Table 10.2

Assumptions and boundaries

Non-reinforced wall

- The wind load q_{Ed} = ± 0,6 kN/m2.
- The greater first order moment

$M_{2,end} = N_{Ed}*e_{2,end}+1/2*70mm*b*l_w*25kN/m^3*285mm$

- The lower first order moment

$M_{1,end} = N_{Ed}*e_{1,end}-1/2*70mm*b*l_w*25kN/m^3*285mm$

- Concrete is C30/37, $\gamma_c = 1.5$ (2.4.2.4)
- Total first order eccentricity $e_{tot} \geq e_0$ (12.12; 6.1.4)
- Stress of the cross-section: $f_{cd,pl} \leq \sigma_c \leq f_{ctd,pl}$
- The coefficient $\beta = 1.0$ (Table 12.1)

Reinforced wall

- The wind load q_{Ed} = ± 0,6 kN/m2.
- The greater first order moment

$M_{2,end} = N_{Ed}*e_{2,end}+1/2*70mm*b*l_w*25kN/m^3*285mm$

- The lower first order moment

$M_{1,end} = N_{Ed}*e_{1,end}-1/2*70mm*b*l_w*25kN/m^3*285mm$

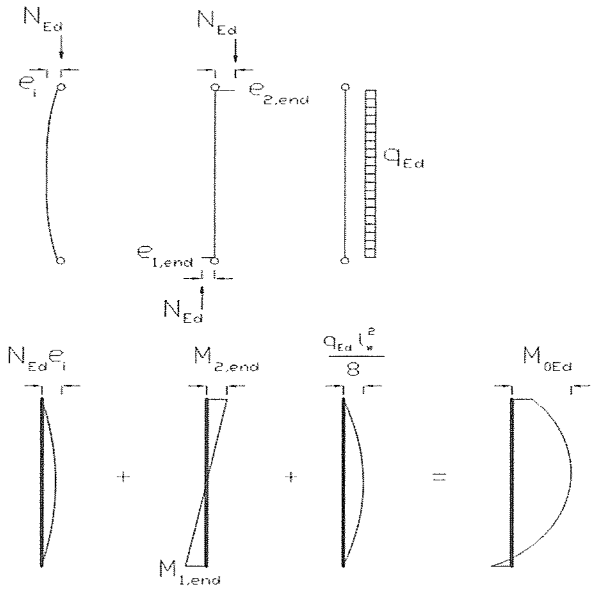
- Concrete is C30/37, $\gamma_c = 1.5$ (2.4.2.4)
- Reinforcement is B500K, $\gamma_s = 1.15$ (2.4.2.4)
- Vertical reinforcement $0.002A_C \leq A_{s,v} \leq 0.06A_C$
- The effect creep ratio $\varphi_{eff} = 2.0$ (3.1.4; 5.8.4)
- The coefficient $\beta = 1.0$ (Table 12.1)
- The effective depth $d = h_w - c_{nom} - 1.5d_{s,v}$ (5.8.8.3)
- Total eccentricity $e_d \geq e_0$ (6.1.4)

The width of the wall shell	The height of the element	Non-reinforced eccentricity			Reinforcement $e_{1,end}=e_{2,end}=h_w/4$			
		$e_{1,end}=e_{2,end}=0$	$e_{1,end}=e_{2,end}=20mm$	$e_{1,end}=e_{2,end}=h_w/4$	5-150	6-150	8-150	10-150
120	2400	587	220	-				
	2700	505	177	-				
	3000	424	-	-				
	3300	342	-	-				
	3600	261	-	-				
	4200	-	-	-				
	4800	-	-	-				
	5400	-	-	-				
	6000	-	-	-				
150	2400	1052	844	-		490	610	690
	2700	971	732	-		390	530	620
	3000	889	615	-		330	460	560
	3300	807	489	-		270	390	490
	3600	726	343	-		230	330	410
	4200	563	-	-		140	220	300
	4800	399	-	-		90	170	230
	5400	-	-	-		70	120	170
	6000	-	-	-		50	90	140
180	2400	1468	1300	177		750	890	980
	2700	1436	1209	167		640	780	900
	3000	1354	1098	155		550	680	830
	3300	1272	986	-		460	610	750
	3600	1191	871	-		390	530	670
	4200	1028	626	-		250	400	520
	4800	864	-	-		180	290	400
	5400	701	-	-		120	210	300
	6000	480	-	-		90	150	230
200	2400	1699	1518	208			1090	1190
	2700	1699	1497	198			980	1100
	3000	1664	1413	186			880	1010
	3300	1583	1303	174			780	930
	3600	1501	1192	-			680	840
	4200	1338	963	-			550	700
	4800	1175	717	-			400	540
	5400	1011	405	-			300	410
	6000	848	-	-			230	320

Simplified design method for walls and columns

EN 1992-1-1:2004

12.6.5.2



Initial data

Overall width of the cross-section

b = 1000 mm

Overall depth of the cross-section

h_w = 150 mm

Clear height of the member

l_w = 3000 mm

Wind load $q_{Ed} = 0,6 \text{ kN/m}^2$

q_{Ed} = 0.6 kN/m²

Design axial normal force

N_{Ed} = 889 kN

The smaller first order moment

$M_{1,end}$ = -0.7 kNm

The greater first order moment

$M_{2,end}$ = 0.7 kNm

The partial safety factor for concrete

γ_C = 1.5 — 2.4.2.4

Characteristic axial tensile strength of concrete

$f_{ctk,0.05}$ = 2.0 MPa — Table 3.1

Characteristic compressive cylinder

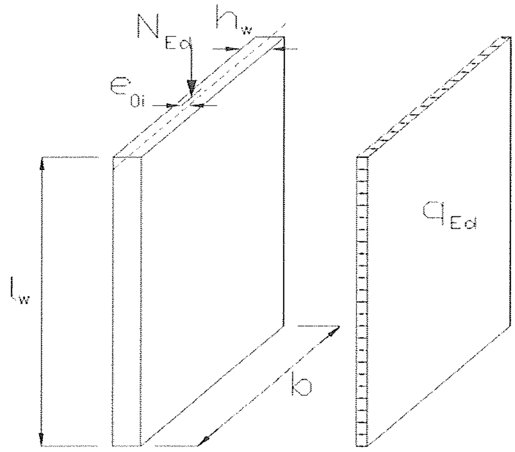
f_{ck} = 30 MPa — Table 3.1

The coefficients taking account of long term effects on the compressive strength and of unfavourable effects resulting from the way the load is applied — 3.1.6

α_{cc} = 0.85

Coefficient which depends on the support conditions — Table 12.1

β = 1.0



Design values

The acciditional eccentricity covering the effects of geometrical imperfections — $e_i = l_0/400$ — 5.2 (7)

e_i = 8 mm

The minimum eccentricity of normal force — $e_0 = \max(h_{w/30}; 20\text{mm})$ — 6.1 (4)

e_0 = 20 mm

The effective length of the member — $l_0 = \beta \times l_w$ — (12.9)

l_0 = 3000 mm

The slenderness of walls — $\lambda = \lambda_0 * 12^{1/2}/h_w$ — (12.8)

λ = 69

The coefficients taking account of the less ductile properties of plain concrete — 12.3.1

$\alpha_{cc,pl} = 0,8\alpha_{cc}$ — $\alpha_{ct,pl} = 0,6\alpha_{ct} = 0,6$

$\alpha_{cc,pl}$ = 0.68 — $\alpha_{ct,pl}$ = 0.6

The value of the design compressive strength — $f_{cd} = \alpha_{cc,pl} f_{ck}/\gamma_C$ — 12.3.1; (3.15)

$f_{cd,pl}$ = 13.6 MPa

The value of the design tensile strength — $f_{ctd} = \alpha_{ct,pl} f_{ctk,0.05}/\gamma_C$ — 12.3.1; (3.16)

$f_{ctd,pl}$ = 0.80 MPa

The smaller total first order moment		$M_{01} = M_{1,end}$	
M_{01} = -0.7 kNm			
The greater total first order moment		$M_{02} = M_{2,end}$	
M_{02} = 0.7 kNm			
An equivalent first order end moment		$M_{0e} = 0{,}6\ M_{02} + 0{,}4\ M_{01} \geq 0{,}4\ M_{02}$	5.8.8.2 (2)
M_{0e} = 0.3 kNm		$\lvert M_{02} \rvert \geq \lvert M_{01} \rvert$	
The first order moment		$M_{0Ed} = M_{0e} + q_{Ed} l_w^2/8$	5.8.8.2 (1)
M_{0Ed} = 1.0 kNm			
The design moment		$M_{Ed} = \max(M_{02}; M_{0Ed})$	5.8.8.2 (1)
M_{Ed} = 1.0 kNm			
Total eccentricity		$e_{tot} = M_{Ed}/N_{ed} + e_i \geq e_0$	(12.12); 6.1.4
e_{tot} = 20 mm			
For braced members, the factor Φ may be taken as:		$\Phi = 1{,}14 \times (1 - 2e_{tot}/h_w) - 0{,}02 \times l_0/h_w \leq 1 - 2e_{tot}/h_w$	(12.11)
Φ = 0.44			

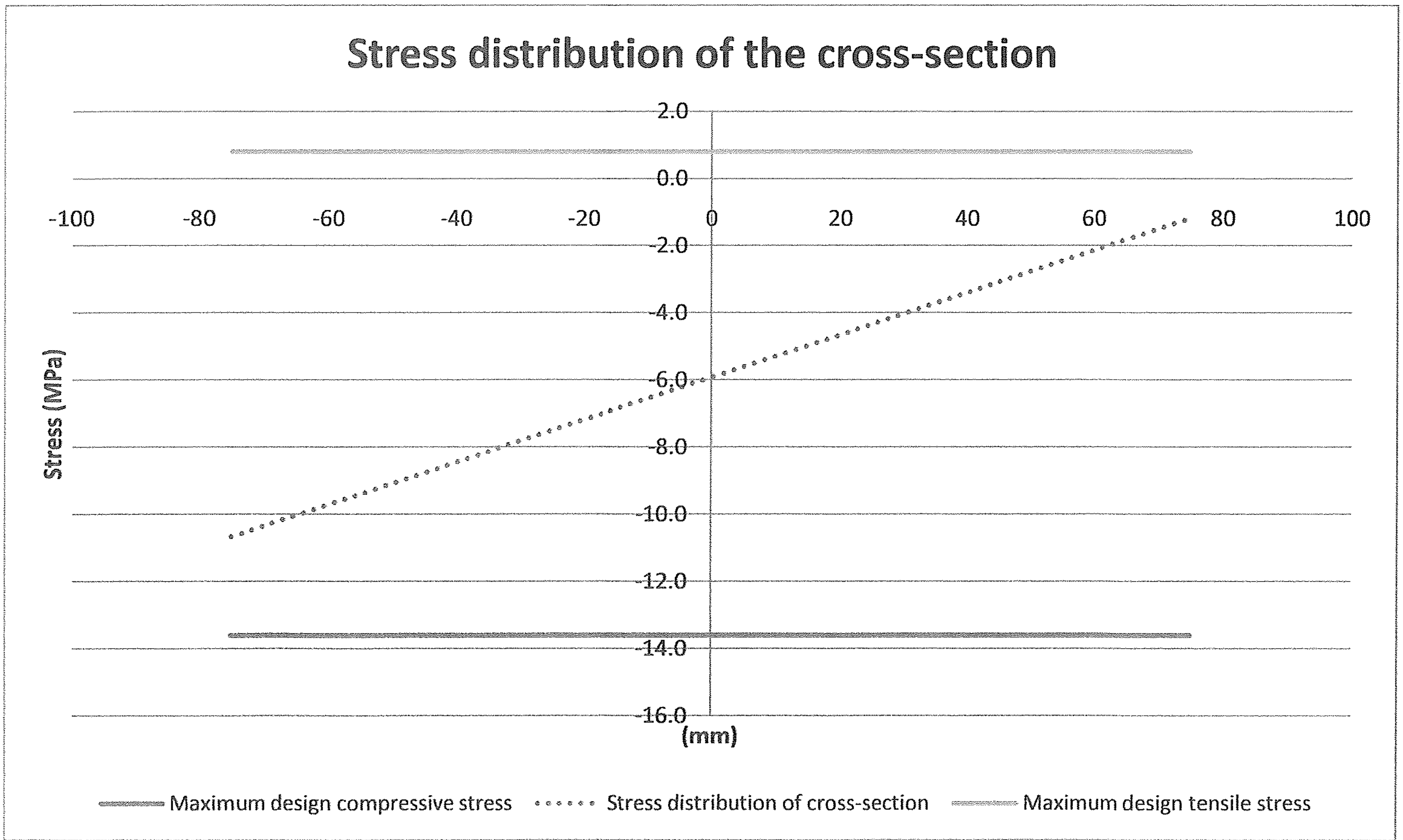
The design resistance in terms of axial force for a slender wall or column in plain concrete:

N_{Rd} = 889 kN/m ≥ N_{Ed} = 889 kN — $N_{Rd} = b \times h_w \times f_{cd,pl} \times \Phi$ (12.1)

OK!

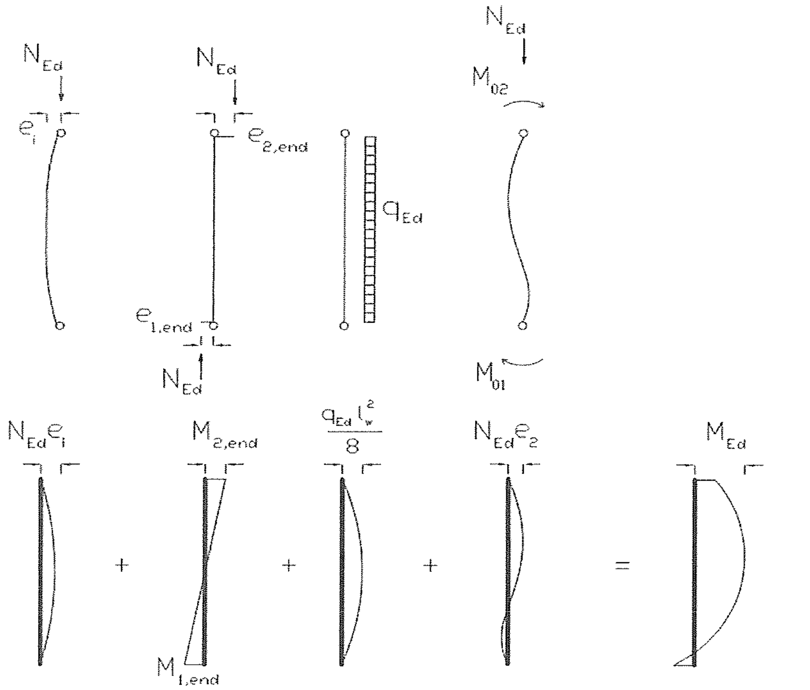
Stress distribution of the cross-section 12.3.1 (2)

$f_{cd,pl}$	=	-13.6 MPa	≤ σ_{min} =	-10.7 Mpa	y =	-75 mm	OK!
$f_{ctd,pl}$	=	0.80 MPa	≥ σ_{max} =	-1.19 Mpa	y =	75 mm	OK!



Design method for reinforced walls

EN 1992-1-1:2004



Initial data

Overall width of the cross-section

b = 1000 mm

Overall depth of the cross-section

h_w = 150 mm

Clear height of the member

l_w = 3000 mm

Wind load $q_{Ed} = 0{,}6\ kN/m^2$

q_{Ed} = 0.6 kN/m^2

Design axial normal force

N_{Ed} = 460 kN

The smaller first order moment

$M_{1,end}$ = 16.5 kNm

The greater first order moment

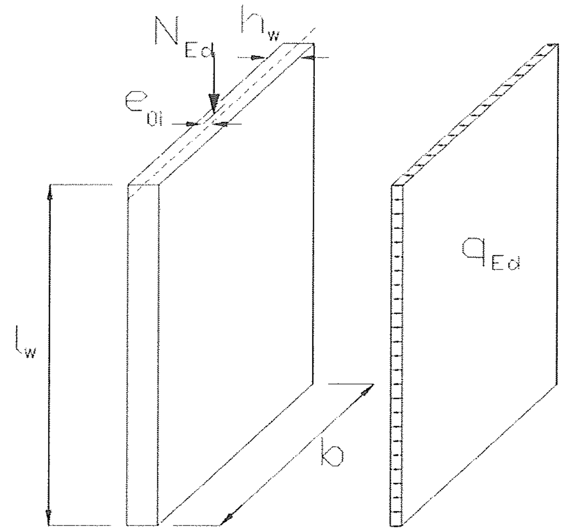
$M_{2,end}$ = 18.0 kNm

Characteristic compressive cylinder

f_{ck} = 30 MPa — Table 3.1

Characteristic axial tensile strength of concrete

$f_{ctk,0.05}$ = 2.0 MPa — Table 3.1



The coefficients taking account of long term effects on the compressive strength and of unfavourable effects resulting from the way the load is applied — 3.1.6

α_{cc} = 0.85

The partial safety factor for concrete

γ_C = 1.5 — 2.4.2.4

Characteristic yield strength of reinforcement

f_{yk} = 500 MPa — 3.2

The partial safety factor for reinforcing

γ_S = 1.15 — 2.4.2.4

Design value of modulus of elasticity of reinforcing steel

E_s = 200 GPa — 3.2.7 (4)

Vertical reinforcement

$d_{s,v}$ = 8 mm — s_v = 150 mm OK!

$A_{s,v}$ = 670 mm^2/m — $0{,}002\ A_c \le A_{s,v} \le 0{,}06\ A_c$ OK!

Horizontal reinforcement

$d_{s,h}$ = 8 mm — s_h = 150 mm OK!

$A_{s,h}$ = 670 mm^2/m — $\max(0{,}001\ A_c\ ;\ 0{,}25\ A_{s,v}) \le A_{s,h}$ OK!

The effective creep ratio — 3.1.4; 5.8.4

φ_{ef} = 2.000

Coefficien which depends on the support conditions — Table 12.1

β = 1.0

Minimum cover due to environmental conditions — 4.4.1.2 (5)

$c_{min,dur}$ = 10 mm — $\Delta c_{dur,\gamma} = 0;\ \Delta c_{dur,st} = 0;\ \Delta c_{dur,add} = 0$

Minimum cover due to bond requirement — 4.4.1.2 (3)

$c_{min,b}$ = 8 mm

The greater value of minimum cover		4.4.1.2 (2)
c_{min} = 10 mm	$c_{min} = \max(c_{min,b} ; c_{min,dur} ; 10mm)$	
Minimum cover due to environmental conditions		4.4.1.3
Δc_{dev} = 10 mm		
The nominal cover		4.4.1.1 (2)
c_{nom} = 20 mm	$c_{nom} = c_{min} + \Delta c_{dev}$	

Design values

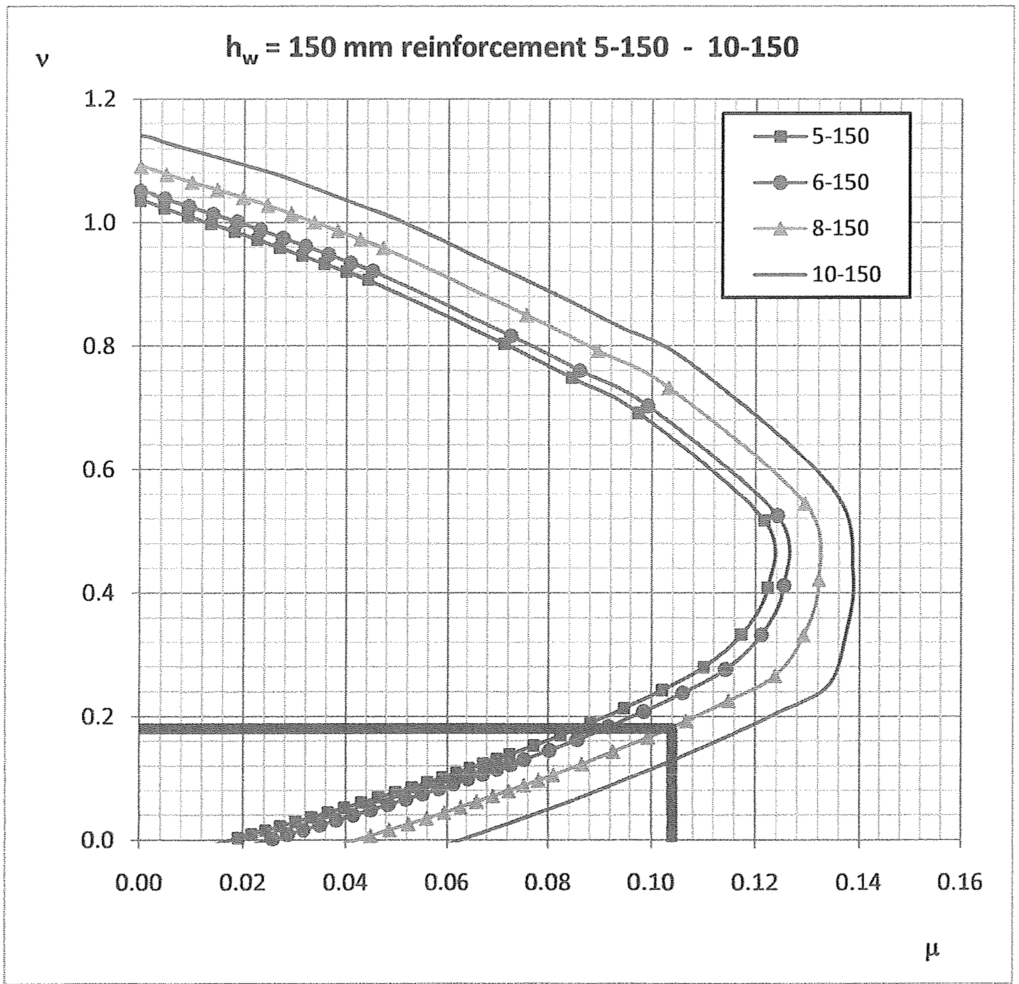
The accididitional eccentricity covering the effects of geometrical imperfections	$e_i = l_0/400$	5.2 (7)
e_i = 8 mm		
The minimum eccentricity of normal force	$e_0 = \max(h_{w/30}; 20mm)$	6.1 (4)
e_0 = 20 mm		
The effective length of the member	$l_0 = \beta \times l_w$	(12.9)
l_0 = 3000 mm		
The slenderness of walls	$\lambda = \lambda_0 * 12^{1/2}/h_w$	(12.8)
λ = 69.3		
The effective depth	$d = h_w - c_{nom} - 1,5*d_{s,v}$	5.8.8.3
d = 118.0 mm		
The effective depth of compression reinforcement	$d_c = h_w - d$	5.8.8.3
d' = 32.0 mm		
The value of the design compressive strength	$f_{cd} = \alpha_{cc} f_{ck}/\gamma_C$	(3.15)
f_{cd} = 17.0 MPa		
The value of the design tensile strength	$f_{ctd} = f_{ctk,0.05}/\gamma_C$	(3.16)
f_{ctd} = 1.33 MPa		
The design yield strength of reinforcement	$f_{yd} = f_{yk}/\gamma_S$	3.2.7 (2)
f_{sd} = 435 MPa		
The mechanical reinforcement ratio	$\omega = A_S f_{yd}/A_c f_{cd}$	5.8.3.1
ω = 0.057		
The smaller total first order moment	$M_{01} = M_{1,end} + e_i N_{Ed}$	
M_{01} = 20.0 kNm		
The greater total first order moment	$M_{02} = M_{2,end} + e_i N_{Ed}$	
M_{02} = 21.4 kNm		
An equivalent first order end moment	$M_{0e} = 0,6\ M_{02} + 0,4\ M_{01} \geq 0,4\ M_{02}$	5.8.8.2 (2)
M_{0e} = 20.8 kNm	$\lvert M_{02} \rvert \geq \lvert M_{01} \rvert$	
Moment ratio	$r_m = M_{01}/M_{02}$	5.8.3.1
r_m = 0.9		
Relative normal force	$n = N_{Ed}/A_C f_{cd}$	5.8.3.1
n = 0.180		
Parameter	$A = 1/(1+0,2\varphi_{ef})$	5.8.3.1 (1)
A = 0.714		
Parameter	$B = (1+2\omega)^{1/2}$	5.8.3.1 (1)
B = 1.056		
Parameter	$C = 1,7-r_m$	5.8.3.1 (1)
C = 0.770		
Slenderness criterion for isolated members	$\lambda_{lim} = 20*A*B*C/n^{1/2}$	5.8.3.1
λ_{lim} = 27.3		

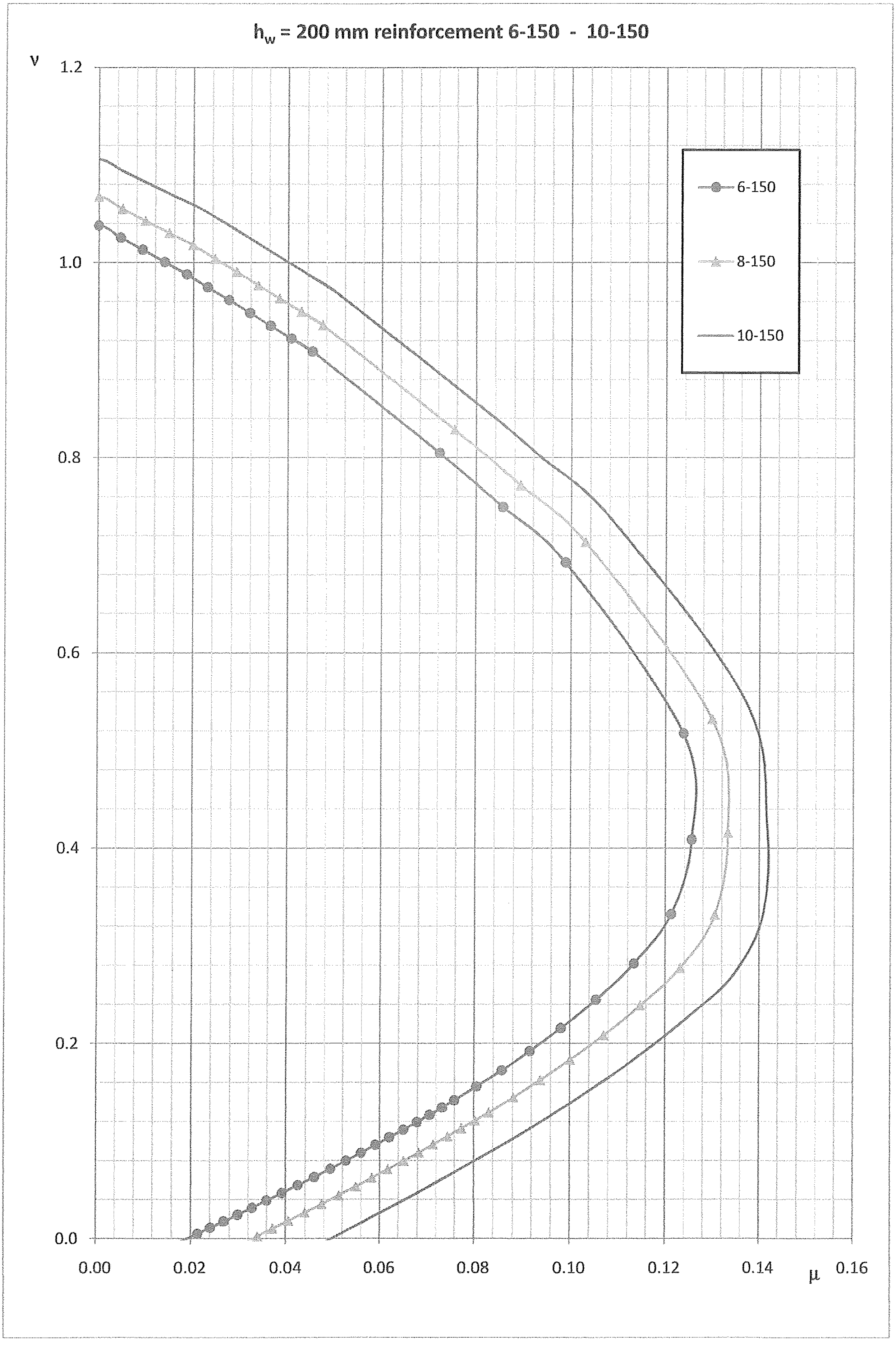
SECOND ORDER EFFECTS HAVE TO BE TAKE INTO ACCOUNT!

The effect of creep			$K_\varphi = 1 + (0{,}35 + f_{ck}/200 - \lambda/150)*\varphi_{ef} \geq 1$	5.8.8.3 (4)
K_φ	=	1.076		
Expression			$K_r = (1 + \omega - n) / (1 - \omega - 0{,}4) \leq 1$	5.8.8.3 (3)
K_r	=	1.000		
Deflection			$e_2 = (K_r K_\varphi f_{yd}/(E_s*0{,}45d)*l_0^2)/10$	5.8.8.3 (3)
e_2	=	39.7 mm		
The nominal second order moment			$M_2 = N_{Ed}e_2$	5.8.8.2 (3)
M_2	=	18.2 kNm		
The first order moment			$M_{0Ed} = M_{0e} + q_{Ed}l_w^2/8$	5.8.8.2 (1)
M_{0Ed}	=	21.5 kNm		
The design moment			$M_{Ed} = \max(M_{02}; M_{0Ed} + M_2; M_{01} + 0{,}5M_2) \geq N_{Ed}e_0$	5.8.8.2 (1); 6.1.4
M_{Ed}	=	39.8 kNm		
The design eccentricity			$e_d = M_{Ed} / N_{ed}$	
e_d	=	86.4 mm		

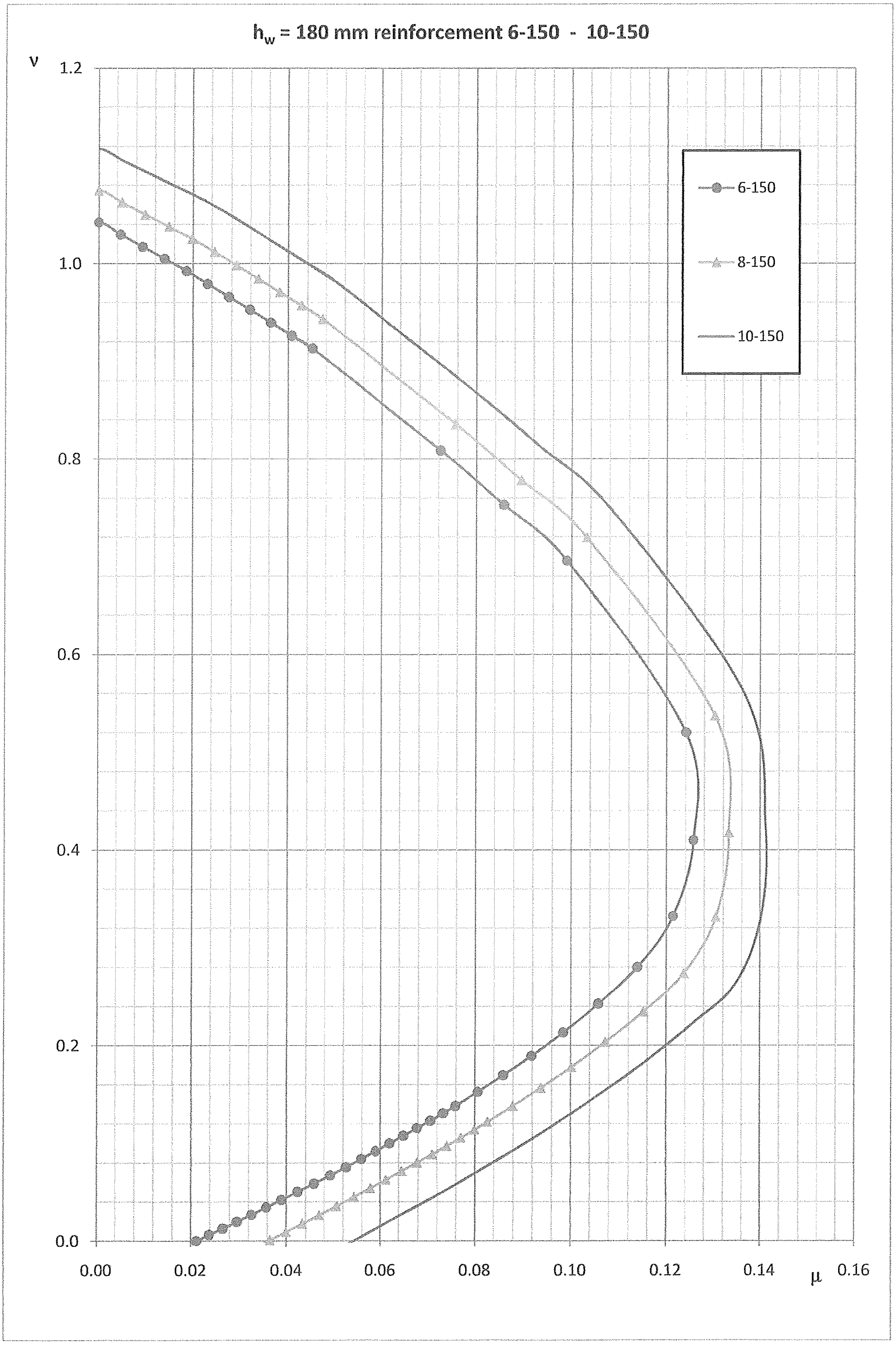
Interaction diagram

μ	=	**0.104**	$\mu = M_{Ed} / bh^2f_{cd}$	
ν	=	**0.180**	$\nu = N_{Ed} / bhf_{cd}$	

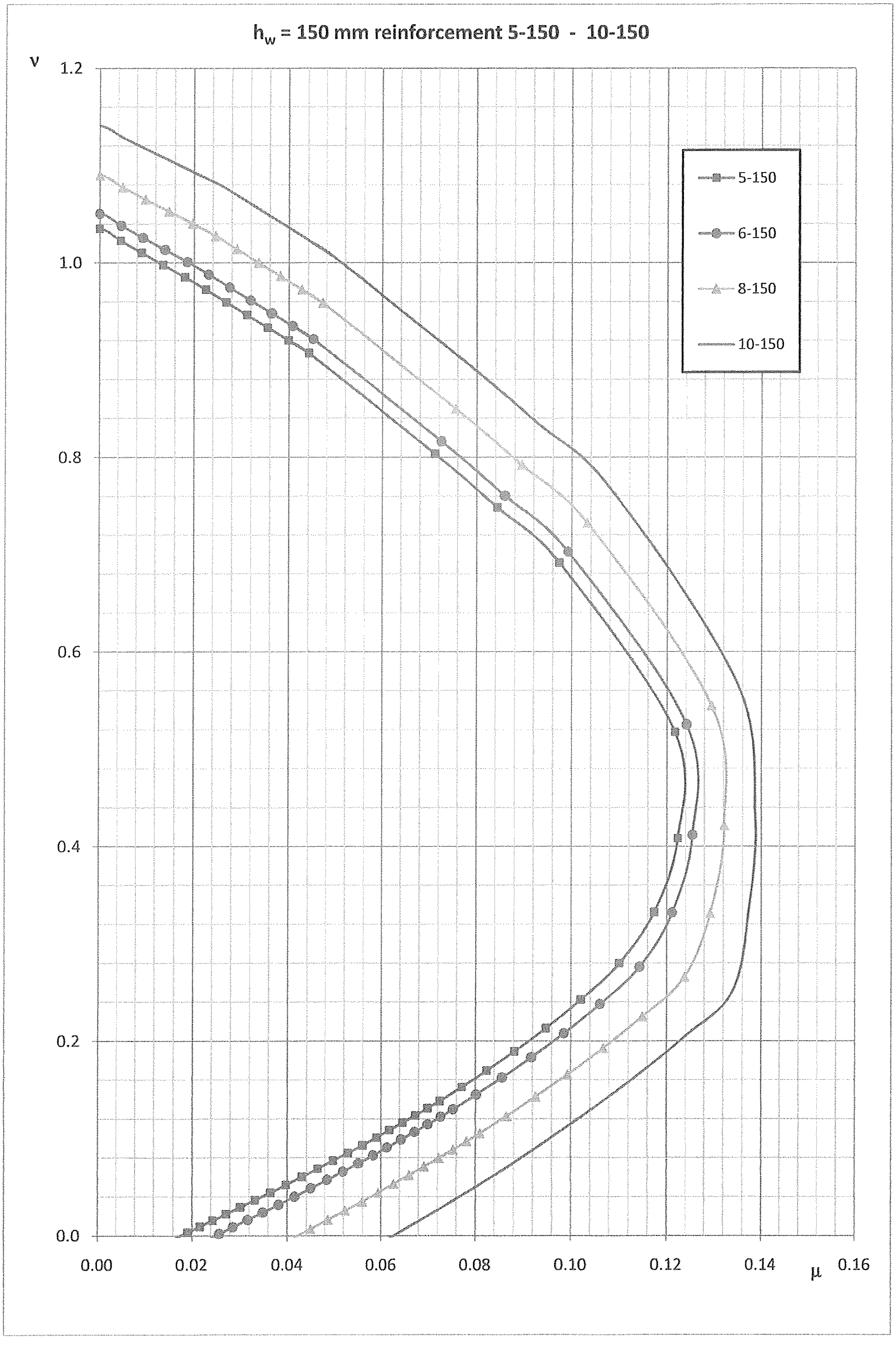




h_w = 200 mm reinforcement 6-150 - 10-150
ν
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
μ
6-150
8-150
10-150



hw = 180 mm reinforcement 6-150 - 10-150
ν
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
μ
6-150
8-150
10-150



h_w = 150 mm reinforcement 5-150 - 10-150
ν
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
μ
0.16
5-150
6-150
8-150
10-150