Resistance of cross-sections

EN 1993 is intended to be used with Eurocodes EN 1990 - Basis of Structural Design, EN 1991 - Actions on structures and EN 1992 to EN 1999, when steel structures or steel components are referred to.

Symbols

Section	-	Designation
Steel grade	-	Standard steel grade
ε	-	Coefficient depending on f_y
f_y	-	Yeld strength
f_u	-	Ultimate strength
A	-	Cross section area
A_{vz}	-	Shear area on z-z axis
A_{vy}	-	Shear area on y-y axis
A_w	-	Area of a web
A_f	-	Area of one flange
h_w	-	Web heigth
t_w	-	Web thickness
$W_{el,min,y}$	-	Mimimum elastic section modulus for y-y axis
$W_{pl,y}$	-	Plastic section modulus for y-y axis
$W_{el,min,z}$	-	Mimimum elastic section modulus for z-z axis
$W_{pl,z}$	-	Plastic section modulus for z-z axis
Class	-	Section class
c	-	Width or depth of a part of a cross section
t	-	Thickness
A_{net}	-	Net area of a cross section
$N_{t,Rd}$	-	Design values of the resistance to tension forces
$N_{p,Rd}$	-	Design plastic resistance to normal forces of the gross cross-section
$N_{u,Rd}$	-	Design ultimate resistance to normal forces of the net cross-section at holes for fasteners
$N_{c,Rd}$	-	Design resistance to normal forces of the cross-section for uniform compression
$A_{f,net}$	-	Net area of the tension flange
$M_{el,Rd}$	-	Elastic design values of the resistance to bending moments
$M_{pl,Rd}$	-	Plastic design values of the resistance to bending moments
$M_{c,Rd}$	-	Design resistance for bending
$M_{el,y,Rd}$	-	Elastic design values of the resistance to bending moments for y-y axis
$M_{pl,y,Rd}$	-	Plastic design values of the resistance to bending moments for y-y axis
$M_{c,y,Rd}$	-	Design resistance for bending for y-y axis
$M_{el,z,Rd}$	-	Elastic design values of the resistance to bending moments for z-z axis
$M_{pl,z,Rd}$	-	Plastic design values of the resistance to bending moments for z-z axis
$M_{c,z,Rd}$	-	Design resistance for bending for z-z axis
$V_{pl,Rd}$	-	Plastic design shear resistance
$V_{pl,y,Rd}$	-	Plastic design shear resistance for y-y axis
$V_{pl,z,Rd}$	-	Plastic design shear resistance for z-z axis
ρ	-	Reduction factor for reduced design values of the resistance to bending moment
n	-	Ratio of design normal force to design plastic resistance to normal forces
a	-	Ratio of web area to gross area
$M_{N,y,Rd}$	-	Design plastic moment resistance reduced due to the axial force for z-z axis
$M_{N,y,Rd}$	-	Design plastic moment resistance reduced due to the axial force for y-y axis
N_{Ed}	-	Design normal force
M_{Ed}	-	Design bending moment
V_{Ed}	-	Design shear force
$\sigma_{N,x,Ed}$	-	Design value of the local longitudinal stress due to axial force
$\sigma_{M,x,Ed}$	-	Design value of the local longitudinal stress due to bending moment
τ_{Ed}	-	Design value of the local shear stress

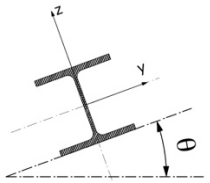
References

EN 1993-1-1:2005 "Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings

Resistance of cross-sections

Object:

Section and Materials



Section	HE 100 A							
Steel grade	S 235	fy = 235 Mpa (t ≤ 40 mm)						
ε =	1,00	fu = 360 Mpa (t ≤ 40 mm)						
A =	21,2	cm²						
A_{vz} =	7,56	cm²	$W_{el,min,y}$ =	73	cm³			
A_{vy} =	17,24	cm³	$W_{pl,y}$ =	83	cm³			
A_w =	4,00	cm²	$W_{el,min,z}$ =	27	cm³			
A_f =	8,00	cm²	$W_{pl,z}$ =	41	cm³			
h_w/t_w =	0,86							

θ 0 °

Section class Class 1

Internal web			Outstand flanges		
c/t =	11,20		c/t =	4,44	
Class 1	Internal web bending		Class 1	Outstand flanges compression	
Class 1	Internal web compression				

Resistance of cross section

Tension

A_{net}		cm²						
$N_{t,Rd}$ =	499	kN	$N_{pl,Rd}$ =	499 kN				
			$N_{u,Rd}$ =					

Compresion

$N_{c,Rd}$ =	499	kN

Bending moment

$A_{f,net}$		cm²						
$M_{el,Rd}$ =	17,1	kN m	$M_{el,y,Rd}$ =	17,1	kN m	$M_{el,z,Rd}$ =	6,3	kN m
$M_{pl,Rd}$ =	19,5	kN m	$M_{pl,y,Rd}$ =	19,5	kN m	$M_{pl,z,Rd}$ =	10	kN m
$M_{c,Rd}$ =	19,5	kN m	$M_{c,y,Rd}$ =	19,5	kN m	$M_{c,z,Rd}$ =	9,67	kN m

Shear

$V_{pl,Rd}$ =	103	kN	$V_{pl,z,Rd}$ =	103	kN	$V_{pl,y,Rd}$ =	234	kN

Bending and shear (§6.2.8)

ρ =	0,00	Shear effect on moment resistance may be neglected (§6.2.8(2))						
$M_{c,Rd}$ =	19,5	kN m	$M_{c,y,Rd}$ =	19,5	kN m	$M_{c,z,Rd}$ =	9,7	kN m

Bending and axial force (§6.2.9)

n =	0,24		
a =	0,25	Axial force effect on bending resistance for z-z axis may be neglected (§6.2.9.1(4))	
$M_{N,y,Rd}$ =	16,9	kN m	Eq. (6.36) §6.2.9.1(5)
$M_{N,z,Rd}$ =	9,7	kN m	Eq. (6.37) §6.2.9.1(5)

Design values of action effect

N_{Ed} 120 kN M_{Ed} 10 kN m V_{Ed} 10 kN

Elastic analysis

$\sigma_{N,x,Ed}$ =	56,5 MPa	$\sigma_{M,x,Ed}$ =	137,4 MPa	τ_{Ed} =	25,0 MPa	Eq. (6.21) §6.2.6(5)	
Eq. (6.1) =	0,72	§6.2.1(5)					

Plastic analysis

N_{Ed} / $N_{t,Rd}$ =	0,24	Eq. (6.5) §6.2.3(1)
N_{Ed} / $N_{c,Rd}$ =	0,24	Eq. (6.9) §6.2.4(1)
M_{Ed} / $M_{c,Rd}$ =	0,51	Eq. (6.12) §6.2.5(1)
V_{Ed} / $V_{pl,Rd}$ =	0,10	Eq. (6.17) §6.2.6(1)
M_{Ed} / $M_{c,Rd}$ =	0,51	Eq. (6.12), Eq. (6.29)
M_{Ed} / $M_{N,Rd}$ =	0,59	Eq. (6.31) §6.2.9.1(2)
Eq. (6.41) =	0,35	§6.2.9.1(6)
Eq. (6.45) =	0,35	§6.2.10(3)
Eq. (6.2) =	0,75	§6.2.1(7)

Note:

Bending moment

Fastener holes in tension zone of the web need not be allowed for, provided that the limit given in §6.2.5 (4) is satisfied for the complete tension zone comprising the tension flange plus the tension zone of the web.

Fastener holes except for oversize and slotted holes in compression zone of the cross-section need not be allowed for, provided that they are filled by fasteners.

National annex for EN 1993-1-1

EN 1993 gives values with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1993-1 should have a National Annex containing all Nationally Determined Parameters to be used for the design of steel structures to be constructed in the relevant country.

The National Annex may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned.

National choice is allowed in EN 1993-1-1 through the following values:

Action safety factors

γ_G	1,35
γ_Q	1,50

Materials safety factors

γ_{M0}	1,00
γ_{M1}	1,00
γ_{M2}	1,25

Nominal values of yeld strength fy and ultimate tensile strength fu

Steel grade	f_y [N/mm^2]	f_u [N/mm^2]
S 235	235	360
S 275	275	430
S 355	355	510
S 450	440	550

Section	Typ.	h	hw	b	tw	tf	r1	A	P	Jy	Wy	Wypl	iy	Jz	Wz	Wzpl	iz	Avy	Avz	c/t flange	c/t web
HE 100 A	H	96	80	100	5	8	12	21,2	16,7	349,2	72,76	83,01	4,06	133,8	26,76	41,14	2,51	17,24	7,56	4,44	11,20
HE 1000 A	H	990	928	300	16,5	31	30	347	272	553800	11190	12820	39,96	14000	933,6	1470	6,35	193,68	184,52	3,60	52,61
HE 120 A	H	114	98	120	5	8	12	25,3	19,9	606,2	106,3	119,5	4,89	230,9	38,48	58,85	3,02	20,44	8,46	5,69	14,80
HE 140 A	H	133	116	140	5,5	8,5	12	31,4	24,7	1033	155,4	173,5	5,73	389,3	55,62	84,85	3,52	25,04	10,128	6,50	16,73
HE 160 A	H	152	134	160	6	9	15	38,8	30,4	1673	220,1	245,1	6,57	615,6	76,95	117,6	3,98	30,73	13,21	6,89	17,33
HE 180 A	H	171	152	180	6	9,5	15	45,3	36	2510	293,6	324,9	7,45	924,6	102,7	156,5	4,52	36,13	14,47	7,58	20,33
HE 200 A	H	190	170	200	6,5	10	18	53,8	42,3	3692	388,6	429,5	8,28	1336	133,6	203,8	4,98	42,78	18,08	7,88	20,62
HE 220 A	H	210	188	220	7	11	18	64,3	50,5	5410	515,2	568,5	9,17	1955	177,7	270,6	5,51	51,18	20,67	8,05	21,71
HE 240 A	H	230	206	240	7,5	12	21	76,8	60,3	7763	675,1	744,6	10,05	2769	230,7	351,7	6	61,39	25,18	7,94	21,87
HE 260 A	H	250	225	260	7,5	12,5	24	86,8	68,2	10450	836,4	919,8	10,97	3668	282,1	430,2	6,5	69,945	28,758	8,18	23,60
HE 280 A	H	270	244	280	8	13	24	97,3	76,4	13670	1013	1112	11,86	4763	340,2	518,1	7	77,74	31,74	8,62	24,50
HE 300 A	H	290	262	300	8,5	14	27	113	88,3	18260	1260	1383	12,74	6310	420,6	641,2	7,49	90,23	37,25	8,48	24,47
HE 320 A	H	310	279	300	9	15,5	27	124	97,6	22930	1479	1628	13,58	6985	465,7	709,7	7,49	99,29	41,165	7,65	25,00
HE 340 A	H	330	297	300	9,5	16,5	27	134	105	27690	1678	1850	14,4	7436	495,7	755,9	7,46	105,29	44,978	7,17	25,58
HE 360 A	H	350	315	300	10	17,5	27	143	112	33090	1891	2088	15,22	7887	525,8	802,3	7,43	111,3	49	6,74	26,10
HE 400 A	H	390	352	300	11	19	27	159	125	45070	2311	2562	16,84	8564	570,9	872,9	7,34	120,28	57,35	6,18	27,09
HE 450 A	H	440	398	300	11,5	21	27	178	140	63720	2896	3216	18,92	9465	631	965,5	7,29	132,23	65,755	5,58	29,91
HE 500 A	H	490	444	300	12	23	27	198	155	86970	3550	3949	20,98	10370	691,1	1059	7,24	144,22	74,68	5,09	32,50
HE 550 A	H	540	492	300	12,5	24	27	212	166	111900	4146	4622	22,99	10820	721,3	1107	7,15	150,3	83,76	4,86	35,04
HE 600 A	H	590	540	300	13	25	27	227	178	141200	4787	5350	24,97	11270	751,4	1156	7,05	156,3	93,25	4,66	37,38
HE 650 A	H	640	588	300	13,5	26	27	242	190	175200	5474	6136	26,93	11720	781,6	1205	6,97	162,22	103,15	4,47	39,56
HE 700 A	H	690	636	300	14,5	27	27	261	204	215300	6241	7032	28,75	12180	811,9	1257	6,84	168,28	117	4,29	40,14
HE 800 A	H	790	734	300	15	28	30	286	224	303400	7682	8699	32,58	12640	842,6	1312	6,65	175,7	138,8	4,02	44,93
HE 900 A	H	890	830	300	16	30	30	321	252	422100	9485	10810	36,29	13550	903,2	1414	6,5	187,7	163,3	3,73	48,13
HE 100 B	H	100	80	100	6	10	12	26	20,4	449,5	89,91	104,2	4,16	167,3	33,45	51,42	2,53	21,24	9,04	3,50	9,33
HE 1000 B	H	1000	928	300	19	36	30	400	314	644700	12890	14860	40,15	16280	1085	1716	6,38	223,68	212,44	3,07	45,68
HE 120 B	H	120	98	120	6,5	11	12	34	26,7	864,4	144,1	165,2	5,04	317,5	52,92	80,97	3,06	27,64	10,965	4,07	11,38
HE 140 B	H	140	116	140	7	12	12	43	33,7	1509	215,6	245,4	5,93	549,7	78,52	119,8	3,58	34,84	13,08	4,54	13,14
HE 160 B	H	160	134	160	8	13	15	54,3	42,6	2492	311,5	354	6,78	889,2	111,2	170	4,05	43,53	17,59	4,69	13,00
HE 180 B	H	180	152	180	8,5	14	15	65,3	51,2	3831	425,7	481,4	7,66	1363	151,4	231	4,57	52,33	20,24	5,05	14,35
HE 200 B	H	200	170	200	9	15	18	78,1	61,3	5696	569,6	642,5	8,54	2003	200,3	305,8	5,07	62,78	24,83	5,17	14,89
HE 220 B	H	220	188	220	9,5	16	18	91	71,5	8091	735,5	827	9,43	2843	258,5	393,9	5,59	73,18	27,92	5,45	16,00
HE 240 B	H	240	206	240	10	17	21	106	83,2	11260	938,3	1053	10,31	3923	326,9	498,4	6,08	85,4	33,24	5,53	16,40
HE 260 B	H	260	225	260	10	17,5	24	118	93	14920	1148	1283	11,22	5135	395	602,2	6,58	95,9	37,55	5,77	17,70
HE 280 B	H	280	244	280	10,5	18	24	131	103	19270	1376	1534	12,11	6595	471	717,6	7,09	105,78	41,13	6,15	18,67
HE 300 B	H	300	262	300	11	19	27	149	117	25170	1678	1869	12,99	8563	570,9	870,1	7,58	120,28	47,45	6,18	18,91
HE 320 B	H	320	279	300	11,5	20,5	27	161	127	30820	1926	2149	13,82	9239	615,9	939,1	7,57	129,22	51,728	5,72	19,57
HE 340 B	H	340	297	300	12	21,5	27	171	134	36660	2156	2408	14,65	9690	646	985,7	7,53	135,26	56,09	5,44	20,25
HE 360 B	H	360	315	300	12,5	22,5	27	181	142	43190	2400	2683	15,46	10140	676,1	1032	7,49	141,23	60,563	5,19	20,88
HE 400 B	H	400	352	300	13,5	24	27	198	155	57680	2884	3232	17,08	10820	721,3	1104	7,4	150,28	70	4,84	22,07
HE 450 B	H	450	398	300	14	26	27	218	171	79890	3551	3982	19,14	11720	781,4	1198	7,33	162,28	79,68	4,46	24,57
HE 500 B	H	500	444	300	14,5	28	27	239	187	107200	4287	4815	21,19	12620	841,6	1292	7,27	174,22	89,78	4,13	26,90

HE 550 B	H	550	492	300	15	29	27	254	199	136700	4971	5591	23,2	13080	871,8	1341	7,17	180,3	100,11	3,98	29,20
HE 600 B	H	600	540	300	15,5	30	27	270	212	171000	5701	6425	25,17	13530	902	1391	7,08	186,3	110,85	3,84	31,35
HE 650 B	H	650	588	300	16	31	27	286	225	210600	6480	7320	27,12	13980	932,3	1441	6,99	192,22	122	3,71	33,38
HE 700 B	H	700	636	300	17	32	27	306	241	256900	7340	8327	28,96	14440	962,7	1495	6,87	198,28	137,12	3,58	34,24
HE 800 B	H	800	734	300	17,5	33	30	334	262	359100	8977	10230	32,78	14900	993,6	1553	6,68	205,75	161,78	3,37	38,51
HE 900 B	H	900	830	300	18,5	35	30	371	291	494100	10980	12580	36,48	15820	1054	1658	6,53	217,75	188,78	3,16	41,62
IPE 100	I	100	88,6	55	4,1	5,7	7	10,3	8,1	171	34,2	39,41	4,07	15,92	5,79	9,15	1,24	6,6874	5,0817	3,24	18,20
IPE 120	I	120	107	64	4,4	6,3	7	13,2	10,4	317,8	52,96	60,73	4,9	27,67	8,65	13,58	1,45	8,4844	6,3052	3,62	21,23
IPE 140	I	140	126	73	4,7	6,9	7	16,4	12,9	541,2	77,32	88,34	5,74	44,92	12,31	19,25	1,65	10,499	7,6463	3,93	23,87
IPE 160	I	160	145	82	5	7,4	9	20,1	15,8	869,3	108,7	123,9	6,58	68,31	16,66	26,1	1,84	12,83	9,656	3,99	25,44
IPE 180	I	180	164	91	5,3	8	9	24	18,8	1317	146,3	166,4	7,42	100,9	22,16	34,6	2,05	15,258	11,254	4,23	27,55
IPE 200	I	200	183	100	5,6	8,5	12	28,5	22,4	1943	194,3	220,6	8,26	142,4	28,47	44,61	2,24	18,232	13,996	4,14	28,39
IPE 220	I	220	202	110	5,9	9,2	12	33,4	26,2	2772	252	285,4	9,11	204,9	37,25	58,11	2,48	21,476	15,881	4,35	30,10
IPE 240	I	240	220	120	6,2	9,8	15	39,1	30,7	3892	324,3	366,6	9,97	283,6	47,27	73,92	2,69	25,455	19,148	4,28	30,71
IPE 270	I	270	250	135	6,6	10,2	15	45,9	36,1	5790	428,9	484	11,23	419,9	62,2	96,95	3,02	29,466	22,133	4,82	33,27
IPE 300	I	300	279	150	7,1	10,7	15	53,8	42,2	8356	557,1	628,4	12,46	603,8	80,5	125,2	3,35	34,029	25,68	5,28	35,01
IPE 330	I	330	307	160	7,5	11,5	18	62,6	49,1	11770	713,1	804,3	13,71	788,1	98,52	153,7	3,55	39,585	30,813	5,07	36,13
IPE 360	I	360	335	170	8	12,7	18	72,7	57,1	16270	903,6	1019	14,95	1043	122,8	191,1	3,79	45,962	35,138	4,96	37,33
IPE 400	I	400	373	180	8,6	13,5	21	84,5	66,3	23130	1156	1307	16,55	1318	146,4	229	3,95	52,382	42,691	4,79	38,49
IPE 450	I	450	421	190	9,4	14,6	21	98,8	77,6	33740	1500	1702	18,48	1676	176,4	276,4	4,12	59,265	50,844	4,75	40,30
IPE 500	I	500	468	200	10,2	16	21	116	90,7	48200	1928	2194	20,43	2142	214,2	335,9	4,31	67,764	59,852	4,62	41,76
IPE 550	I	550	516	210	11,1	17,2	24	134	106	67120	2441	2787	22,35	2668	254,1	400,5	4,45	77,168	72,325	4,39	42,13
IPE 600	I	600	562	220	12	19	24	156	122	92080	3069	3512	24,3	3387	307,9	485,6	4,66	88,56	83,8	4,21	42,83
IPE 80	I	80	69,6	46	3,8	5,2	5	7,64	6	80,14	20,03	23,22	3,24	8,49	3,69	5,82	1,05	4,9952	3,5736	3,10	15,68
UPN 80	U	80	64	45	6	8	8	11	8,64	106	26,5	31,8	3,1	19,4	6,36	12,1	1,33	7,16	4,92	3,88	
UPN 100	U	100	83	50	6	8,5	8,5	13,5	10,6	206	41,2	49	3,91	29,3	8,49	16,2	1,47	8,52	6,2325	4,18	
UPN 120	U	120	102	55	7	9	9	17	13,4	364	60,7	72,6	4,62	43,2	11,1	21,2	1,59	9,86	8,54	4,33	
UPN 140	U	140	120	60	7	10	10	20,4	16	605	86,4	103	5,45	62,7	14,8	28,3	1,75	12	10,1	4,30	
UPN 160	U	160	139	65	7,5	10,5	10,5	24	18,8	925	116	138	6,21	85,3	18,3	35,2	1,89	13,575	12,24	4,48	
UPN 180	U	180	158	70	8	11	11	28	22	1350	150	179	6,95	114	22,4	42,9	2,02	15,36	14,69	4,64	
UPN 200	U	200	177	75	8,5	11,5	11,5	32,2	25,3	1910	191	228	7,7	148	27	51,8	2,14	17,155	17,25	4,78	
UPN 220	U	220	195	80	9	12,5	12,5	37,4	29,4	2690	245	292	8,48	197	33,6	64,1	2,3	19,85	20,088	4,68	
UPN 240	U	240	214	85	9,5	13	13	42,3	33,2	3600	300	358	9,22	248	39,6	75,7	2,42	21,97	23,125	4,81	
UPN 260	U	260	232	90	10	14	14	48,3	37,9	4820	371	442	9,99	317	47,7	91,6	2,56	25,1	26,46	4,71	
UPN 280	U	280	250	95	10	15	15	53,3	41,8	6280	448	532	10,9	399	57,2	109	2,74	28,3	28,55	4,67	
UPN 300	U	300	268	100	10	16	16	58,8	46,2	8030	535	632	11,7	495	67,8	130	2,9	32	30,96	4,63	
UPN 320	U	320	285	100	14	17,5	17,5	75,8	59,5	10870	679	826	12,1	597	80,6	152	2,81	35,9	46,313	3,91	
UPN 350	U	350	318	100	14	16	16	77,3	60,6	12840	734	918	12,9	570	75	143	2,72	32,78	50,1	4,38	
UPN 380	U	380	348	102	13,5	16	16	80,4	63,1	15760	829	1014	14	615	78,7	148	2,77	33,42	52,48	4,53	
UPN 400	U	400	364	110	14	18	18	91,5	71,8	20350	1020	1240	14,9	846	102	190	3,04	40,54	57,66	4,33	
U 30x15	U	30	21	15	4	4,5	4,5	2,21	1,74	2,53	1,69		1,07	0,38	0,39		0,42	1,37	1,2425	1,44	
U 40x20	U	40	29	20	5	5,5	5	3,36	2,86	7,58	3,79		1,44	1,14	0,86		0,56	1,91	1,71	1,82	
U 50x25	U	50	38	25	5	6	6	4,92	3,86	16,8	6,73		1,85	2,49	1,48		0,71	3,02	2,58	2,33	
U 60x30	U	60	48	30	6	6	6	6,46	5,07	31,6	10,5		2,21	4,51	2,16		0,84	3,58	3,58	3,00	
U 30x33	U	30	16	33	5	7	7	5,44	4,27	6,39	4,26		1,08	5,33	2,68		0,99	4,64	1,66	3,00	
U 40x35	U	40	26	35	5	7	7	6,21	4,87	14,1	7,05		1,5	6,68	3,08		1,04	4,91	2,15	3,29	

U 50x38	U	50	36	38	5	7	7	7,12	5,59	26,4	10,6	1,92	9,12	3,75	1,13	5,32	2,64	3,71
U 65x42	U	65	50	42	5,5	7,5	7,5	9,03	7,09	57,5	17,7	2,52	14,1	5,07	1,25	6,28	3,705	3,87