A contribution to the characteristic shear strength of a CLT wall under shear

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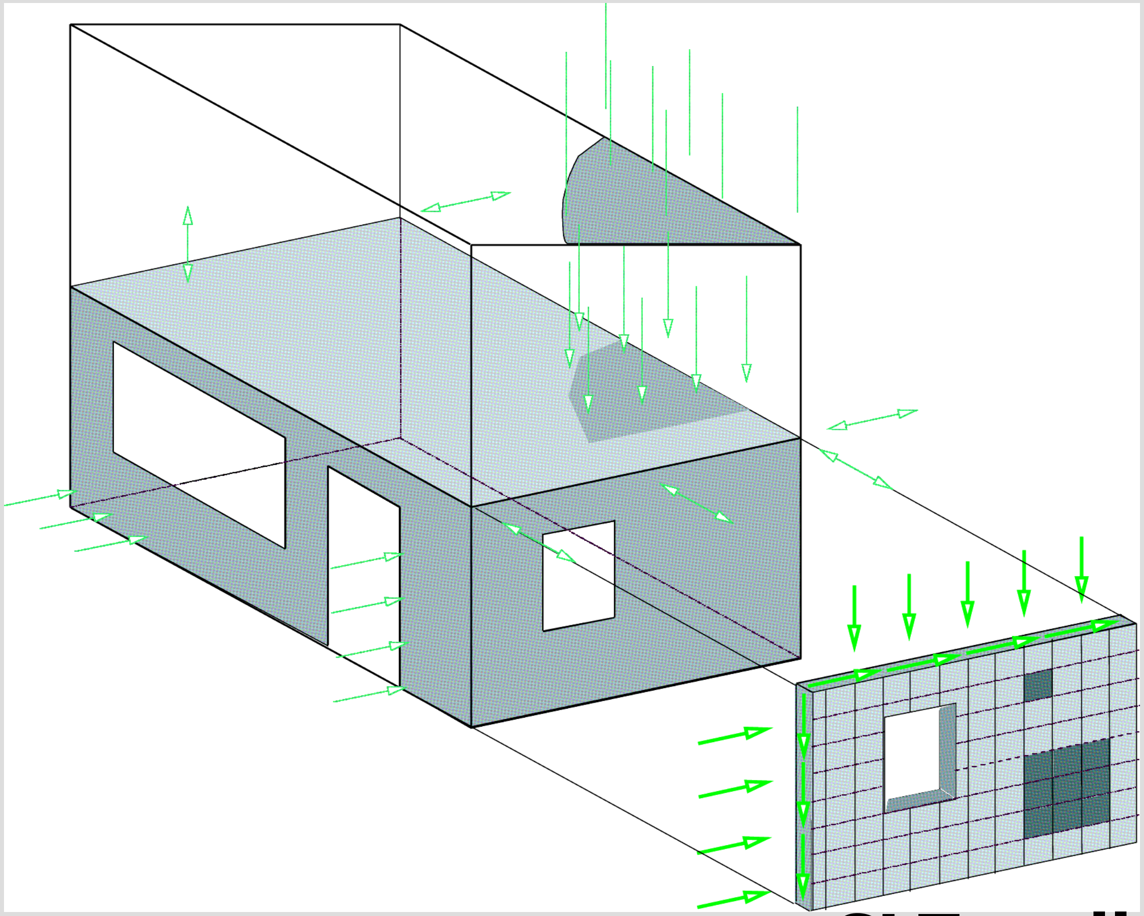
Timber Massive Construction

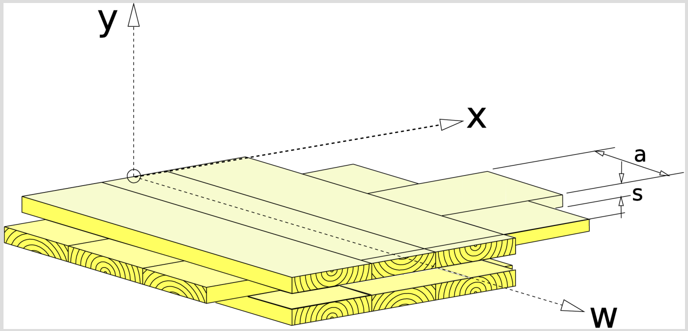


CLT wall

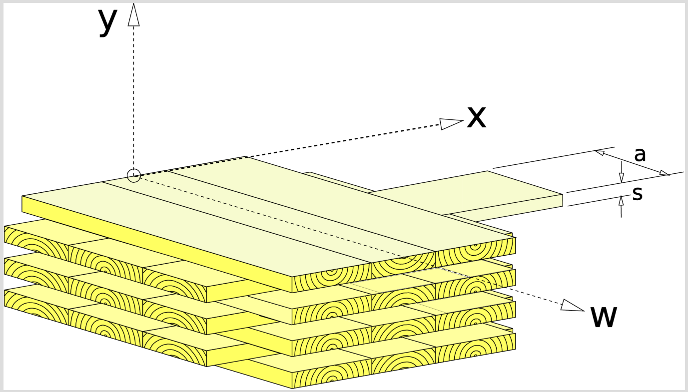
Timber Massive Construction: Single family house Styria/Austria 2007

CLT – internal structure

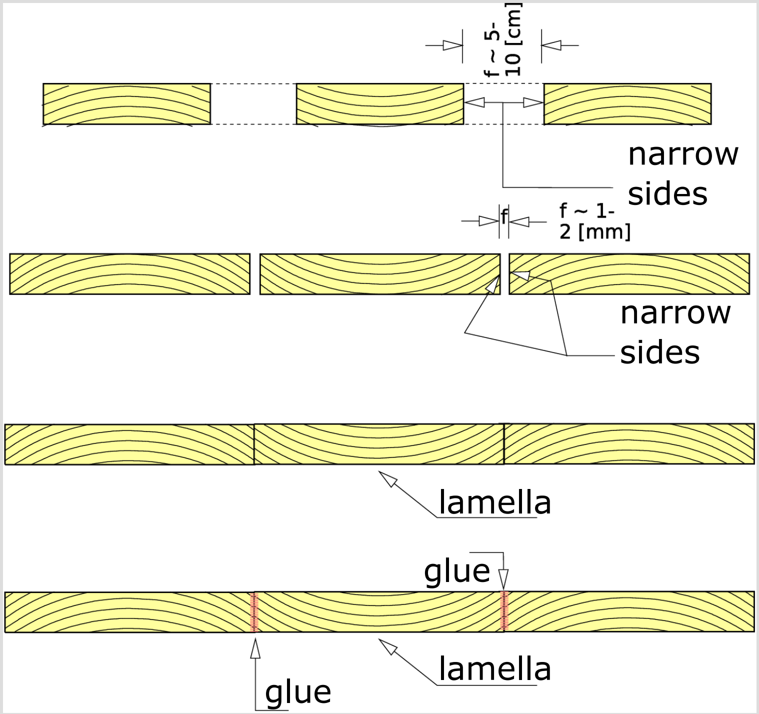
3-layered CLT



7-layered CLT

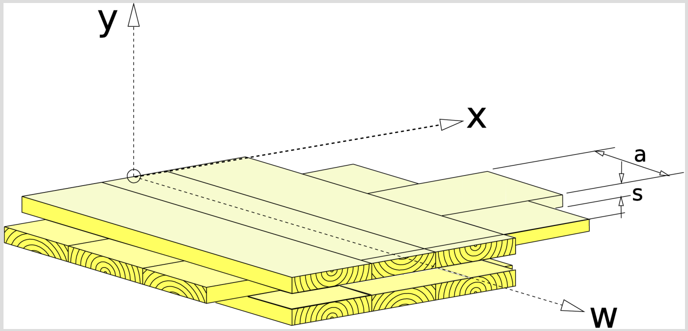


Various possibilities for gaps between boards:



CLT – internal structure

3-layered CLT



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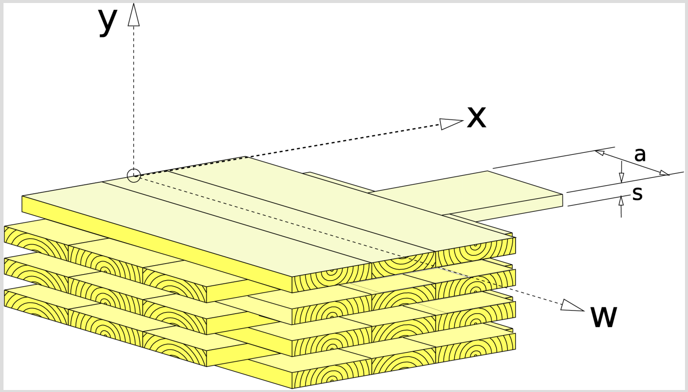

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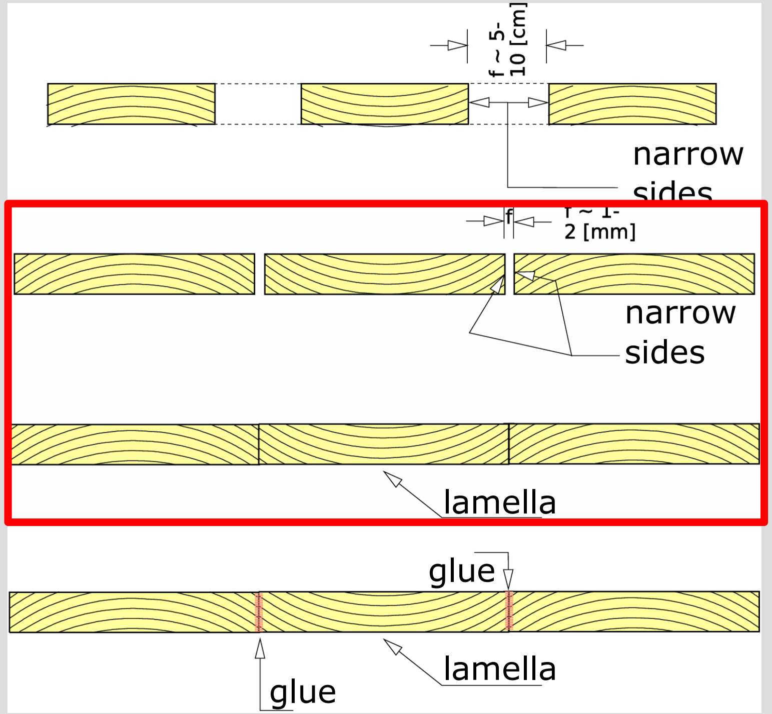
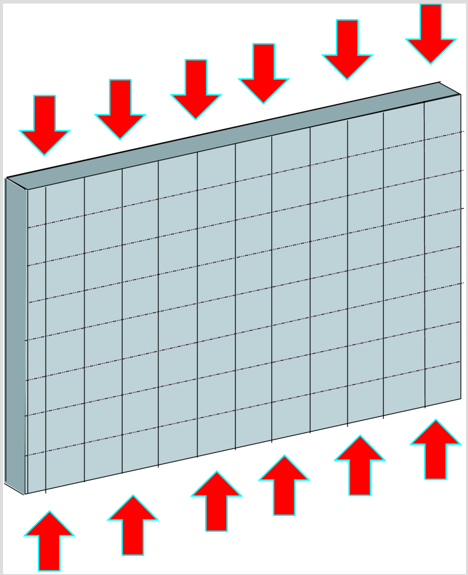
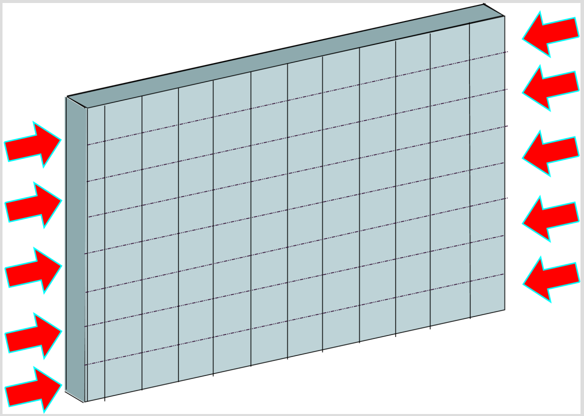
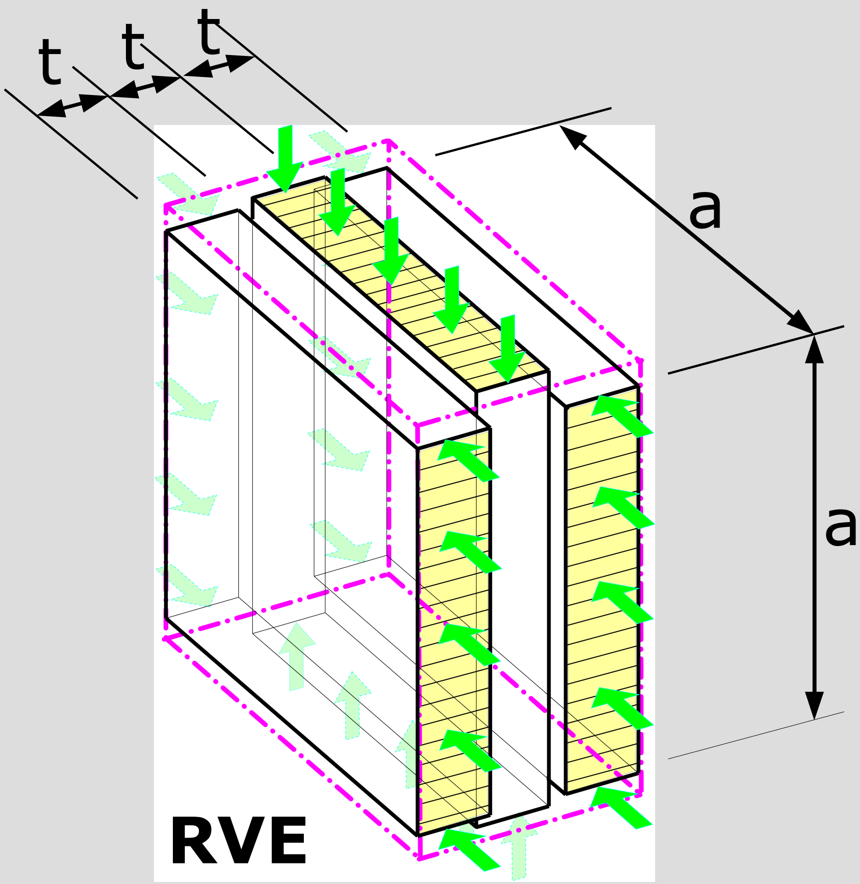


Loads on CLT structures

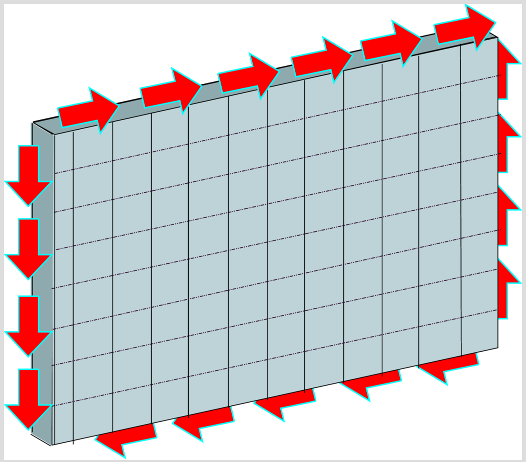


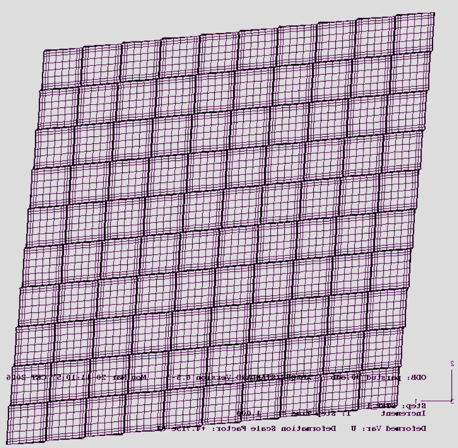


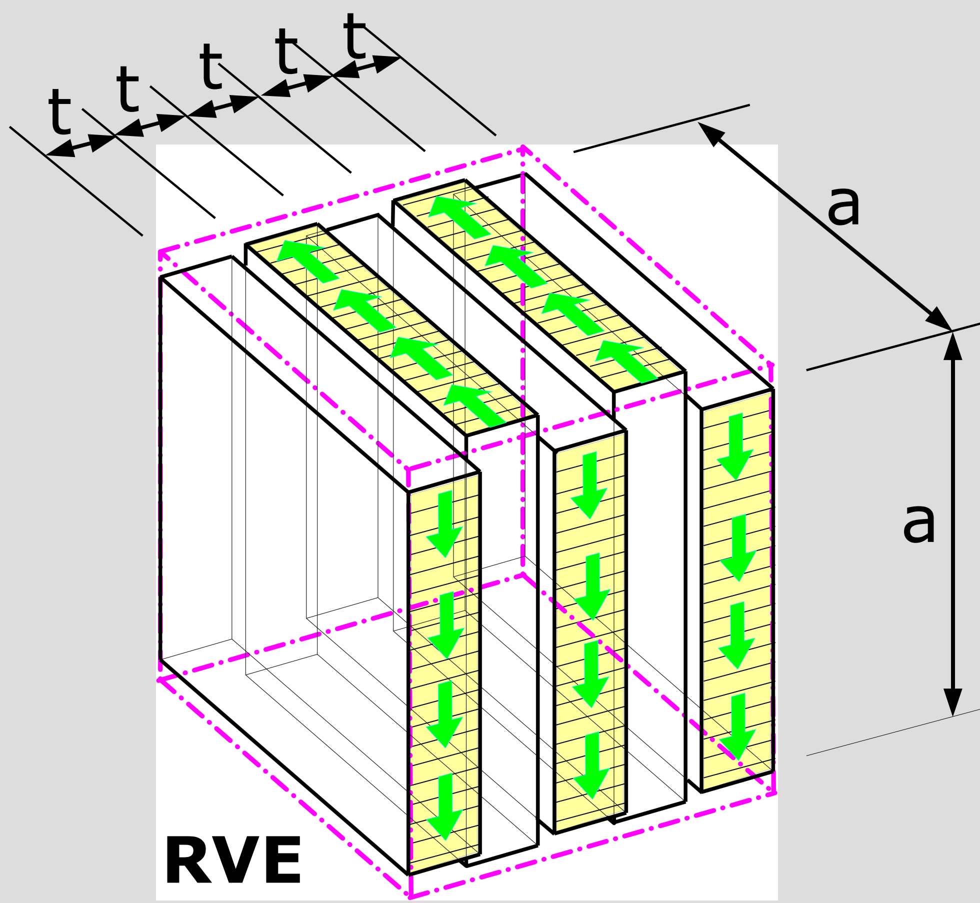


Parameter: t/a

Loads on CLT structures

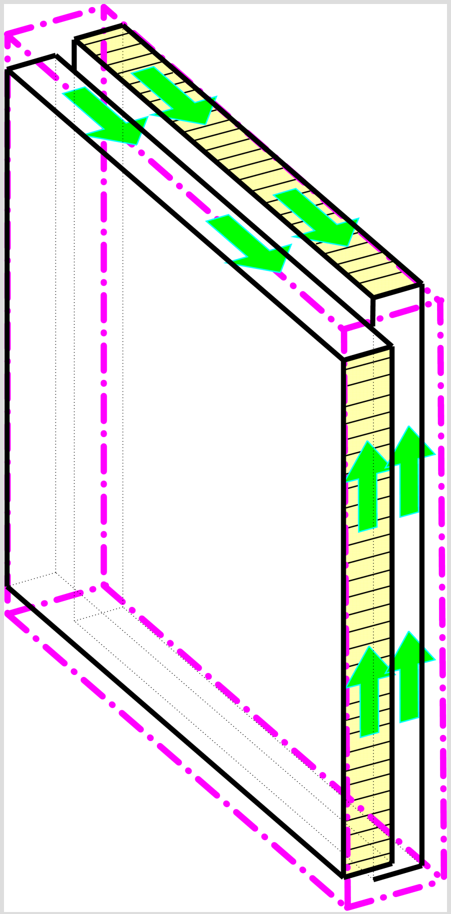


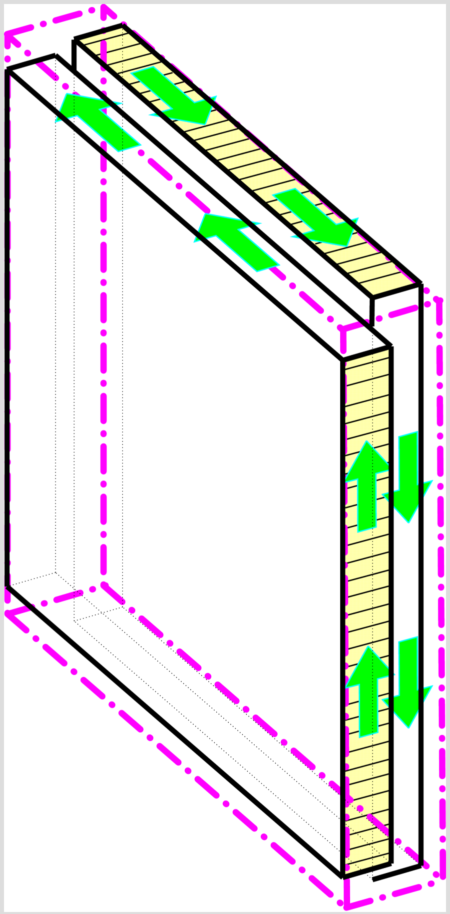


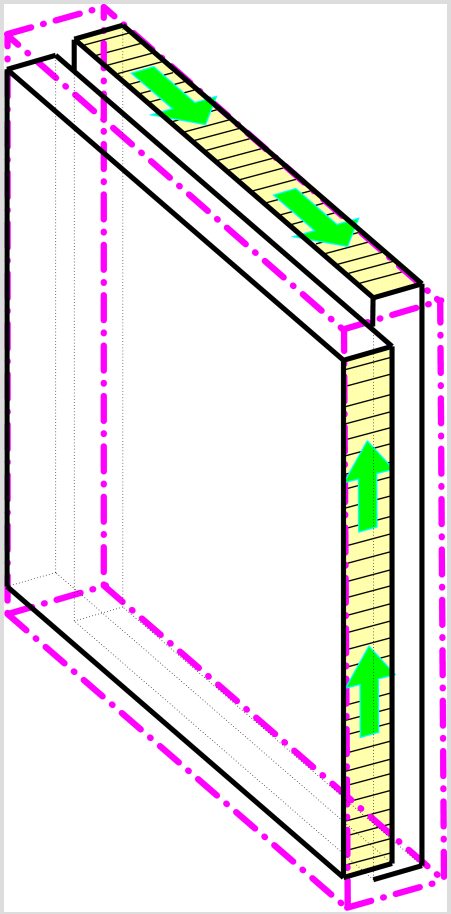


Parameter: t/a

CLT - effective shear stiffness

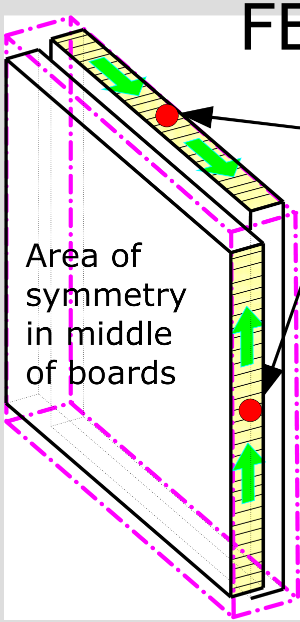






global shear + **local torsion** = **Shear in CLT**

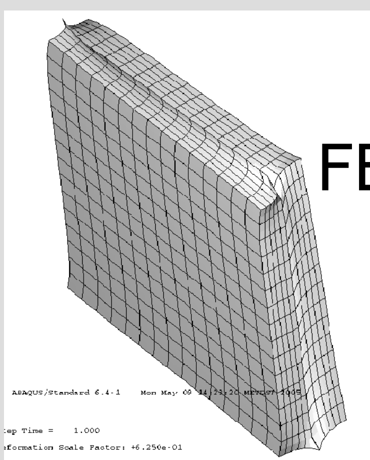
FE model



Anti-symmetric condition in cross section area

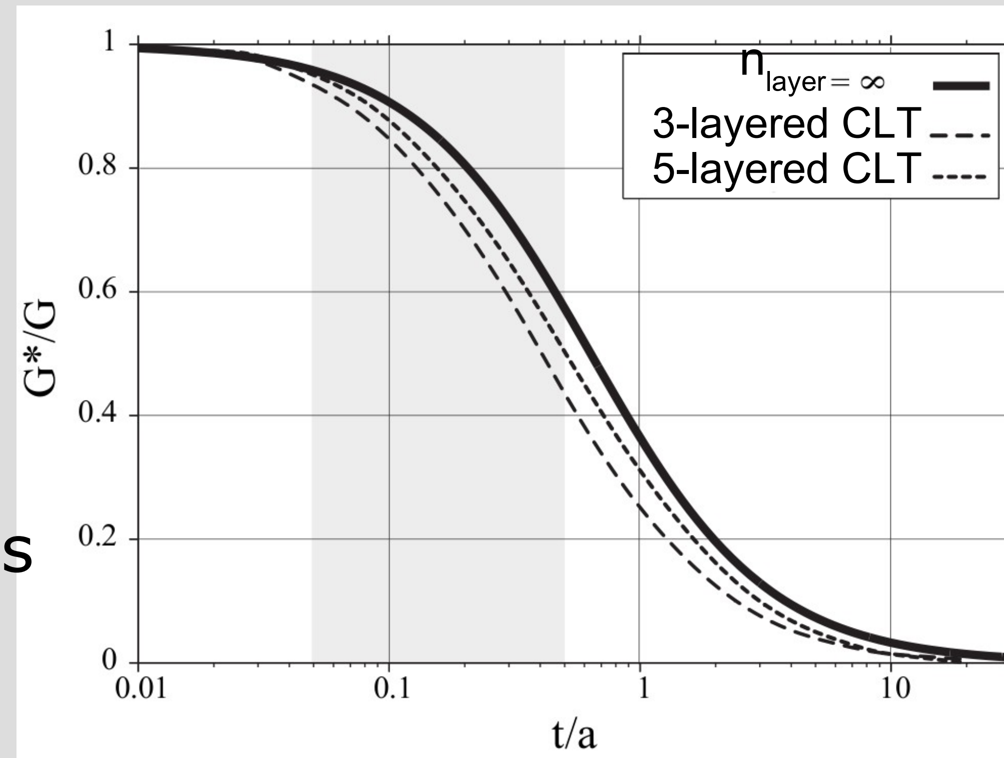
Ref-Point F, w

Effective shear stiffness CLT shear wall



e.g t/a=0.10

FE analysis

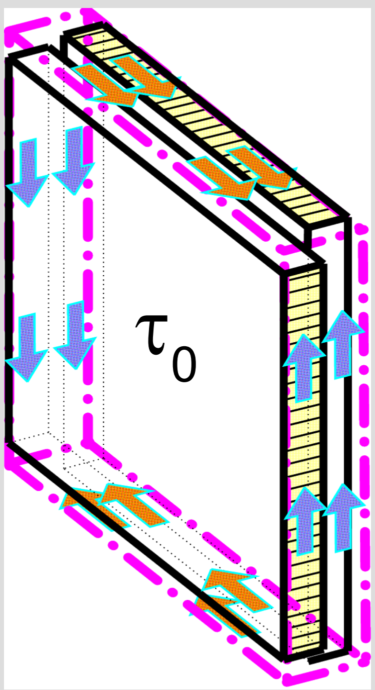


G^* effective shear stiffness of CLT structure

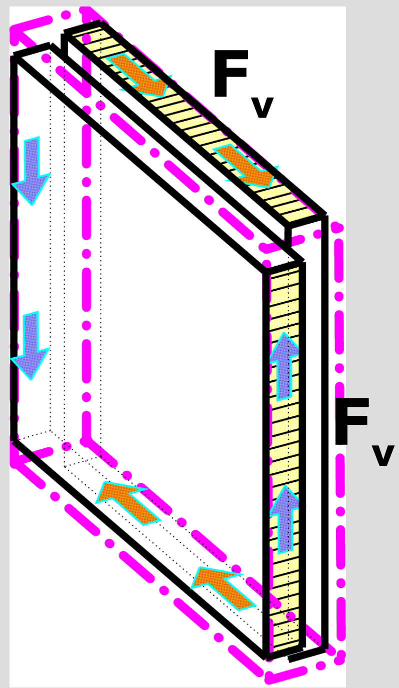
G shear stiffness of single lamella

CLT – shear strength

Perfect shear stress situation
CLT regarded as planar plate with loads in plane

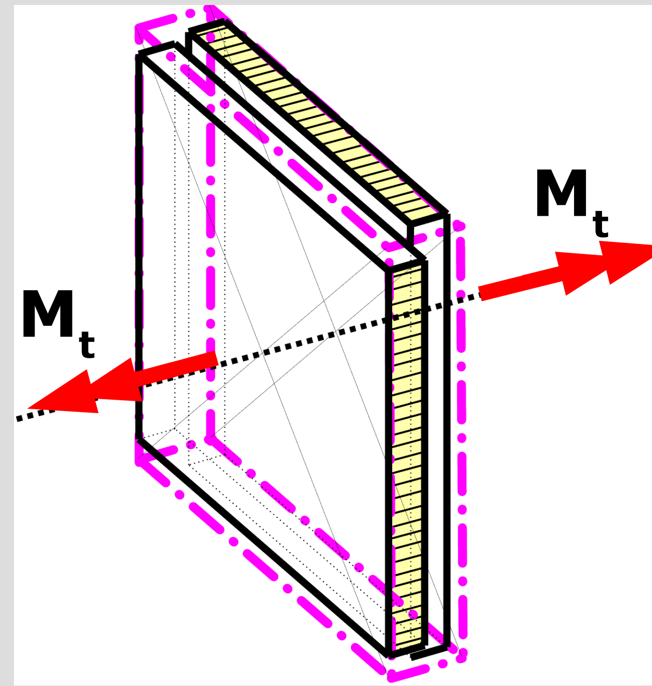


Shear force mechanism



$\tau_v = 2 \cdot \tau_0$

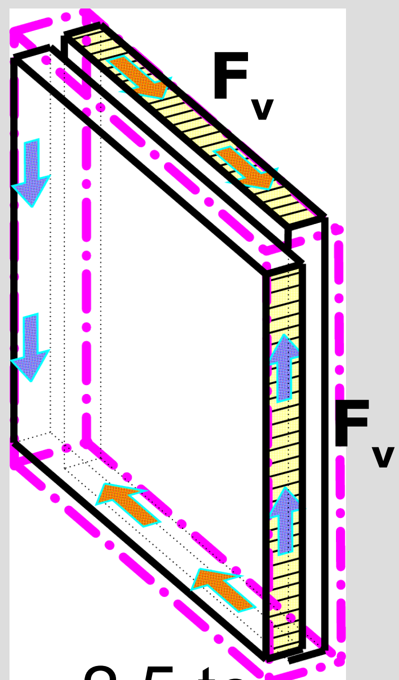
Internal torsional mechanism



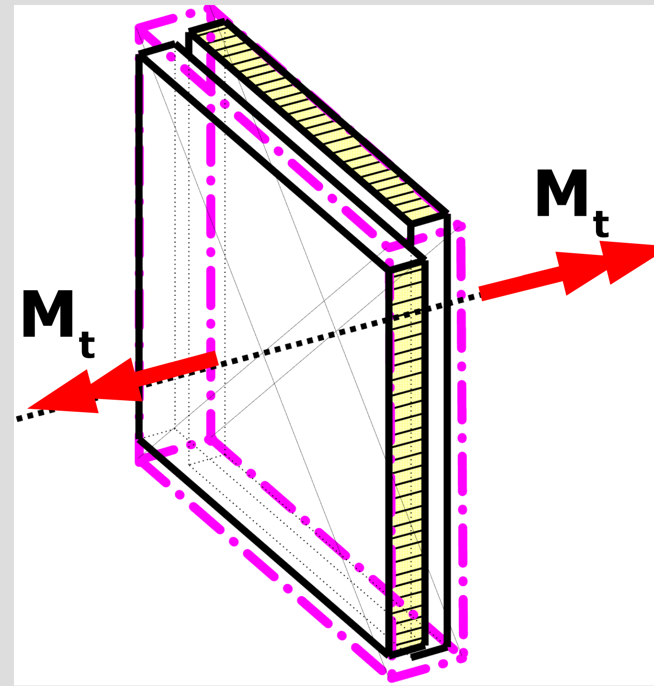
$\tau_t = 3 \cdot \tau_0 \cdot t/a$

CLT – shear strength

Shear force mechanism



Internal torsional mechanism



Conventional values for **shear strength:** **shear force** resistance and **torsion** mechanism

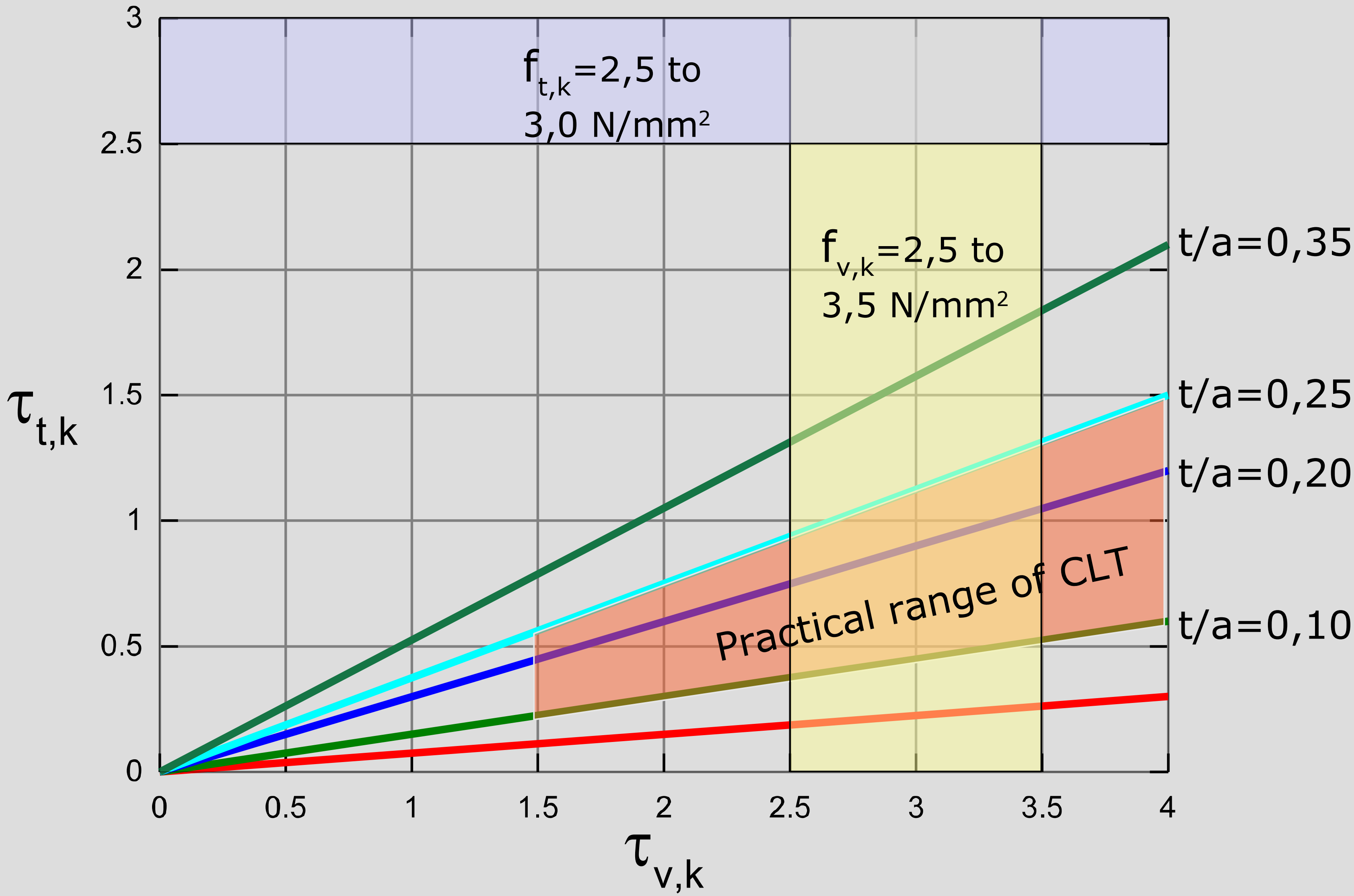
$f_{v,k}$=2,5 to 3,5 N/mm²

► Verification with A_{net}

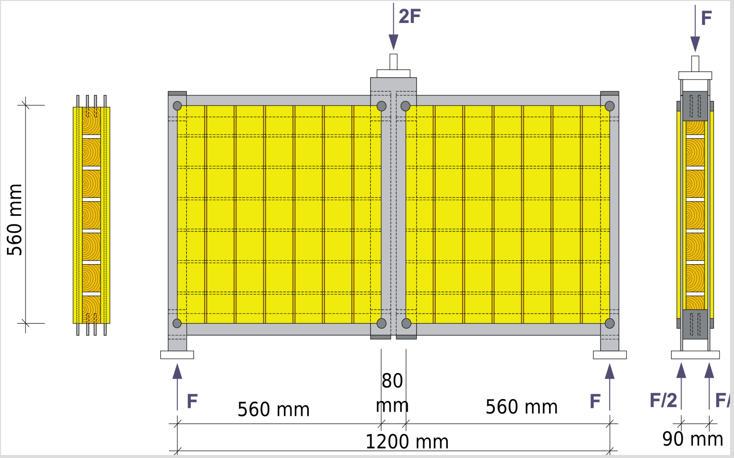
$f_{t,k}$=2,5 to 3,0 N/mm²

- *Blaß/Görlacher 'Bauen mit Holz', 2002*
- *G. Jeitler, hbf Graz, 2004*

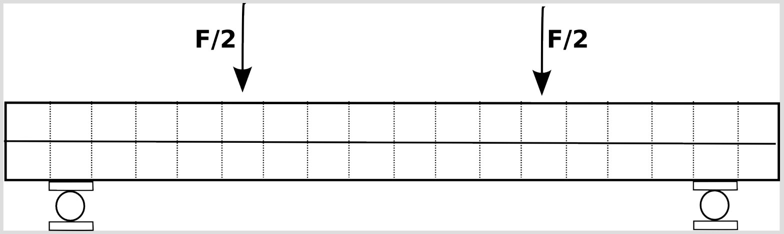
CLT – shear strength



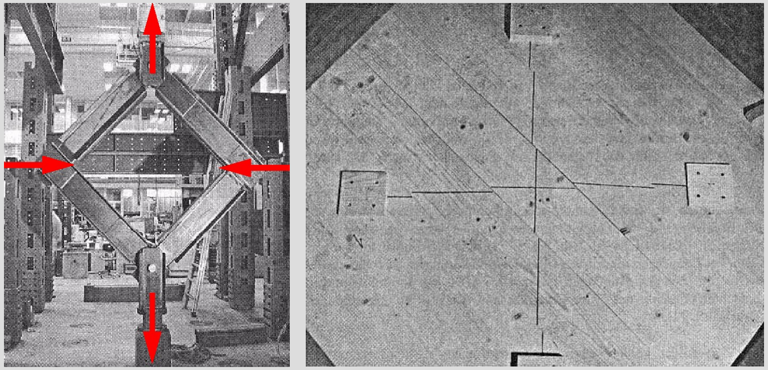
Class of shear field tests
hbf Graz(2006)



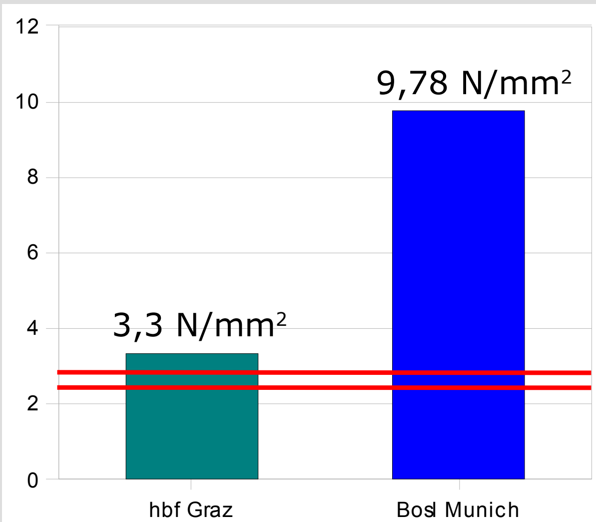
Class of CUAP tests
e.g. hbf Graz (2007,2008)



Bosl Munich (2002)

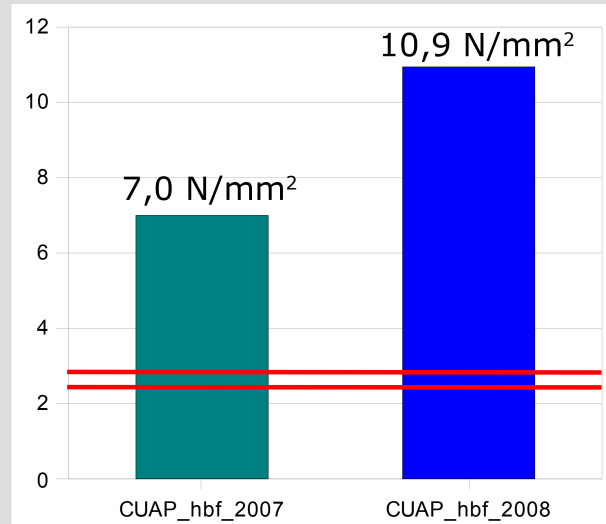


Class of shear field tests

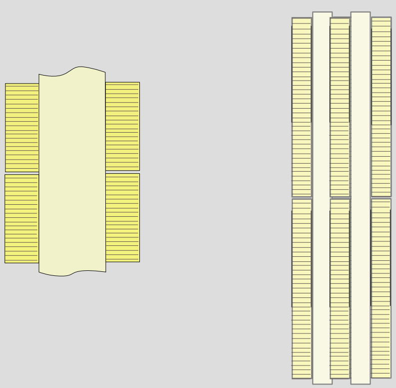


Class of CUAP tests

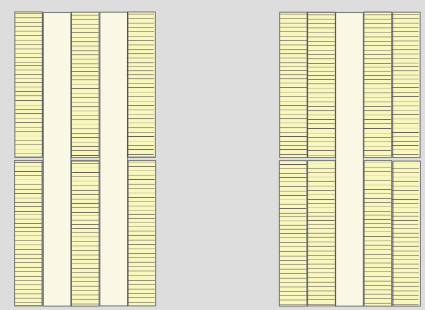
$f_{v,k}$ = ?
(CLT)



$f_{v,k}$=2,5 to
3,0 N/mm²
(glulam)

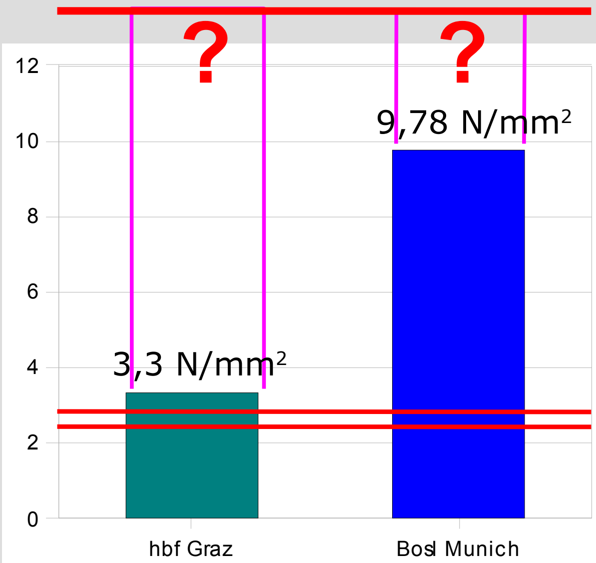


Tested
CLT sections

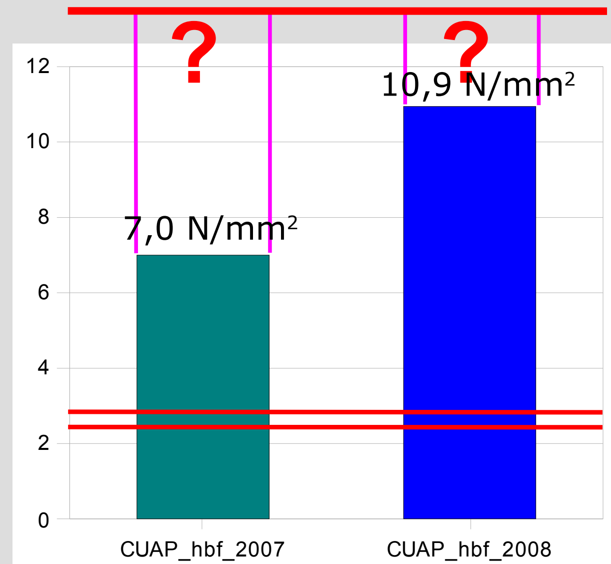


Remark: stresses with net-section!

Class of shear field tests



Class of CUAP tests



$f_{v,k}$ = ? (CLT)

$f_{v,k}$=2,5 to 3,0 N/mm² (glulam)

Remarks:

- ETA-06/0138 (KLH): $f_{v,k}$=5,2 N/mm²
- Upper limit: shear strength of plywood acc. DIN 1052:2004 Tabelle F.11 (A_{net} conversion)
- Test configuration for determinating adequate shear strength values in experiments still open

DIN 1052:2004
possible upper limit for shear strength for plywood

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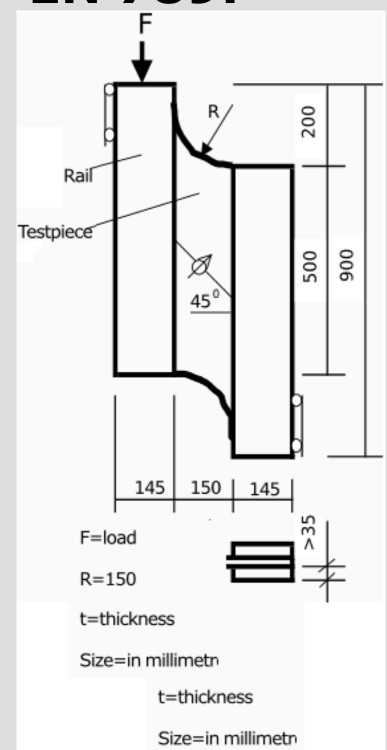
22 **Anhang** F
(normativ) Materialeigenschaften

Tabelle F.11: Rechenwerte für die charakteristischen Festigkeits-, Steifigkeits- und Rohdichtekennwerte für Sperrholz der Biegefestigkeitsklassen F 25/10 nach DIN EN 636:2003-11 mit einer charakteristischen Rohdichte von mindestens 400 kg/m³

	1		2	3
1	Beanspruchung		parallel zur Faserrichtung der Deckfurniere	rechtwinklig zur Faserrichtung der Deckfurniere
	Festigkeitskennwerte in N/mm²			
	Plattenbeanspruchung			
2	Biegung	$f_{m,k}$	25	10
3	Druck	$f_{c,90,k}$	6,5	
4	Schub	$f_{v,k}$	1,1	0,65
	Scheibenbeanspruchung			
5	Biegung	$f_{m,k}$	22	14
6	Zug	$f_{t,k}$	18	9
7	Druck	$f_{c,k}$	18	9
8	Schub	$f_{v,k}$	8 (5) [1])	

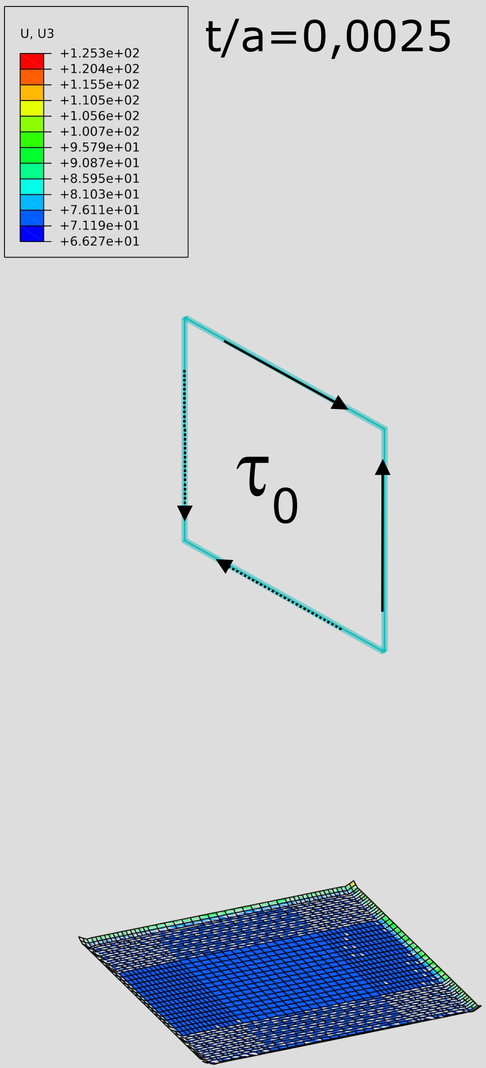
EN 789:

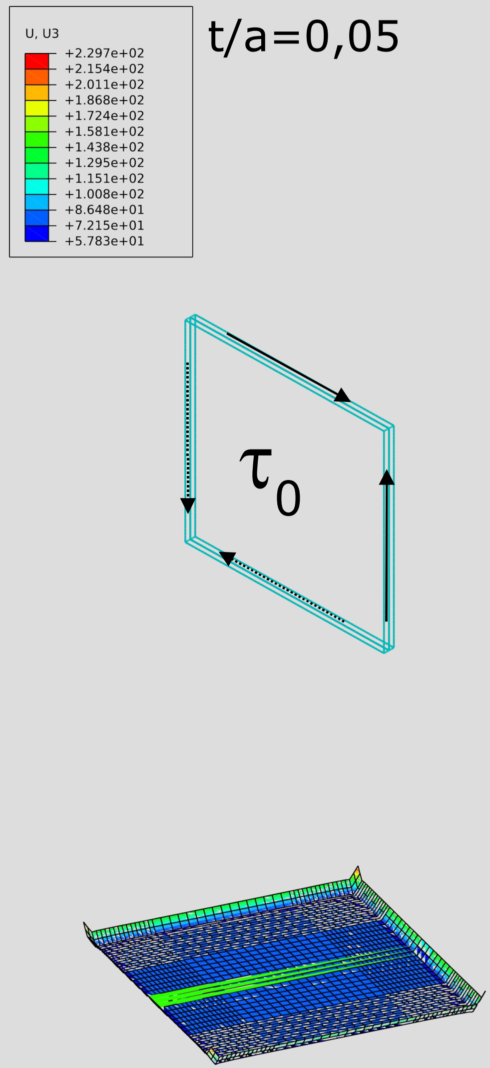


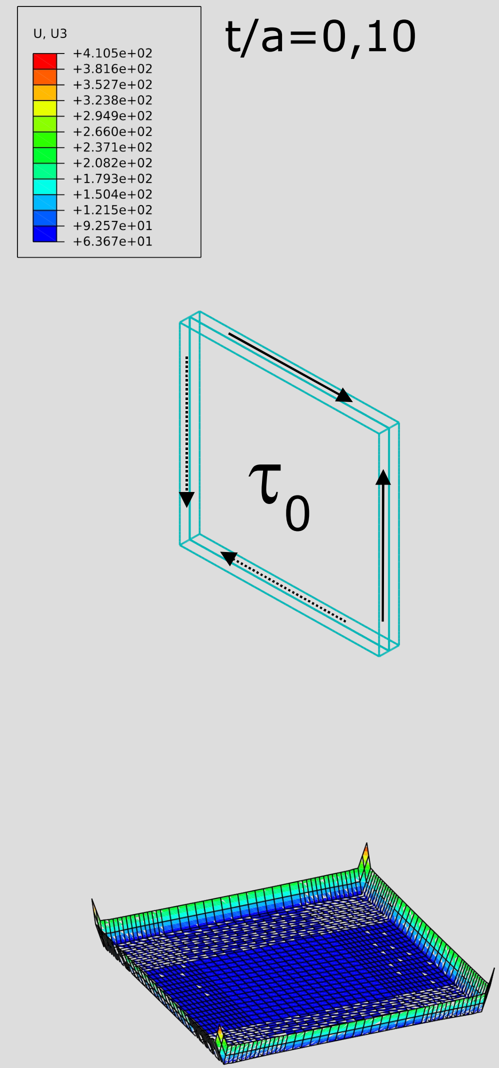
3-layered plywood: $f_{v,k}$=5 N/mm² for gross section
→ $f_{v,k}$ ≈ 3·5=15 N/mm² for net section

n-layered plywood: $f_{v,k}$=8 N/mm² for gross section
→ $f_{v,k}$ ≈ 2·8=16 N/mm² for net section

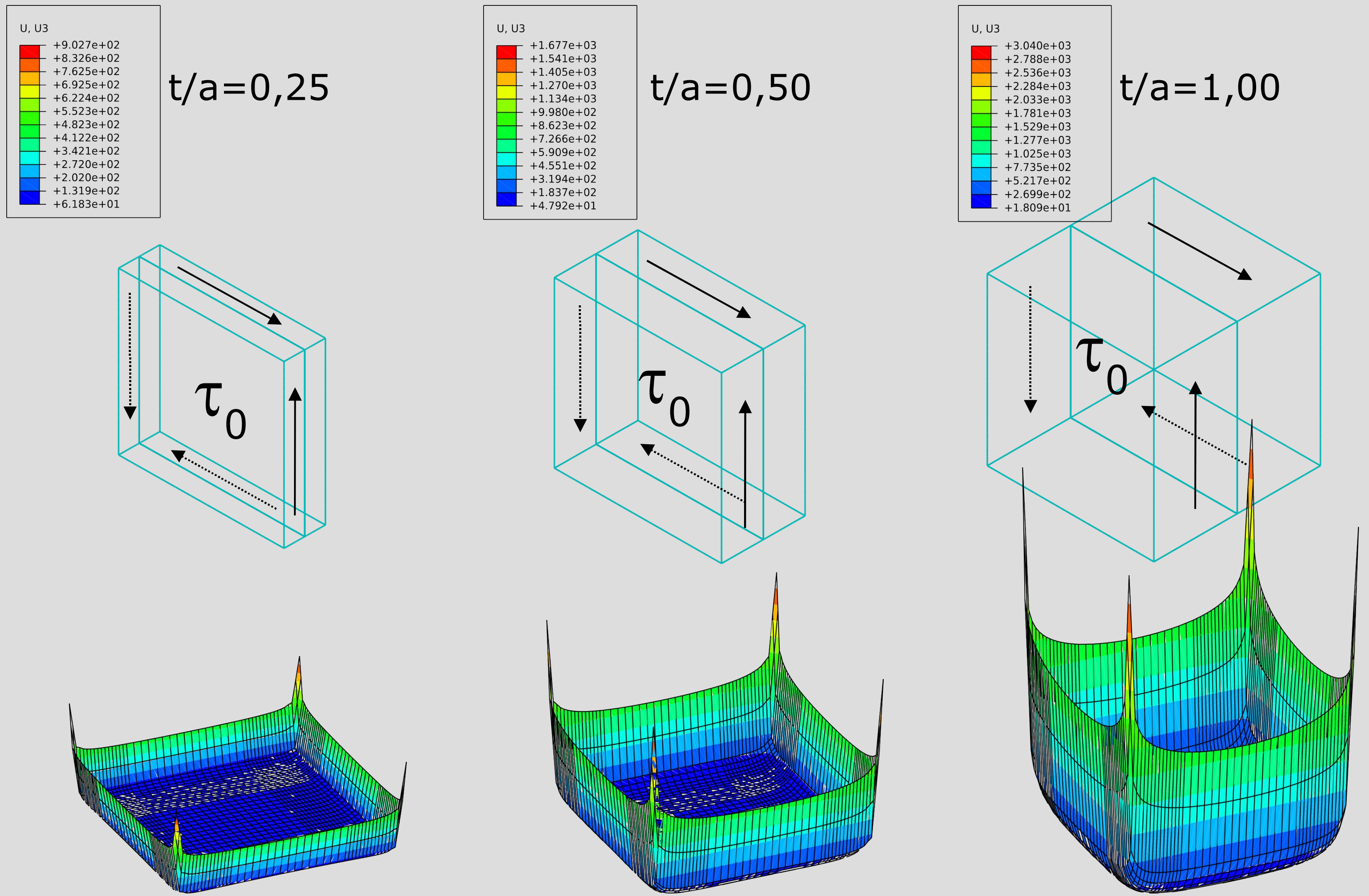
Linear elastic stress peaks



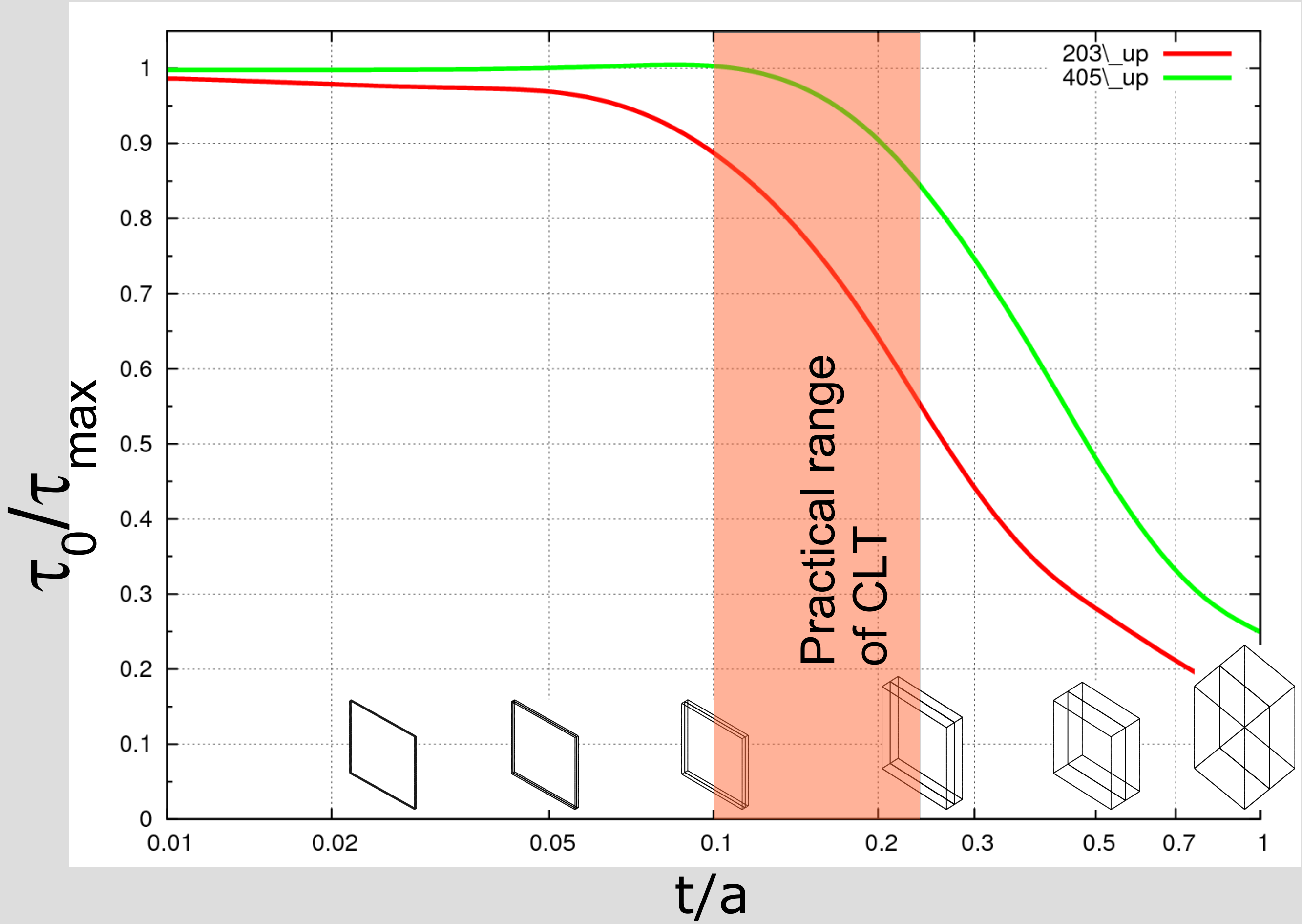




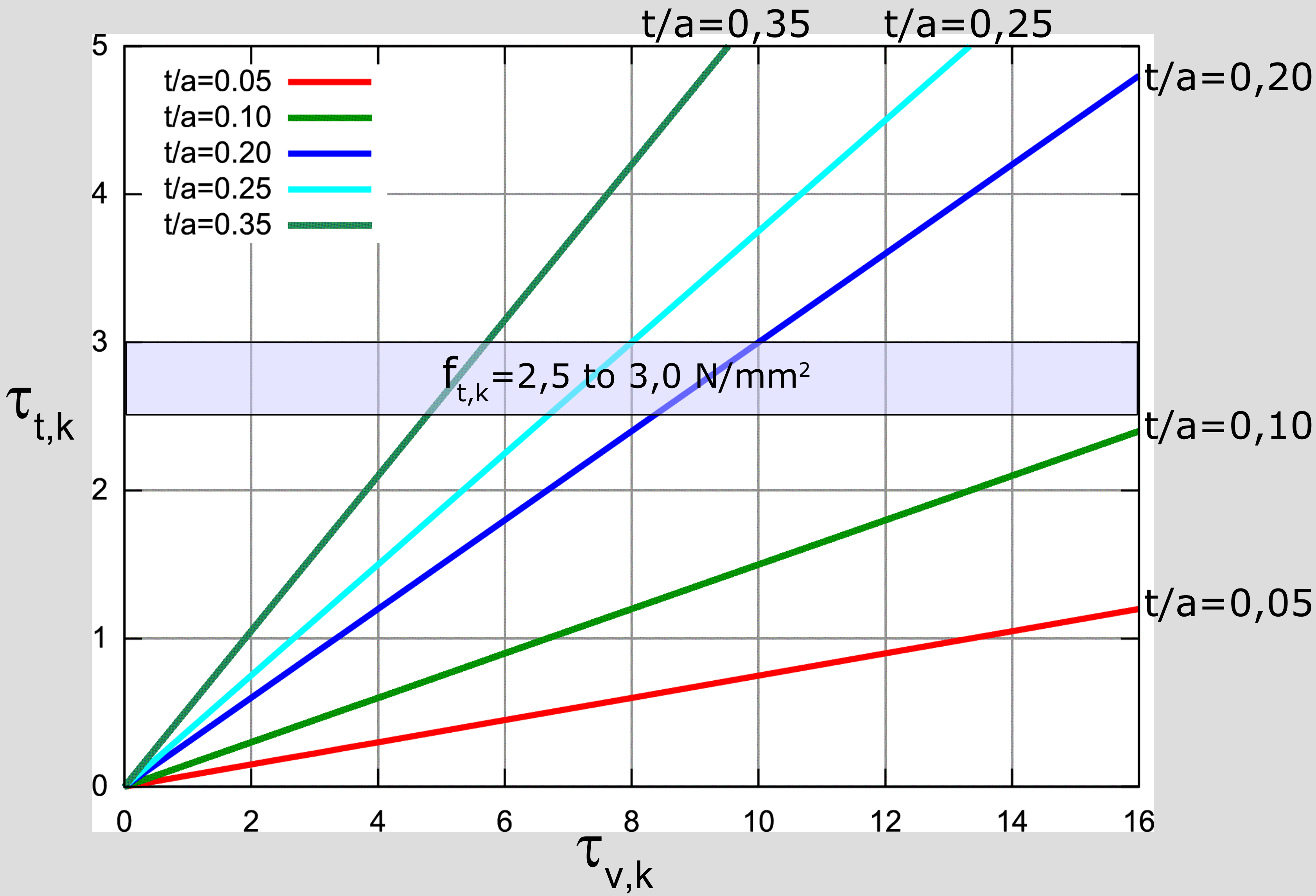
Linear elastic stress peaks

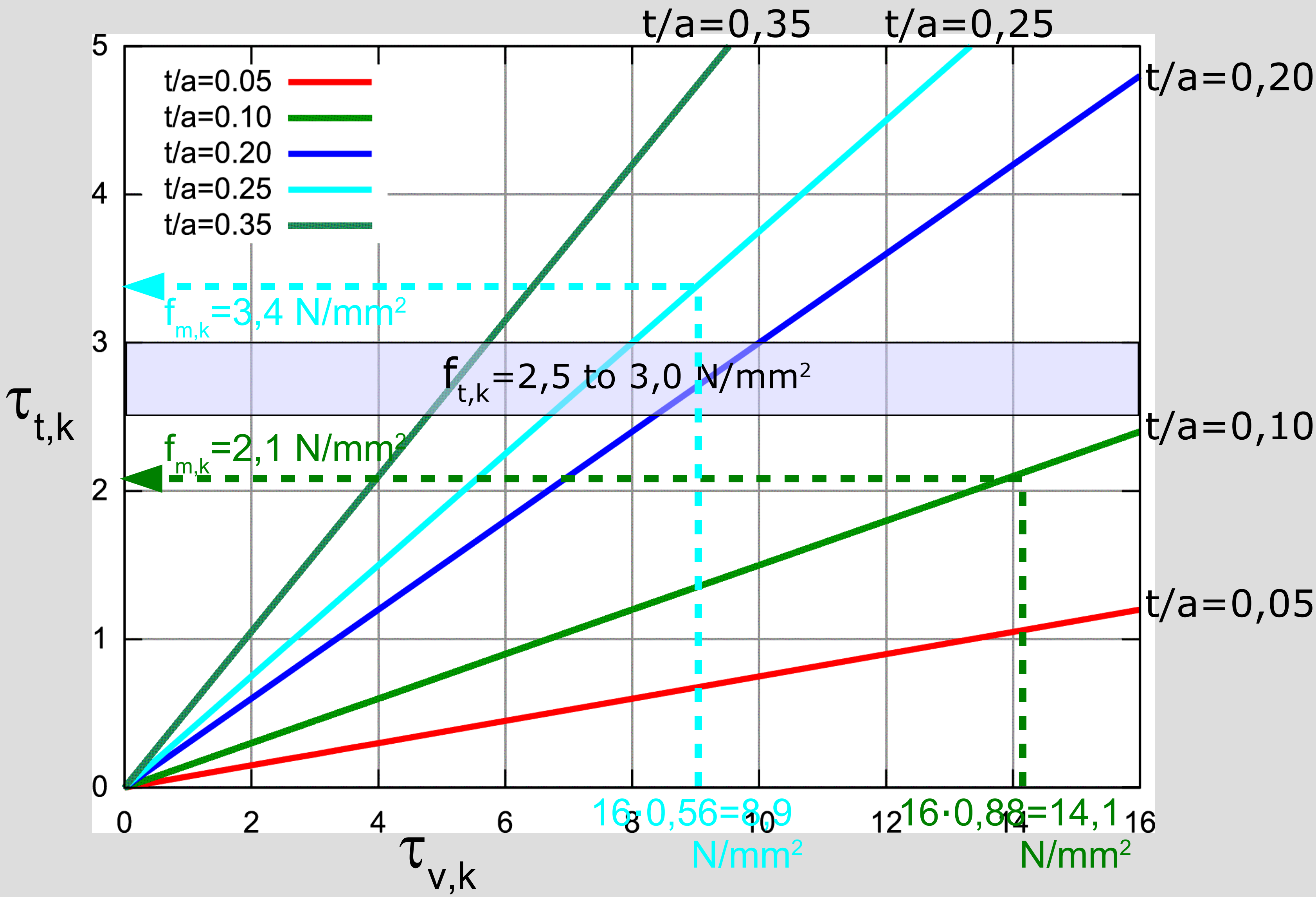


Linear elastic stress peaks



Reduction of shear strength due to high local elastic stress peaks
(absolute value of shear strength for CLT is still unknown)


t/a=0,35
t/a=0,25
t/a=0,20
t/a=0,10
t/a=0,05
t/a=0.05
t/a=0.10
t/a=0.20
t/a=0.25
t/a=0.35
$f_{t,k}$=2,5 to 3,0 N/mm²
$\tau_{t,k}$
$\tau_{v,k}$
0
1
2
3
4
5
0
2
4
6
8
10
12
14
16


t/a=0,35
t/a=0,25
t/a=0,20
t/a=0,10
t/a=0,05
t/a=0.05
t/a=0.10
t/a=0.20
t/a=0.25
t/a=0.35
f m,k =3,4 N/mm²
f t,k =2,5 to 3,0 N/mm²
f m,k =2,1 N/mm²
τ t,k
τ v,k
16·0,56=8,9 N/mm²
16·0,88=14,1 N/mm²
0
1
2
3
4
5
0
2
4
6
8
10
12
14
16

Summary:

- Present test results show, that shear strength for CLT is remarkable higher than conventional shear strength for e.g. glulam
- Test results failed mostly due to load introduction (shear field tests) or bending (CUAP)
- Reliable value for shear strength for CLT is still unknown (test configuration!).
- Conclusion 1: Torsional mechanism can limit overall shear bearing capacity for higher (t/a) values, if high shear strength values are introduced.
- Conclusion 2: strong decrease of effective shear strength for higher (t/a) values due to elastic stress peaks.
- Conclusion 3: With increasing thickness of the boards, a reduction of shear strength can be expected.

Thank you for your attention!