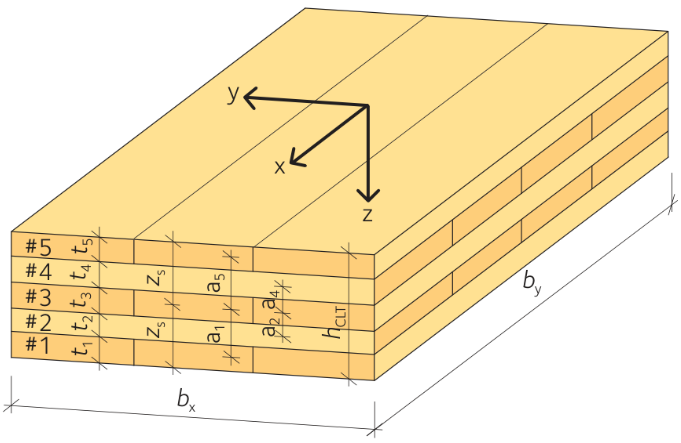
CLT panel verification according to Sweedish wood - CLT Handbook

All static images are taken from this book

HP1: All material strenghts along x axis equal to the y ones, since the material is the same for each layer

HP2: The panel is symmetric



3.66

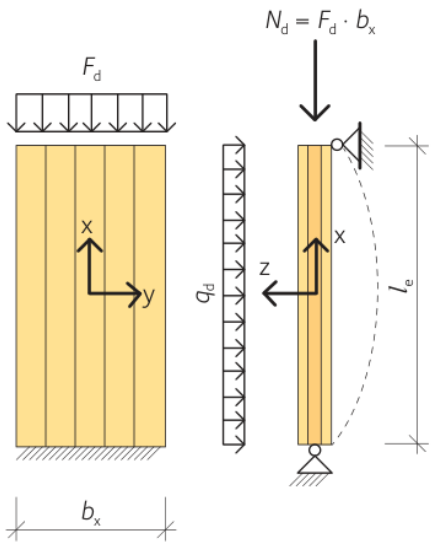
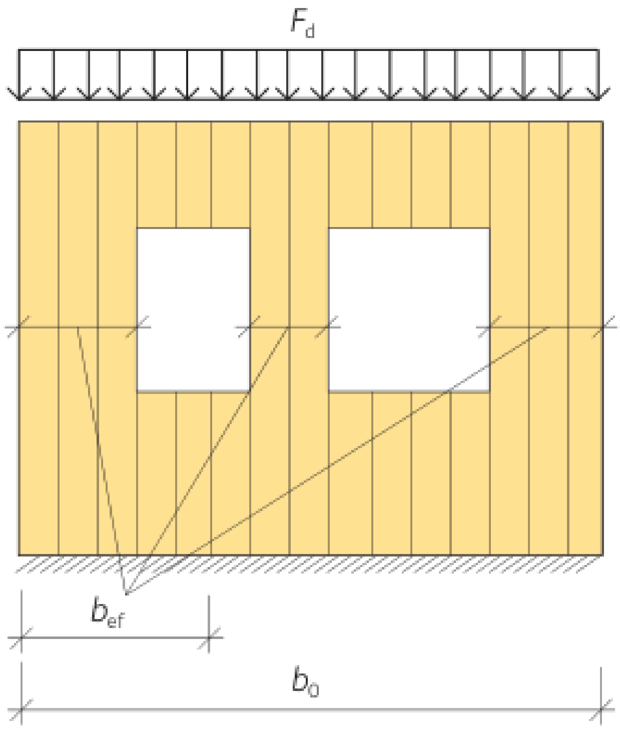


Figure 3.27 CLT wall panel subject to transverse load and compressive force.



Loads

$q_{d,SLE} = 0.62 \frac{kN}{m}$

$q_{d,SLU} = 7.5 \frac{kN}{m}$

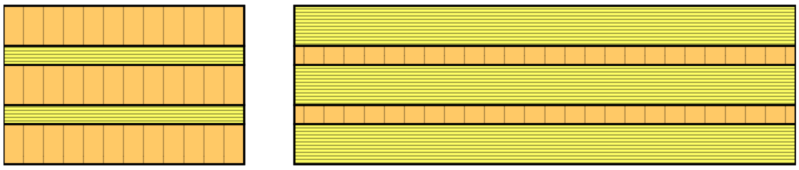
Geometry

$b = 2.4 m$

$l = 5 m$

Caratteristiche meccaniche legno C24		
$\gamma_M = 1.45$ $k_{mod} = 1.1$		
$f_{m,k} = 24$ MPa	$f_{m,d} = 18.21$ MPa	$E_{0,mean} = 11000$ MPa
$f_{t,0,k} = 14.5$ MPa	$f_{t,0,d} = 11$ MPa	$E_{0,05} = 7400$ MPa
$f_{t,90,k} = 0.4$ MPa	$f_{t,90,d} = 0.303$ MPa	$E_{90,mean} = 370$ MPa
$f_{c,0,k} = 21$ MPa	$f_{c,0,d} = 15.93$ MPa	$G_{mean} = 690$ MPa
$f_{c,90,k} = 2.5$ MPa	$f_{c,90,d} = 1.9$ MPa	$r_k = 350$ kg/m^3
$f_{v,k} = 4$ MPa	$f_{v,d} = 3.03$ MPa	$r_{mean} = 420$ kg/m^3

Caratteristiche del pannello in CLT	
$t_{x,net} = 120$ mm	$t_{y,net} = 38$ mm
$A_{x,full} = 3792$ cm^2	$A_{y,full} = 7900$ cm^2
$A_{x,net} = 2880$ cm^2	$A_{y,net} = 1900$ cm^2
$I_{x,net} = 70675.2$ cm^4	$I_{y,net} = 17106.3$ cm^4
$W_{x,net} = 8946.23$ cm^3	$W_{y,net} = 2165.36$ cm^3
$W_{z,x,net} = 115200$ cm^3	$W_{z,y,net} = 158333$ cm^3
$S_{R,x,net} = 5664$ cm^3	$S_{R,y,net} = 2802.5$ cm^3
$S_{x,net} = 6144$ cm^3	$S_{y,net} = 2802.5$ cm^3
$i_{x,net} = 4.95$ cm	$i_{y,net} = 3$ cm



$k_{sys} = \mathbf{min}\left(1.15;\ 1 + \frac{0.1 \cdot b}{m}\right) = \mathbf{min}\left(1.15;\ 1 + \frac{0.1 \cdot 2.4\ m}{m}\right) = 1.15$ [Swedish Wood CLT Handbook §3.1.6]

$E_{0,mean} \cdot A_{x,net} = 11000\ MPa \cdot 288000\ mm^2 = 3168000\ kN$

$E_{0,mean} \cdot I_{x,net} = 11000\ MPa \cdot 706752000\ mm^4 = 7774.27\ kN \cdot m^2$

$G_{mean} \cdot A_{x,net} = 690\ MPa \cdot 288000\ mm^2 = 198720\ kN$

Azioni agenti

$M_{Ed,y} = \frac{q_{d,SLU} \cdot l^2}{8} = \frac{7.5\ kN/m \cdot (5\ m)^2}{8} = 23.44\ kNm$

$M_{Ed,x} = 0\ kNm$

$V_{Ed,xz} = q_{d,SLU} \cdot l = 7.5\ kN/m \cdot 5\ m = 37.5\ kN$

$V_{Ed,yz} = 0\ kN$

$V_{Ed,xy} = 0\ kN$

$V_{Ed,yx} = 0\ kN$

Momento flettente attorno y e x

$\sigma_{m,y,d} = \frac{M_{Ed,y}}{W_{x,net}} = \frac{23.44\ kNm}{8946228\ mm^3} = 2.62\ MPa$

$\sigma_{m,x,d} = \frac{M_{Ed,x}}{W_{y,net}} = \frac{0\ kNm}{2165359\ mm^3} = 0\ MPa$

$\frac{\sigma_{m,y,d}}{k_{sys} \cdot f_{m,d}} = \frac{2.62\ MPa}{1.15 \cdot 18.21\ MPa} = 0.125 \le 1 = 1$ Ok ✓

$\frac{\sigma_{m,x,d}}{k_{sys} \cdot f_{m,d}} = \frac{0\ MPa}{1.15 \cdot 18.21\ MPa} = 0 \le 1 = 1$ Ok ✓

$\frac{\sigma_{m,y,d}}{k_{sys} \cdot f_{m,d}} + \frac{\sigma_{m,x,d}}{k_{sys} \cdot f_{m,d}} = \frac{2.62\ MPa}{1.15 \cdot 18.21\ MPa} + \frac{0\ MPa}{1.15 \cdot 18.21\ MPa} = 0.125 \le 1 = 1$ Ok ✓

Momento flettente attorno z in direzione x

TODO

Wz

Momento flettente attorno z in direzione y

TODO

Wz

Taglio perpendicolare al piano

TODO

+rolling shear

Taglio nel piano

$\tau_{v,xy,d} = \frac{V_{Ed,xy}}{A_{x,net}} = \frac{0\ kN}{288000\ mm^2} = 0\ kPa$

$\tau_{v,yx,d} = \frac{V_{Ed,yx}}{A_{y,net}} = \frac{0\ kN}{190000\ mm^2} = 0\ kPa$

$$\frac{\tau_{v,xy,d}}{f_{v,d}} = \frac{0\,\mathrm{kPa}}{3.03\,\mathrm{MPa}} = 0 \leq 1 = 1 \text{ Ok ✓}$$

$$\frac{\tau_{v,yx,d}}{f_{v,d}} = \frac{0\,\mathrm{kPa}}{3.03\,\mathrm{MPa}} = 0 \leq 1 = 1 \text{ Ok ✓}$$

Taglio tra i pannelli

TODO

3.48

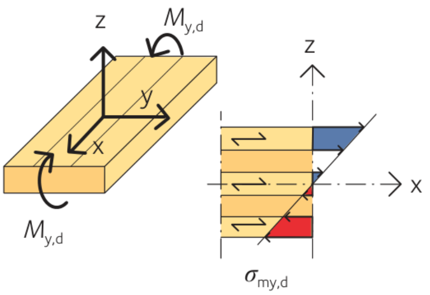


Figure 3.19 Bending stresses in CLT panel with moment about y-axis.

3.49

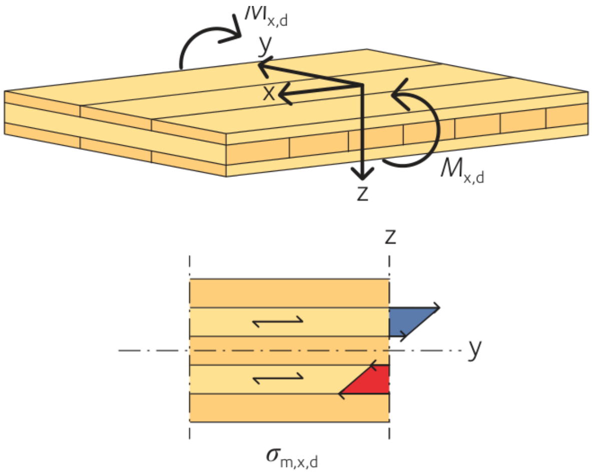


Figure 3.20 Bending stresses in CLT panel with moment about x-axis.

3.50 a

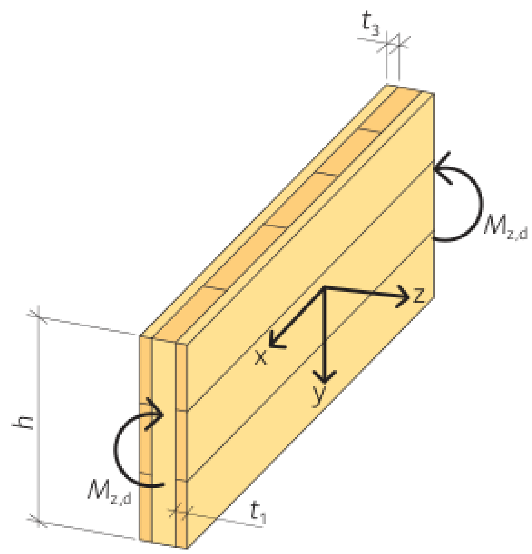


Figure 3.21 CLT panel with moment about z-axis.

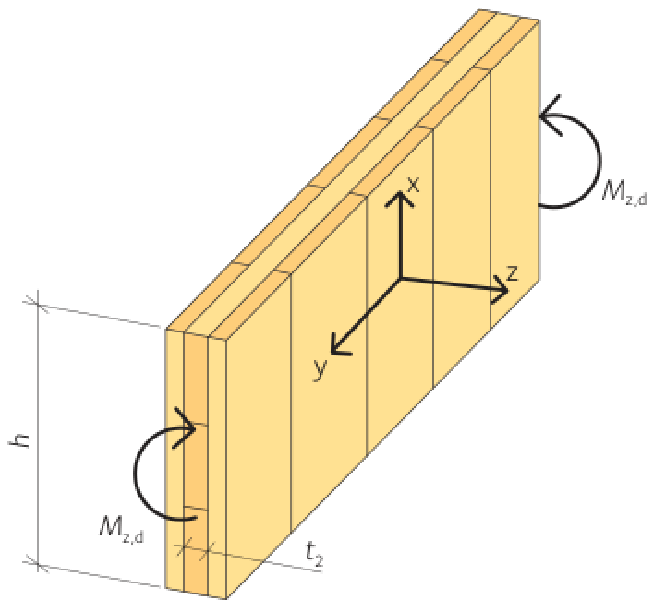


Figure 3.22 CLT panel with bending moment about z-axis.

3.55

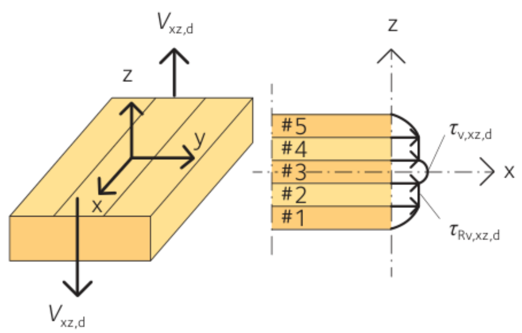


Figure 3.23 Shear stresses from shear force $V_{xz,d}$ in CLT panel.

3.56

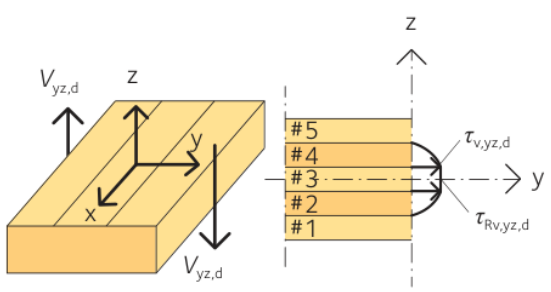


Figure 3.24 Shear stresses from shear force $V_{yz,d}$ in CLT panel.

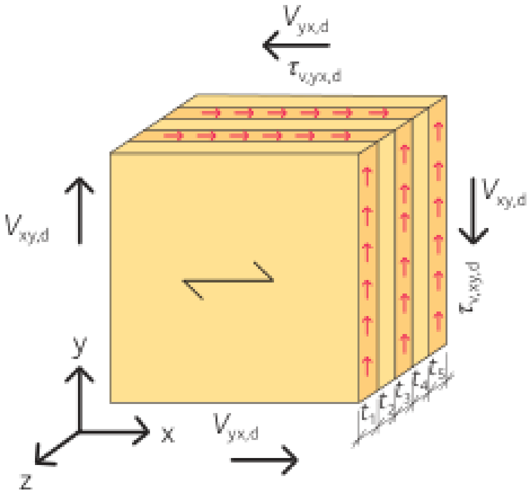


Figure 3.25 Shear stresses in relation to layer thickness in CLT panel.

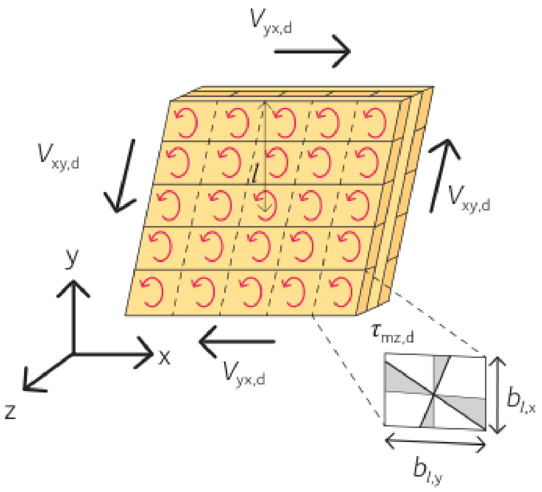


Figure 3.26 Shear stress between the layers of a CLT panel.