COMPANY NAME		Calc. No.	CALC. NUMBER	
CALCULATION SHEET		Project No.	PROJECT NUMBER	
Project Title:	**Project Name**	**Calc. By**	Date	Rev.
Subject:	**Wood Element Subjected to Combined Compression and Bending**	Author	today	0

Maximum working loads (Ultimate Limit State)

F_{Ed}=	60	kN*m	axial force (compression)
$M_{y,Ed}$=	5	kN*m	bending moment y-y
$M_{z,Ed}$=	0.5	kN*m	bending moment z-z

Element dimensions - Rectangular cross section

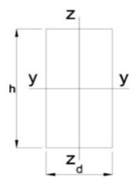
$L_{y.b}$ =	520	cm	y-y buckling length
$L_{z.b}$ =	520	cm	z-z buckling length
h =	40	cm	height
d =	13	cm	width

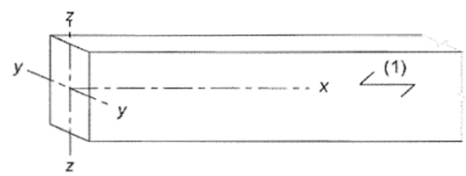
Section Properties

A = d*h =	520.00	cm^2	section area
$I_y = d*h^3/12$ =	69333.33	cm^4	y-y moment of inertia
$I_z = d^3*h/12$ =	7323.33	cm^4	z-z moment of inertia
$i_y = (Iy/A)^{0.5}$ =	11.55	cm	y-y radius of gyration
$i_z = (Iz/A)^{0.5}$ =	3.75	cm	z-z radius of gyration

Slenderness ratios

$\lambda_y = L_{y.b} / i_y$ =	45.03	bending about the y-axis
$\lambda_z = L_{z.b} / i_z$ =	138.56	bending about the z-axis





Material characteristics per EN 338-97 - Table 1

Wood strength class: C14

$f_{m,k}$ =	14	N/mm^2	Characteristic bending strength
$f_{c,0,k}$ =	16	kN/mm^2	Characteristic compressive strength
$E_{0,05}$ =	4.7	kN/mm^2	5% value of modulus of elasticity
γ_m =	1.3	per EN 1995-1-1 - Table 2.3	
ρ_{wood} =	600	kg/m^3	timber density

Per EN 1995-1-1 - Section 3.2 (3), formula (3.1)

for (h<150mm) $k_h = \min((15/h)^{0.2} ; 1.3)$

k_h = 1.00

k_{mod} = 0.9 per EN 1995-1-1 - Table 3.1

Per EN 1995-1-1 - Section 2.4.1, formula (2.14)

Wood design compressive strength

$f_{c.0.d} = k_{mod} * f_{c,0,k} / \gamma_m$ = 11.08 N/mm^2

Wood design bending strength about y and z axis

$f_{m.y.d} = f_{m.z.d} = k_{mod} * k_h * f_{m,k} / \gamma_m$ = 9.69 N/mm^2

Per EN 1995-1-1 - Section 6.1.6 (2)

k_m = 0.7 for rectangular sections

$\sigma_{c,0,d}$ =	F_{Ed} / A =	1.15	N/mm^2	Design compressive stress
$\sigma_{m.y.d}$ =	$M_{y,Ed} * (h/2) / I_y$ =	1.44	N/mm^2	Design bending stress about the principal y axis
$\sigma_{m.z.d}$ =	$M_{z,Ed} * (d/2) / I_z$ =	0.44	N/mm^2	Design bending stress about the principal z axis

Stresses verification - Combined bending and axial compression

Check on for y-y axis per EN 1995-1-1 - Section 6.2.4, formula (6.19)

$(\sigma_{c,0,d} / f_{c,0,d})^2 + (\sigma_{m.y.d} / f_{m.y.d}) + k_m * (\sigma_{m.z.d} / f_{m.z.d})$ = 0.19 < 1 **element OK**

Check on for z-z axis per EN 1995-1-1 - Section 6.2.4, formula (6.20)

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m * (\sigma_{m.y.d} / f_{m.y.d}) + (\sigma_{m.z.d} / f_{m.z.d})$ = 0.16 < 1 **element OK**

Strability verification - Combined bending and axial compression per EN 1995-1-1 - Section 6.3.2

$\lambda_{rel,y}$ =	$(\lambda_y /\pi) * (f_{c,0,k} / E_{0,05})^{0.5}$=	0.836	Relative slenderness ratio - y axis (deflection in the z direction) - Formula (6.21)
$\lambda_{rel,z}$ =	$(\lambda_z /\pi) * (f_{c,0,k} / E_{0,05})^{0.5}$=	2.573	Relative slenderness ratio - z axis (deflection in the y direction) - Formula (6.22)

β_c = 0.2 (0.2 for solid timber and 0.1 for glued laminated timber) factor per EN 1995-1-1 - formula (6.29)

$k_y = 0.5 * (1 + \beta_c * (\lambda_{rel,y} - 0.3) + \lambda^2_{rel,y})$ =	0.903	formula (6.27)	$k_{c,y} = 1 / [k_y + (k^2_y - \lambda^2_{rel,y})^{0.5}]$ =	0.803	formula (6.25)
$k_z = 0.5 * (1 + \beta_c * (\lambda_{rel,z} - 0.3) + \lambda^2_{rel,z})$ =	4.039	formula (6.28)	$k_{c,z} = 1 / [k_z + (k^2_z - \lambda^2_{rel,z})^{0.5}]$ =	0.140	formula (6.26)

Check on for y-y axis per EN 1995-1-1 - Section 6.3.2, formula (6.23)

$\sigma_{c,0,d} / (k_{c,y} * f_{c,0,d}) + (\sigma_{m.y.d} / f_{m.y.d}) + k_m * (\sigma_{m.z.d} / f_{m.z.d})$ = 0.31 < 1 **element OK**

Check on for z-z axis per EN 1995-1-1 - Section 6.3.2, formula (6.24)

$\sigma_{c,0,d} / (k_{c,z} * f_{c,0,d}) + k_m * (\sigma_{m.y.d} / f_{m.y.d}) + (\sigma_{m.z.d} / f_{m.z.d})$ = 0.89 < 1 **element OK**

References: EN 338 : 2003 - Structural Timber; Strength Classes
EN 1995-1-1:2004 - Eurocode 5: Design of timber structures - Part 1-1: Common rules and rules for buildings