

COST E55
Modelling the Performance of
Timber Structures

Ductility Aspects for Joints

Hans Joachim Blass



Timber joints

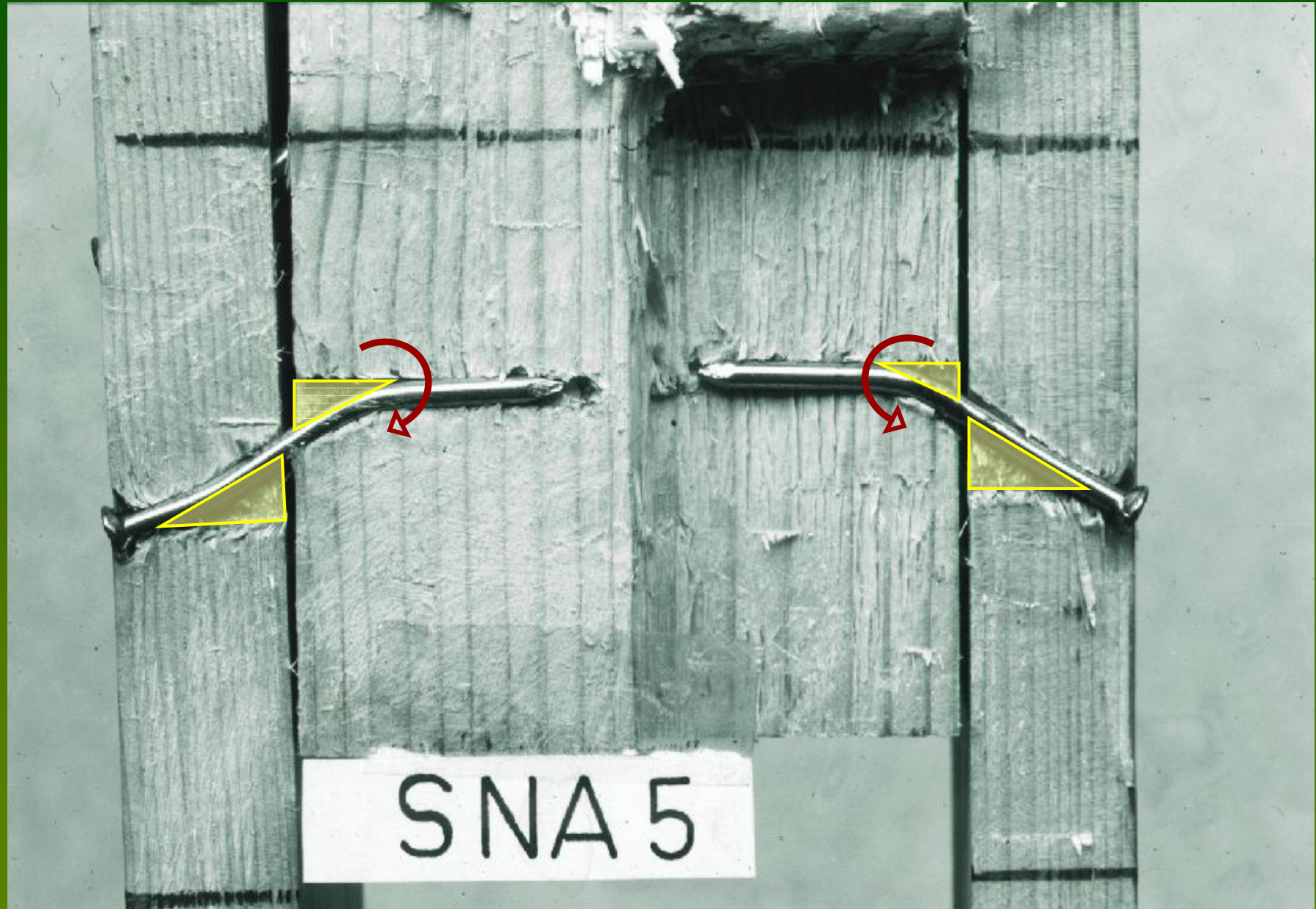
- Glued joints
- Joints with mechanical fasteners
- Carpenter joints

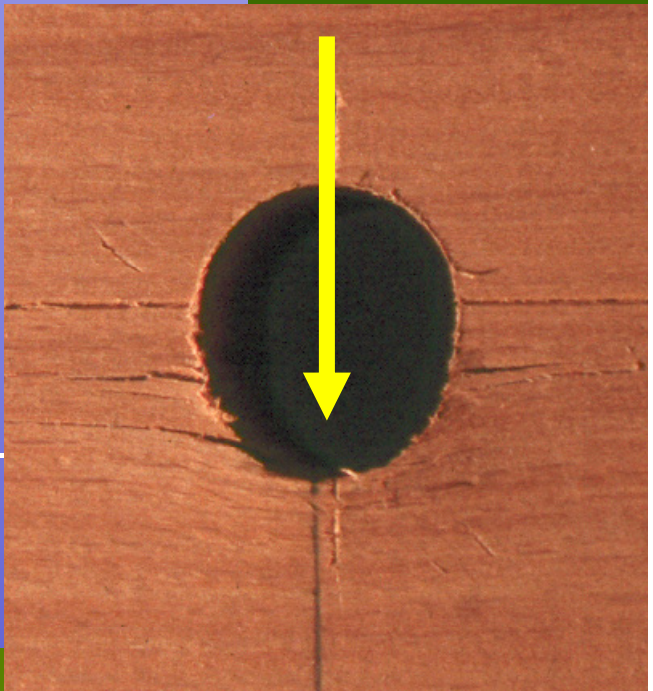
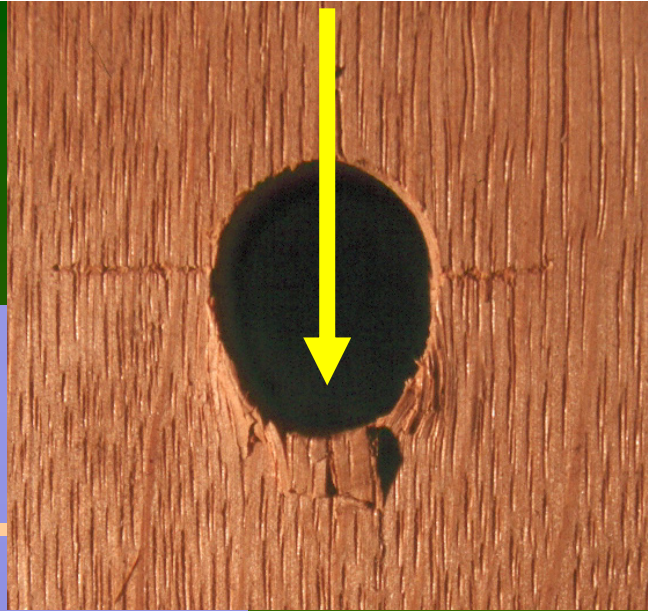
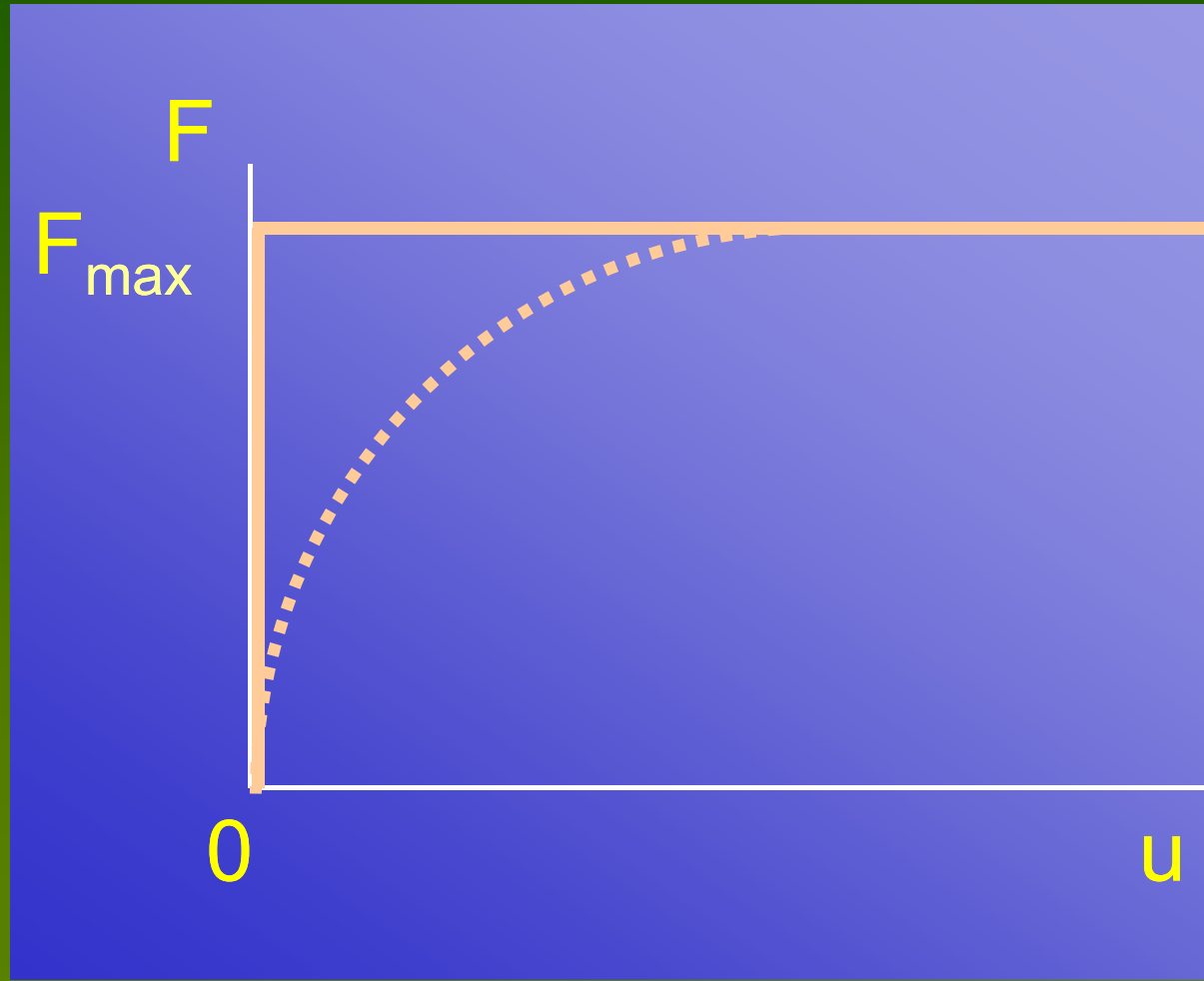


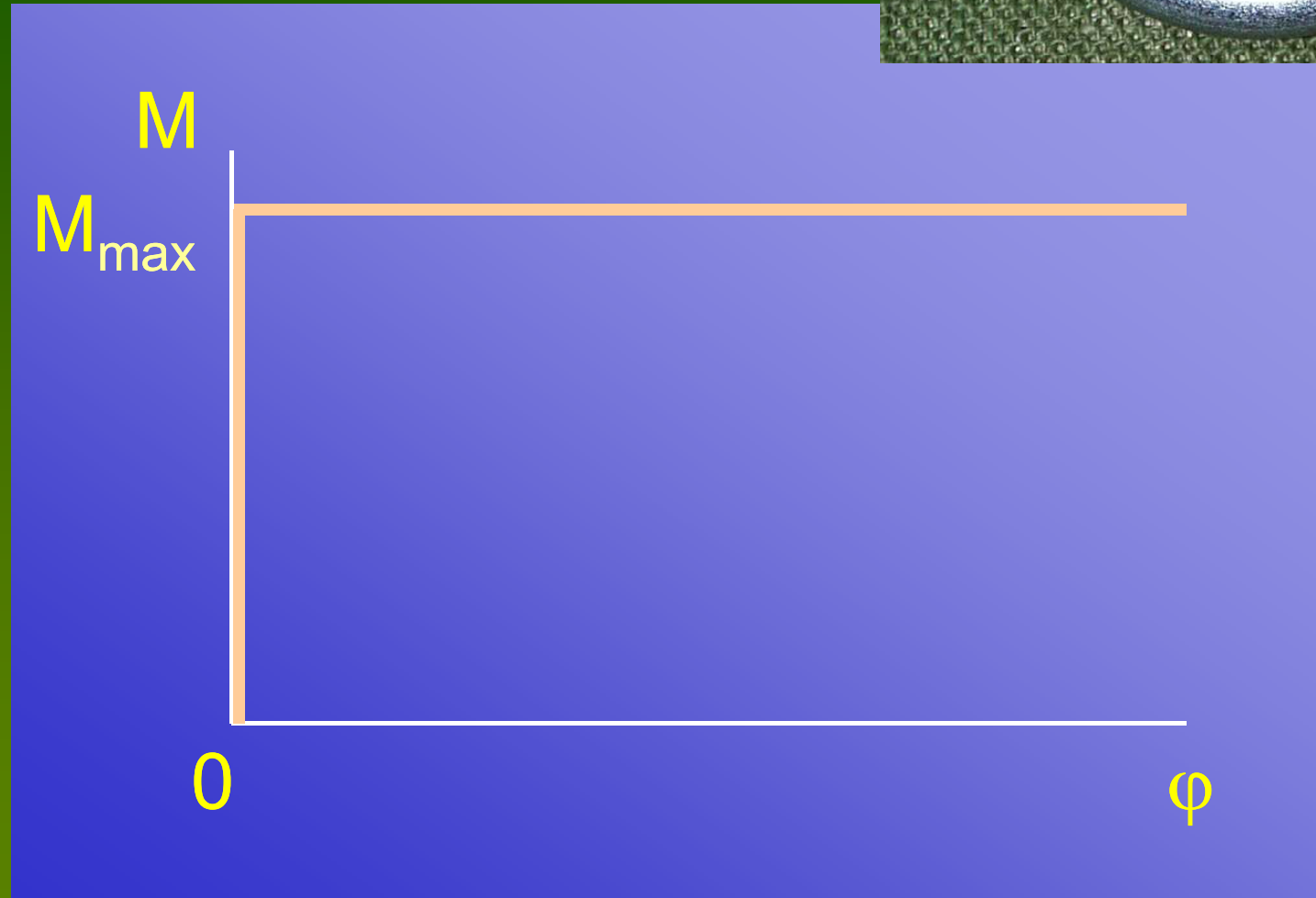
Joints with mechanical fasteners

- Dowel type timber joints
- Connector joints
- Truss plate joints





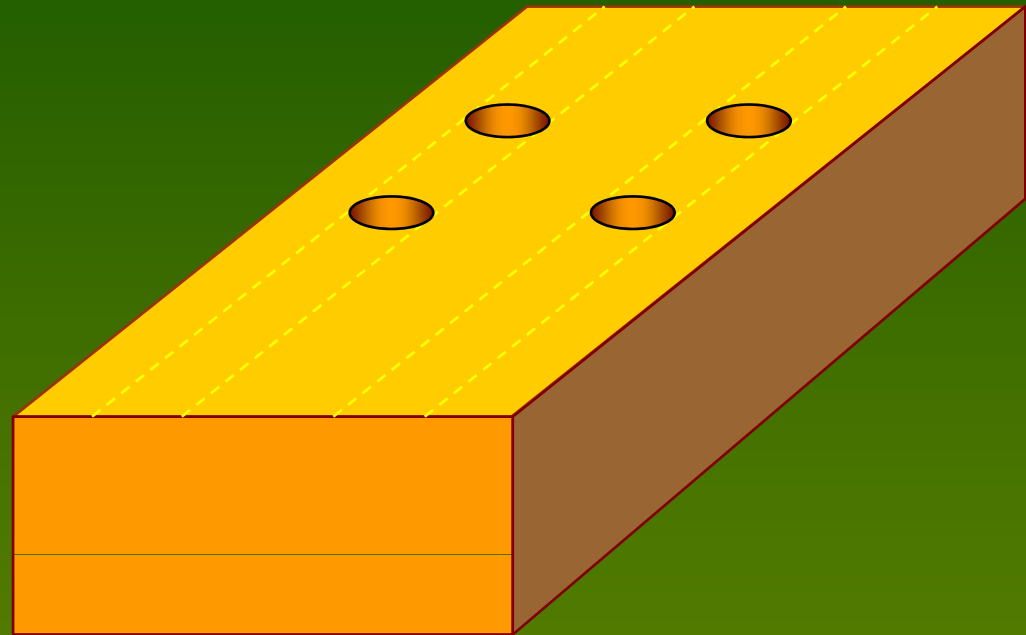




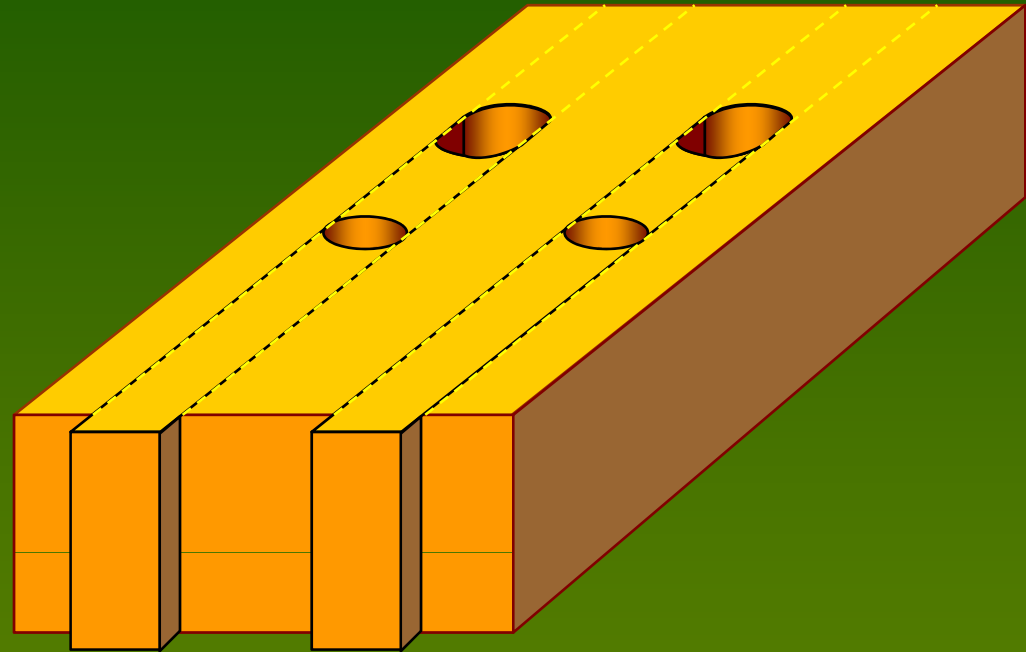
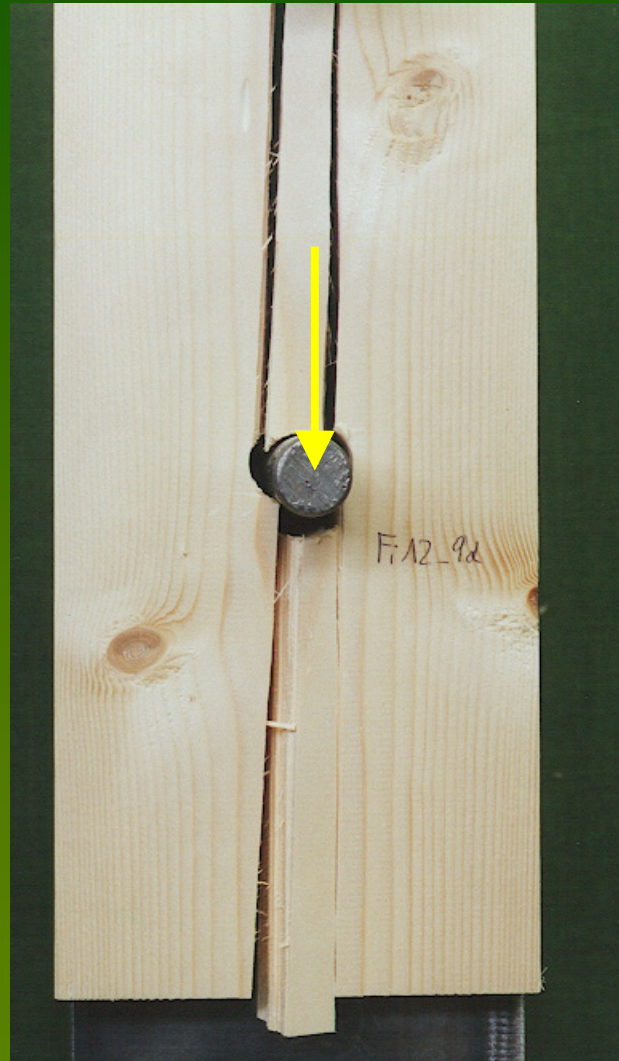
Brittle failure of dowel-type fasteners

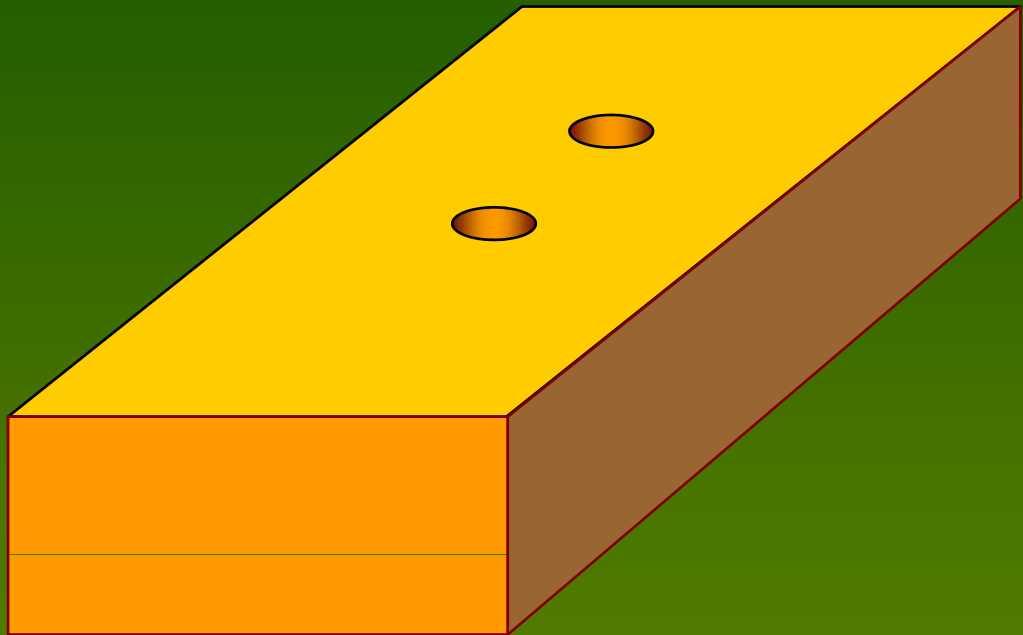


Failure modes in joints

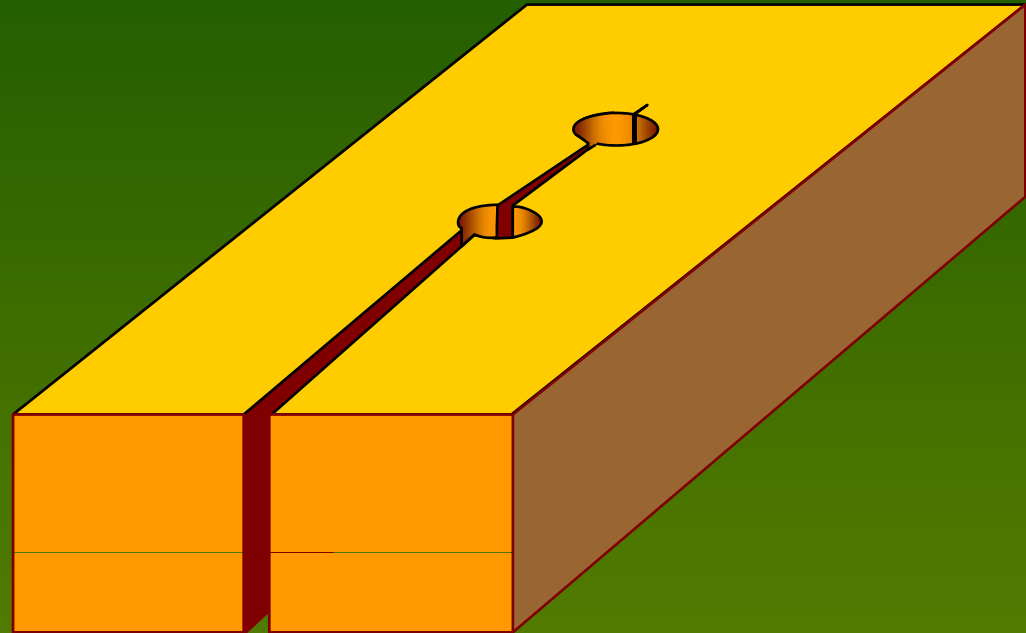
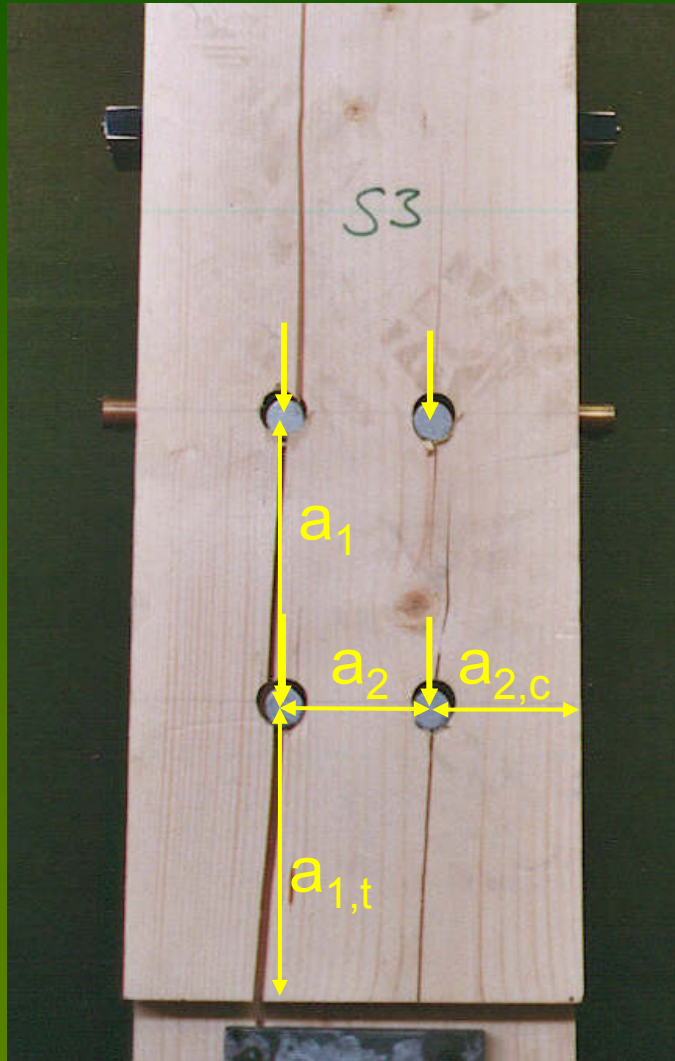


Row shear failure



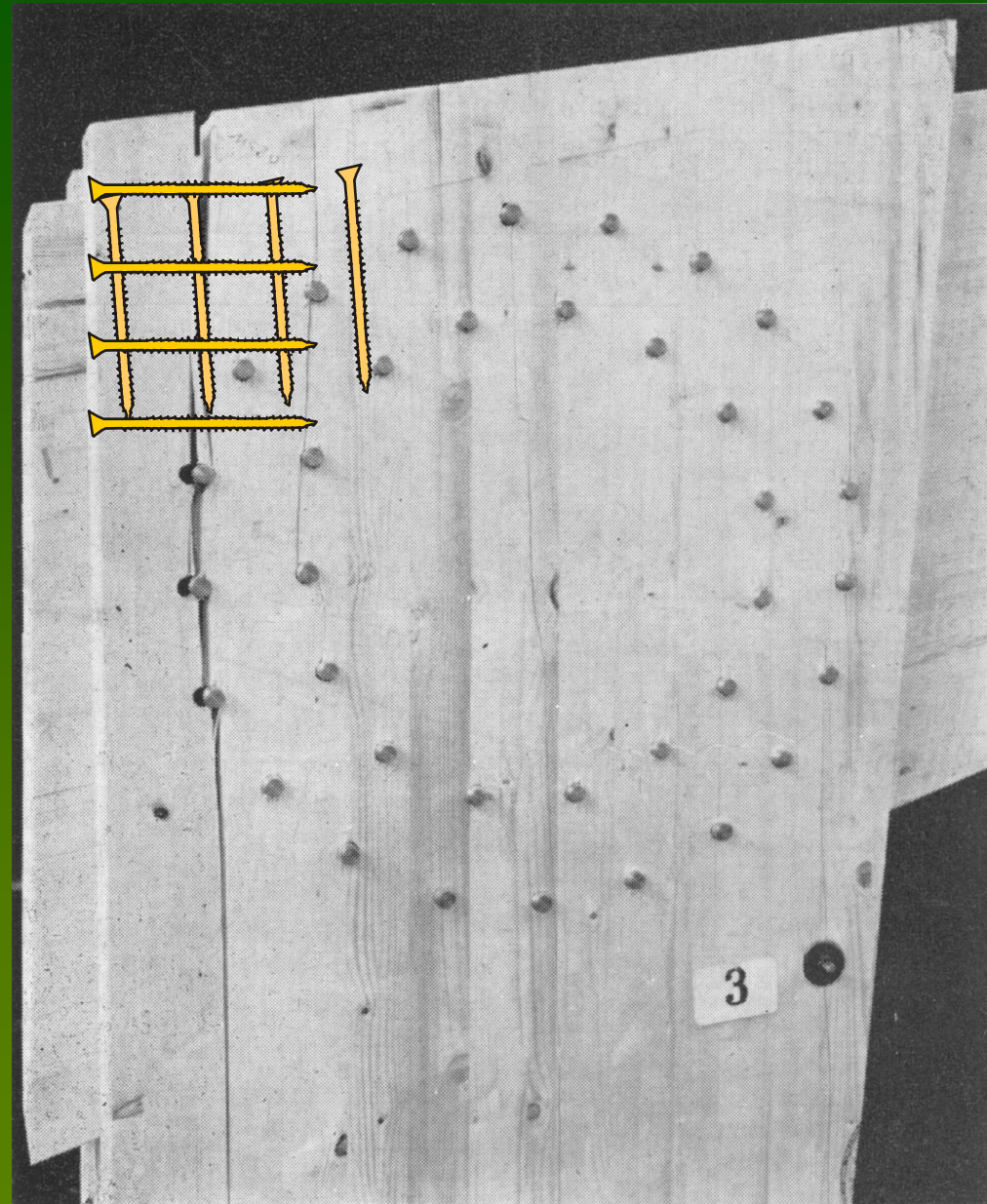


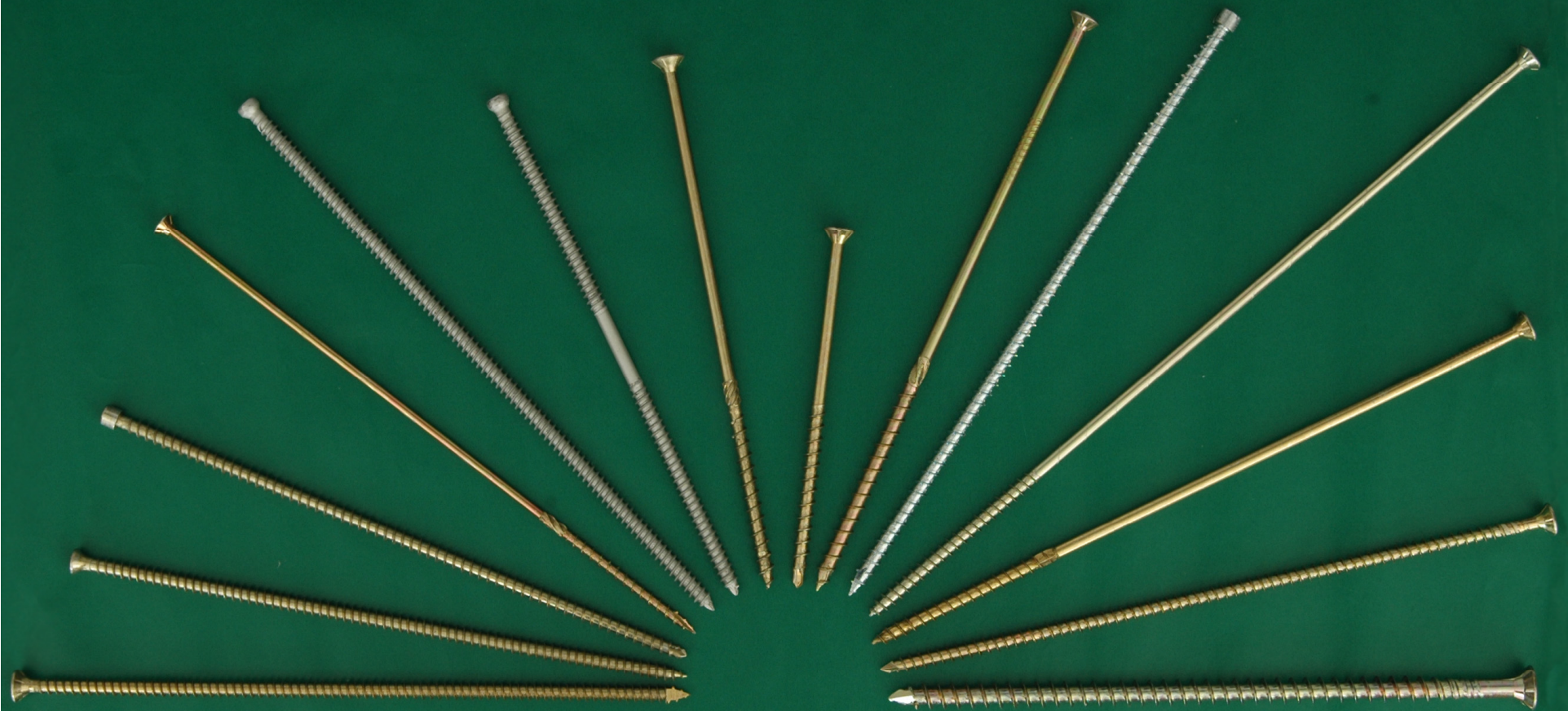
Splitting



Heimeshoff (1977):

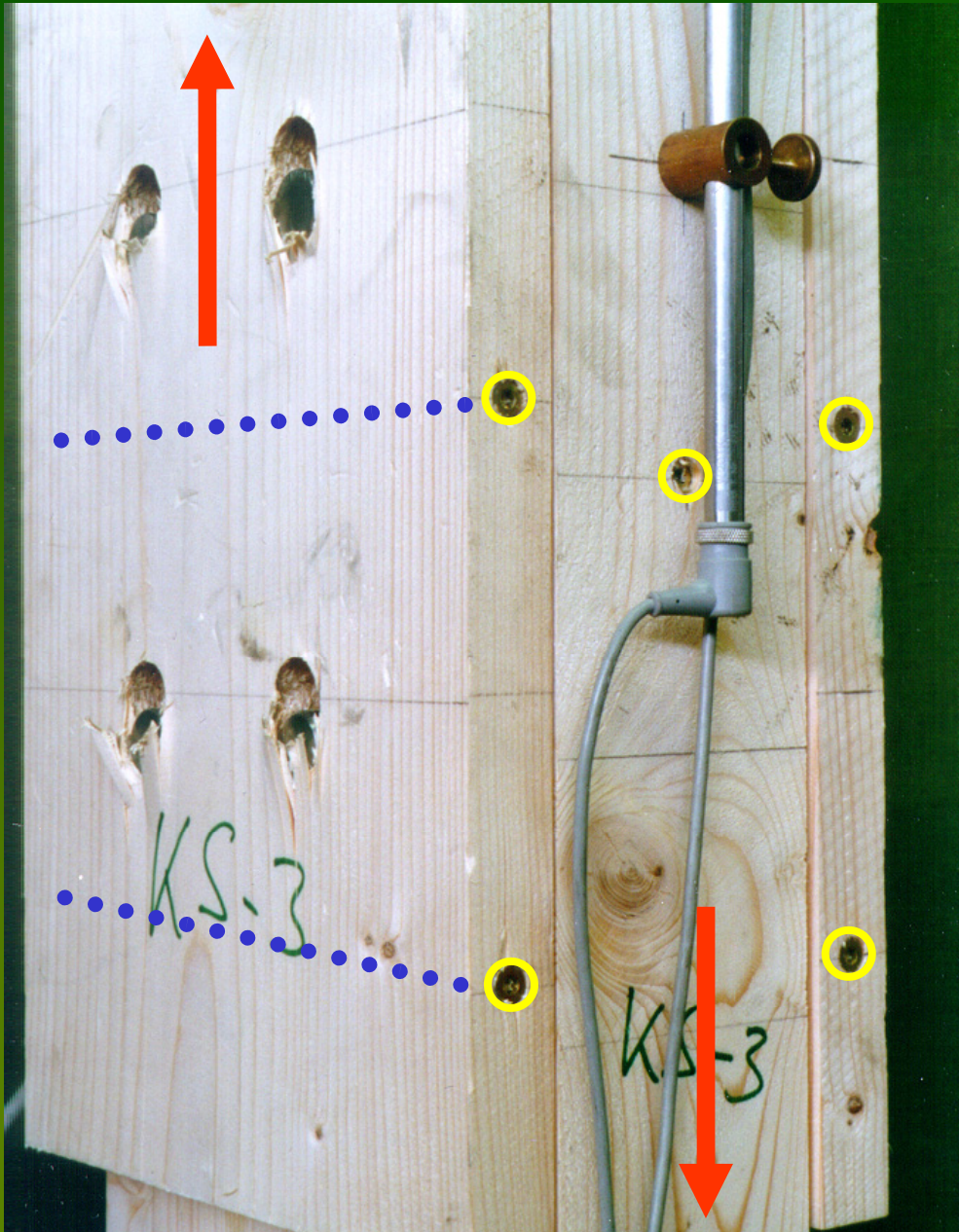
Reinforcement in frame corners
by using ringed shank nails or
screws





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Reinforcement using self-drilling screws

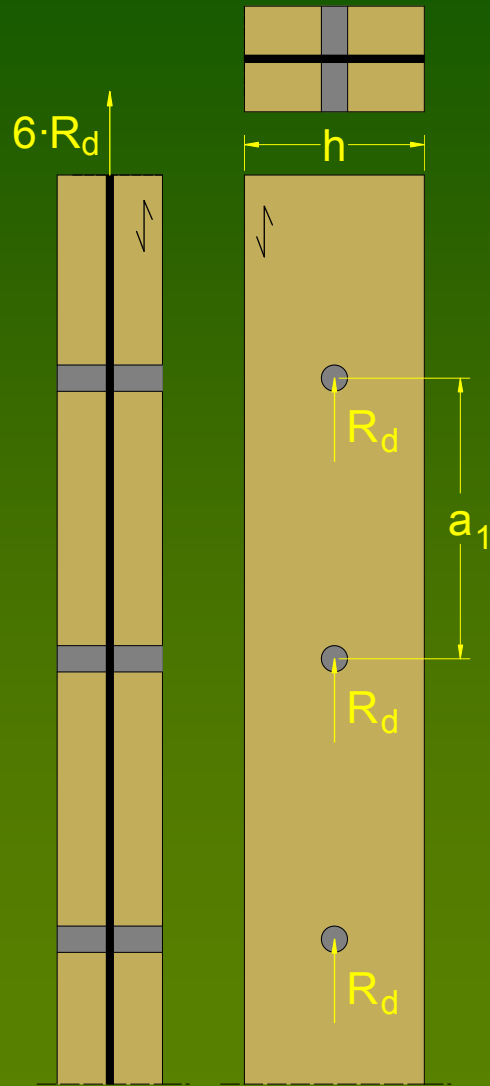




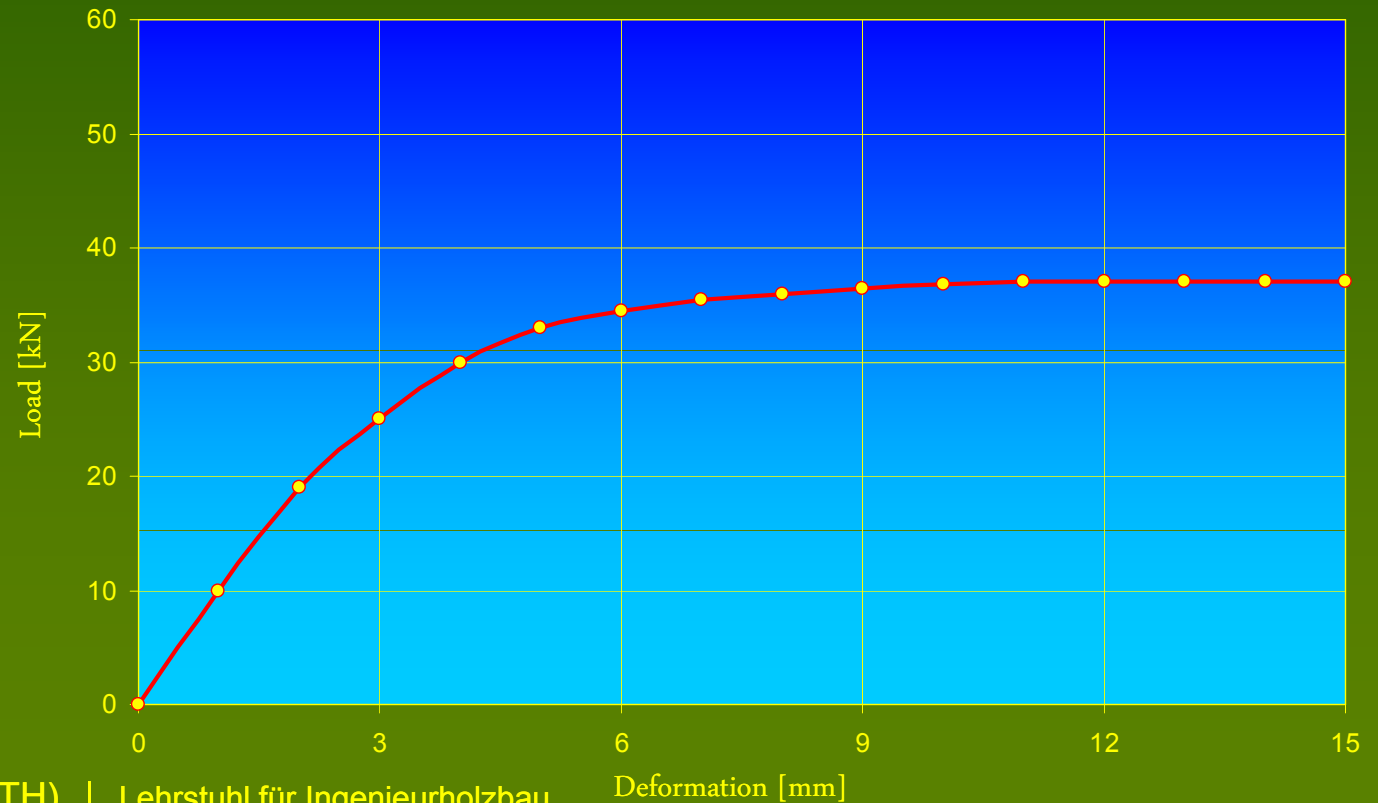
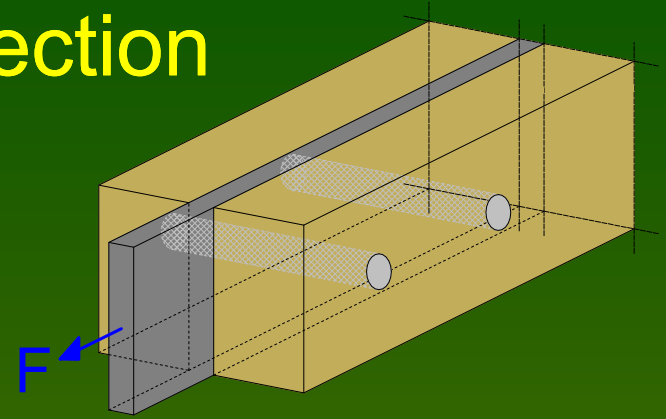
Crack growth
is stopped by
the screws



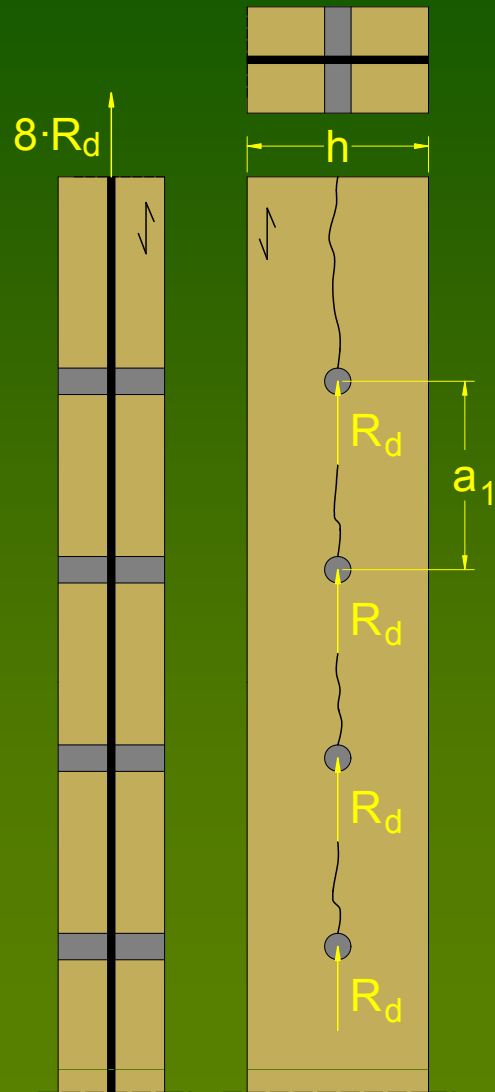
Non reinforced connection



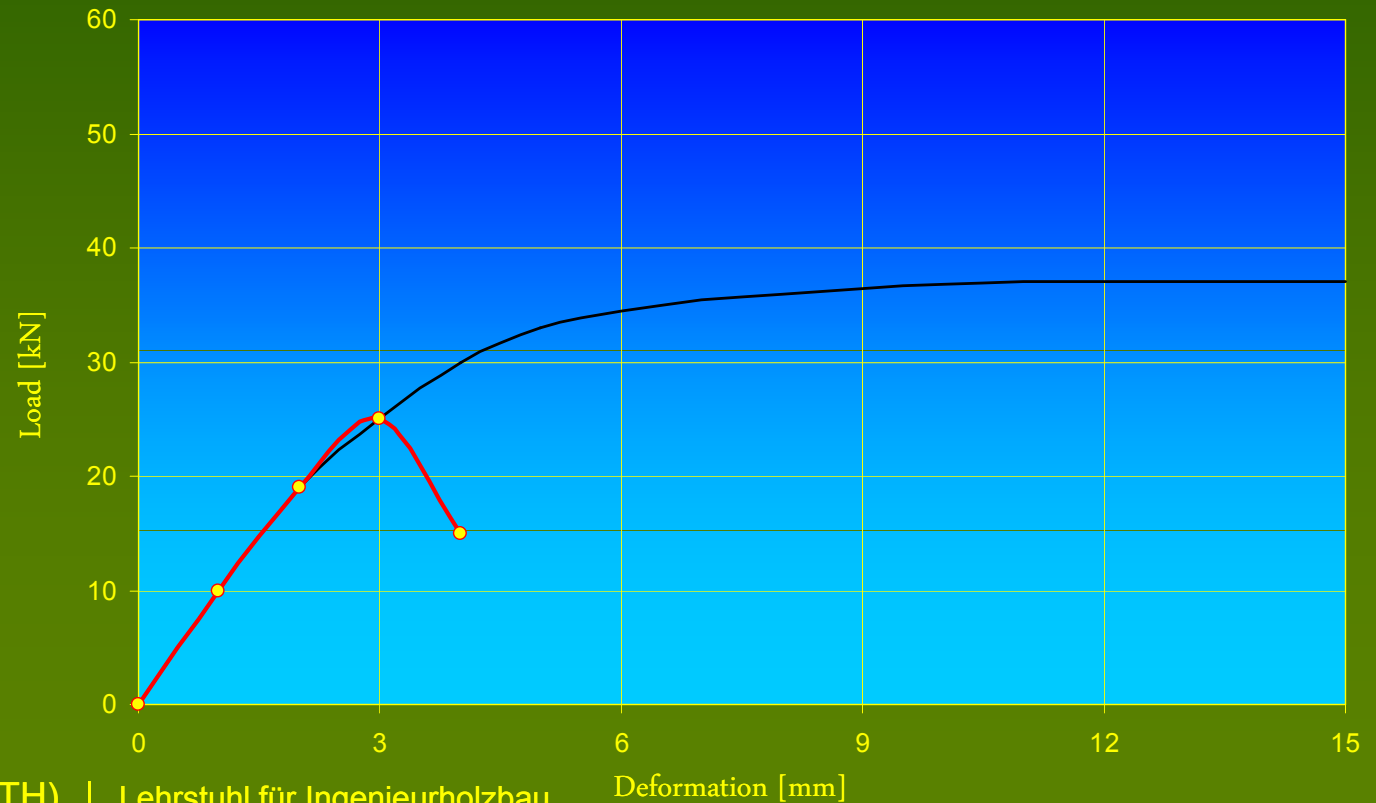
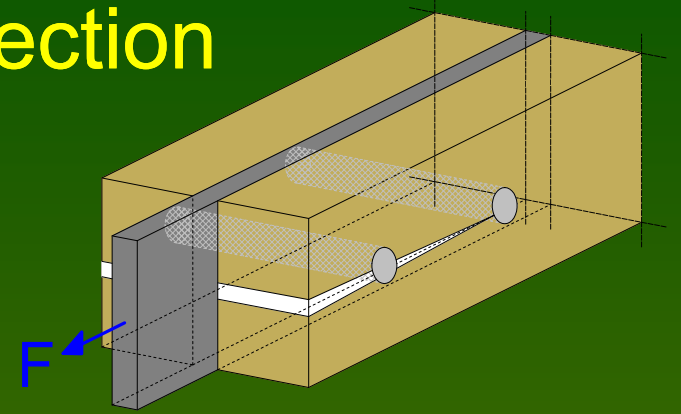
Large spacing a_1



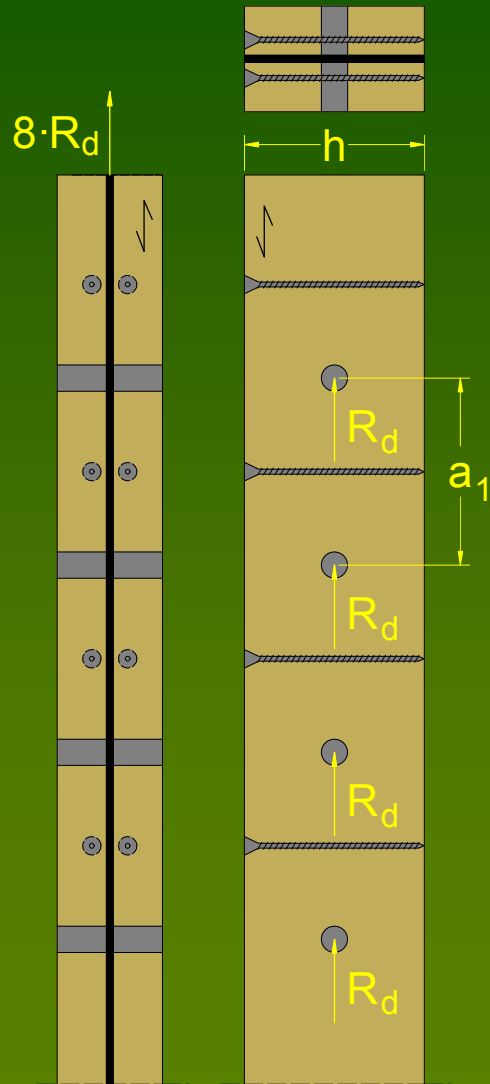
Non reinforced connection



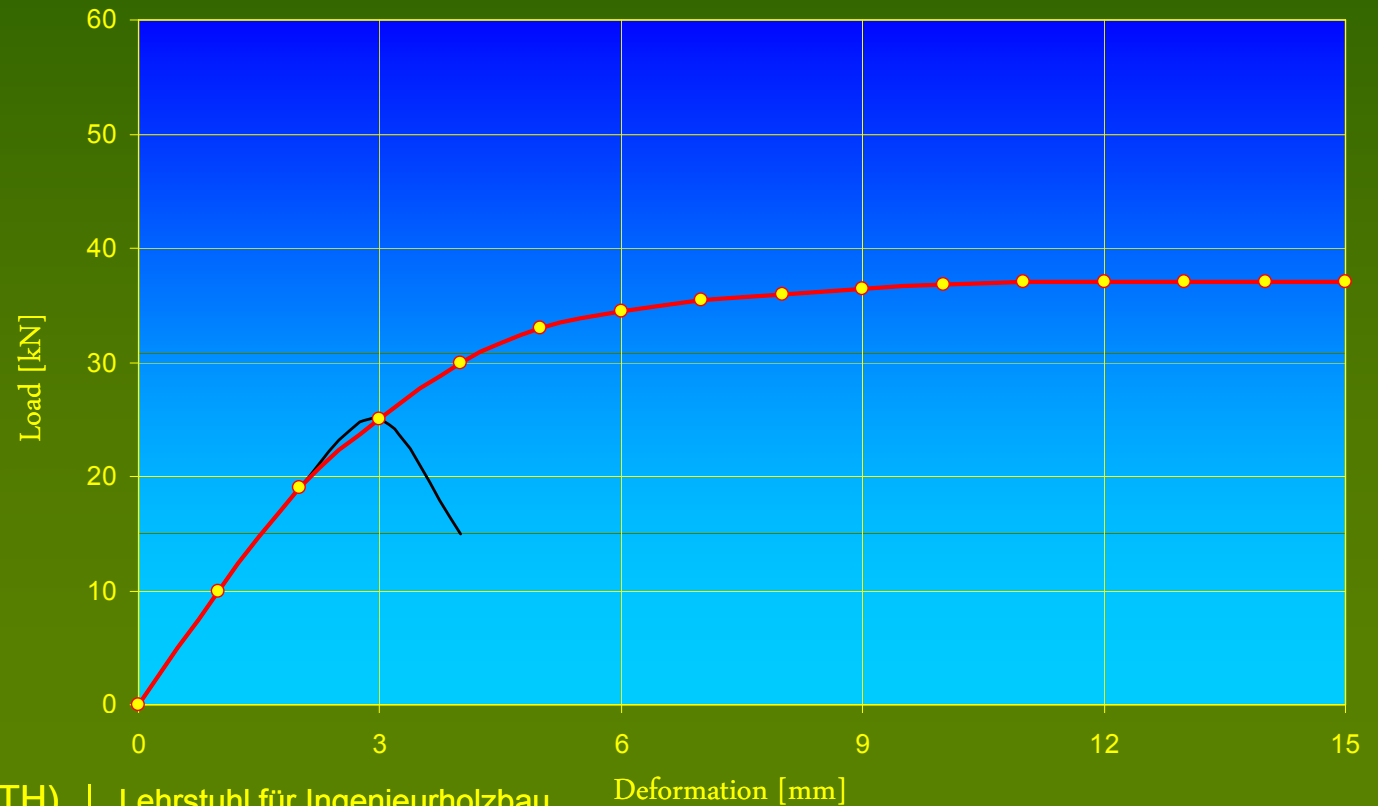
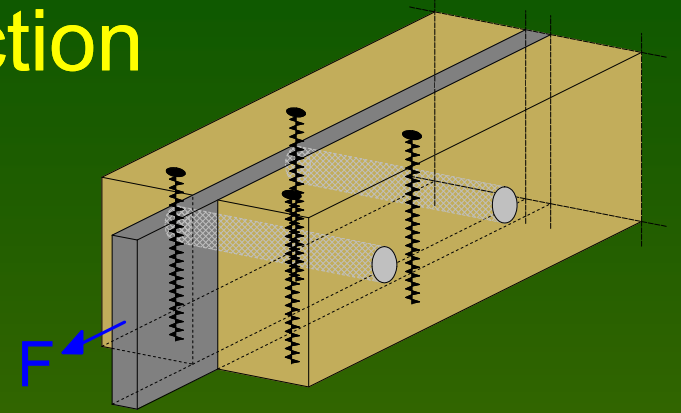
Minimum spacing a_1



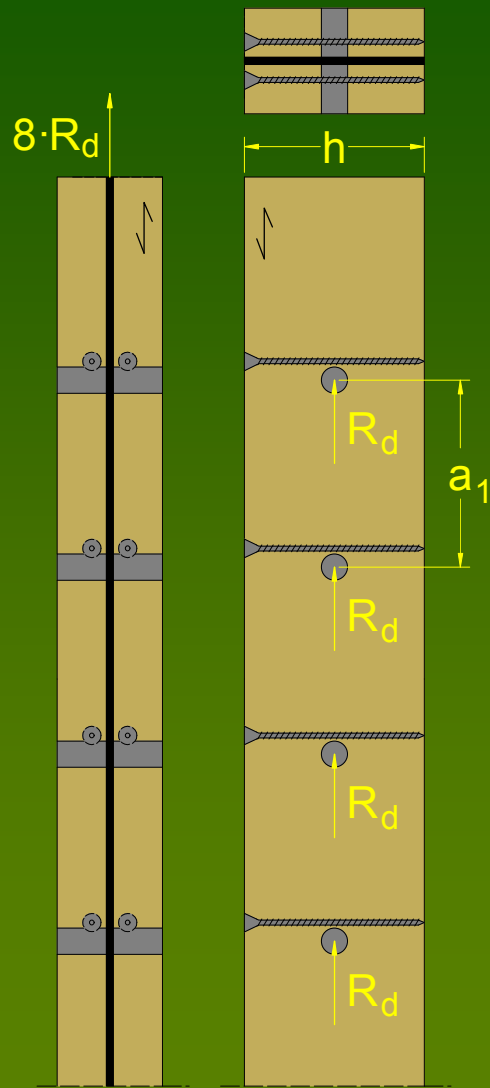
Reinforced connection



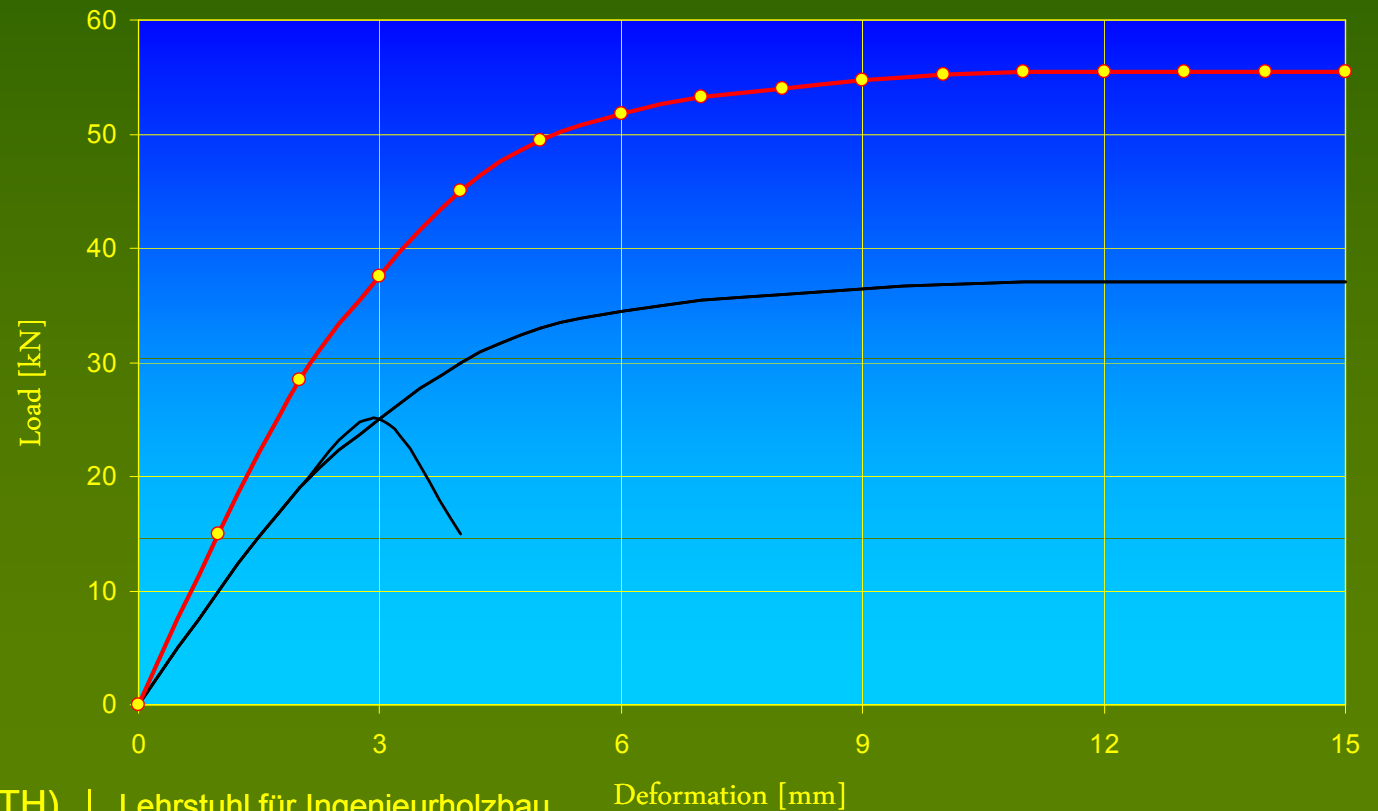
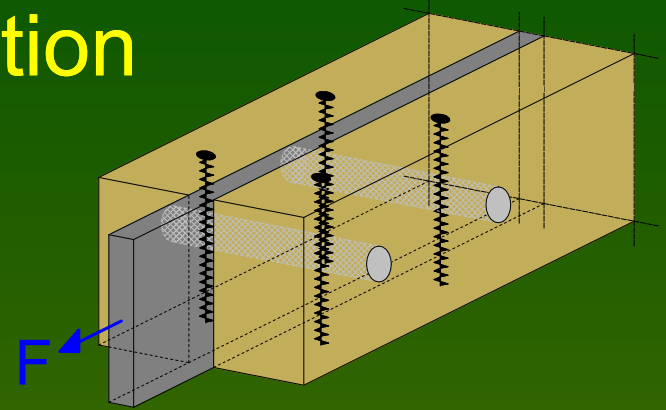
Minimum spacing a_1



Reinforced connection



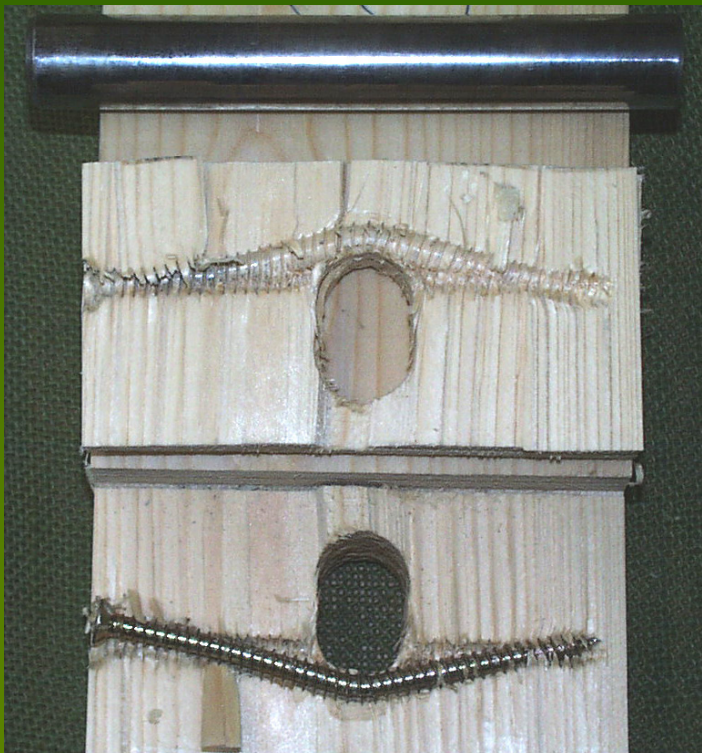
Minimum spacing a_1

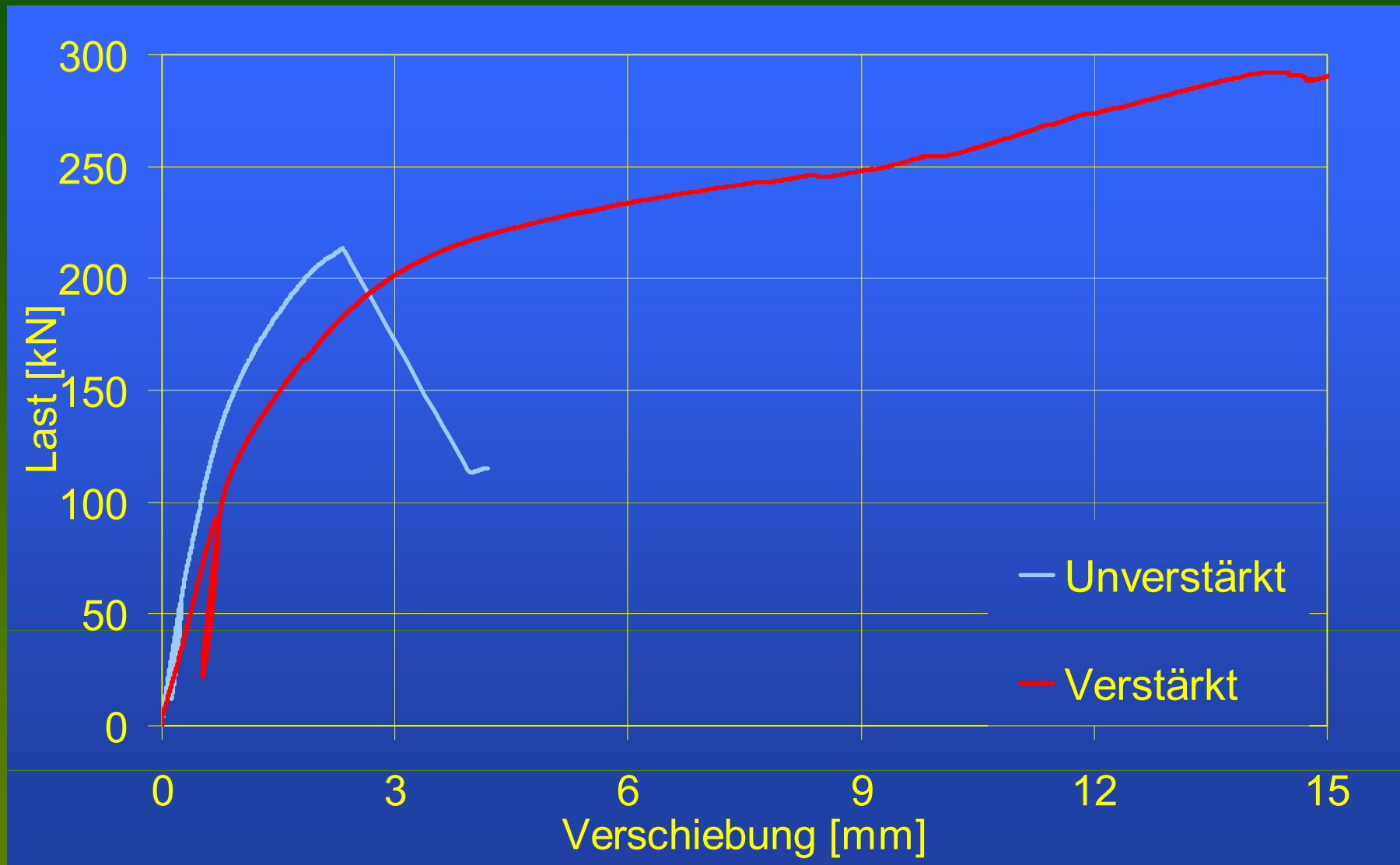


Non reinforced joint: Failure mode splitting



Reinforced joint: embedding failure





Berechnung von verstärkten Verbindungen - Version 1.0

Datum: 18.01.2007

ALLGEMEINE PARAMETER

Anzahl hintereinander

Anzahl nebeneinander

Abstand der Verbindungen

Winkel zwischen Keilen

charakteristische Fugenfestigkeit

Modifikationsbeiwert

charakteristischer Fugenabstand

Allgemeine Parameter

Tragfähigkeitsklasse

Bemessungswert der Fugenfestigkeit

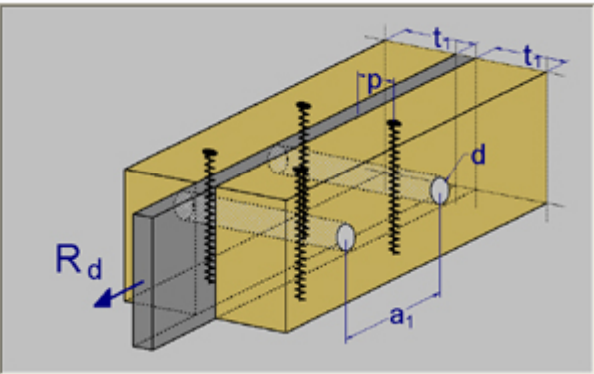
Bemessungswert der Fugenabstände

Anzahl der Vollgewindestchrauben

Berechnung von verstärkten Verbindungen - Version 1.0 Zum Beenden bitte...

Info | Allgemeine Eingaben | Verstärkungselemente | **Stahlblech-Holz-Verbindung** | Holz-Holz-Verbindung

- [-] Einschnittige Verbindung
- [+] Zweischnittige Verbindung
 - [+] Außenliegende Stahlbleche
 - [] Innenliegendes Stahlblech



Durchmesser d in mm:

Bauteildicke t₁ in mm:

Fließmoment M_{y,k} in Nm: DIN 1052

Lochleibungsfestigkeit f_{h,k}: DIN 1052

Fugenabstand p in mm: p = 2,5 ds

R_{ef,d} [kN] = 125

R_{pl,d} [kN] = 175

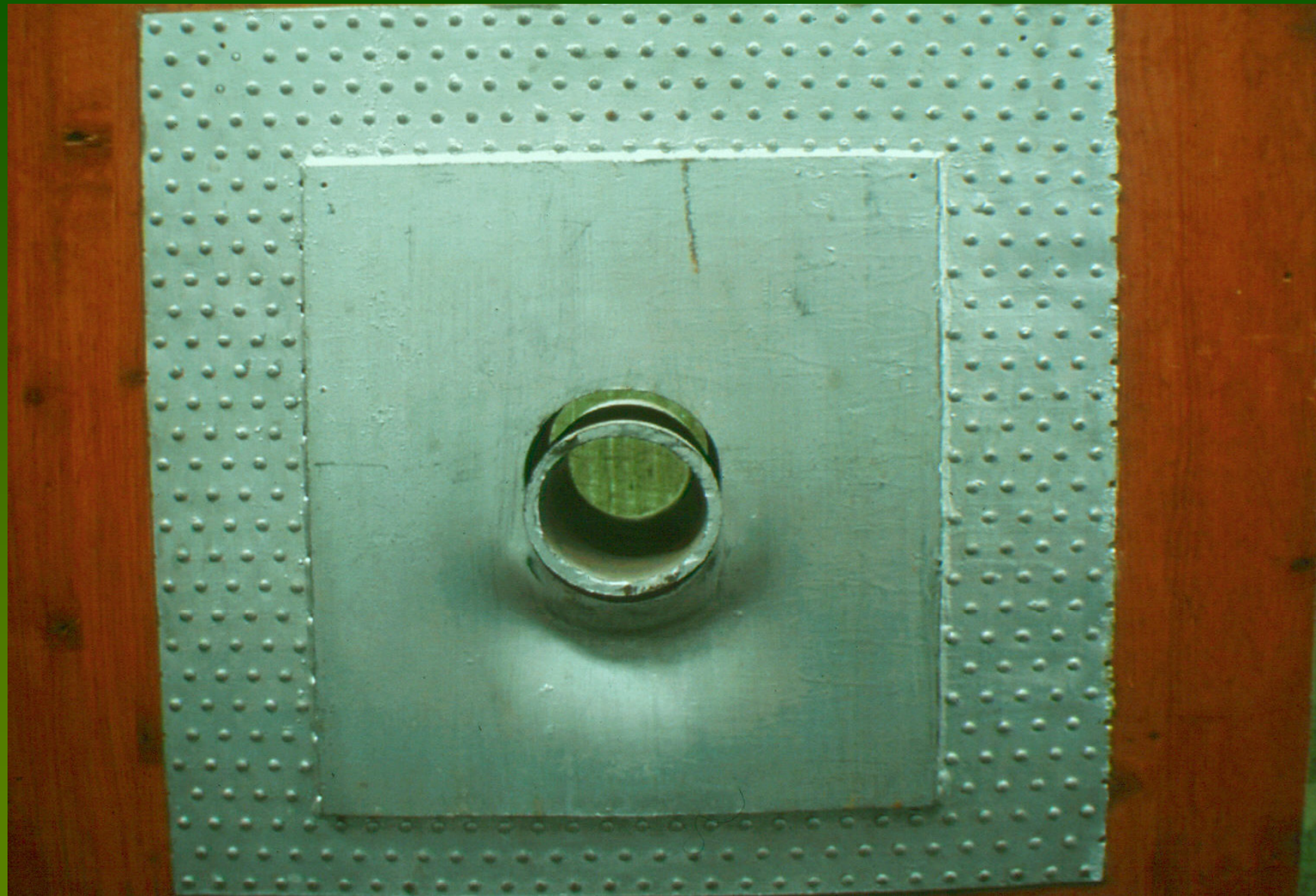
R_{ver,d} [kN] = 213

Traglastzuwachs [%] = 69.8

100
g/n
= 0.
36l
8.0
= 2
2

Skating arena Grefrath 1972

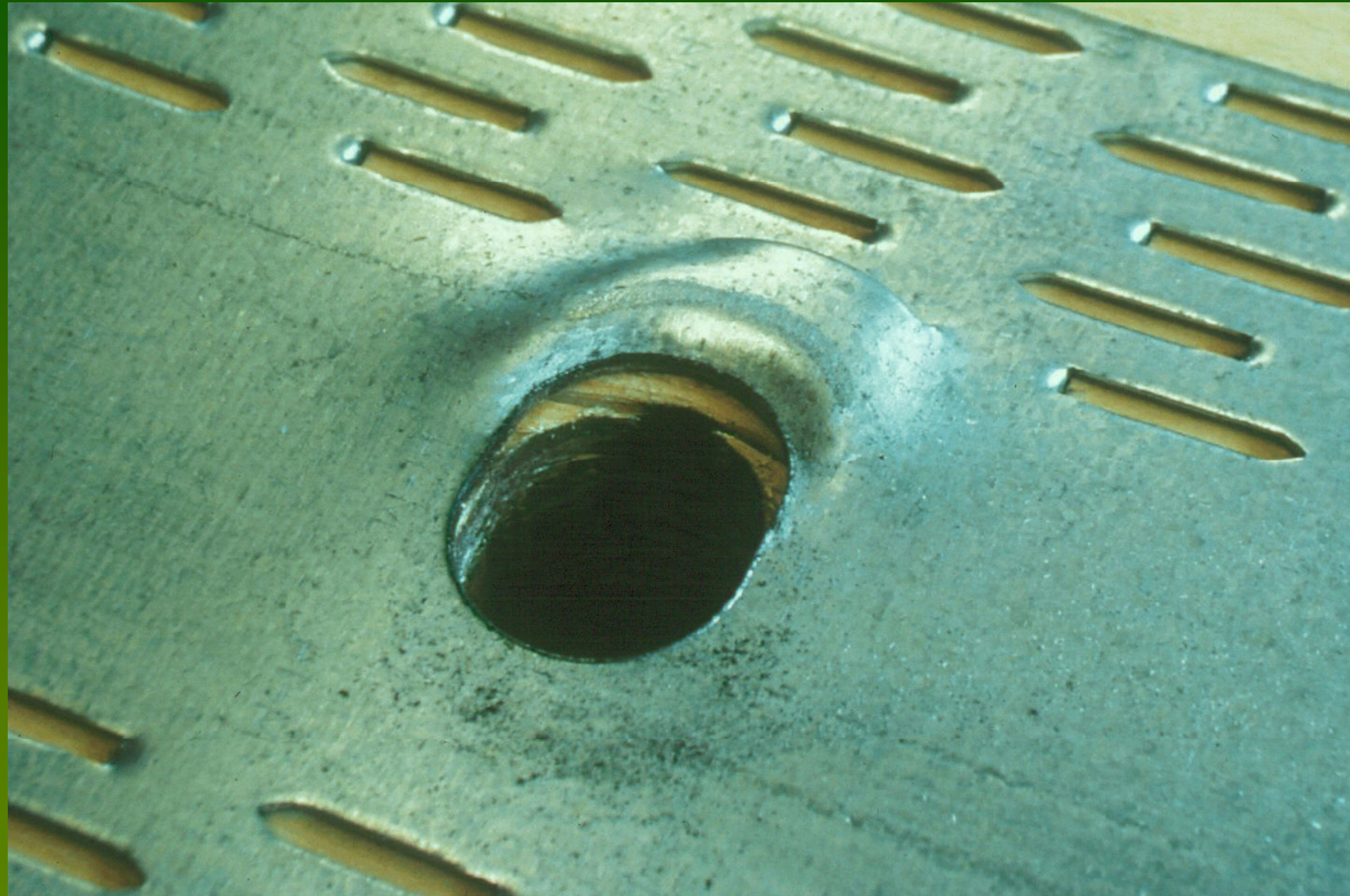




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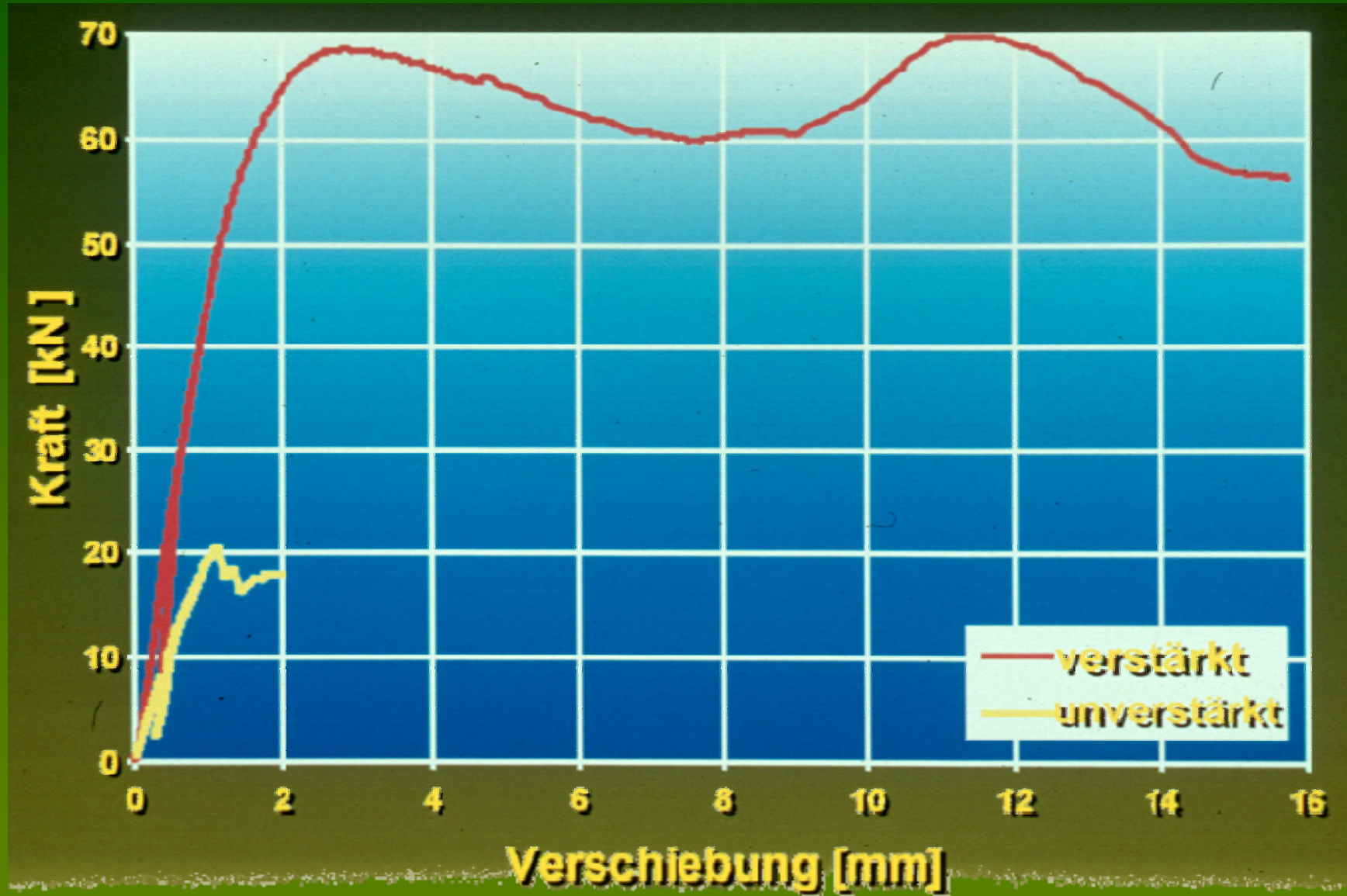
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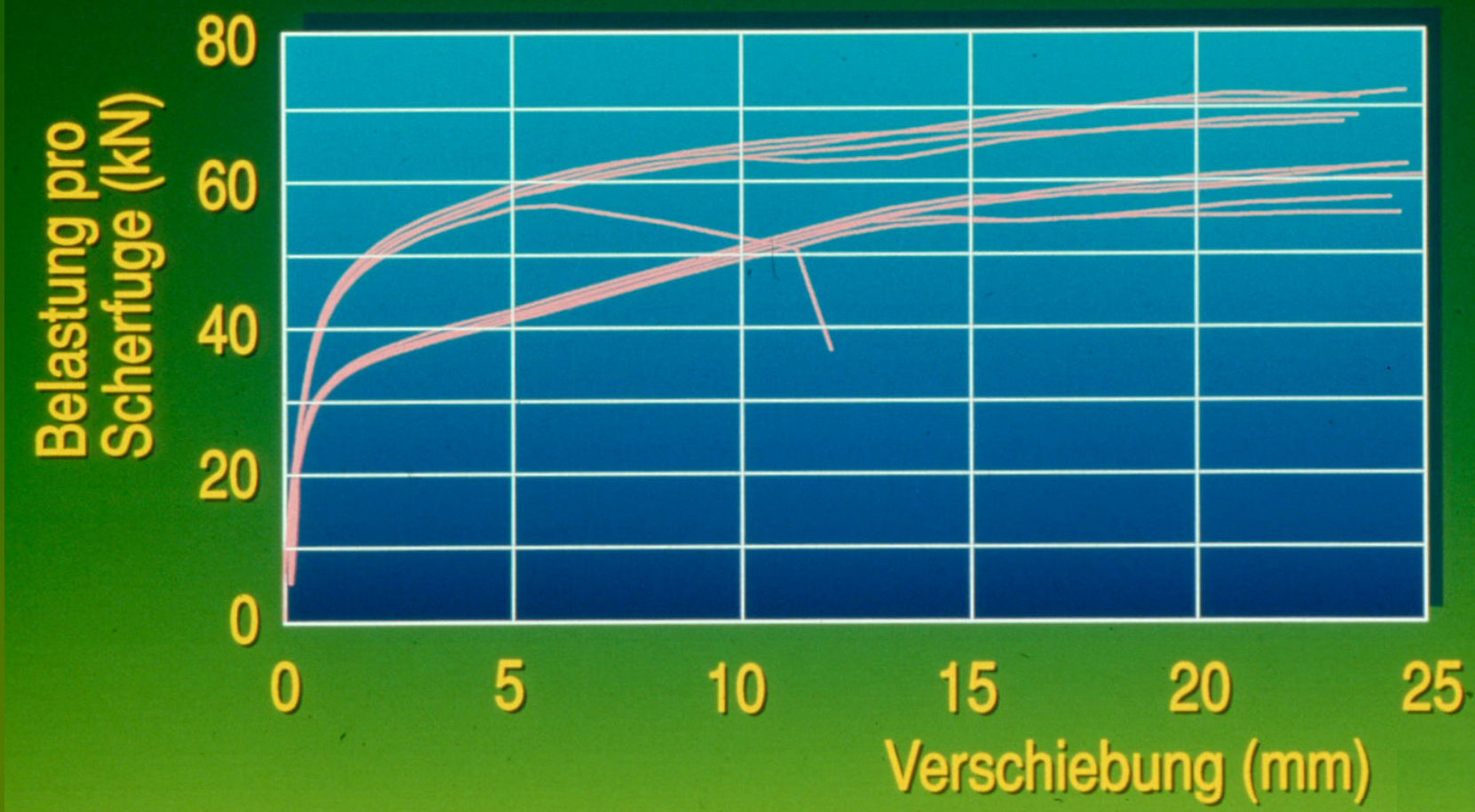
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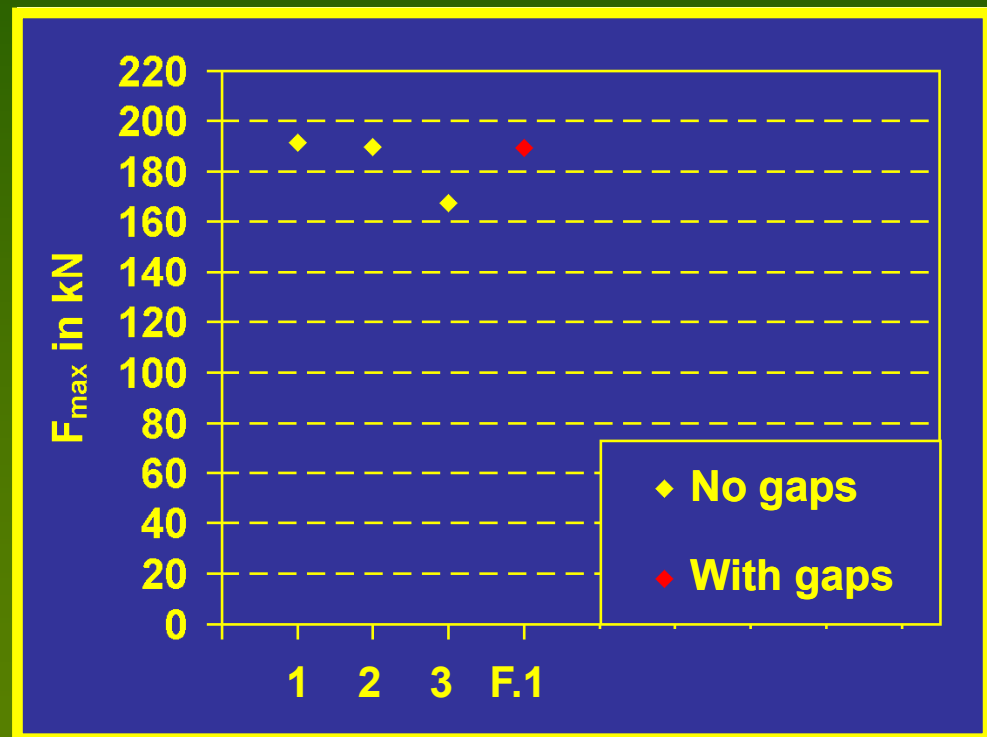
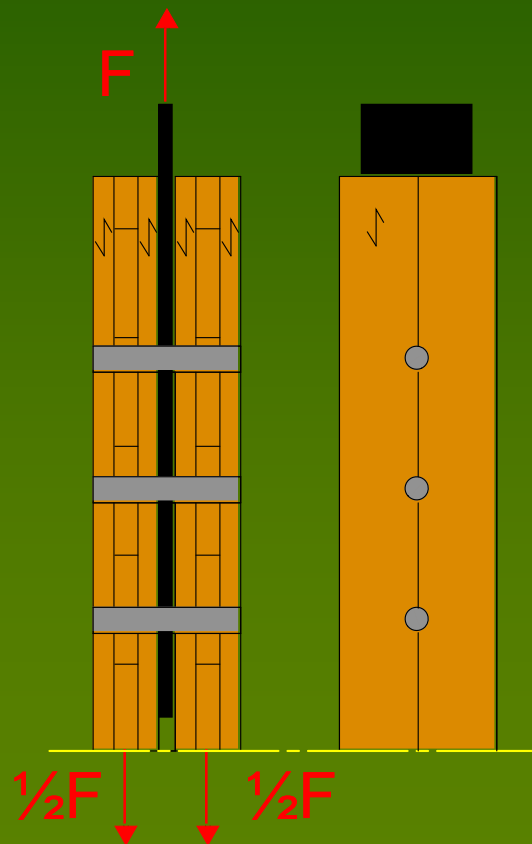


Cross Laminated Timber



Dowelled connection with CLT

- Dowels in double shear with steel centre member



Dowelled connection with CLT

- Observations:

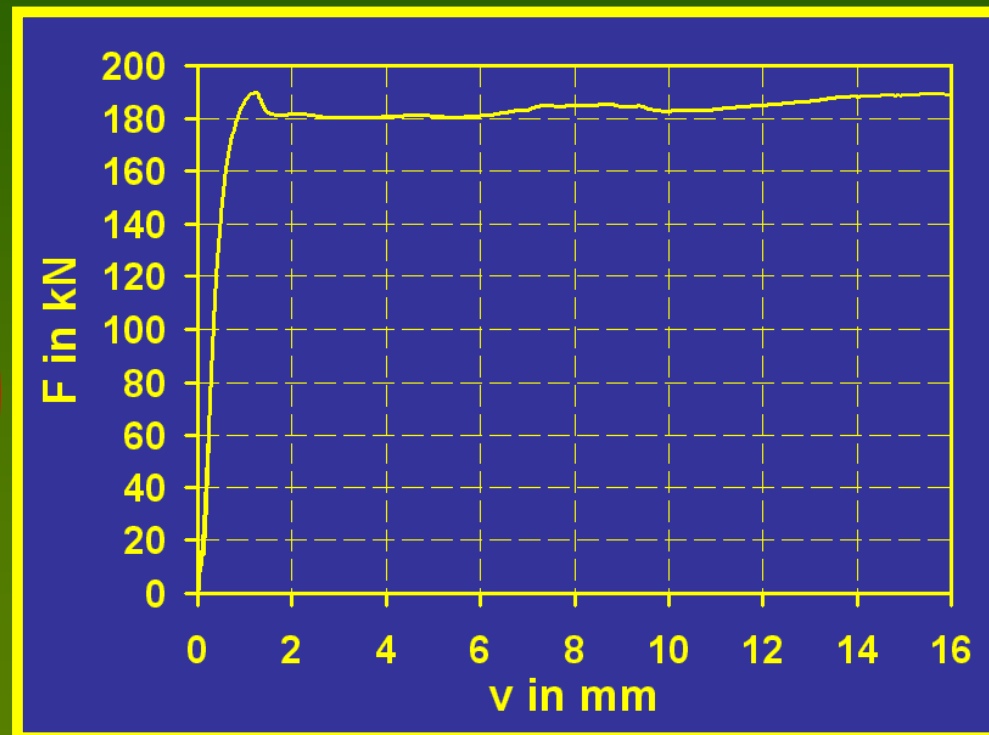
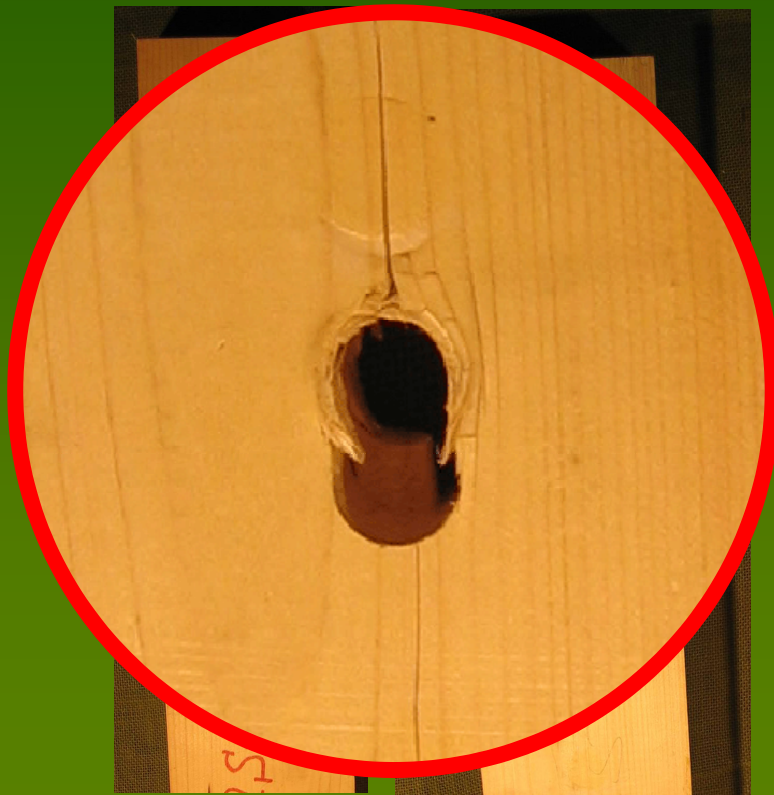


- Cracks in outer layers
- Block shear in outer layers
- Embedding deformation



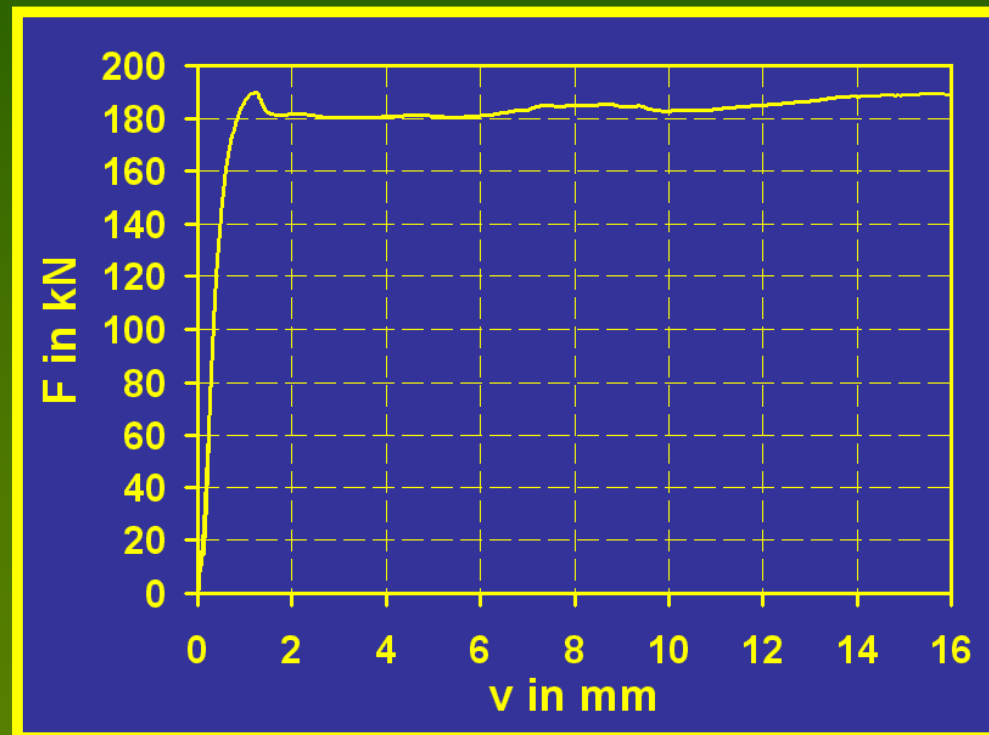
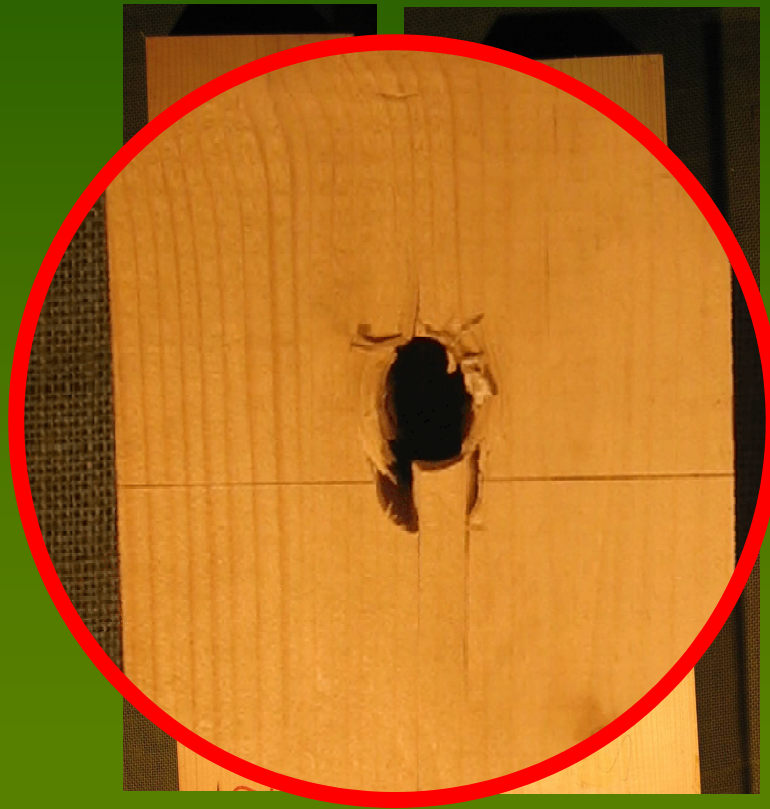
Dowelled connection with CLT

- Cracks in outer layer – Embedding deformation



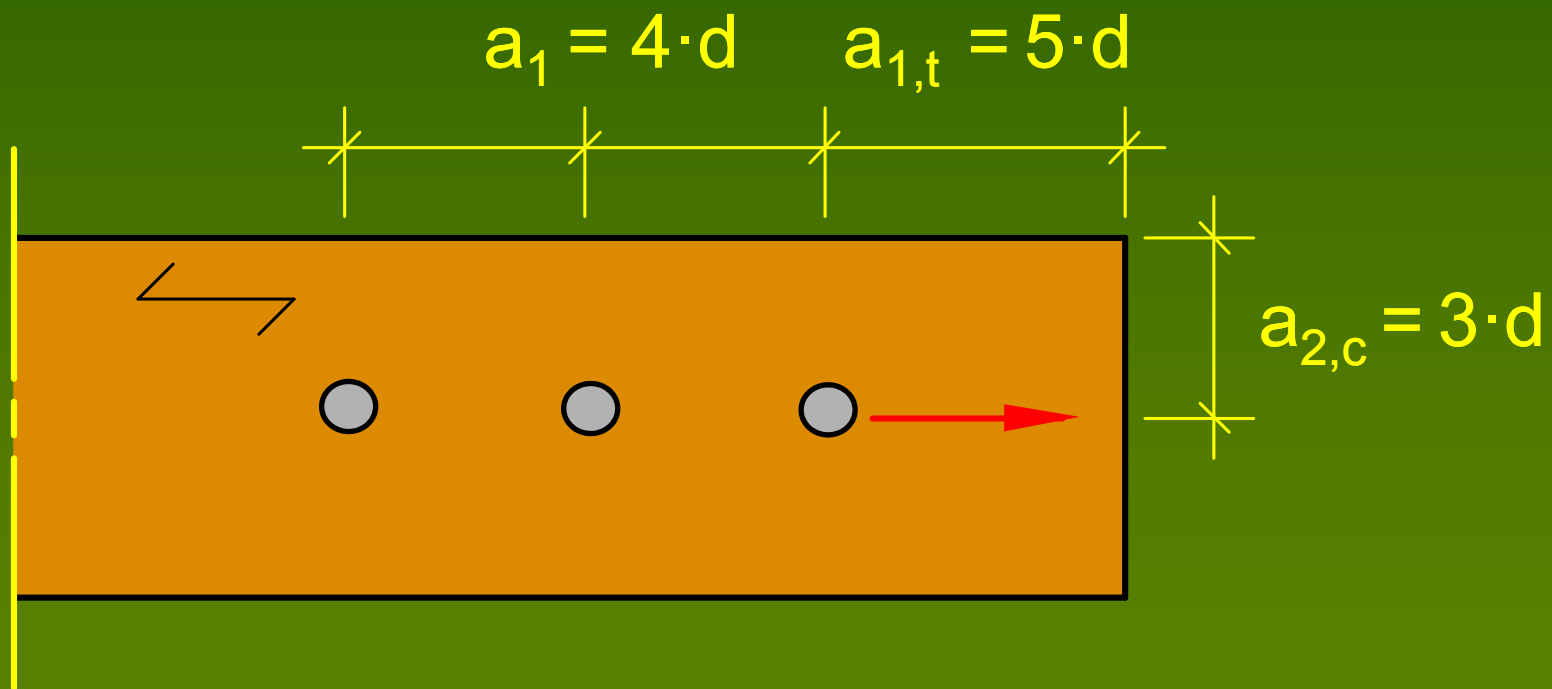
Dowelled connection with CLT

- Block shear in outer layer – Embedding deformation



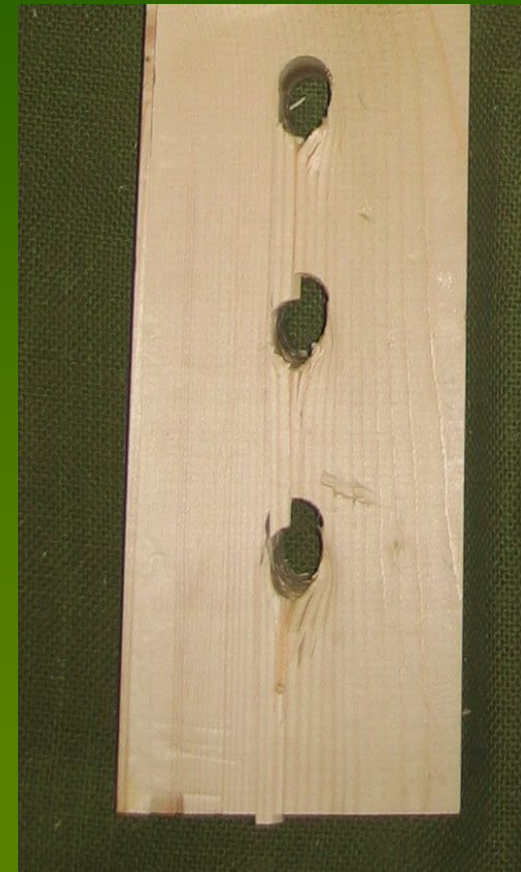
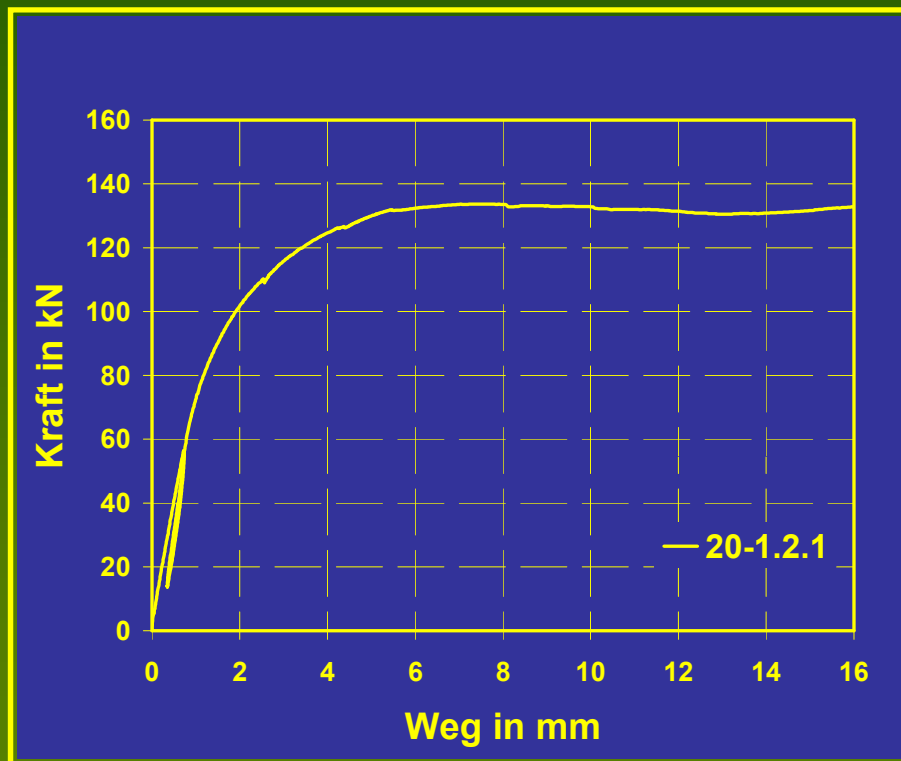
Dowelled connection with CLT

- Minimum spacing and end/edge distances



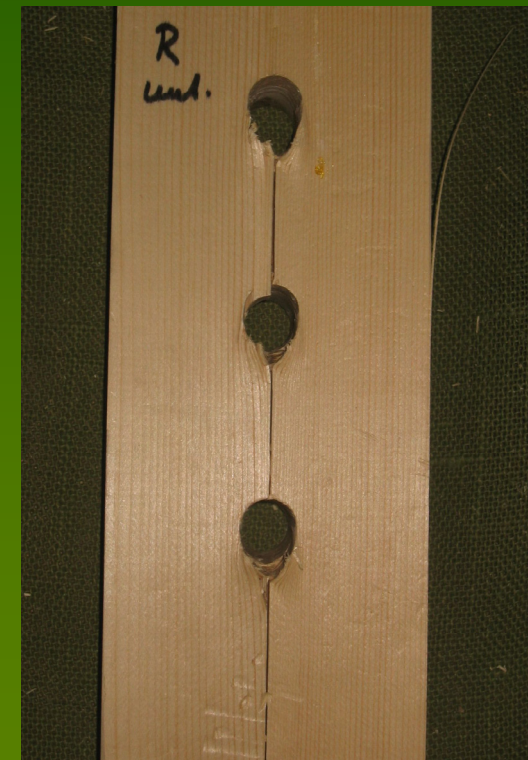
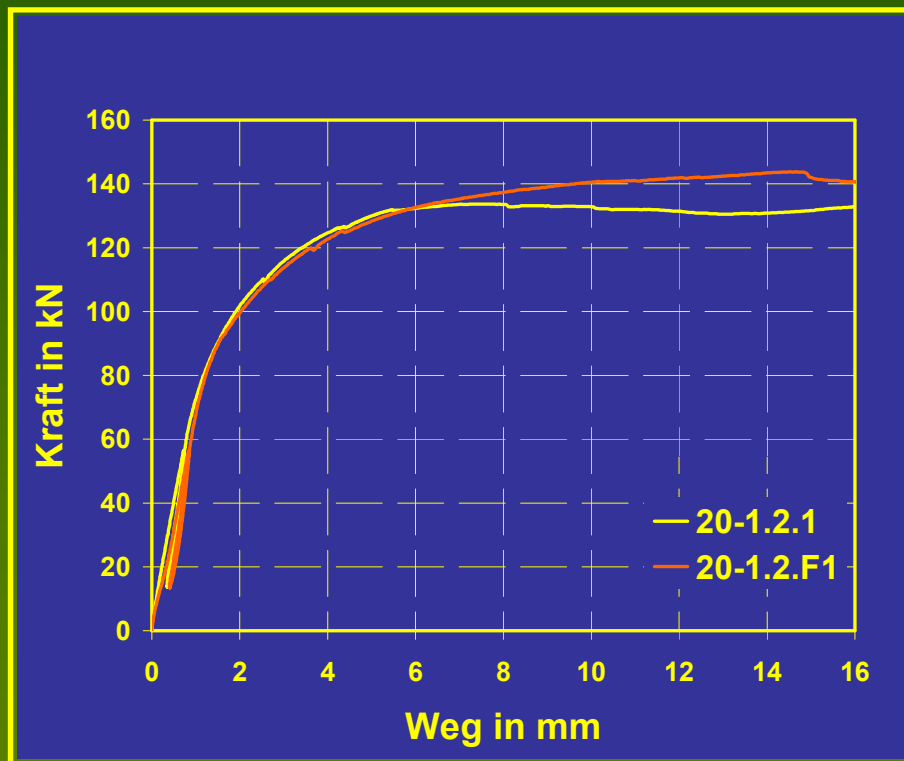
Dowelled connection with CLT

- Load-deformation behaviour



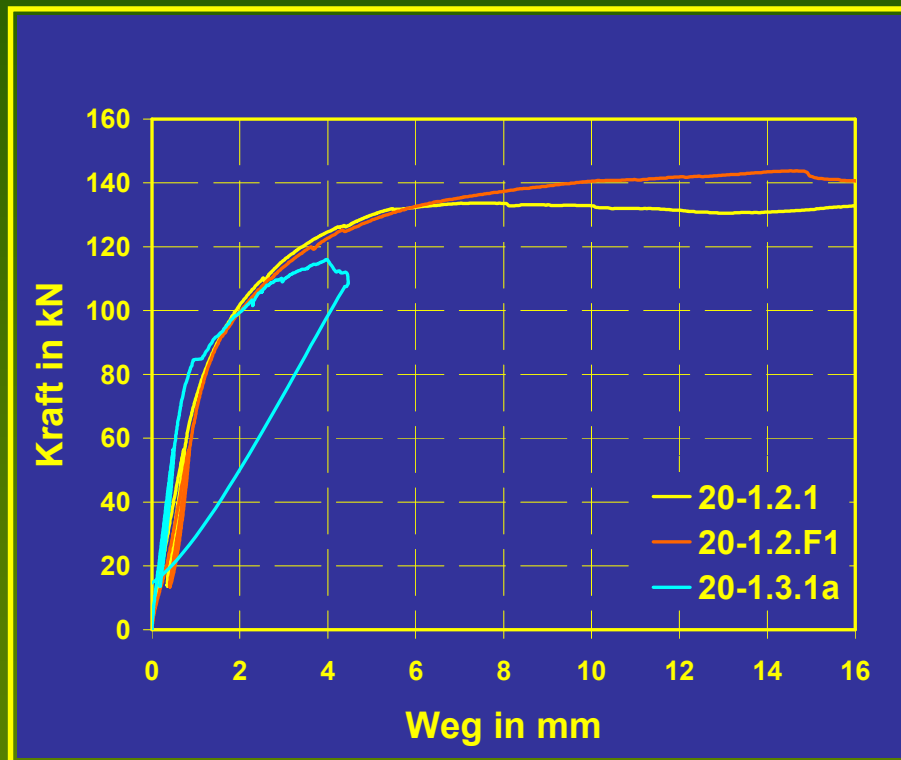
Dowelled connection with CLT

- Load-deformation behaviour - fasteners in gaps



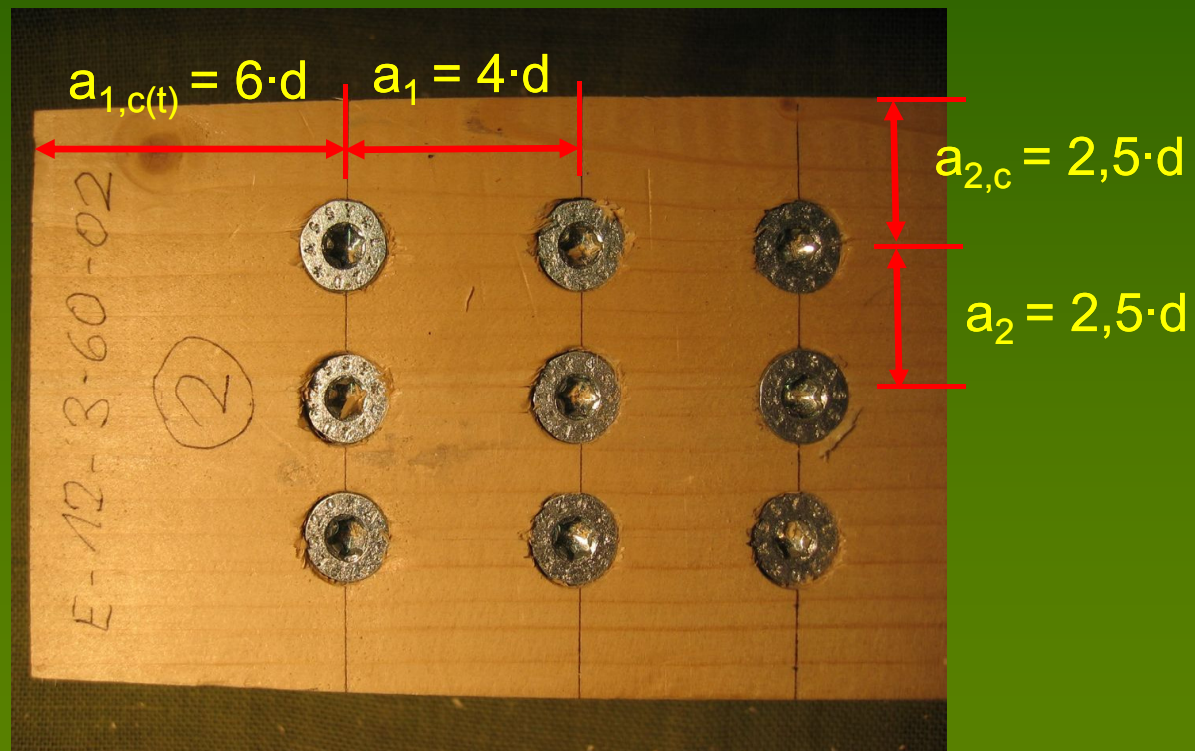
Dowelled connection with CLT

- Further reduced spacing \rightarrow brittle failure



Connections with screws

- Minimum spacing and end/edge distances



Axially loaded fasteners

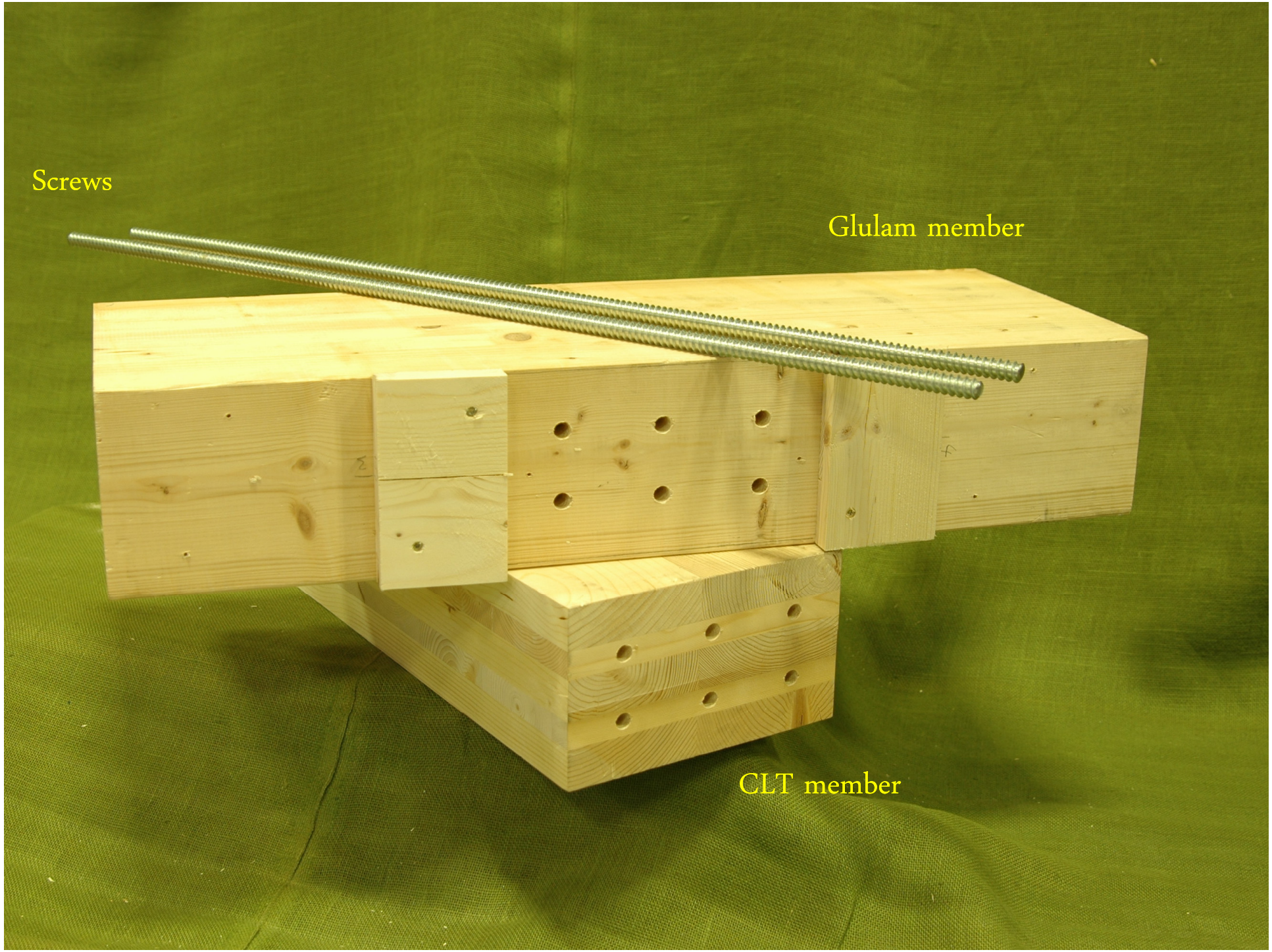
- Ductile behaviour in mild or stainless steel fasteners
- Withdrawal or head pull-through must not be governing



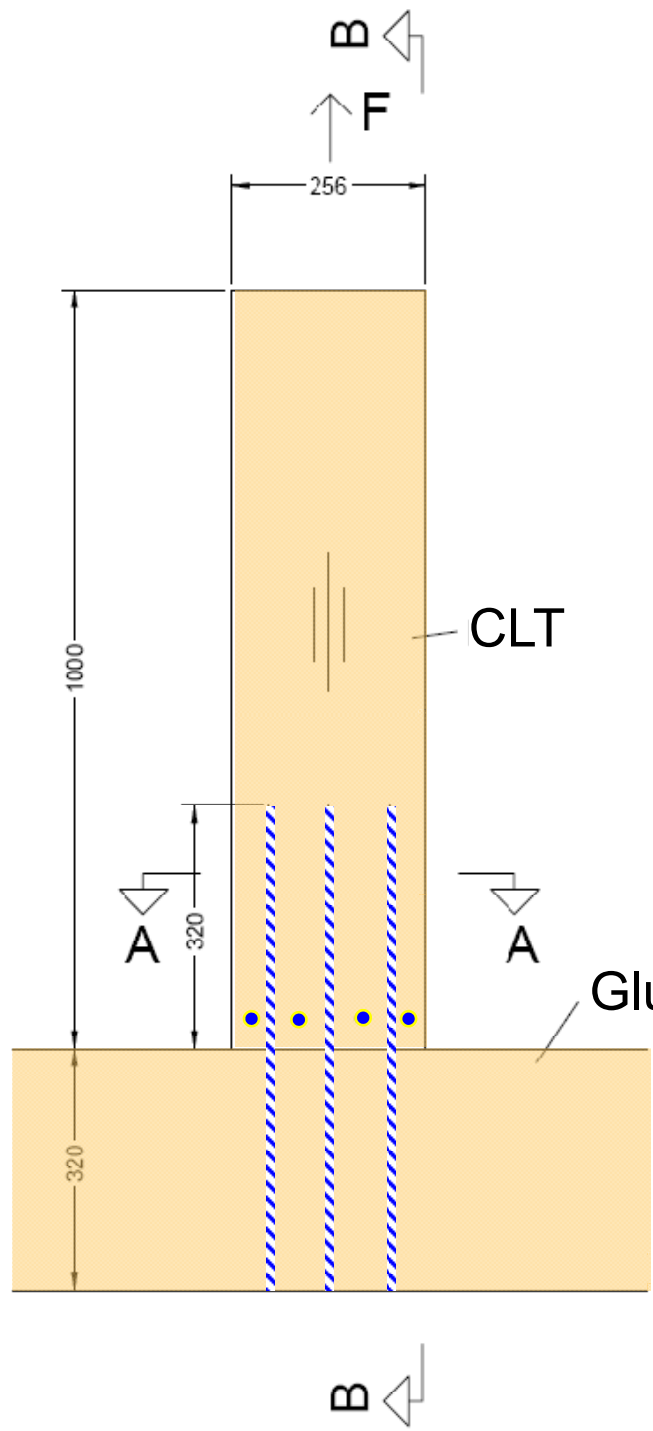
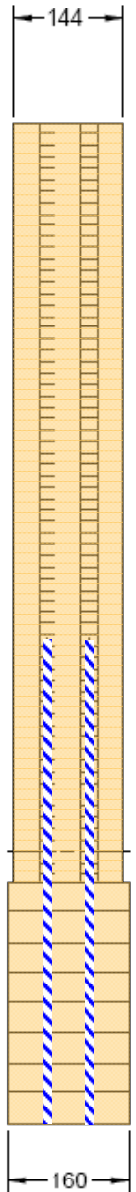
Screws

Glulam member

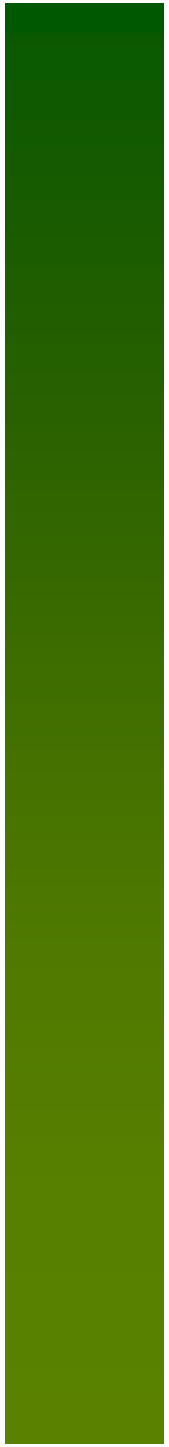
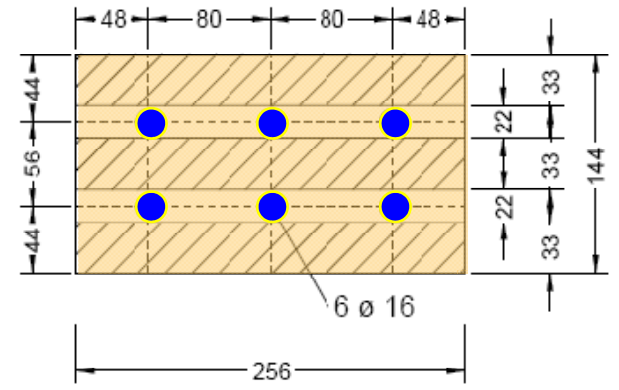
CLT member



B - B

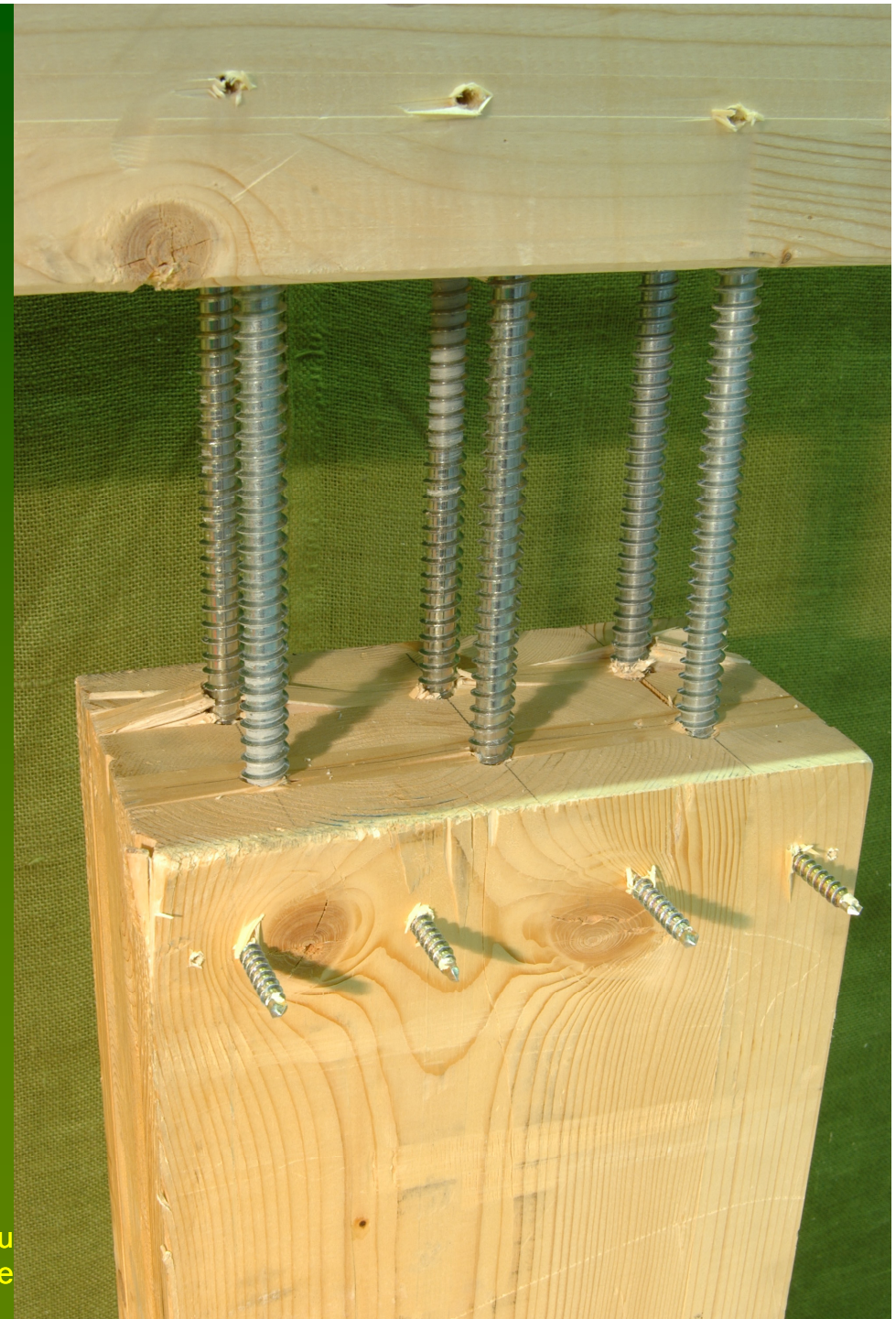


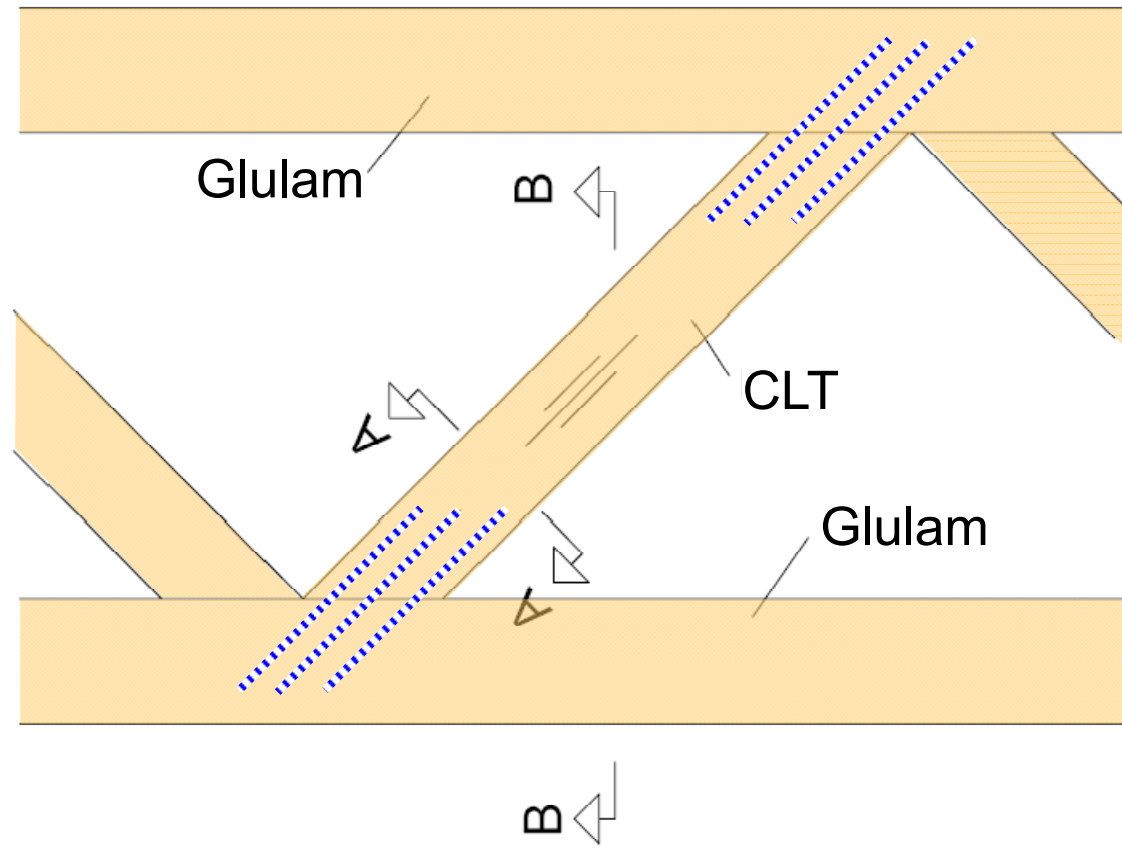
A - A



Axially loaded screws

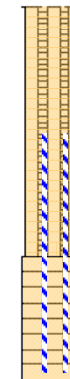
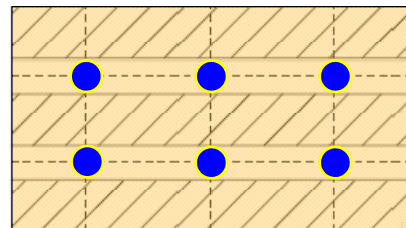
- Preliminary tests leading to splitting or withdrawal failure





B - B

A - A



Conclusions

- Ductile joint behaviour requires plastic deformation in fasteners and/or in timber
- Plastic fastener deformation in bending requires large embedding deformation without preliminary timber failure due to splitting or shear
- Plastic fastener deformation in tension requires mild and/or stainless steel fasteners with large withdrawal capacity



Conclusions

- Even mild steel fasteners may fail in a brittle manner due to fatigue loads
- Brittle timber failure due to splitting or shear may be prevented by reinforcement
- Reinforcements perpendicular to the grain may be glued-on or mechanical fasteners as self-drilling screws
- Connections between timber members made of CLT or plywood generally show ductile behaviour



Natürlich
HOLZ
Allem gewachsen.

Vielen Dank für Ihre Aufmerksamkeit!



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