960	4 300
HL 1100 B	$N_{b,y,Rd}$	19 890	19 890	19 890	19 890	19 890	19 840	19 760	19 670	19 580	19 490	19 390	19 290	19 180
	$N_{b,z,Rd}$	19 560	19 020	18 270	17 070	15 190	12 810	10 520	8 640	7 160	6 010	5 110	4 390	3 810
HL 1100 A	$N_{b,y,Rd}$	16 960	16 960	16 960	16 960	16 960	16 920	16 850	16 780	16 700	16 620	16 540	16 450	16 360
	$N_{b,z,Rd}$	16 680	16 230	15 590	14 590	13 000	10 990	9 040	7 430	6 160	5 170	4 400	3 780	3 280
HL 1000 x 976	$N_{b,y,Rd}$	55 930	55 930	55 930	55 930	55 890	55 470	55 040	54 600	54 150	53 680	53 190	52 670	52 130
	$N_{b,z,Rd}$	54 650	52 480	49 700	45 900	40 850	35 020	29 380	24 550	20 610	17 470	14 950	12 910	11 260
HL 1000 x 883	$N_{b,y,Rd}$	51 760	51 760	51 760	51 760	51 680	51 280	50 880	50 460	50 030	49 590	49 120	48 630	48 100
	$N_{b,z,Rd}$	50 490	48 420	45 730	42 020	37 110	31 570	26 340	21 930	18 380	15 550	13 300	11 480	10 000
HL 1000 x 748	$N_{b,y,Rd}$	43 850	43 850	43 850	43 850	43 760	43 420	43 070	42 710	42 340	41 960	41 550	41 130	40 670
	$N_{b,z,Rd}$	42 710	40 890	38 500	35 180	30 830	26 020	21 600	17 920	14 990	12 670	10 820	9 340	8 130
HL 1000 x 642	$N_{b,y,Rd}$	37 600	37 600	37 600	37 600	37 500	37 210	36 910	36 600	36 270	35 940	35 580	35 210	34 810
	$N_{b,z,Rd}$	36 570	34 960	32 830	29 850	25 970	21 780	17 990	14 890	12 430	10 500	8 960	7 730	6 730
HL 1000 x 591	$N_{b,y,Rd}$	34 620	34 620	34 620	34 620	34 520	34 250	33 970	33 690	33 390	33 080	32 750	32 410	32 040
	$N_{b,z,Rd}$	33 650	32 160	30 170	27 390	23 780	19 910	16 430	13 590	11 340	9 570	8 170	7 040	6 130
HL 1000 x 554	$N_{b,y,Rd}$	32 460	32 460	32 460	32 460	32 360	32 110	31 840	31 570	31 290	30 990	30 690	30 360	30 010
	$N_{b,z,Rd}$	31 530	30 120	28 220	25 570	22 130	18 480	15 220	12 580	10 490	8 850	7 550	6 510	5 670
HL 1000 x 539	$N_{b,y,Rd}$	30 930	30 930	30 930	30 930	30 850	30 610	30 360	30 110	29 840	29 570	29 280	28 970	28 650
	$N_{b,z,Rd}$	30 070	28 750	26 990	24 530	21 330	17 870	14 760	12 220	10 200	8 610	7 350	6 340	5 520
HL 1000 x 483	$N_{b,y,Rd}$	27 050	27 050	27 050	27 050	26 990	26 780	26 560	26 340	26 120	25 880	25 630	25 360	25 080
	$N_{b,z,Rd}$	26 310	25 150	23 620	21 490	18 700	15 690	12 970	10 740	8 970	7 570	6 460	5 570	4 850
HL 1000 x 443	$N_{b,y,Rd}$	24 380	24 380	24 380	24 380	24 330	24 140	23 950	23 750	23 540	23 330	23 100	22 870	22 620
	$N_{b,z,Rd}$	23 700	22 660	21 280	19 340	16 820	14 100	11 650	9 640	8 050	6 800	5 800	5 000	4 360
HL 1000 M	$N_{b,y,Rd}$	22 240	22 240	22 240	22 240	22 220	22 110	22 000	21 890	21 780	21 650	21 530	21 390	21 240
	$N_{b,z,Rd}$	21 870	21 280	20 440	19 120	17 050	14 400	11 850	9 730	8 070	6 780	5 760	4 950	4 300
HL 1000 B	$N_{b,y,Rd}$	19 580	19 580	19 580	19 580	19 570	19 480	19 380	19 290	19 190	19 080	18 970	18 850	18 720
	$N_{b,z,Rd}$	19 270	18 750	18 020	16 870	15 070	12 760	10 510	8 640	7 170	6 020	5 120	4 400	3 820
HL 1000 A	$N_{b,y,Rd}$	16 430	16 430	16 430	16 430	16 430	16 350	16 280	16 190	16 110	16 020	15 930	15 830	15 730
	$N_{b,z,Rd}$	16 180	15 750	15 160	14 230	12 770	10 860	8 980	7 390	6 140	5 160	4 390	3 770	3 270
HL 1000 AA	$N_{b,y,Rd}$	15 000	15 000	15 000	15 000	14 990	14 920	14 850	14 770	14 690	14 610	14 520	14 430	14 330
	$N_{b,z,Rd}$	14 750	14 350	13 770	12 870	11 440	9 640	7 920	6 500	5 390	4 530	3 850	3 300	2 870
HL 920 x 1377	$N_{b,y,Rd}$	78 930	78 930	78 930	78 930	78 420	77 000	75 580	74 150	72 710	71 250	69 760	68 250	66 710
	$N_{b,z,Rd}$	76 050	70 500	64 590	58 200	51 510	44 890	38 770	33 390	28 800	24 960	21 760	19 100	16 860
HL 920 x 1269	$N_{b,y,Rd}$	72 760	72 760	72 760	72 760	72 430	71 150	69 860	68 570	67 270	65 950	64 610	63 250	61 860
	$N_{b,z,Rd}$	70 100	64 980	59 530	53 630	47 450	41 350	35 710	30 750	26 520	22 980	20 040	17 580	15 530
HL 920 x 1194	$N_{b,y,Rd}$	68 490	68 490	68 490	68 490	68 130	66 910	65 690	64 470	63 240	61 980	60 710	59 420	58 100
	$N_{b,z,Rd}$	65 880	61 010	55 800	50 180	44 290	38 510	33 190	28 530	24 580	21 280	18 540	16 260	14 350
HL 920 x 1077	$N_{b,y,Rd}$	61 740	61 740	61 740	61 740	61 570	61 080	60 590	60 070	59 540	58 990	58 410	57 800	57 140
	$N_{b,z,Rd}$	60 640	58 510	55 870	52 380	47 740	42 050	36 060	30 560	25 900	22 070	18 950	16 420	14 340
HL 920 x 970	$N_{b,y,Rd}$	55 640	55 640	55 640	55 640	55 460	55 020	54 570	54 100	53 620	53 110	52 580	52 020	51 420
	$N_{b,z,Rd}$	54 610	52 640	50 200	46 960	42 630	37 380	31 920	26 980	22 820	19 420	16 670	14 430	12 600
HL 920 x 787	$N_{b,y,Rd}$	46 090	46 090	46 090	46 090	45 880	45 500	45 110	44 710	44 300	43 860	43 400	42 910	42 380
	$N_{b,z,Rd}$	45 120	43 410	41 240	38 320	34 410	29 800	25 200	21 150	17 810	15 120	12 960	11 200	9 770
HL 920 x 725	$N_{b,y,Rd}$	42 450	42 450	42 450	42 450	42 240	41 890	41 530	41 160	40 770	40 360	39 930	39 470	38 980
	$N_{b,z,Rd}$	41 530	39 930	37 890	35 130	31 450	27 130	22 870	19 170	16 120	13 680	11 710	10 130	8 830
HL 920 x 656	$N_{b,y,Rd}$	38 420	38 420	38 420	38 420	38 220	37 900	37 570	37 230	36 880	36 500	36 110	35 690	35 240
	$N_{b,z,Rd}$	37 560	36 100	34 230	31 680	28 280	24 340	20 470	17 130	14 400	12 210	10 450	9 030	7 880
HL 920 x 588	$N_{b,y,Rd}$	34 410	34 410	34 410	34 410	34 220	33 930	33 630	33 330	33 000	32 670	32 310	31 930	31 530
	$N_{b,z,Rd}$	33 610	32 280	30 570	28 220	25 110	21 520	18 050	15 080	12 660	10 720	9 180	7 930	6 910
HL 920 x 537	$N_{b,y,Rd}$	31 390	31 390	31 390	31 390	31 210	30 940	30 670	30 390	30 100	29 790	29 460	29 110	28 740
	$N_{b,z,Rd}$	30 650	29 420	27 840	25 670	22 790	19 480	16 320	13 620	11 420	9 680	8 280	7 150	6 230
HL 920 x 491	$N_{b,y,Rd}$	27 850	27 850	27 850	27 850	27 710	27 480	27 240	26 990	26 730	26 460	26 180	25 870	25 550
	$N_{b,z,Rd}$	27 210	26 140	24 750	22 850	20 340	17 440	14 630	12 220	10 260	8 690	7 440	6 430	5 600
HL 920 x 449	$N_{b,y,Rd}$	25 130	25 130	25 130	25 130	25 010	24 800	24 580	24 360	24 130	23 880	23 630	23 350	23 060
	$N_{b,z,Rd}$	24 570	23 610	22 370	20 690	18 450	15 860	13 330	11 150	9 370	7 940	6 800	5 870	5 120
HL 920 x 420	$N_{b,y,Rd}$	23 180	23 180	23 180	23 180	23 110	22 990	22 860	22 730	22 600	22 450	22 300	22 130	21 950
	$N_{b,z,Rd}$	22 860	22 290	21 510	20 340	18 500	15 990	13 360	11 060	9 220	7 760	6 610	5 680	4 940
HL 920 x 390	$N_{b,y,Rd}$	21 170	21 170	21 170	21 170	21 100	20 990	20 880	20 760	20 640	20 510	20 370	20 220	20 050
	$N_{b,z,Rd}$	20 870	20 350	19 630	18 540	16 830	14 520	12 100	10 020	8 340	7 020	5 980	5 140	4 470
HL 920 x 368	$N_{b,y,Rd}$	19 710	19 710	19 710	19 710	19 650	19 550	19 450	19 340	19 220	19 100	18 970	18 830	18 670
	$N_{b,z,Rd}$	19 440	18 950	18 280	17 270	15 670	13 510	11 260	9 320	7 760	6 530	5 560	4 780	4 150
HL 920 x 344	$N_{b,y,Rd}$	18 290	18 290	18 290	18 290	18 230	18 140	18 040	17 940	17 830	17 720	17 600	17 470	17 330
	$N_{b,z,Rd}$	18 030	17 570	16 950	16 010	14 530	12 520	10 440	8 640	7 190	6 050	5 150	4 430	3 850

* Steel grade S460M

Table 8: Design buckling resistance of strong and weak axis of HD column sections in HISTAR 355 (continued)

Section designation	Axis	Compression resistance $N_{b,y,Rd}$, $N_{b,z,Rd}$ [kN] for buckling length L_b [m]												
		2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00
UC 356 x 406 x 1299	$N_{b,y,Rd}$	58 570	58 570	56 530	53 830	51 200	48 610	46 070	43 570	41 110	38 700	36 360	34 110	31 960
	$N_{b,z,Rd}$	58 070	53 380	48 900	44 540	40 300	36 240	32 430	28 930	25 790	23 010	20 570	18 440	16 590
UC 356 x 406 x 1202	$N_{b,y,Rd}$	54 310	54 310	52 140	49 580	47 080	44 630	42 220	39 840	37 510	35 240	33 040	30 920	28 910
	$N_{b,z,Rd}$	53 710	49 300	45 090	40 990	37 010	33 200	29 650	26 400	23 490	20 920	18 680	16 730	15 040
UC 356 x 406 x 1086	$N_{b,y,Rd}$	49 200	49 200	47 190	44 860	42 590	40 360	38 170	36 010	33 890	31 820	29 820	27 900	26 070
	$N_{b,z,Rd}$	48 430	44 340	40 430	36 620	32 940	29 430	26 180	23 230	20 610	18 310	16 310	14 580	13 080
UC 356 x 406 x 990	$N_{b,y,Rd}$	44 800	44 800	42 780	40 610	38 500	36 430	34 400	32 390	30 430	28 520	26 670	24 910	23 240
	$N_{b,z,Rd}$	43 980	40 210	36 600	33 090	29 700	26 480	23 500	20 810	18 430	16 350	14 550	12 990	11 650
UC 356 x 406 x 900	$N_{b,y,Rd}$	40 780	40 780	38 750	36 740	34 780	32 850	30 960	29 090	27 270	25 510	23 810	22 190	20 660
	$N_{b,z,Rd}$	39 930	36 460	33 130	29 890	26 770	23 810	21 090	18 640	16 480	14 600	12 980	11 580	10 380
UC 356 x 406 x 818	$N_{b,y,Rd}$	37 020	36 990	36 100	35 180	34 210	33 180	32 060	30 850	29 530	28 110	26 590	25 010	23 410
	$N_{b,z,Rd}$	36 460	34 290	32 040	29 640	27 080	24 420	21 780	19 280	17 000	14 980	13 230	11 730	10 440
UC 356 x 406 x 744	$N_{b,y,Rd}$	33 650	33 570	32 740	31 890	30 980	30 020	28 970	27 820	26 580	25 240	23 820	22 340	20 850
	$N_{b,z,Rd}$	33 090	31 090	29 010	26 790	24 420	21 970	19 550	17 260	15 190	13 370	11 790	10 440	9 290
UC 356 x 406 x 677	$N_{b,y,Rd}$	30 650	30 530	29 760	28 960	28 110	27 210	26 220	25 140	23 970	22 710	21 370	19 990	18 610
	$N_{b,z,Rd}$	30 100	28 250	26 330	24 280	22 100	19 840	17 620	15 530	13 640	11 990	10 570	9 350	8 310
UC 356 x 406 x 634	$N_{b,y,Rd}$	28 660	28 530	27 800	27 050	26 250	25 390	24 450	23 420	22 310	21 110	19 840	18 540	17 230
	$N_{b,z,Rd}$	28 120	26 380	24 560	22 620	20 550	18 420	16 320	14 360	12 610	11 070	9 750	8 620	7 660
UC 356 x 406 x 592	$N_{b,y,Rd}$	26 790	26 650	25 950	25 240	24 470	23 650	22 760	21 780	20 710	19 560	18 350	17 120	15 890
	$N_{b,z,Rd}$	26 260	24 610	22 900	21 060	19 110	17 100	15 130	13 290	11 650	10 220	9 000	7 950	7 060
UC 356 x 406 x 551	$N_{b,y,Rd}$	24 910	24 750	24 100	23 420	22 700	21 920	21 070	20 140	19 120	18 040	16 890	15 730	14 570
	$N_{b,z,Rd}$	24 390	22 850	21 240	19 520	17 690	15 800	13 970	12 260	10 730	9 410	8 280	7 310	6 490
UC 356 x 406 x 509	$N_{b,y,Rd}$	23 030	22 860	22 250	21 610	20 940	20 200	19 400	18 520	17 560	16 530	15 450	14 360	13 280
	$N_{b,z,Rd}$	22 530	21 100	19 600	17 990	16 280	14 530	12 820	11 240	9 830	8 610	7 570	6 690	5 930
UC 356 x 406 x 467	$N_{b,y,Rd}$	21 110	20 940	20 370	19 780	19 140	18 460	17 710	16 880	15 980	15 020	14 020	13 010	12 010
	$N_{b,z,Rd}$	20 630	19 300	17 910	16 420	14 830	13 210	11 640	10 190	8 900	7 790	6 840	6 040	5 360
UC 356 x 406 x 393	$N_{b,y,Rd}$	17 770	17 580	17 090	16 580	16 020	15 420	14 760	14 040	13 250	12 410	11 540	10 670	9 820
	$N_{b,z,Rd}$	17 320	16 190	15 000	13 720	12 360	10 970	9 640	8 410	7 340	6 410	5 620	4 960	4 390
UC 356 x 406 x 340	$N_{b,y,Rd}$	15 370	15 180	14 750	14 300	13 810	13 270	12 690	12 040	11 340	10 590	9 820	9 060	8 320
	$N_{b,z,Rd}$	14 960	13 970	12 920	11 800	10 610	9 400	8 240	7 180	6 250	5 460	4 780	4 210	3 730
UC 356 x 406 x 287	$N_{b,y,Rd}$	12 980	12 800	12 430	12 040	11 610	11 150	10 640	10 080	9 460	8 820	8 160	7 500	6 880
	$N_{b,z,Rd}$	12 620	11 770	10 870	9 910	8 890	7 860	6 870	5 980	5 200	4 530	3 970	3 490	3 090
UC 356 x 406 x 235	$N_{b,y,Rd}$	10 610	10 450	10 140	9 810	9 460	9 070	8 640	8 170	7 650	7 110	6 560	6 020	5 510
	$N_{b,z,Rd}$	10 300	9 600	8 860	8 060	7 210	6 360	5 550	4 820	4 190	3 650	3 190	2 810	2 480
UC 356 x 368 x 202	$N_{b,y,Rd}$	9 130	8 980	8 710	8 420	8 110	7 770	7 390	6 970	6 520	6 050	5 570	5 100	4 660
	$N_{b,z,Rd}$	8 790	8 140	7 460	6 710	5 940	5 170	4 460	3 840	3 310	2 870	2 500	2 190	1 930
UC 356 x 368 x 177	$N_{b,y,Rd}$	8 000	7 870	7 630	7 370	7 100	6 790	6 450	6 080	5 680	5 260	4 840	4 430	4 040
	$N_{b,z,Rd}$	7 700	7 130	6 520	5 870	5 180	4 510	3 880	3 340	2 880	2 490	2 170	1 900	1 680
UC 356 x 368 x 153	$N_{b,y,Rd}$	6 910	6 790	6 580	6 360	6 120	5 850	5 560	5 230	4 880	4 520	4 150	3 790	3 450
	$N_{b,z,Rd}$	6 640	6 150	5 620	5 050	4 460	3 870	3 330	2 860	2 470	2 130	1 860	1 630	1 440
UC 356 x 368 x 129	$N_{b,y,Rd}$	5 830	5 720	5 540	5 350	5 150	4 920	4 670	4 390	4 090	3 780	3 460	3 160	2 880
	$N_{b,z,Rd}$	5 600	5 180	4 730	4 240	3 740	3 240	2 790	2 390	2 060	1 780	1 550	1 360	1 200
UC 305 x 305 x 283	$N_{b,y,Rd}$	12 790	12 490	12 070	11 620	11 130	10 580	9 970	9 290	8 580	7 850	7 140	6 470	5 850
	$N_{b,z,Rd}$	12 030	10 960	9 790	8 530	7 280	6 140	5 150	4 350	3 690	3 160	2 740	2 380	2 090
UC 305 x 305 x 240	$N_{b,y,Rd}$	10 850	10 580	10 210	9 820	9 390	8 900	8 360	7 770	7 150	6 520	5 910	5 340	4 820
	$N_{b,z,Rd}$	10 180	9 260	8 250	7 160	6 090	5 110	4 290	3 610	3 060	2 620	2 260	1 970	1 730
UC 305 x 305 x 198	$N_{b,y,Rd}$	8 960	8 710	8 400	8 070	7 700	7 290	6 820	6 320	5 790	5 270	4 760	4 290	3 860
	$N_{b,z,Rd}$	8 380	7 610	6 760	5 850	4 950	4 150	3 470	2 920	2 470	2 110	1 820	1 590	1 390
UC 305 x 305 x 158	$N_{b,y,Rd}$	7 140	6 930	6 680	6 400	6 100	5 750	5 370	4 950	4 520	4 090	3 690	3 310	2 980
	$N_{b,z,Rd}$	6 670	6 030	5 340	4 600	3 880	3 240	2 700	2 260	1 920	1 640	1 410	1 230	1 080
UC 305 x 305 x 137	$N_{b,y,Rd}$	6 190	6 000	5 770	5 530	5 260	4 960	4 620	4 250	3 870	3 500	3 150	2 820	2 530
	$N_{b,z,Rd}$	5 760	5 210	4 600	3 960	3 330	2 770	2 310	1 930	1 640	1 400	1 200	1 050	920
UC 305 x 305 x 118	$N_{b,y,Rd}$	5 330	5 160	4 960	4 750	4 510	4 250	3 950	3 630	3 300	2 980	2 670	2 390	2 150
	$N_{b,z,Rd}$	4 950	4 470	3 940	3 380	2 840	2 360	1 960	1 640	1 390	1 190	1 020	890	780
UC 305 x 305 x 97*	$N_{b,y,Rd}$	4 380	4 230	4 070	3 890	3 700	3 470	3 220	2 960	2 680	2 410	2 160	1 940	1 730
	$N_{b,z,Rd}$	4 060	3 660	3 220	2 760	2 310	1 920	1 590	1 330	1 120	960	830	720	630
UC 254 x 254 x 167	$N_{b,y,Rd}$	7 500	7 200	6 870	6 500	6 080	5 600	5 080	4 540	4 030	3 560	3 140	2 780	2 460
	$N_{b,z,Rd}$	6 840	6 030	5 150	4 250	3 450	2 790	2 280	1 890	1 580	1 340	1 150	1 000	870
UC 254 x 254 x 132	$N_{b,y,Rd}$	5 910	5 660	5 390	5 090	4 740	4 350	3 920	3 490	3 080	2 710	2 390	2 110	1 870
	$N_{b,z,Rd}$	5 380	4 730	4 010	3 300	2 660	2 150	1 750	1 450	1 210	1 030	880	760	670
UC 254 x 254 x 107	$N_{b,y,Rd}$	4 780	4 580	4 360	4 100	3 810	3 480	3 120	2 770	2 430	2 130	1 870	1 650	1 460
	$N_{b,z,Rd}$	4 350	3 810	3 220	2 630	2 120	1 700	1 390	1 140	960	810	690	600	520
UC 254 x 254 x 89	$N_{b,y,Rd}$	3 970	3 800	3 610	3 400	3 150	2 870	2 570	2 270	1 990	1 750	1 530	1 350	1 190
	$N_{b,z,Rd}$	3 600	3 150	2 660	2 170	1 740	1 400	1 140	940	780	660	570	490	430
UC 254 x 254 x 73*	$N_{b,y,Rd}$	3 260	3 110	2 960	2 780	2 570	2 330	2 080	1 840	1 610	1 410	1 230	1 080	960
	$N_{b,z,Rd}$	2 950	2 580	2 170	1 760	1 410	1 130	920	760	630	530	460	400	350

* Steel grade S355M

Table 9: Design buckling resistance of strong and weak axis of HD column sections in HISTAR 460 (continued)

Section designation	Axis	Compression resistance $N_{b,y,Rd}$, $N_{b,z,Rd}$ [kN] for buckling length L_b [m]												
		2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00
UC 356 x 406 x 1299	$N_{b,y,Rd}$	74 250	73 990	71 390	68 770	66 090	63 320	60 430	57 420	54 310	51 120	47 910	44 730	41 630
	$N_{b,z,Rd}$	72 830	68 330	63 630	58 600	53 250	47 730	42 310	37 230	32 680	28 700	25 270	22 350	19 860
UC 356 x 406 x 1202	$N_{b,y,Rd}$	68 850	68 410	65 940	63 440	60 880	58 220	55 440	52 550	49 570	46 520	43 470	40 460	37 550
	$N_{b,z,Rd}$	67 410	63 160	58 720	53 960	48 900	43 700	38 620	33 900	29 690	26 030	22 890	20 230	17 960
UC 356 x 406 x 1086	$N_{b,y,Rd}$	62 370	61 940	59 690	57 420	55 080	52 660	50 130	47 500	44 780	42 010	39 230	36 490	33 850
	$N_{b,z,Rd}$	60 850	56 890	52 730	48 270	43 520	38 680	34 010	29 720	25 930	22 670	19 900	17 550	15 560
UC 356 x 406 x 990	$N_{b,y,Rd}$	56 790	56 260	54 170	52 050	49 860	47 590	45 220	42 750	40 210	37 620	35 040	32 520	30 090
	$N_{b,z,Rd}$	55 300	51 640	47 780	43 630	39 230	34 760	30 470	26 560	23 130	20 190	17 700	15 600	13 820
UC 356 x 406 x 900	$N_{b,y,Rd}$	51 700	51 090	49 130	47 150	45 100	42 970	40 740	38 420	36 040	33 620	31 220	28 890	26 670
	$N_{b,z,Rd}$	50 250	46 860	43 280	39 430	35 360	31 230	27 300	23 740	20 640	17 990	15 750	13 870	12 280
UC 356 x 406 x 818	$N_{b,y,Rd}$	46 930	46 640	45 830	44 960	43 990	42 900	41 630	40 130	38 380	36 350	34 070	31 630	29 140
	$N_{b,z,Rd}$	46 320	44 860	43 120	40 900	37 980	34 290	30 110	25 970	22 260	19 110	16 500	14 340	12 550
UC 356 x 406 x 744	$N_{b,y,Rd}$	42 660	42 350	41 600	40 780	39 870	38 840	37 630	36 200	34 520	32 590	30 430	28 140	25 830
	$N_{b,z,Rd}$	42 070	40 720	39 100	37 020	34 280	30 820	26 950	23 170	19 820	16 990	14 650	12 730	11 140
UC 356 x 406 x 677	$N_{b,y,Rd}$	39 710	39 360	38 630	37 840	36 950	35 920	34 720	33 290	31 600	29 670	27 540	25 320	23 130
	$N_{b,z,Rd}$	39 110	37 820	36 250	34 220	31 520	28 150	24 460	20 920	17 830	15 250	13 130	11 400	9 970
UC 356 x 406 x 634	$N_{b,y,Rd}$	37 140	36 790	36 100	35 350	34 500	33 520	32 370	31 000	29 390	27 540	25 520	23 420	21 360
	$N_{b,z,Rd}$	36 560	35 330	33 840	31 900	29 320	26 110	22 620	19 300	16 430	14 040	12 080	10 480	9 160
UC 356 x 406 x 592	$N_{b,y,Rd}$	34 720	34 370	33 710	33 000	32 190	31 250	30 140	28 820	27 260	25 480	23 540	21 560	19 620
	$N_{b,z,Rd}$	34 160	33 000	31 580	29 730	27 270	24 210	20 920	17 820	15 150	12 940	11 130	9 650	8 430
UC 356 x 406 x 551	$N_{b,y,Rd}$	32 280	31 940	31 310	30 640	29 870	28 970	27 910	26 640	25 150	23 450	21 610	19 750	17 940
	$N_{b,z,Rd}$	31 750	30 660	29 320	27 570	25 240	22 360	19 280	16 400	13 930	11 880	10 220	8 860	7 740
UC 356 x 406 x 509	$N_{b,y,Rd}$	29 850	29 510	28 920	28 280	27 560	26 700	25 690	24 480	23 060	21 450	19 720	17 970	16 300
	$N_{b,z,Rd}$	29 340	28 320	27 070	25 430	23 240	20 540	17 670	15 010	12 730	10 860	9 330	8 090	7 070
UC 356 x 406 x 467	$N_{b,y,Rd}$	27 360	27 030	26 490	25 890	25 210	24 410	23 450	22 310	20 960	19 450	17 840	16 230	14 690
	$N_{b,z,Rd}$	26 880	25 930	24 770	23 220	21 170	18 660	16 000	13 570	11 500	9 800	8 410	7 290	6 370
UC 356 x 406 x 393	$N_{b,y,Rd}$	23 020	22 710	22 240	21 720	21 120	20 410	19 550	18 530	17 340	16 000	14 600	13 220	11 930
	$N_{b,z,Rd}$	22 590	21 780	20 770	19 430	17 630	15 460	13 200	11 160	9 430	8 030	6 890	5 970	5 210
UC 356 x 406 x 340	$N_{b,y,Rd}$	19 910	19 620	19 200	18 740	18 200	17 570	16 800	15 880	14 800	13 610	12 380	11 180	10 060
	$N_{b,z,Rd}$	19 530	18 810	17 920	16 730	15 130	13 220	11 250	9 490	8 010	6 810	5 840	5 060	4 410
UC 356 x 406 x 287	$N_{b,y,Rd}$	16 820	16 550	16 190	15 790	15 320	14 760	14 080	13 270	12 330	11 290	10 230	9 210	8 270
	$N_{b,z,Rd}$	16 480	15 870	15 100	14 060	12 680	11 030	9 360	7 870	6 640	5 640	4 840	4 180	3 650
UC 356 x 406 x 235	$N_{b,y,Rd}$	13 750	13 520	13 220	12 880	12 490	12 010	11 440	10 740	9 940	9 080	8 200	7 360	6 600
	$N_{b,z,Rd}$	13 460	12 950	12 310	11 440	10 290	8 920	7 540	6 330	5 340	4 530	3 880	3 360	2 930
UC 356 x 368 x 202	$N_{b,y,Rd}$	11 830	11 620	11 360	11 060	10 710	10 290	9 780	9 160	8 460	7 700	6 940	6 220	5 560
	$N_{b,z,Rd}$	11 530	11 050	10 430	9 570	8 430	7 160	5 960	4 960	4 150	3 510	3 000	2 590	2 260
UC 356 x 368 x 177	$N_{b,y,Rd}$	10 370	10 180	9 950	9 680	9 370	9 000	8 540	7 990	7 360	6 680	6 010	5 380	4 810
	$N_{b,z,Rd}$	10 100	9 680	9 130	8 360	7 350	6 230	5 180	4 300	3 600	3 040	2 600	2 240	1 960
UC 356 x 368 x 153	$N_{b,y,Rd}$	8 960	8 790	8 590	8 350	8 080	7 750	7 350	6 860	6 310	5 720	5 140	4 600	4 110
	$N_{b,z,Rd}$	8 720	8 360	7 870	7 200	6 320	5 340	4 440	3 690	3 080	2 610	2 230	1 920	1 670
UC 356 x 368 x 129	$N_{b,y,Rd}$	7 550	7 410	7 230	7 040	6 800	6 520	6 170	5 750	5 280	4 780	4 280	3 830	3 410
	$N_{b,z,Rd}$	7 350	7 040	6 630	6 050	5 300	4 470	3 710	3 070	2 570	2 170	1 850	1 600	1 390
UC 305 x 305 x 283	$N_{b,y,Rd}$	16 570	16 190	15 780	15 300	14 720	14 010	13 130	12 090	10 950	9 790	8 690	7 710	6 840
	$N_{b,z,Rd}$	15 960	15 100	13 880	12 150	10 090	8 160	6 600	5 390	4 470	3 750	3 190	2 750	2 390
UC 305 x 305 x 240	$N_{b,y,Rd}$	14 040	13 720	13 360	12 930	12 420	11 790	11 000	10 080	9 080	8 080	7 160	6 330	5 610
	$N_{b,z,Rd}$	13 520	12 780	11 710	10 190	8 410	6 770	5 460	4 460	3 690	3 100	2 640	2 270	1 970
UC 305 x 305 x 198	$N_{b,y,Rd}$	11 580	11 300	11 000	10 640	10 190	9 640	8 960	8 170	7 320	6 490	5 730	5 060	4 480
	$N_{b,z,Rd}$	11 140	10 510	9 600	8 310	6 820	5 470	4 400	3 590	2 970	2 490	2 120	1 820	1 580
UC 305 x 305 x 158	$N_{b,y,Rd}$	9 230	9 000	8 750	8 450	8 080	7 610	7 040	6 380	5 680	5 010	4 410	3 880	3 430
	$N_{b,z,Rd}$	8 880	8 360	7 600	6 530	5 320	4 250	3 410	2 780	2 300	1 930	1 640	1 410	1 220
UC 305 x 305 x 137	$N_{b,y,Rd}$	7 990	7 790	7 560	7 300	6 970	6 550	6 040	5 460	4 850	4 270	3 750	3 300	2 910
	$N_{b,z,Rd}$	7 680	7 220	6 550	5 610	4 550	3 630	2 910	2 370	1 960	1 640	1 390	1 200	1 040
UC 305 x 305 x 118	$N_{b,y,Rd}$	6 870	6 700	6 500	6 270	5 980	5 610	5 160	4 650	4 120	3 620	3 180	2 790	2 460
	$N_{b,z,Rd}$	6 610	6 210	5 620	4 790	3 880	3 080	2 470	2 010	1 660	1 390	1 180	1 010	880
UC 305 x 305 x 97*	$N_{b,y,Rd}$	5 640	5 500	5 340	5 140	4 900	4 590	4 210	3 780	3 340	2 930	2 570	2 250	1 990
	$N_{b,z,Rd}$	5 420	5 090	4 590	3 900	3 140	2 500	2 000	1 620	1 340	1 120	950	820	710
UC 254 x 254 x 167	$N_{b,y,Rd}$	9 680	9 390	9 040	8 610	8 040	7 320	6 490	5 640	4 860	4 180	3 620	3 150	2 760
	$N_{b,z,Rd}$	9 230	8 490	7 340	5 870	4 530	3 510	2 780	2 240	1 840	1 540	1 300	1 120	970
UC 254 x 254 x 132	$N_{b,y,Rd}$	7 630	7 390	7 110	6 740	6 270	5 670	4 980	4 300	3 690	3 170	2 740	2 380	2 080
	$N_{b,z,Rd}$	7 270	6 660	5 720	4 540	3 480	2 690	2 130	1 710	1 410	1 180	1 000	850	740
UC 254 x 254 x 107	$N_{b,y,Rd}$	6 180	5 980	5 740	5 430	5 030	4 510	3 940	3 390	2 890	2 480	2 140	1 860	1 620
	$N_{b,z,Rd}$	5 880	5 380	4 580	3 610	2 760	2 130	1 680	1 350	1 110	930	780	670	580
UC 254 x 254 x 89	$N_{b,y,Rd}$	5 130	4 960	4 760	4 500	4 150	3 720	3 240	2 770	2 370	2 030	1 750	1 510	1 320
	$N_{b,z,Rd}$	4 880	4 460	3 790	2 970	2 260	1 750	1 380	1 110	910	760	640	550	480
UC 254 x 254 x 73*	$N_{b,y,Rd}$	4 210	4 070	3 900	3 680	3 380	3 020	2 620	2 230	1 900	1 630	1 400	1 210	1 060
	$N_{b,z,Rd}$	4 000	3 650	3 080	2 400	1 830	1 410	1 110	890	730	610	520	440	380

* Steel grade S460M

5. Fabrication guidelines

1. General

The general recommendations given in this chapter shall be observed to ensure the successful fabrication, welding, and heat treatment of the fine-grained high-strength HISTAR 355 and HISTAR 460 steels for structural and offshore applications.

For aspects not covered within these guidelines, it is recommended to ask the advice of the Technical Advisory of ArcelorMittal Long Carbon Europe.

2. Machining

HISTAR 355/460 beams can be machined under the same conditions as structural steels featuring the same level of tensile strength. Tool wear from drilling and cutting of beams in HISTAR grades is similar to the one of beams in structural grades of the same level of strength.

3. Flame cutting

HISTAR 355/460 beams can be cut with a torch, using a process normally applied to structural steels featuring the same level of tensile strength. No preheating is required when flame cutting is performed at ambient temperatures > 0° C.

4. Welding

HISTAR steels offer a good weldability for manual and automatic processes, provided the general rules for welding are respected. Shielded Metal Arc Welding (SMAW) or Manual Metal Arc (MMA) welding, Gas Metal Arc Welding (MIG/MAG), Flux-Cored Arc Welding (FCAW), and Submerged Arc Welding (SAW) are processes successfully used to weld HISTAR 355 and 460 grades.

Flame cut groove surfaces have to be descaled by grinding before welding. HISTAR 355 / 460 and conventional structural grades can be combined by welding. For these cases the welding conditions of the conventional grade have to be integrated in the welding procedure.

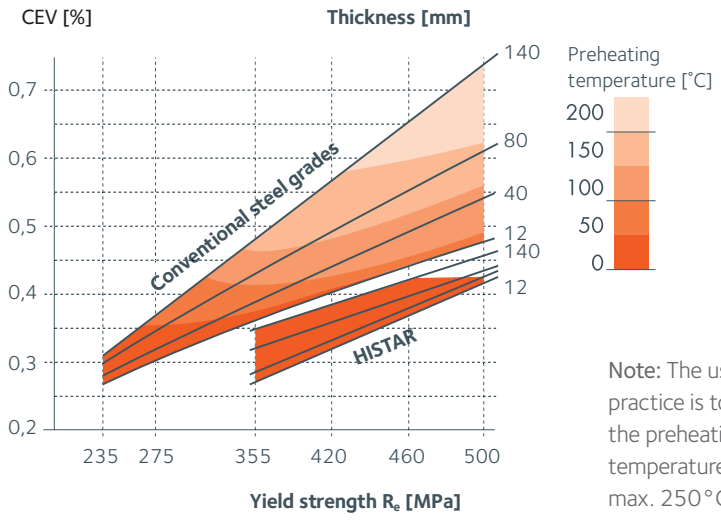
4.1 Preheat temperatures

The preheat temperature for avoiding cold cracking represents the lowest temperature before starting the first run and below which the weld region shall not fall during welding.

Thanks to the low carbon equivalent values of the HISTAR grades (see figure 8), it is generally not necessary to preheat, as long as:

- the energy supply ranges between 10 and 60 kJ/cm,
- the temperature of the product is > 0° C,
- electrodes with low hydrogen content and low carbon equivalent are used.

Figure 8: Preheating temperatures for conventional structural steel grades and HISTAR grades (acc. to EN 1011-2:2001/method A)



Note: The usual practice is to limit the preheating temperature at max. 250°C.

No preheat conditions for HISTAR grades :

- For $R_e < 460$: $H_2 \leq 10$ ml /100g
- For $R_e \geq 460$: $H_2 \leq 5$ ml /100g
- E > 10 kJ/cm

$$CEV\ (\%) = C + \frac{Mn}{6} + \frac{(Cr+Mo+V)}{5} + \frac{(Cu+Ni)}{15}$$

Diandong Powerplant, P.R China

Recommendations for the preheating temperature of fine grain steels are given in EN 1011-2:2001 in function of the carbon equivalent, the thickness of the product, the hydrogen content of welding consumables and the heat input. These recommendations apply to normal fabrication restraint conditions and welding of parent metal at temperatures > 0° C.

From these recommendations and specific trials on HISTAR 355 and HISTAR 460 grades, the following preheating temperatures have been deduced:

HISTAR 355: no preheating required over the entire thickness range with:

- diffusible hydrogen content of deposited metal ≤ 10 ml/100g
- heat input values ≥ 10 kJ/cm

HISTAR 460: no preheating required over the entire thickness range with:

- Diffusible hydrogen content of deposited metal ≤ 5 ml/100g
- heat input values ≥ 10 kJ/cm

Shanghai World Finance Center, P.R. China

HISTAR 460 may also be welded with consumables containing hydrogen levels between 5 and 10 ml/100g. In this case, a slight preheating is advised when combined with thick sections at a low range of heat input.

Table 10 indicates the preheating requirements applicable for the HISTAR 460 grade in function of the thickness, heat input and hydrogen content of the weld consumables.

Some preheating may be required for ambient temperatures < 0° C, electrodes with high hydrogen content, high restraint conditions or low heat input welds (such as repair welds, tack welds or single pass welds on thick material). In case of special applications, the fabricator may apply a more conservative preheating procedure. In any case, preheating is not detrimental to the quality of the HISTAR grades if the cooling time from 800°C to 500°C is less than 25s. This condition is satisfied with the usual welding energies and preheating temperature. Otherwise the HISTAR producer should be asked for advice.

Drying of the groove area is recommended before carrying out welding or if the surface of the beam is wet.

4.2 Welding consumables

The filler metal has to be selected in order to ensure the intended mechanical properties of the weld joint.
The consumable should be chosen according to the following criteria:

- the mechanical properties of the weld metal shall comply with the requirements of the HISTAR grade, in particular the impact energy,
- matching or slight "overmatching" of the tensile properties in comparison with the base metal is common welding practice,
- in order to use the "no preheat" procedure, the diffusible hydrogen content in the deposited weld metal must be low, i.e. $H_2 \leq 10$ml/100g for HISTAR 355 and $H_2 \leq 5$ml/100g for HISTAR 460,
- basic covered electrodes and fluxes are to be dried before use for 2 hours at 300° C and stored at 150° C in a drying oven and/or a quiver. When using dry electrodes, only the storage at 150° C is required. The recommendations of the manufacturer shall be followed,
- as for the welding of conventional structural steels, electrodes containing nickel are recommended in case of high toughness requirements at low temperature (e.g. bridges, offshore).

Table 11 summarises the information allowing a suitable choice of the welding consumables: tensile and impact properties of the HISTAR grades as well as the standards for the classification of the welding consumables for the various welding processes. Typical examples for choosing the welding consumables are included in the table. Other choices may also be adequate. Advice on commercial designations is available upon request and may be provided by the welding consumable producers.

The hydrogen content of the weld consumables is indicated in the standard designation as H5 or H10 respectively for contents lower than 5 or 10 ml/100g. No hydrogen is present in the weld consumables for the flux free welding processes (GMAW, MAG).

4.3 Weld bevel preparation

The bevel preparation can de done by oxycutting, milling, plasma or waterjet cutting.

Bevels for V or half V joints are possible without restriction.

For other bevel types (K or X joints) in material thicknesses greater than 63 mm, it is recommended to locate the weld root at about a third up to a quarter of the material thickness.

5. Stress relieving

A stress relief post weld heat treatment (PWHT) may be necessary when the layout of the structure and/or the expected stress condition after welding requires a reduction of the residual stresses.

Stress relieving of HISTAR steel grades is performed at temperatures between 530° C and 580° C. The holding time should be 2 minutes per mm of product thickness, but not less than 30 minutes and not more than 90 minutes.

Table 10: Preheating requirements for HISTAR 460 (acc. to EN 1011-2:2001/method A)

Combined thickness [mm]	Hydrogen content of consumables [ml/100 g]			
	5-10		≤ 5	
	Heat input [kJ/cm]		Heat input [kJ/cm]	
	10-15	15-60	10-15	15-60
≤50	No preheat	No preheat	No preheat	No preheat
> 50	100°C	No preheat	No preheat	No preheat

6. Flame straightening

Flame straightening is defined as a fast and local heating in order to eliminate deformations or to give to a structural member a required shape. HISTAR 355/460 grades can be flame straightened following the procedures usually applied to fine grain steels. The flame straightening temperature may go up to 650°C in case of a local full section heating. For local superficial heating, the flame straightening temperature may go up to 900°C. Further guidance concerning flame straightening is given in CEN/TR 10347:2006.

In order to improve the efficiency of the flame straightening process, restrain forces should be applied to the structural element through calibrated jacks or other suitable devices. In the areas to be flame straightened, the stresses from the restraining forces shall be less than the yield stress of the steel at elevated temperature.

7. Hot forming

The operations of hot forming and normalizing at temperatures higher than those of the stress relieving treatment are not suited for the HISTAR steels.

8. Cold forming

The cold forming behaviour of the HISTAR steels is comparable to the one of conventional structural steels of the same range of tensile strength. The usual cold deformation rules apply. In particular, it is recommended to control and limit the degree of cold deformation. Cold forming modifies the mechanical properties of steel; they should remain compatible with the intended use of the structure.

9. Galvanising

Upon agreement, HISTAR grades are delivered with a silicon content ranging between 0.14 % and 0.25 % and are as such capable of forming a zinc layer during hot dip galvanising. Fabrication recommendations for steel elements to be galvanized must be followed. More detailed information on this topic are given in the brochure "Corrosion protection of rolled steel sections using hot dip galvanisation" (available upon request).

10. Beam Finishing

To save time and costs to the customer, the structural shapes from ArcelorMittal can be delivered with processing like cold sawing, drilling, coping, straightening, cambering, weld-edge bevelling, welding, and surface coating.

Table 11: Choice of the welding consumables metals following the European classification

Grade	Tensile test			Notch impact test		Welding process (EN ISO 4063:2000)			
						SMAW (111)	MAG (135) GMAW (13)	FCAW (136)	SAW (121)
HISTAR	R_e min [MPa]	R_m [MPa]	A_{5d} min [%]	Temperature [°C]	Energy min. [J]	Standard (Designation)	Standard (Designation)	Standard (Designation)	Standard (Designation)
355	355	470-630	22	-20	40	EN ISO 2560-A (E 42 3 *** H10)	EN ISO 14341-A (G 42 3 ***)	EN ISO 17632-A (T 42 3 *** H10)	EN 760 EN 756
355 L	355	470-630	22	-50	27	EN ISO 2560-A (E 42 5 *** H5)	EN ISO 14341-A (G 42 5 ***)	EN ISO 17632-A (T 42 5 *** H5)	EN 760 EN 756
355 TZK- OS	355	460-620	22	-40	50				
460	460	540-720	17	-20	40	EN ISO 2560-A (E 46 3 *** H5)	EN ISO 14341-A (G 46 3 ***)	EN ISO 17632-A (T 46 3 *** H5)	EN 760 EN 756
460 L	460	540-720	17	-50	27	EN ISO 2560-A (E 46 5 *** H5)	EN ISO 14341-A (G 46 5 ***)	EN ISO 17632-A (T 46 5 *** H5)	EN 760 EN 756
460 TZK- OS	460	540-720	17	-40	60				

6. Technical delivery conditions

1. Rolling tolerances

Tolerances on dimensions and weight of beams in HISTAR grades and in structural steels are identical. They are given in the sales catalogue "Beams, Channels and Merchant Bars".

2. Mechanical testing

For the structural HISTAR grades, tensile test and Charpy V-notch impact test are performed in accordance with EN 10025-1:2004. Supplementary tests are possible upon agreement at an extra.

The frequency of mechanical testing for the HISTAR Offshore grades is in accordance with EN 10225:2009, i.e. once per 40 t or part thereof. The following tests are performed: one tensile test and one set of three Charpy V-Notch impact tests. Position and orientation of samples for these tests are in accordance with EN 10225:2009. Supplementary tests such as through thickness tensile tests according to EN 10164:2004 and impact tests in transverse direction can be performed upon agreement at an extra.

If other tests, such as weldability evaluation tests, are requested, this has to be agreed upon.

3. Ultrasonic testing

Ultrasonic testing is carried out upon agreement at an extra. The procedure for this test must be agreed between the purchaser and the manufacturer.

In case of order following EN 10164:2004, ultrasonic testing is performed in accordance with EN 10306:2001 class 2.3.

4. Certification

The type of certification shall be specified at the time of order.

5. Surface conditioning

HISTAR beams are delivered in standard ex-mill condition with surface quality in accordance with EN 10163-3:2004, Class C, Subclass 1. Other conditions are possible upon agreement.

Material can be supplied shot-blasted with or without coating upon agreement at an extra. Procedures have to be agreed upon between the purchaser and the manufacturer. Shot-blasted material with or without coating can be supplied with surface condition in accordance with EN 10163-3:2004, Class D, upon agreement at an extra.

7. Reference projects

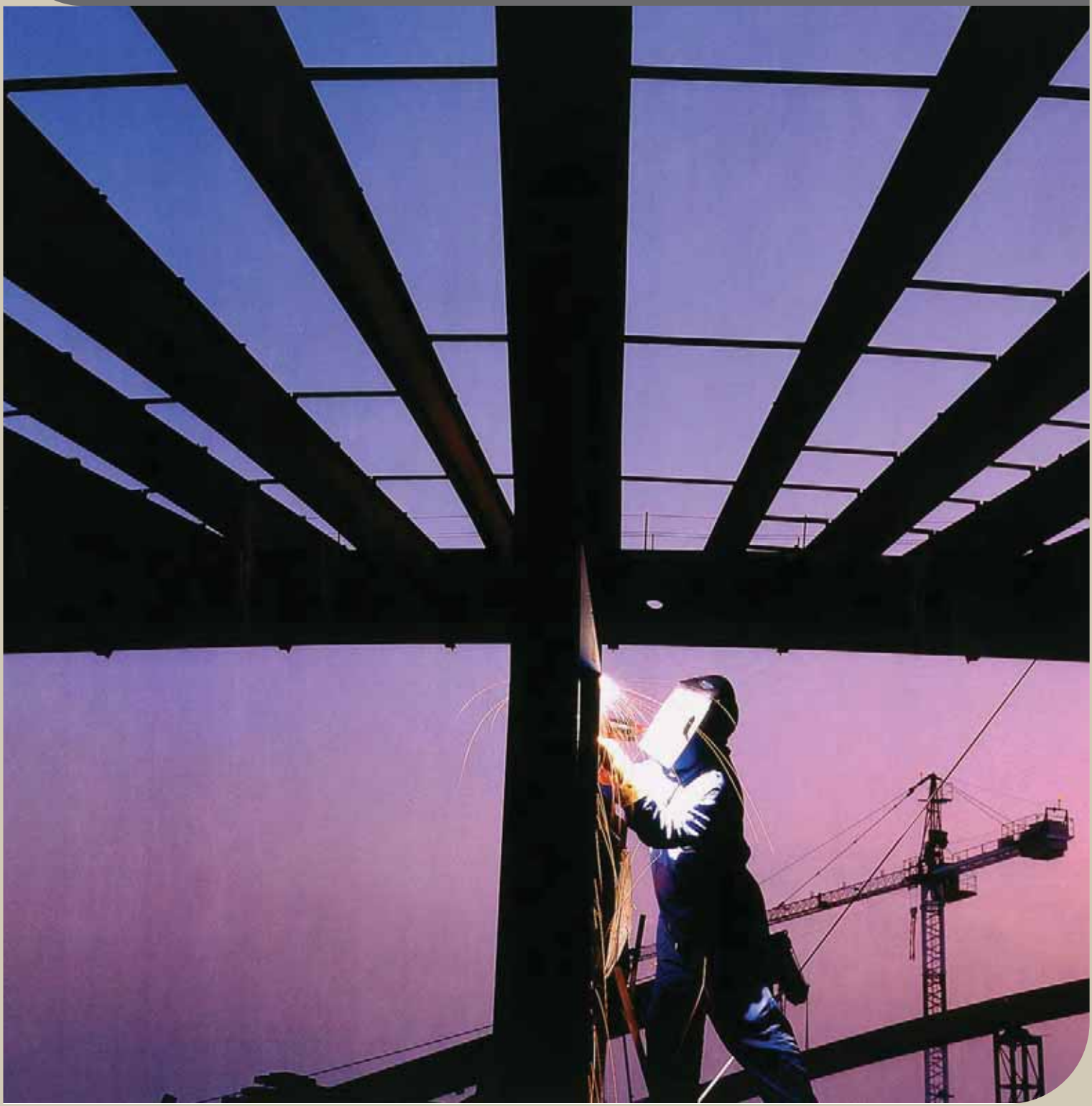


Table 12: Reference projects with HISTAR steel grade / ASTM A913 steel grade

Projects US & Canada	Location
WTC4	NEW YORK, NY
250 WEST 55th ST	NEW YORK, NY
UNIVERSITY OF CHICAGO MEDICAL CENTER	CHICAGO, IL
FOUNTAINBLEAU CASINO	LAS VEGAS, NV
KAISER HOSPITAL	OAKLAND, CA
DALLAS COWBOYS STADIUM	ARLINGTON, TX
WTC TRANSPORTATION HUB	NEW YORK, NY
COLTS STADIUM	INDIANAPOLIS, IN
THE BOW	CALGARY, AB
MARLINS STADIUM	MIAMI, FL
5TH & COLUMBIA	SEATTLE, WA
TEXAS STATION TRUSS	RENO, NV
PENNY LANE	CALGARY, AL
CARDINALS STADIUMS	GLENDALE, AZ
555 MISSION STREET	SAN FRANCISCO, CA
COSMOPOLITAN	LAS VEGAS, NV
STANDARD HOTEL	NEW YORK, NY
LURIE HOSPITAL	CHICAGO, IL
155 WACKER	CHICAGO, IL
BOIENG 777 ASSEMBLY BULDING	EVERETT, WA
ONE LONDON PLACE	LONDON, ON
BAY ADELAIDE CENTER	TORONTO, ON
AT&T BUILDING	CANADA
ROSE GARDEN ARENA (TRAILBLAZERS)	PORTLAND, OR
GM PLACE (GRIZZLIES & CANUCKS)	VANCOUVER, BC
BALTIMORE CONVENTION CENTER	BALTIMORE, MD
TORONTO CONVENTION CENTER	TORONTO, ON
LAS VEGAS CLUB TOWER	LAS VEGAS, NV
COREL CENTER (PALLADIUM ARENA)	OTTAWA, ON
AIOC BUILDING	MONTREAL, QC
MAYAGUEZ SHOPPING CENTER	SAN JUAN, PR
TRICO STEEL MILL	DECATUR, AL
BANK ONE STADIUM	PHOENIX, AR
POTLACH	NEW ORLEANS, LA
KREMCO - OFFSHORE PLATFORMS	CLEARFIELD, UT
ST. FRANCIS HOSPITAL	LYNWOOD, CA
SAN AIRPORT PEDESTRIAN BRIDGE	SAN DIEGO, CA
CHIRON LIFE SCIENCES BUILDING	EMERYVILLE, CA
ADOBE SYSTEMS HD - PHASE II	SAN JOSE, CA
BARUCH COLOGE	NEW YORK, NY
GLIDER OFFSHORE	GULF OF MEXICO
CONDE NAST - 4 TIMES SQUARE	NEW YORK, NY
BOSTON GARDENS	BOSTON, MA
BROOKLYN RENAISSANCE	NEW YORK, NY
GLENDALE PLAZE	GLENDALE, AZ
MGM CASINO HOTEL	LAS VEGAS, NV
MILLER PARK	MILWAUKEE, WI
NEW PACIFIC NW BASEBALL PARK	SEATTLE, WA
TRANS WORLD DOME	ST. LOUIS, MO
URSA OFFSHORE	GULF OF MEXICO
AIR CANADA CENTRE	TORONTO, ON
KAISER HOSPITAL	SANTA CLARA, CA
BROWARD COUNTY CIVIC ARENA	MIAMI, FL
PROVIDENCE MALL	PROVIDENCE, RI
POMONA SCIENCE BUILDING	POMONA, CA
BUENA VENTURA MALL	VENTURE, CA
LDS ASSEMBLY BUILDING	SALT LAKE CITY, UT
HARVARD UNIVERSITY	BOSTON, MA
BECHTEL BUILDING - 199 FREMONT ST	SAN FRANCISCO, CA
BOSTON ARTERY	BOSTON, MA
NETHERCUTT CAR MUSEUM	LOS ANGELES, CA
MAYO CLINIC	ROCHESTER, MN
WATER TOWER	SANTA MONICA, CA
MALKER HALL, U OF CALIFORNIA	DAVIS, CA
AURORA ARENA	GRAND FORKS, ND
NATIONWIDE ARENA	ST. PAUL, MN
AUSTIN CONVENTION CENTER	AUSTIN, TX

Projects US & Canada	Location
RELIANT STADIUM	HOUSTON, TX
MARINERS STADIUM PRACTICE FIELD	SEATTLE, WA
MINNEAPOLIS CONVENTION CENTER EXP	MINNEAPOLIS, MN
CIVIC CENTER PLAZA	WALNUT CREEK, CA
300 MADISON AVE	NEW YORK, NY
33 ARCH ST	BOSTON, MA
PHELPS DODGE TOWER	PHOENIX, CA
WASHINGTON CONVENTION CENTER	WASHINGTON, DC
ARIZONA CARDINALS NFL STADIUM	PHOENIX, CA
RANDOM HOUSE	NEW YORK, NY
LIVERMORE CIVIC CENTER LIBRARY	LIVERMORE, CA
CALTRANS DISTRICT 7 HQ	LOS ANGELES, CA
PRESBYTERIAN HOSPITAL FOUNDATION	TOWER WHITTIER, CA
TOWER AT CCCC	FRESNO, CA
COLORADO CONVENTION CENTER EXP.	DENVER, CO
MANULIFE FINANCIAL US HQ	BOSTON, MA
SLOAN-KETTERING HOSPITAL	NEW YORK, NY
CORONA CITY HALL	CORONA, CA
JEWISH HOSPITAL (SMARTBEAM)	LOUISVILLE, KY
INTERMOUNTAIN MEDICAL CENTER (IMC)	SALT LAKE CITY, UT
PRESSAGE FACTORY	EDMONTON, AB
NORTHWEST AIRLINE HANGAR	DETROIT, MI
VISA BUILDING SAN	MATEO, CA
DEVOS PLACE CONVENTION CENTER	GRAND RAPIDS, MI
VIRGINIA BEACH CONVENTION CENTER	RICHMOND, VA
CHILLIWACK ARENA	CHILLIWACK, BC
GUTHRIE THEATRE	MINNEAPOLIS, MN
SAVE-ON-FOODS MEMORIAL CENTRE	VICTORIA, BC
HEARST TOWER	NEW YORK, NY
UCLA, CNSI COURT OF SCIENCES BUILDING	LOS ANGELES, CA
BROADWAY 655	SAN DIEGO, CA
MIAMI PERFORMING ARTS CENTER	MIAMI, FL
CIRA CENTER	PHILADELPHIA, PA
111 SOUTH WACKER	CHICAGO, IL
1220 FOUNDATION TOWER HOSPITAL	LOS ANGELES, CA
DENVER ART MUSEUM	DENVER, CO
CHARLOTTE ARENA	CHARLOTTE, NC
MCCORMICK PLACE EXP.	CHICAGO, IL
WASHINGTON MUTUAL HQ - SEATTLE ART MUSEUM	SEATTLE, WA
WESTIN HQ HOTEL AT THE BCEC	BOSTON, MA
RED ROCK CASINO	LAS VEGAS, NV
PALAZZO CASINO, VENETIAN EXP.	LAS VEGAS, NV
ONE SOUTH DEARBORN	CHICAGO, IL
CALTRANS BUILDING	SAN DIEGO, CA
2000 AVENUE OF THE STARS	LOS ANGELES, CA
RIVER AIR	NEW YORK, NY
US CENSUS BUILDING	BIRMINGHAM, AL
PRENTICE HOSPITAL	CHICAGO, IL
HARTFORD 21/ TOWN SQUARE	HARTFORD, CT
SOUTH PLACER JUSTICE CENTER	PLACER COUNTY, CA
PROVIDENCE NORTH PAVILION	PORTLAND, OR
CONVENTION CENTER	RALEIGH, NC
EL CAMINO HOSPITAL	MOUNTAIN VIEW, CA
PHOENIX CONVENTION CENTER	PHOENIX, AZ
MOMO	CHICAGO, IL
ST. JAMES PROJECT	BOSTON, MA
NYU - PALLADIUM	NEW YORK, NY
111 HUNTINGTON	BOSTON, MA
WEST ANGELES CATHEDRAL	LOS ANGELES, CA
SHERATON GRAND BALLROOM	SACRAMENTO, CA
MORGAN STANLEY DEAN WITTER	NEW YORK, NY
850 CHERRY AVENUE	SAN BRUNO,CA
ERNST &YOUNG - 5 TIMES SQUARE	NEW YORK, NY
ST. JOHNS HOSPITAL	SANTA MONICA,CA
MOSCONE CENTER	SAN FRANCISCO, CA

Projects Europe	Location
VOIRON	GRENOBLE, F
SALLE MULTISPORT	DUNKERQUE, F
CENTRE DE RETRAITEMENTS DES DECHETS	ISSY LES MOULINEAUX, F
RHEINENERGIE STADION	KOELN, D
POSTTOWER	BONN, D
MESSEHALLEN	BREMEN, D
LEHRTER BAHNHOF	BERLIN, D
VELODROM	BERLIN, D
SPORT PALEIS	ANTWERP, B
TOUR PLEIADE	BRUSSELS, B
ESPACE LEOPOLD	BRUSSELS, B
REMBRANDT TOWER	AMSTERDAM, NL
DESIO TOWER	MILANO, I
DIAMOND TOWER LE VARESINE	MILANO, I
DAEWOO TOWER	WARSAW, PL
TORRE MAPFRE	BARCELONA, E
PUERTE EUROPA	MADRID, E
TORRE CRISTAL	MADRID, E
TORRE REPSOL	MADRID, E
VARIOUS PARKING PROJECTS	EUROPE
VARIOUS BRIDGE PROJECTS	EUROPE
VARIOUS OFF-SHORE PLATFORMS	NORTH SEA, UK+N
FEDERATION COMPLEX	MOSCOW, RUS
EURASIA TOWER	MOSCOW, RUS
EMBANKMENT TOWER	MOSCOW, RUS
IMMEUBLE BASALTE	PARIS, F
STADE DE LA ROUTE DE LORIENT	RENNES, F
SALLE DE SPECTACLE	MONTPELLIER, F
HOTEL DE VILLE	MONTPELLIER, F
CAR PARK AT FOOTBALL STADIUM	LUXEMBOURG, L
THE SQUAIRE AIRRAIL CENTER	FRANKFURT, D
NEW ORLEANS TOWER	ROTTERDAM, NL
VARIOUS BEARING PILE PROJECTS	EUROPE
BELGACOM TOWER	BRUSSELS, B
ISTANBUL LRT BRIDGES	ISTANBUL, TR
FENERBAHCE BASKETBALL ARENA	ISTANBUL, TR
DIAMOND OF ISTANBUL	ISTANBUL, TR
HILTON DOUBLETREE HOTEL	ISTANBUL, TR
TARABYA HOTEL	ISTANBUL, TR
SABIHA GOKCEN HANGARS	ISTANBUL, TR
ZORLU TOWER	ISTANBUL, TR
THE PINNACLE	LONDON, UK
25 CHURCHILL PLACE	LONDON, UK

Projects Asia	Location
NEW POLY PLAZA	BEIJING, CHINA
LANXI POWER PLANT	ZHEJIANG, CHINA
DIANDONG POWER PLANT	YUNNAN, CHINA
SHANGHAI WORLD FINANCIAL CENTER	SHANGHAI, CHINA
EMIRATES TOWER	DUBAI, UAE
QUATAR INTERNATIONAL AIRPORT	DOHA, Q
BLAST DOOR FOR NEW HIGH COURT	SINGAPORE, SGP
VARIOUS BEARING PILES	HONG KONG, CHINA
EMIRATES ENGINEERING CENTRE & MAINTENANCE HALLS	DUBAI, UAE
EREN PAPER FACTORY	TEKIRDAG, TR
CMA TOWER	RIYADH, KSA
PENTOMINIUM TOWER	DUBAI, UAE
TRUMP TOWER	MUMBAI, INDIA
ASTANA ARENA	ASTANA, KZ

Projects Australia	Location
SOUTHERN CROSS	MELBOURNE, AUS
SOUTHERN CROSS II	MELBOURNE, AUS

Projects South America	Location
TRINIDAD MANSION	TRINIDAD, TT

8. Hot rolled sections in sustainable construction

The preservation of natural resources in our industrialized societies has become a priority in the creation of the built environment. Consequently, the industrialized building concepts have to comply with changing economical parameters like the incorporation of life cycle analyses in the design of buildings, as well as with technological changes for considering at an equal level sustainability goals with respect to the environmentand society.

These sustainability goals are in nature:

- ecological
- economical
- socio-cultural
- technical oriented
- process oriented

They are interdependent as well as ambivalent, providing a coherent response to complex questions and ensuring the future generations a pleasant built environment.

Sustainable construction using hot rolled steel sections is fully consistent with the various aspects of the sustainability goals.

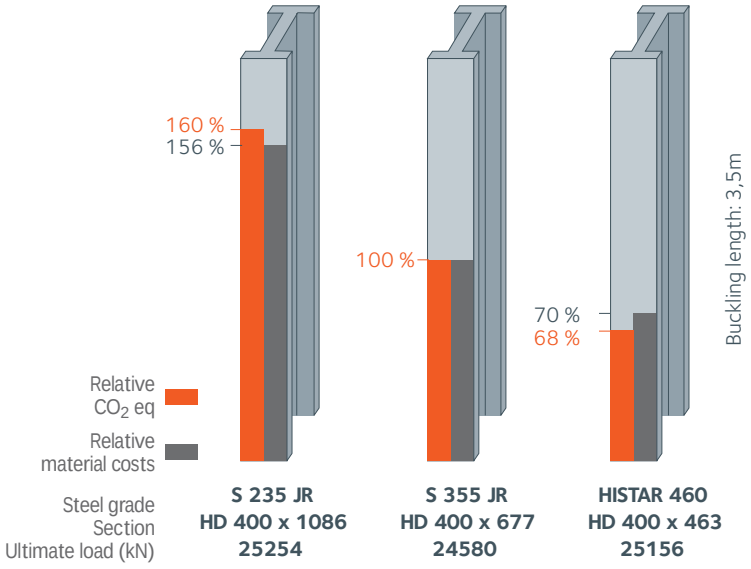
- Ecological aspects of sustainability

  The main ecological goals aim at using construction materials that are safe from health and environmental points of view, at reducing structures waste when dismantling buildings at the end of their service life, and at preserving as best possible the energy content in the construction materials, thus maintaining their ideal efficiency, Here, structural steels offer high material efficiency and rolled sections constitute the most recycled construction material in the world. In the modern electric arc furnace (EAF) route, steel is produced using 100% scrap as a raw material (upcycling). Also, used steel elements can be deployed for further use in renovation and refurbishment of existing buildings. In addition, the EAF technology of steel allows for significant reductions of noise, particle- and CO_2-emissions as well as water and primary energy consumption in the production mills.

- Economical aspects of sustainability

  Beside being interested in the reduction of investment costs, investors are also concerned about the optimization of operational costs and the achievement the longest possible service life in combination with high flexibility in use of the building. Rolled sections in structural steel allow architects and designers to easily fulfill the requirements of investors by combining high quality, functionality, aesthetics, low weight and short construction time. Slender superstructures can be designed which decrease construction height and foundation works leading to a further decrease of material, fabrication, transport and construction costs. Short construction times and therefore reduced traffic disturbance save user costs during construction. Tenders including the lifecycle costs prove the competitiveness and sustainability of steel and composite structures. Recovered steel can be recycled indefinitely. Assuming an appropriate design, whole structures or their individual steel elements can be re-used after dismantling of the original building and offer so significant economical life-cycle potential.

Figure 9: CO_2 reduction of HISTAR steels in heavy columns



- Socio-cultural aspects of sustainability

  This aspect allows the architect to reconcile his own aesthetic demands for a building with the social expectations of its surrounding environment. Again, thanks to the prefabrication construction system, rolled steel sections provide the user with transparent and lean structures combined with robustness and safety. Local inhabitants and their social environment remain clean in uncontaminated surroundings as steel in structures does not release any harmful substances into the environment.

- Technical aspects of sustainability

  Structures made of rolled beams have the advantage of being able to resist high level utilization and are adaptable to changes in use. These robust construction solutions are capable of coping well with variations in use during service life without damage or loss of functionality.

- Process aspects of sustainability

  Steel constructions offer many advantages through their flexibility, lightness and cost effectiveness. Rolled beams are used as primary bearing elements. They are industrially produced to a high quality, offer good availability in a full range of sizes and steel grades, including HISTAR. Fabricated in specialized workshops the end product is delivered to site ready for erection. Quality control has already been carried out at the production. Smaller construction sites and plant equipment are therefore needed whilst minimal noise and dust disturbance on site are characteristics for steel construction. Structures using hot rolled sections reduce erection times. Hence, transportation cost as well as accident potential is reduced.

Choosing HISTAR steels and using their full potential, leads to create the best conditions for a contemporary, economical, ecological and consistent sustainable construction. In design and service life, the slenderness both, for columns and beams, are a major advantage for steel construction. With an optimal use of HISTAR steels, as described in Chapter 3 of the present brochure, up to 60 % of steel weight reduction can be achieved, -- and thus directly reducing of, most importantly, the Global Warming Potential (CO_2 , Carbon Footprint) and the Primary Energy Consumption.
Since years, WorldSteel association is collecting information on the steel production all over the world. In 2010 a large update was made on the database regrouping all the environmental impact of steel production and steel recycling. All theses impact value were peer reviewed by an independent organism (PE International) to confirm that all theses calculations are in line with the standard ISO 14040-44. High strength HISTAR grades allow, in comparison with conventional structural steels, to reduce the weight and material costs of steel structures, and to cut welding and assembly time (Figure 9)

To document in a standardized way the environmentally relevant information, an EPD (Environmental Product Declaration) in accordance with ISO 14025 is available for structural steel upon request (www.arcelormittal.com/sections).

HISTAR steels are contributing to a major reduction in greenhouses gases by making it possible to use lighter structures with reduced carbon footprint. Substituting HISTAR for common steel achieves CO_2 reductions of about 30% in steel columns and about 20 % in beams.

The 50000 tons of HISTAR steels produced each year by ArcelorMittal represents a saving of some 14000 tons of CO_2, which roughly equates to the annual emissions of 4000 vehicles.

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Technical Advisory & Finishing

Technical Advisory

We are happy to provide free technical advice to optimise the use of our products and solutions in your projects and to answer your questions about the use of sections and merchant bars. This technical advice covers the design of structural elements, construction details, surface protection, fire safety, metallurgy and welding.

Our specialists are ready to support your initiatives anywhere in the world.

sections.tecom@arcelormittal.com

To facilitate the design of your projects, we also offer free software and technical documentation that you can consult or download from our website:

www.arcelormittal.com/sections

ArcelorMittal has also a website dedicated to a full range of products for the construction market (structures, facades, roofing, etc.):

www.constructalia.com

Finishing

As a complement to the technical capacities of our partners, we are equipped with high-performance finishing tools and offer a wide range of services, such as:

- drilling
- flame cutting
- T cut-outs
- notching
- cambering
- curving
- straightening
- cold sawing to exact length
- welding and fitting of studs
- shot and sand blasting
- surface treatment

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Your Partners

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We operate in more than 60 countries on all five continents. Please have a look at our website under "About us" to find our local agency in your country.

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