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

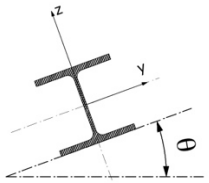
EN 1993-1-1:2005 "Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings

Resistance of cross-sections

Object: Arcareccio di copertura

Section and Materials

Section	IPE 120						
Steel grade	S 235	fy = 235 Mpa (t ≤ 40 mm)					
ε =	1,00	fu = 360 Mpa (t ≤ 40 mm)					
A =	13,2	cm^2					
A_{vz} =	6,31	cm^2	$W_{el,min,y}$ =	53	cm^3		
A_{vy} =	8,48	cm^3	$W_{pl,y}$ =	61	cm^3		
A_w =	4,73	cm^2	$W_{el,min,z}$ =	9	cm^3		
A_f =	4,03	cm^2	$W_{pl,z}$ =	14	cm^3	θ	0 °
h_w/t_w =	1,74						



Section class Class 1

Internal web			Outstand flanges		
c/t =	21,23		c/t =	3,62	
Class 1	Internal web bending		Class 1	Outstand flanges compression	
Class 1	Internal web compression				

Resistance of cross section

Tension

A_{net}		cm^2					
$N_{t,Rd}$ =	310	kN	$N_{pl,Rd}$ =	310 kN			
			$N_{u,Rd}$ =				

Compresion

$N_{c,Rd}$ =	310	kN

Bending moment

$A_{f,net}$		cm^2								
$M_{el,Rd}$ =	12,4	kN m	$M_{el,y,Rd}$ =	12,4	kN m	$M_{el,z,Rd}$ =	2,0	kN m
$M_{pl,Rd}$ =	14,3	kN m	$M_{pl,y,Rd}$ =	14,3	kN m	$M_{pl,z,Rd}$ =	3	kN m
$M_{c,Rd}$ =	14,3	kN m	$M_{c,y,Rd}$ =	14,3	kN m	$M_{c,z,Rd}$ =	3,19	kN m

Shear

$V_{pl,Rd}$ =	86	kN	$V_{pl,z,Rd}$ =	86	kN	$V_{pl,y,Rd}$ =	115	kN

Bending and shear (§6.2.8)

ρ =	0,00	Shear effect on moment resistance may be neglected (§6.2.8(2))						
$M_{c,Rd}$ =	14,3	kN m	$M_{c,y,Rd}$ =	14,3	kN m	$M_{c,z,Rd}$ =	3,2	kN m

Bending and axial force (§6.2.9)

n =	0,00	Axial force effect on bending resistance for y-y axis may be neglected (§6.2.9.1(4))
a =	0,39	Axial force effect on bending resistance for z-z axis may be neglected (§6.2.9.1(4))
$M_{N,y,Rd}$ =	14,3 kN m	Eq. (6.36) §6.2.9.1(5)
$M_{N,z,Rd}$ =	3,2 kN m	Eq. (6.37) §6.2.9.1(5)

Design values of action effect

N_{Ed} 0 kN M_{Ed} 9,06 kN m V_{Ed} 9,06 kN

Elastic analysis

$\sigma_{N,x,Ed}$ =	0,0 MPa	$\sigma_{M,x,Ed}$ =	171,1 MPa	τ_{Ed} =	19,2 MPa	Eq. (6.21) §6.2.6(5)
Eq. (6.1) =	0,55	§6.2.1(5)				

Plastic analysis

N_{Ed} / $N_{t,Rd}$ =	0,00	Eq. (6.5) §6.2.3(1)
N_{Ed} / $N_{c,Rd}$ =	0,00	Eq. (6.9) §6.2.4(1)
M_{Ed} / $M_{c,Rd}$ =	0,63	Eq. (6.12) §6.2.5(1)
V_{Ed} / $V_{pl,Rd}$ =	0,11	Eq. (6.17) §6.2.6(1)
M_{Ed} / $M_{c,Rd}$ =	0,63	Eq. (6.12), Eq. (6.29)
M_{Ed} / $M_{N,Rd}$ =	0,63	Eq. (6.31) §6.2.9.1(2)
Eq. (6.41) =	0,40	§6.2.9.1(6)
Eq. (6.45) =	0,40	§6.2.10(3)
Eq. (6.2) =	0,63	§6.2.1(7)

Note:

Bending moment

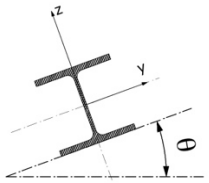
Fastener holes in tension zone of the web need not be allowed for, provided that the limit given in §6.2.5 (4) is satisfied for the complete tension zone comprising the tension flange plus the tension zone of the web.

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.

Resistance of cross-sections

Object: Arcareccio di controvento di copertura

Section and Materials



Section	HE 120 A						
Steel grade	S 235	fy = 235 Mpa (t ≤ 40 mm)					
ε =	1,00	fu = 360 Mpa (t ≤ 40 mm)					
A =	25,3	cm^2					
A_{vz} =	8,46	cm^2	$W_{el,min,y}$ =	106	cm^3		
A_{vy} =	20,44	cm^3	$W_{pl,y}$ =	120	cm^3		
A_w =	4,90	cm^2	$W_{el,min,z}$ =	38	cm^3		
A_f =	9,60	cm^2	$W_{pl,z}$ =	59	cm^3	θ = 0	°
h_w/t_w =	0,87						

Section class Class 1

Internal web			Outstand flanges		
c/t =	14,80		c/t =	5,69	
Class 1	Internal web bending		Class 1	Outstand flanges compression	
Class 1	Internal web compression				

Resistance of cross section

Tension

A_{net}		cm^2					
$N_{t,Rd}$ =	595	kN	$N_{pl,Rd}$ =	595 kN			
			$N_{u,Rd}$ =				

Compresion

$N_{c,Rd}$ =	595	kN

Bending moment

$A_{f,net}$		cm^2						
$M_{el,Rd}$ =	25,0	kN m	$M_{el,y,Rd}$ =	25,0	kN m	$M_{el,z,Rd}$ =	9,0	kN m
$M_{pl,Rd}$ =	28,1	kN m	$M_{pl,y,Rd}$ =	28,1	kN m	$M_{pl,z,Rd}$ =	14	kN m
$M_{c,Rd}$ =	28,1	kN m	$M_{c,y,Rd}$ =	28,1	kN m	$M_{c,z,Rd}$ =	13,83	kN m

Shear

$V_{pl,Rd}$ =	115	kN	$V_{pl,z,Rd}$ =	115	kN	$V_{pl,y,Rd}$ =	277	kN

Bending and shear (§6.2.8)

ρ =	0,00	Shear effect on moment resistance may be neglected (§6.2.8(2))						
$M_{c,Rd}$ =	28,1	kN m	$M_{c,y,Rd}$ =	28,1	kN m	$M_{c,z,Rd}$ =	13,8	kN m

Bending and axial force (§6.2.9)

n =	0,01	Axial force effect on bending resistance for y-y axis may be neglected (§6.2.9.1(4))
a =	0,24	Axial force effect on bending resistance for z-z axis may be neglected (§6.2.9.1(4))
$M_{N,y,Rd}$ =	28,1 kN m	Eq. (6.36) §6.2.9.1(5)
$M_{N,z,Rd}$ =	13,8 kN m	Eq. (6.37) §6.2.9.1(5)

Design values of action effect

N_{Ed}	5,064 kN	M_{Ed}	9,7 kN m	V_{Ed}	9,7 kN

Elastic analysis

$\sigma_{N,x,Ed}$ =	2,0 MPa	$\sigma_{M,x,Ed}$ =	91,3 MPa	τ_{Ed} =	19,8 MPa	Eq. (6.21) §6.2.6(5)
Eq. (6.1) =	0,18	§6.2.1(5)				

Plastic analysis

N_{Ed} / $N_{t,Rd}$ =	0,01	Eq. (6.5) §6.2.3(1)
N_{Ed} / $N_{c,Rd}$ =	0,01	Eq. (6.9) §6.2.4(1)
M_{Ed} / $M_{c,Rd}$ =	0,35	Eq. (6.12) §6.2.5(1)
V_{Ed} / $V_{pl,Rd}$ =	0,08	Eq. (6.17) §6.2.6(1)
M_{Ed} / $M_{c,Rd}$ =	0,35	Eq. (6.12), Eq. (6.29)
M_{Ed} / $M_{N,Rd}$ =	0,35	Eq. (6.31) §6.2.9.1(2)
Eq. (6.41) =	0,12	§6.2.9.1(6)
Eq. (6.45) =	0,12	§6.2.10(3)
Eq. (6.2) =	0,35	§6.2.1(7)

Note:

Bending moment

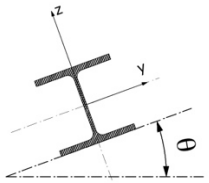
Fastener holes in tension zone of the web need not be allowed for, provided that the limit given in §6.2.5 (4) is satisfied for the complete tension zone comprising the tension flange plus the tension zone of the web.

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.

Resistance of cross-sections

Object: Arcareccio di bordo di copertura

Section and Materials



Section	HE 140 A						
Steel grade	S 235	fy = 235 Mpa (t ≤ 40 mm)					
ε =	1,00	fu = 360 Mpa (t ≤ 40 mm)					
A =	31,4	cm²					
A_{vz} =	10,13	cm²	$W_{el,min,y}$ =	155	cm³		
A_{vy} =	25,04	cm³	$W_{pl,y}$ =	174	cm³		
A_w =	6,38	cm²	$W_{el,min,z}$ =	56	cm³		
A_f =	11,90	cm²	$W_{pl,z}$ =	85	cm³	θ	0 °
h_w/t_w =	0,87						

Section class Class 1

Internal web			Outstand flanges		
c/t =	16,73		c/t =	6,50	
Class 1	Internal web bending		Class 1	Outstand flanges compression	
Class 1	Internal web compression				

Resistance of cross section

Tension

A_{net}		cm²					
$N_{t,Rd}$ =	738	kN	$N_{pl,Rd}$ =	738 kN			
			$N_{u,Rd}$ =				

Compresion

$N_{c,Rd}$ =	738	kN

Bending moment

$A_{f,net}$		cm²							
$M_{el,Rd}$ =	36,5	kN m	$M_{el,y,Rd}$ =	36,5	kN m	$M_{el,z,Rd}$ =	13,1	kN m
$M_{pl,Rd}$ =	40,8	kN m	$M_{pl,y,Rd}$ =	40,8	kN m	$M_{pl,z,Rd}$ =	20	kN m
$M_{c,Rd}$ =	40,8	kN m	$M_{c,y,Rd}$ =	40,8	kN m	$M_{c,z,Rd}$ =	19,94	kN m

Shear

$V_{pl,Rd}$ =	137	kN	$V_{pl,z,Rd}$ =	137	kN	$V_{pl,y,Rd}$ =	340	kN

Bending and shear (§6.2.8)

ρ =	0,00	Shear effect on moment resistance may be neglected (§6.2.8(2))						
$M_{c,Rd}$ =	40,8	kN m	$M_{c,y,Rd}$ =	40,8	kN m	$M_{c,z,Rd}$ =	19,9	kN m

Bending and axial force (§6.2.9)

n =	0,25		
a =	0,24	Axial force effect on bending resistance for z-z axis may be neglected (§6.2.9.1(4))	
$M_{N,y,Rd}$ =	34,8	kN m	Eq. (6.36) §6.2.9.1(5)
$M_{N,z,Rd}$ =	19,9	kN m	Eq. (6.38) §6.2.9.1(5)

Design values of action effect

N_{Ed}	185 kN	M_{Ed}	4,3 kN m	V_{Ed}	4,3 kN

Elastic analysis

$\sigma_{N,x,Ed}$ =	58,9 MPa	$\sigma_{M,x,Ed}$ =	27,7 MPa	τ_{Ed} =	6,7 MPa	Eq. (6.21) §6.2.6(5)
Eq. (6.1) =	0,14	§6.2.1(5)				

Plastic analysis

N_{Ed} / $N_{t,Rd}$ =	0,25	Eq. (6.5) §6.2.3(1)
N_{Ed} / $N_{c,Rd}$ =	0,25	Eq. (6.9) §6.2.4(1)
M_{Ed} / $M_{c,Rd}$ =	0,11	Eq. (6.12) §6.2.5(1)
V_{Ed} / $V_{pl,Rd}$ =	0,03	Eq. (6.17) §6.2.6(1)
M_{Ed} / $M_{c,Rd}$ =	0,11	Eq. (6.12), Eq. (6.29)
M_{Ed} / $M_{N,Rd}$ =	0,12	Eq. (6.31) §6.2.9.1(2)
Eq. (6.41) =	0,02	§6.2.9.1(6)
Eq. (6.45) =	0,02	§6.2.10(3)
Eq. (6.2) =	0,36	§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.