Example Q1

Objective

A column or post support is required to support the end of a timber beam. The Ultimate load to be carried is 32,13kN. Your design must provide a bearing area at the top of at least 100 x 188mm. The room height 2,70m and the clear vertical height under the soffit of the incoming beam is 2,10m. The column/post will be inside a structural wall to frame the opening under the beam. It must also provide lateral stability for the beam end.

You are required to size the timber post and verify that it will comply with EN 1995 for a project in Ireland.
38 x 140 C16 and 47 x 222 C24 material is available.
You are required to:-

1. Verify the post or column complies with the Eurocode for Timber
2. Is there an alternative option for the post material?
3. Comment on benefits and draw backs of the given solution and

Example Q1

Answer

1. Verify the post or column complies with the Eurocode for Timber?

I performed a standard set of verification checks on the subject structural member and increased the number of sections acting together until I found that the combination complied with the application rules given in the current Eurocode EN 1995-1-1:2004. The calculation is attached to this answer sheet; three number sections were required to safely carry the forces.

2. Is there an alternative option for the post material?

I checked both available section sizes.
The result comparison is shown in Table 1 below.

Table 1: Substitution Comparison results

Section	***38 x 140 C16***	***47 x 222 C24***
Number	*3*	*2*
Grade	C16	C24
Bearing U_b	0,43	0,29
Bearing area	114 x 140	94 x 222
Compression U_{cmy}	0,631	0,291
Limiting load F_{c90}	74,47	110,11

3. Comment on benefits and draw backs of the given solution and your alternative if any?

The smallest section of the listed materials required three members acting together to satisfy the structural requirements. The critical aspects were the slenderness value [U_{cmy}] and the bearing at the base of the post [U_b].

The 38 x 140 C16 would normally fit within the common wall panel used in Ireland but the 47 x 222 C24 timber would require a special detail to allow for the greater depth than the standard stud size.

To allow for the bearing area, of 100 x 188 = 18 800mm^2, at the top of the cripple stud a compromise would be required. The 38 x 140 C16 solution would require three sections to give a top area of 114 x 140 = 15 960mm^2; and the 47 x 222 C24 solution would require two sections to give a top area of 94 x 222 = 20 868mm^2.

In the first case the bearing length of 114mm is greater than the required 100mm but the width is too small. In the second case the bearing length of 94mm is too small but the width is adequate for purpose.

In both cases the wall adjacent to the post was assumed to provide full lateral stability in the z axis.

This exercise is to illustrate that in many cases the initial design will have to be changed when the project goes to procurement and fabrication.

Posts or Columns

Post P1 The post is inside a panel in wall

	Storey height =	2,700	m	Wall stud Class =	C16	
	Head binder =	0,038	m	Top rail =	0,038	m
	Bottom rail =	0,038	m	Sole plate =	0,038	m
	Post length =	2,548	m	Cripple height =	2,100	m
	Effective length; L_e =	2,548	m	Eccentricity; e =	0,035	m

TRY 3 x 38 x 140 C16

	Post Style =	Softwood		Post Class =	C16	
	Breadth; b =	38	mm	Depth; h =	140	mm
	No off; N =	3		Area; A = Nbh =	159,6	cm^2
	$I_{yy} = Nbh^3/12$ =	2 606,8	cm^4	$I_{zz} = h(Nb)^3/12$ =	1 728,5	cm^4
	$W_{yy} = Nbh^2/6$ =	372,4	cm^3	$W_{zz} = h(Nb)^2/6$ =	246,9	cm^3
	$r_{yy} = \sqrt{(I_{yy}/A)}$ =	4,04	cm	$r_{zz} = \sqrt{(I_{zz}/A)}$ =	3,29	cm
6.1.6	k_m =	0,7		k_{sys} =	1,1	
Table 3.1	k_{mod} =	0,8		γ_m =	1,3	

Wind pressure is not considered on this post.

Stability in the zz direction is assured by the fixings of the panel to the stud.

	f_{myk} =	16,00	N/mm^2	f_{c0k} =	17,00	N/mm^2
	E_{05} =	5 360	N/mm^2	Service class =	2	
	$f_{myd} = k_{mod} f_{myk} / \gamma_m$ =	9,85	N/mm^2	$f_{c0d} = k_{mod} f_{c0k} / \gamma_m$ =	10,46	N/mm^2
Actions	F_{cd} =	32,13	kN	-> $\sigma_{c0d} = F_{cd} / A$ =	2,013	N/mm^2
	$M_d = F_{cd}\, e$ =	1,125	kNm	$\sigma_{myd} = M_d / W_{yy}$ =	3,020	N/mm^2

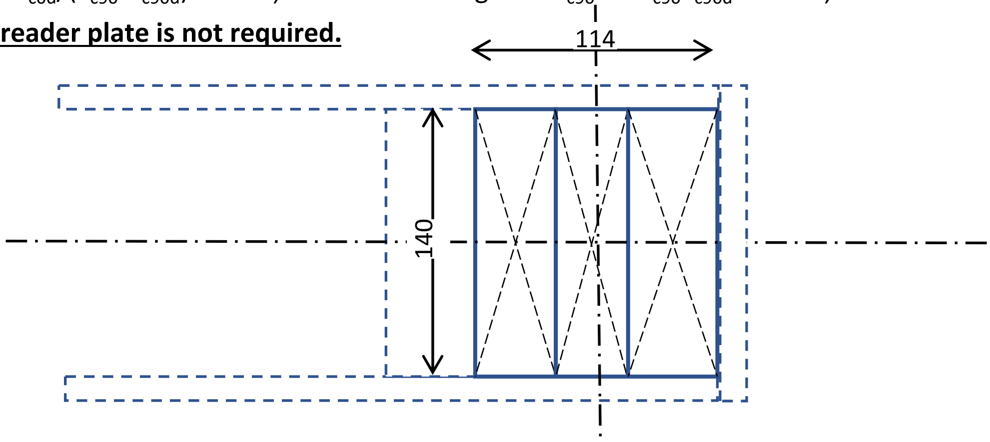
Slenderness

6.3.2	$\lambda_{yy} = L_e / r_{yy}$ =	63,0	
(6.21)	$\lambda_{rely} = \lambda_{yy}/\pi\sqrt{(f_{c0k} / E_{05})}$ =	1,13	From 6.3.2(3) Use expressions (6.23-29)
(6.29)	β_c = IF("Softwood";0,2;0,1) =	0,2	
(6.27)	$k_y = 0,5\,(1 + \beta_c\,(\lambda_{rely} - 0,3) + \lambda_{rely}^2)$ =	1,22	
(6.25)	$k_{cy} = 1/(k_y + \sqrt{(k_y^2 - \lambda_{rely}^2)})$	0,593	
(6.23)	$U_{cmy} = \sigma_{c0d}/(k_{cy} * f_{c0d}) + \sigma_{myd}/f_{myd}$ =	0,631	<= 1

PASS Combined Bending and Compression rules

Bearing	f_{c90k} =	2,20	N/mm^2	L_b = N b =	114	mm
(6.4)	$k_{c90} = (2,38 - L_b/250)*(1 + h/(12 L_b))$ =	2,12		f_{c90d} =	2,2	N/mm^2
	$U_b = \sigma_{c0d}/(k_{c90} * f_{c90d})$ =	0,43		Limiting load $F_{c90} = A\, k_{c90}\, f_{c90d}$ =	74,47	kN

A spreader plate is not required.



Post P2 The post is inside a panel in wall

Storey height =	2,700	m	Wall stud Class =	C16	
Head binder =	0,038	m	Top rail =	0,038	m
Bottom rail =	0,038	m	Sole plate =	0,038	m
Post length =	2,548	m	Cripple height =	2,100	m
Effective length; L_e =	2,548	m	Eccentricity; e =	0,056	m

TRY 2 x 47 x 222 C24

	Post Style =	Softwood		Post Class =	C24	
	Breadth; b =	47	mm	Depth; h =	222	mm
	No off; N =	2		Area; A = Nbh =	208,68	cm²
	$I_{yy} = Nbh^3/12$ =	8 570,5	cm^4	$I_{zz} = h(Nb)^3/12$ =	1 536,6	cm^4
	$W_{yy} = Nbh^2/6$ =	772,1	cm³	$W_{zz} = h(Nb)^2/6$ =	138,4	cm³
	$r_{yy} = \sqrt{(I_{yy}/A)}$ =	6,41	cm	$r_{zz} = \sqrt{(I_{zz}/A)}$ =	2,71	cm
6.1.6	k_m =	0,7		k_{sys} =	1,1	
Table 3.1	k_{mod} =	0,8		γ_m =	1,3	

Wind pressure is not considered on this post.
Stability in the zz direction is assured by the fixings of the panel to the stud.

f_{myk} =	24,00	N/mm²	f_{c0k} =	21,00	N/mm²
E_{05} =	7 370	N/mm²	Service class =	2	
$f_{myd} = k_{mod}f_{myk} / \gamma_m$ =	14,77	N/mm²	$f_{c0d} = k_{mod}f_{c0k} / \gamma_m$ =	12,92	N/mm²
Actions F_{cd} =	32,13	kN	-> $\sigma_{c0d} = F_{cd} / A$ =	1,540	N/mm²
$M_d = F_{cd}\, e$ =	1,783	kNm	$\sigma_{myd} = M_d / W_{yy}$ =	2,310	N/mm²

Slenderness

6.3.2	$\lambda_{yy} = L_e / r_{yy}$ =	39,8	
(6.21)	$\lambda_{rely} = \lambda_{yy}/\pi\sqrt{(f_{c0k} / E_{05})}$ =	0,68	From 6.3.2(3) Use expressions (6.23-29)
(6.29)	β_c = IF("Softwood";0,2;0,1) =	0,2	
(6.27)	$k_y = 0{,}5\,(1 + \beta_c\,(\lambda_{rely} - 0{,}3) + \lambda_{rely}^2)$ =	0,77	
(6.25)	$k_{cy} = 1/(k_y + \sqrt{(k_y^2 - \lambda_{rely}^2)})$	0,888	
(6.23)	$U_{cmy} = \sigma_{c0d}/(k_{cy} * f_{c0d}) + \sigma_{myd}/f_{myd}$ =	0,291	<= 1

PASS Combined Bending and Compression rules

Bearing f_{c90k} =	2,20	N/mm²	L_b = N b =	94	mm
(6.4) $k_{c90} = (2{,}38 - L_b/250)*(1 + h/(12L_b))$ =	2,40		f_{c90d} =	2,2	N/mm²
$U_b = \sigma_{c0d}/(k_{c90} * f_{c90d})$ =	0,29		Limiting load $F_{c90} = A\, k_{c90}\, f_{c90d}$ =	110,11	kN

A spreader plate is not required.