Inquadramento generale sul legno strutturale e novità apportate con l'introduzione delle NTC 2008

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Corso "Progettazione di strutture di legno massiccio e lamellare secondo le NTC 2008"
Ordine degli Ingegneri di Pistoia, ottobre 2010

Il legno materiale affidabile per l'ingegneria civile oggi:

le 4 ragioni di un successo

Caratteristiche meccaniche più affidabili

- Affidabilità della selezione secondo la qualità resistente
- Categorie
- Classificazione a vista e a macchina
- Classi di resistenza

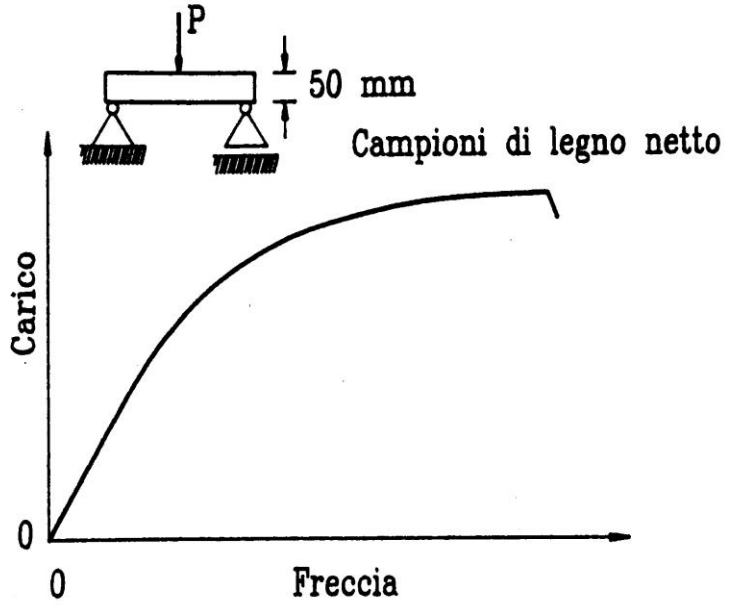
$$\sigma_d \leq f_k \frac{k_{mod}}{\gamma_m}$$

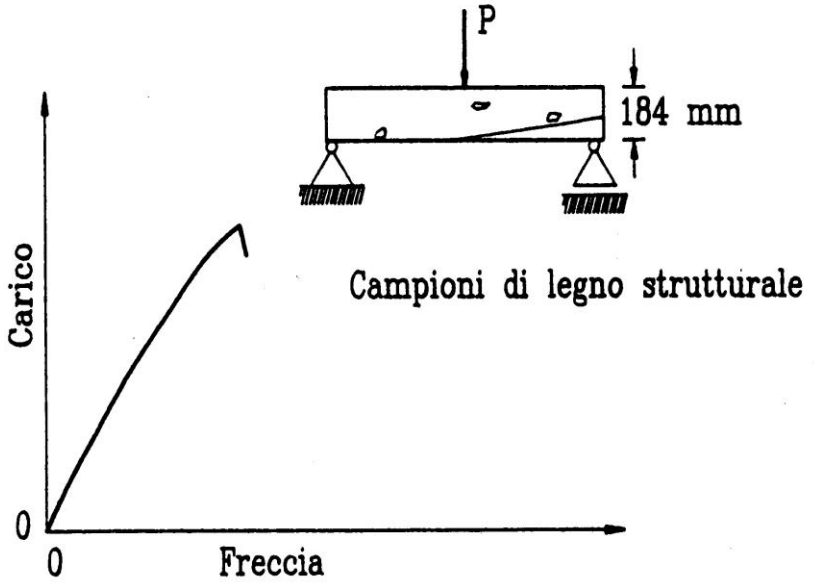
σ_d tensione agente di progetto

f_k resistenza caratteristica al frattile 5%

k_{mod} coefficiente che tiene conto delle condizioni di servizio e della “durata del carico”

γ_m coefficiente parziale di sicurezza del materiale


P
50 mm
Campioni di legno netto
Carico
0
0
Freccia


P
184 mm
Campioni di legno strutturale
Carico
0
0
Freccia

- ✓ a differenza dell' acciaio e del calcestruzzo armato la verifica della sezione si fa sulle tensioni e non sulle azioni interne.

CATEGORIE

Signification des symboles utilisés dans les figures 27 à 29:

Q : somme des «q_i»: pour les bois équarris on les compte sur une surface rectangulaire définie par la hauteur de la face et par une longueur de 150 mm parallèle à l'axe de la pièce; pour les bois ronds on les compte sur une surface courbe définie par le quart du périmètre et une longueur de 150 mm parallèle à l'axe de la pièce

a : distance entre les tangentes au nœud, parallèles aux arêtes

b : largeur

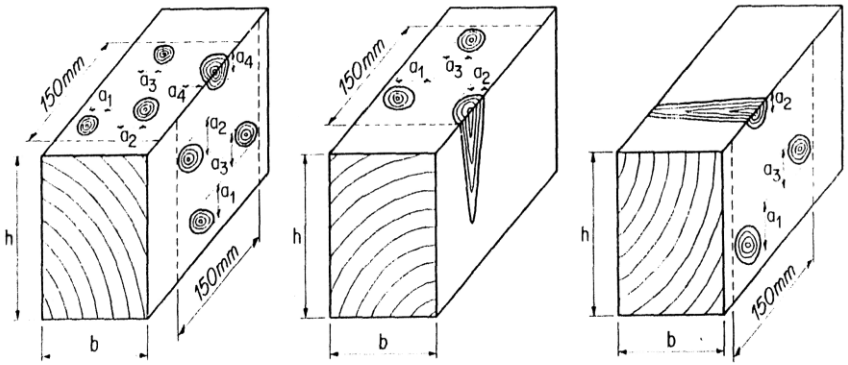
d : diamètre moyen

h : hauteur ou épaisseur

i : 1, 2, 3...n

n : nombre des nœuds pris en considération

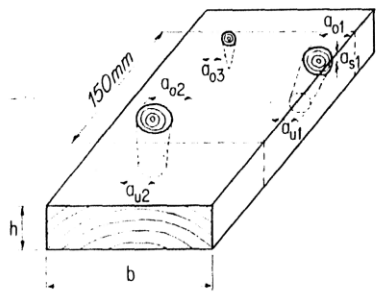
q : rapport entre «a» et la largeur «b» ou la hauteur «h» correspondante.



$$q_i = \frac{a_i}{h} \text{ bzw. } \frac{a_i}{b}$$

$$Q = \Sigma q_i$$

Figures 27a, 27b et 27c Mesure de la nodosité des bois équarris et des lattes



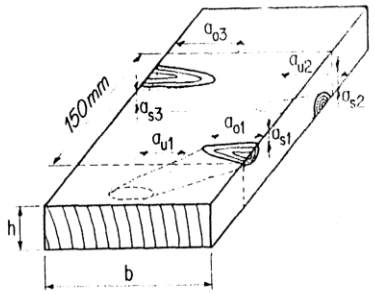
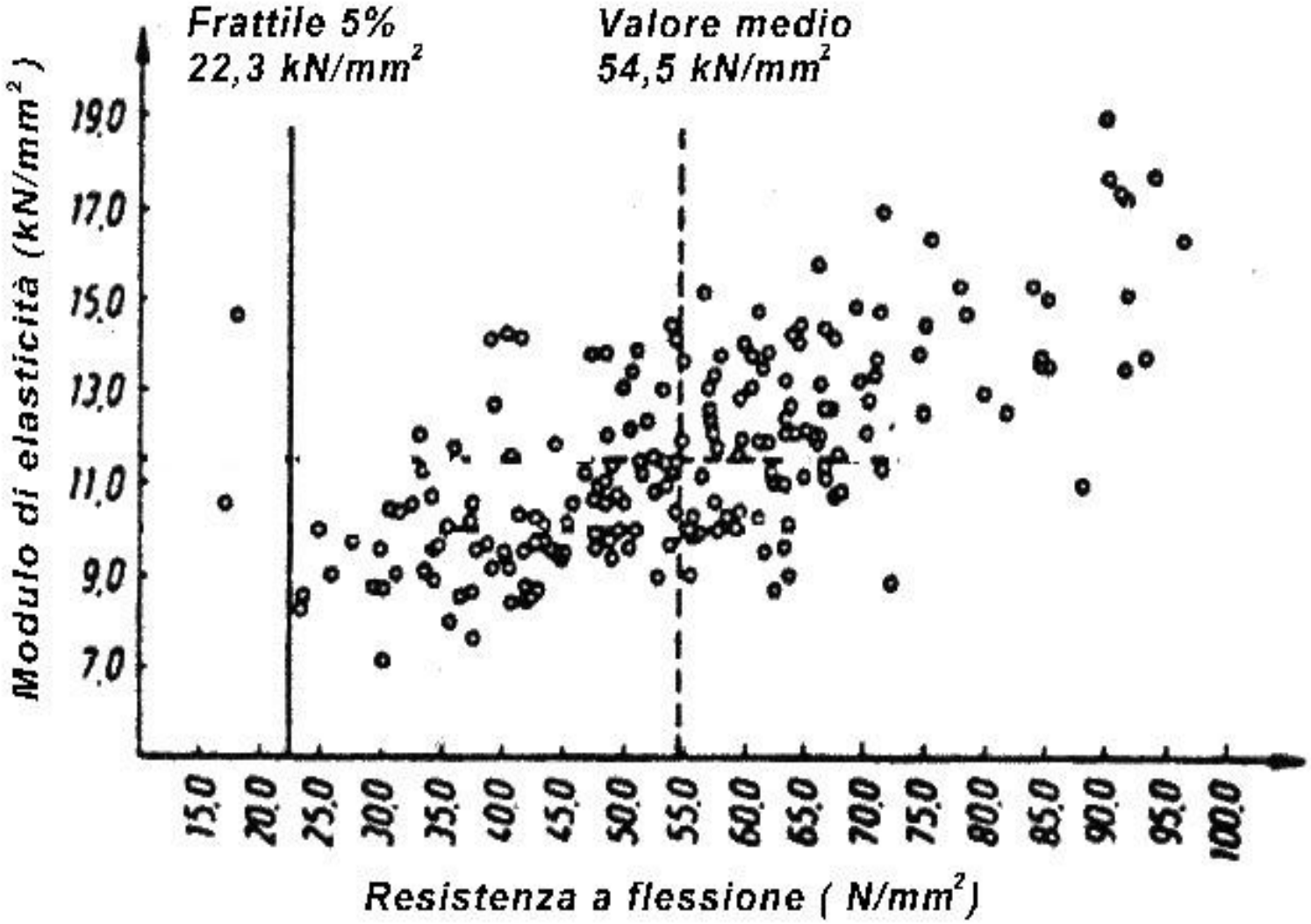
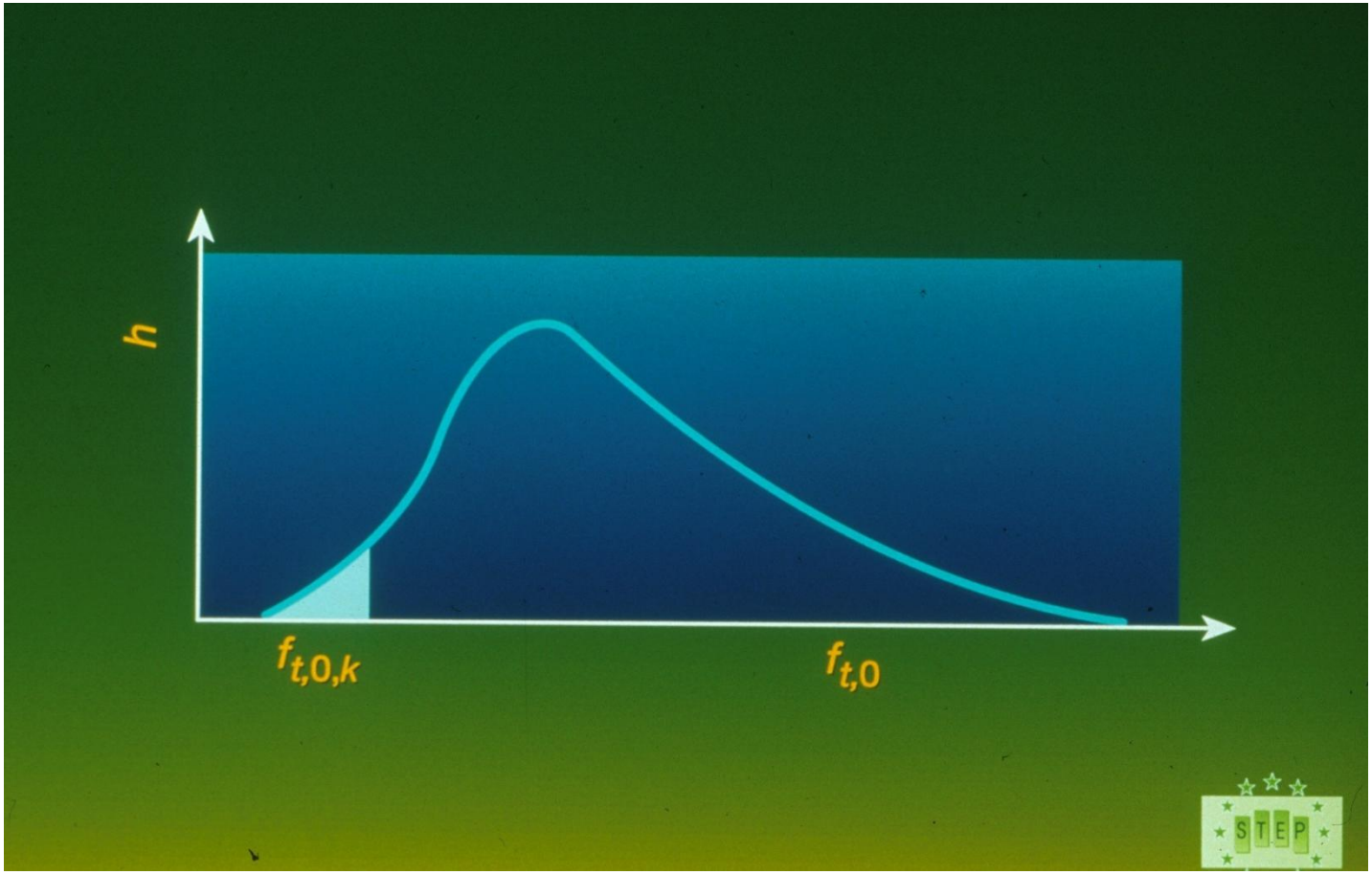
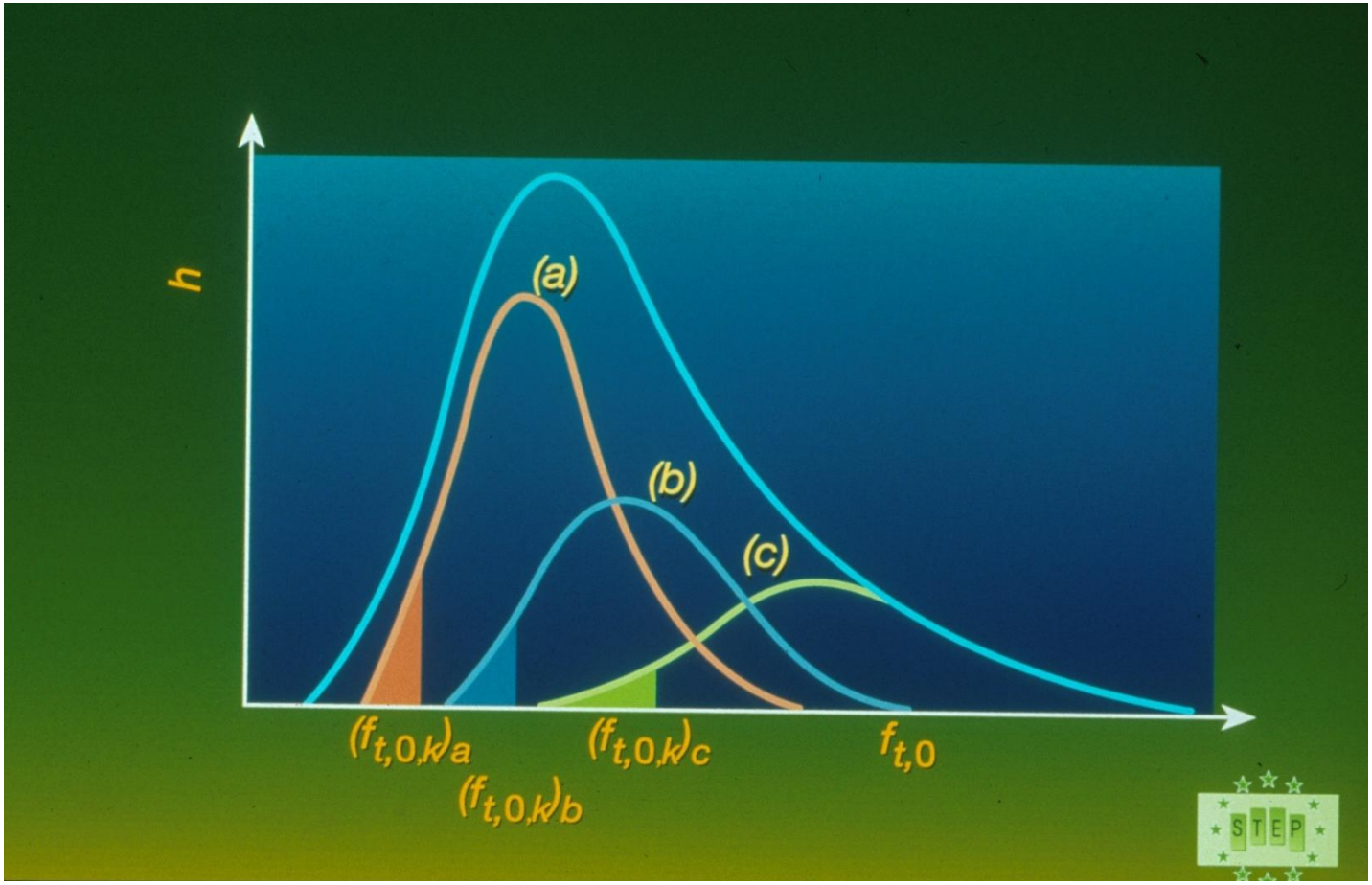


Planche sur quartier

- Norma: UNI 11035
- Regole per Classe S1 / S2 / S3 - Reject
  - Nodi
  - Anelli
  - Fessure (da ritiro / cipollatura… etc.)
  - Svergolamento / Arcuatura / Falcuatura


Frattile 5%
22,3 kN/mm²
Valore medio
54,5 kN/mm²
Modulo di elasticità (kN/mm²)
19,0
17,0
15,0
13,0
11,0
9,0
7,0
15,0
20,0
25,0
30,0
35,0
40,0
45,0
50,0
55,0
60,0
65,0
70,0
75,0
80,0
85,0
90,0
95,0
100,0
Resistenza a flessione (N/mm²)


h
$f_{t,0,k}$
$f_{t,0}$
STEP


h
(a)
(b)
(c)
$(f_{t,0,k})_a$
$(f_{t,0,k})_b$
$(f_{t,0,k})_c$
$f_{t,0}$
STEP

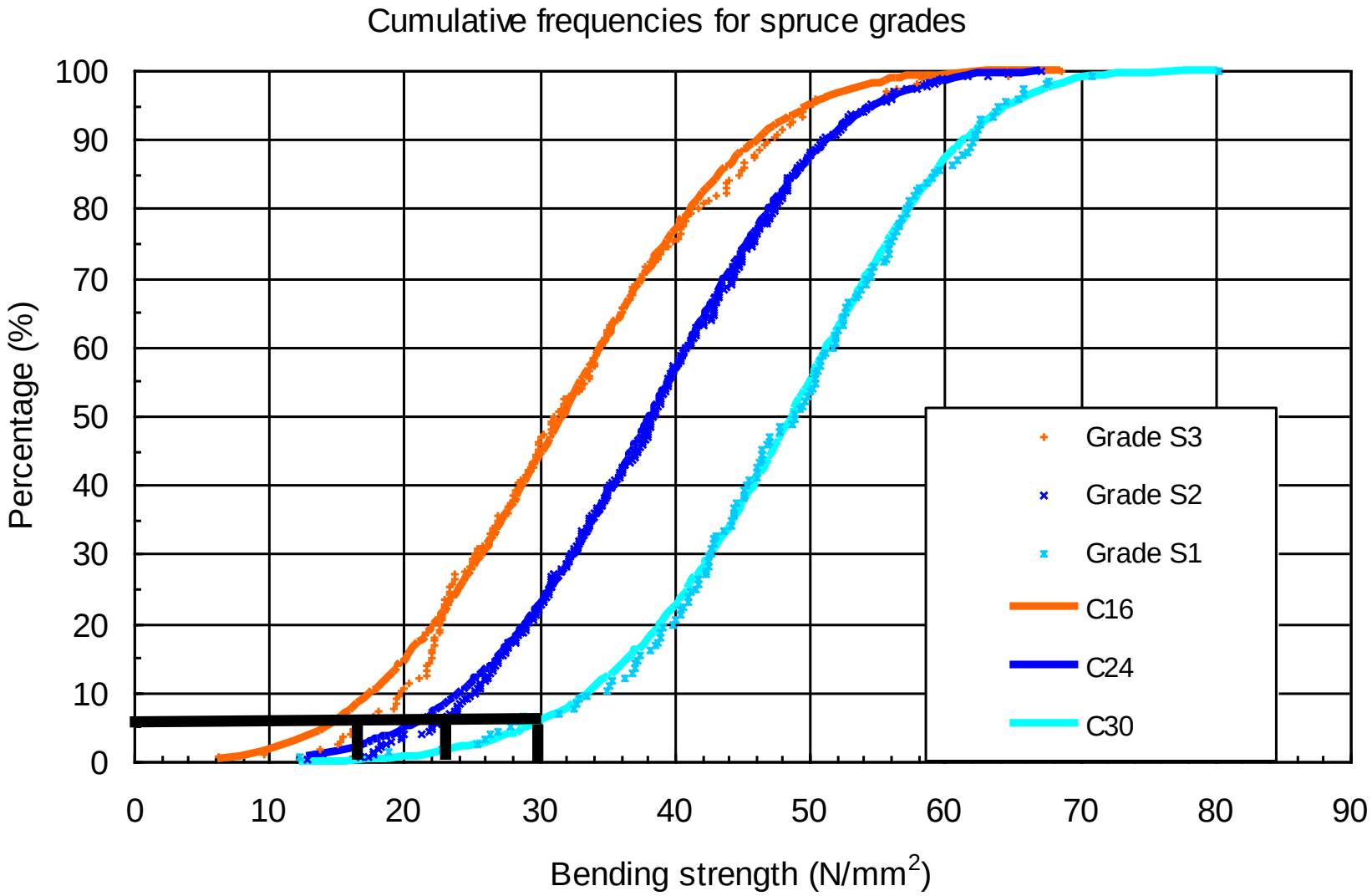

Cumulative frequencies for spruce grades
Percentage (%)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
Bending strength (N/mm2)
Grade S3
Grade S2
Grade S1
C16
C24
C30

Tabella 18-1-Classi di resistenza secondo EN 338, per legno di conifere e di pioppo

Valori di resistenza modulo elastico e massa volumica		C14	C16	C18	C20	C22	C24	C27	C30	C35	C40	C45	C50
Resistenze [MPa]													
flessione	$f_{m,k}$	14	16	18	20	22	24	27	30	35	40	45	50
trazione parallela alla fibratura	$f_{t,0,k}$	8	10	11	12	13	14	16	18	21	24	27	30
trazione perpendicolare alla fibratura	$f_{t,90,k}$	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
compressione parallela alla fibratura	$f_{c,0,k}$	16	17	18	19	20	21	22	23	25	26	27	29
compressione perpendicolare alla fibratura	$f_{c,90,k}$	2.0	2.2	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.1	3.2
taglio	$f_{v,k}$	1.7	1.8	2.0	2.2	2.4	2.5	2.8	3.0	3.4	3.8	3.8	3.8
Modulo elastico [GPa]													
modulo elastico medio parallelo alle fibre	$E_{0,mean}$	7	8	9	9.5	10	11	11.5	12	13	14	15	16
modulo elastico caratteristico parallelo alle fibre	$E_{0,05}$	4.7	5.4	6.0	6.4	6.7	7.4	7.7	8.0	8.7	9.4	10.0	10.7
modulo elastico medio perpendicolare alle fibre	$E_{90,mean}$	0.23	0.27	0.30	0.32	0.33	0.37	0.38	0.40	0.43	0.47	0.50	0.53
modulo di taglio medio	G_{mean}	0.44	0.50	0.56	0.59	0.63	0.69	0.72	0.75	0.81	0.88	0.94	1.00
Massa volumica [kg/m^3]													
massa volumica caratteristica	ρ_k	290	310	320	330	340	350	370	380	400	420	440	460
massa volumica media	ρ_m	350	370	380	390	410	420	450	460	480	500	520	550

CLASSI

CLASSE

Strength Class	Grading rule publishing country (Grading standard)	Grade	Species Commercial name	Source
C24	Austria (ÖNORM B 4100-2)	G.BH	Spruce, Pine, Fir, Larch	CNE Europe
	France (NFB 52001-4)	CF22	Whitewood, Douglas fir	France
	Germany (DIN 4074-1)	S10	Spruce, Pine, Fir, Larch	CNE Europe
	Nordic Countries (INSTA 142)	T2	Redwood, Whitewood	NNE Europe
	The Netherlands (NEN 5466)	B	Spruce + fir	NC Europe
	UK (BS 4978)	SS	Redwood, Whitewood	CNE Europe
		SS	Douglas fir, Larch, Hem-fir, S-P-F	USA + Canada
		SS	Southern pine	USA
		SS	Parana pine	Brazil
		SS	Pitch pine	Caribbean
	USA + Canada (NGRDL+ NLGA)	J + P Sel	Douglas fir, Larch, Hem-fir, S-P-F	USA + Canada

CATEGORIA

Strength class C 24, assignment of visual grades and species according to CEN/TC 124.215.
CNE Europe: Central, North & Eastern Europe
NNE Europe: Northern & North eastern Europe
NC Europe: Northern and Central Europe.

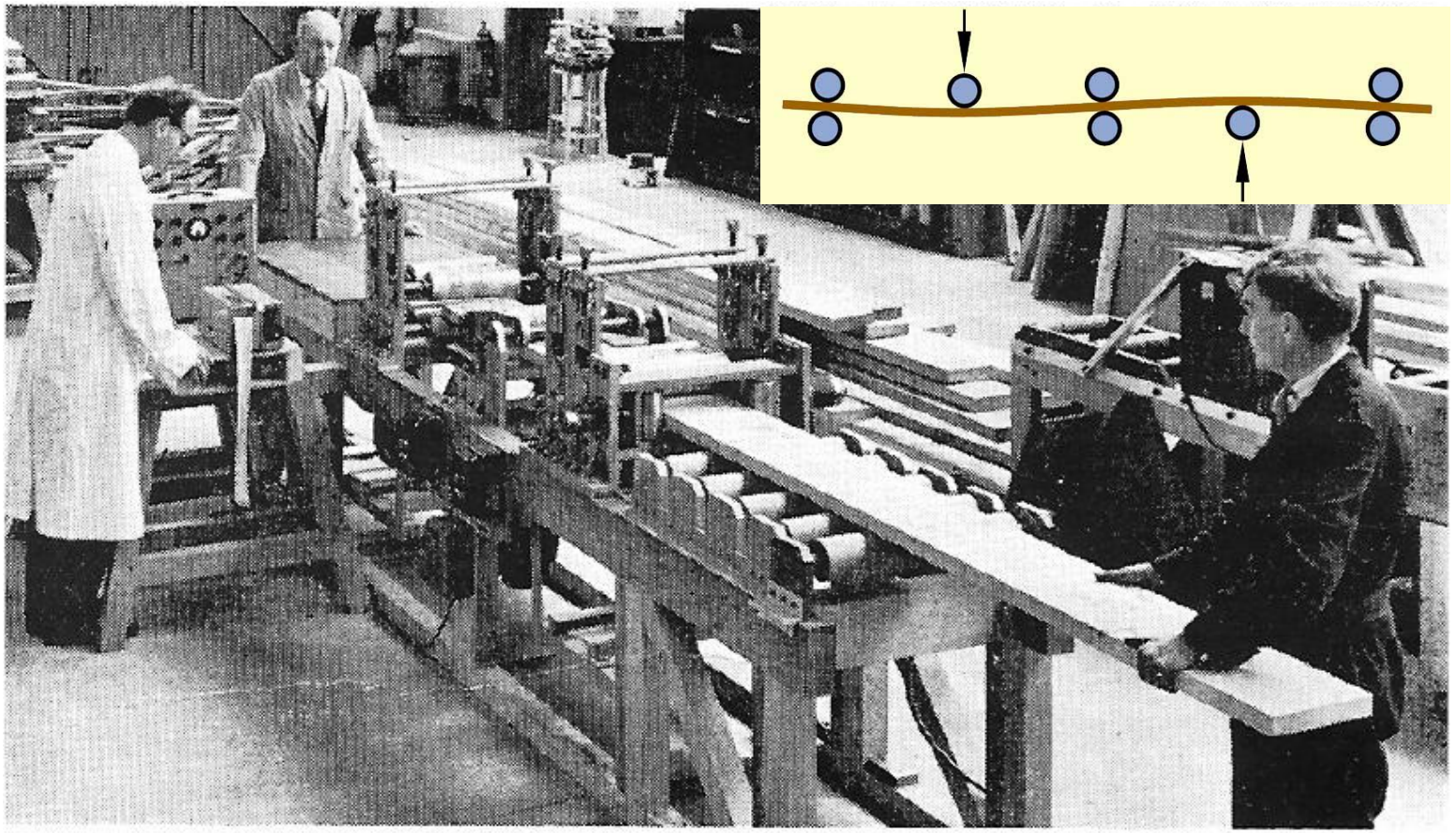
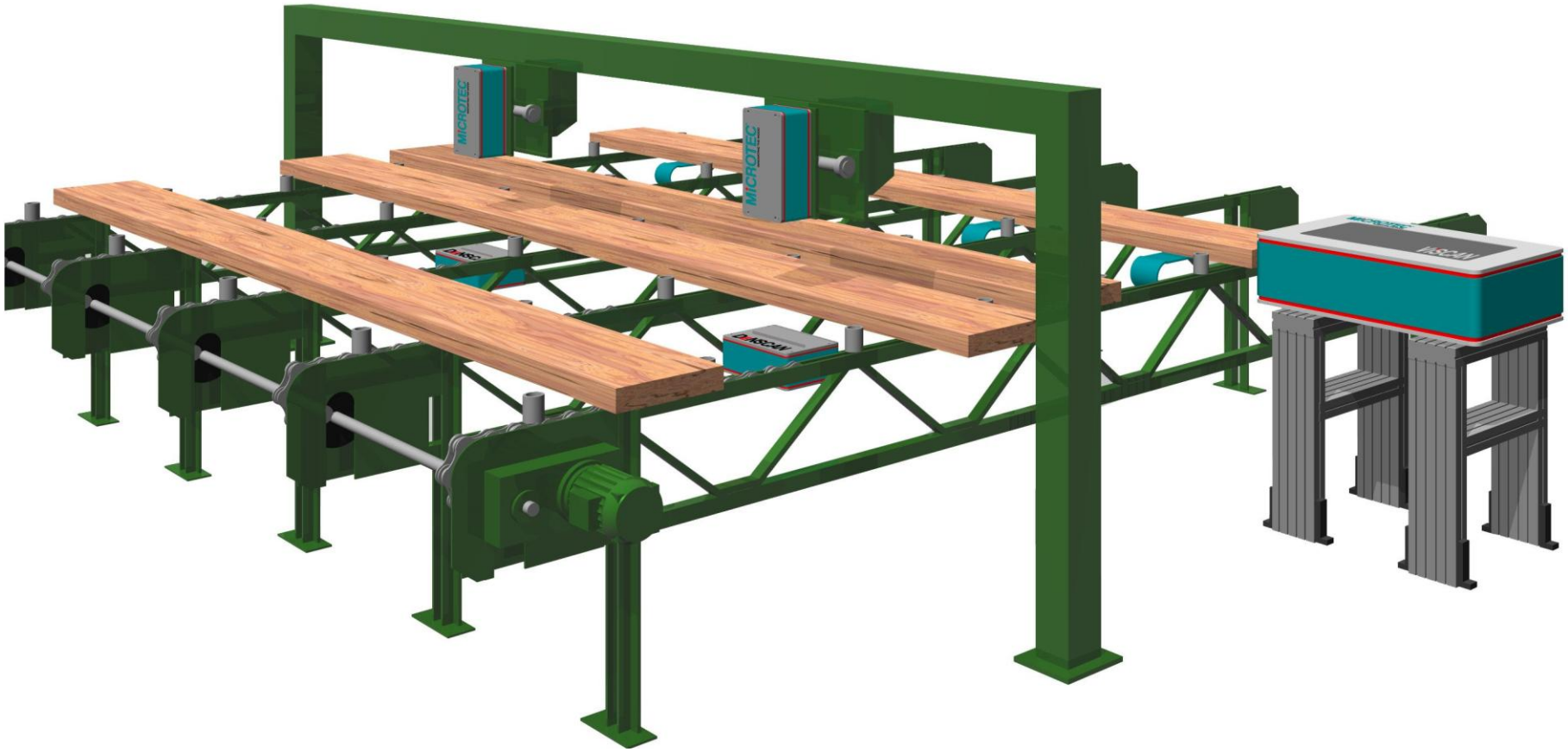


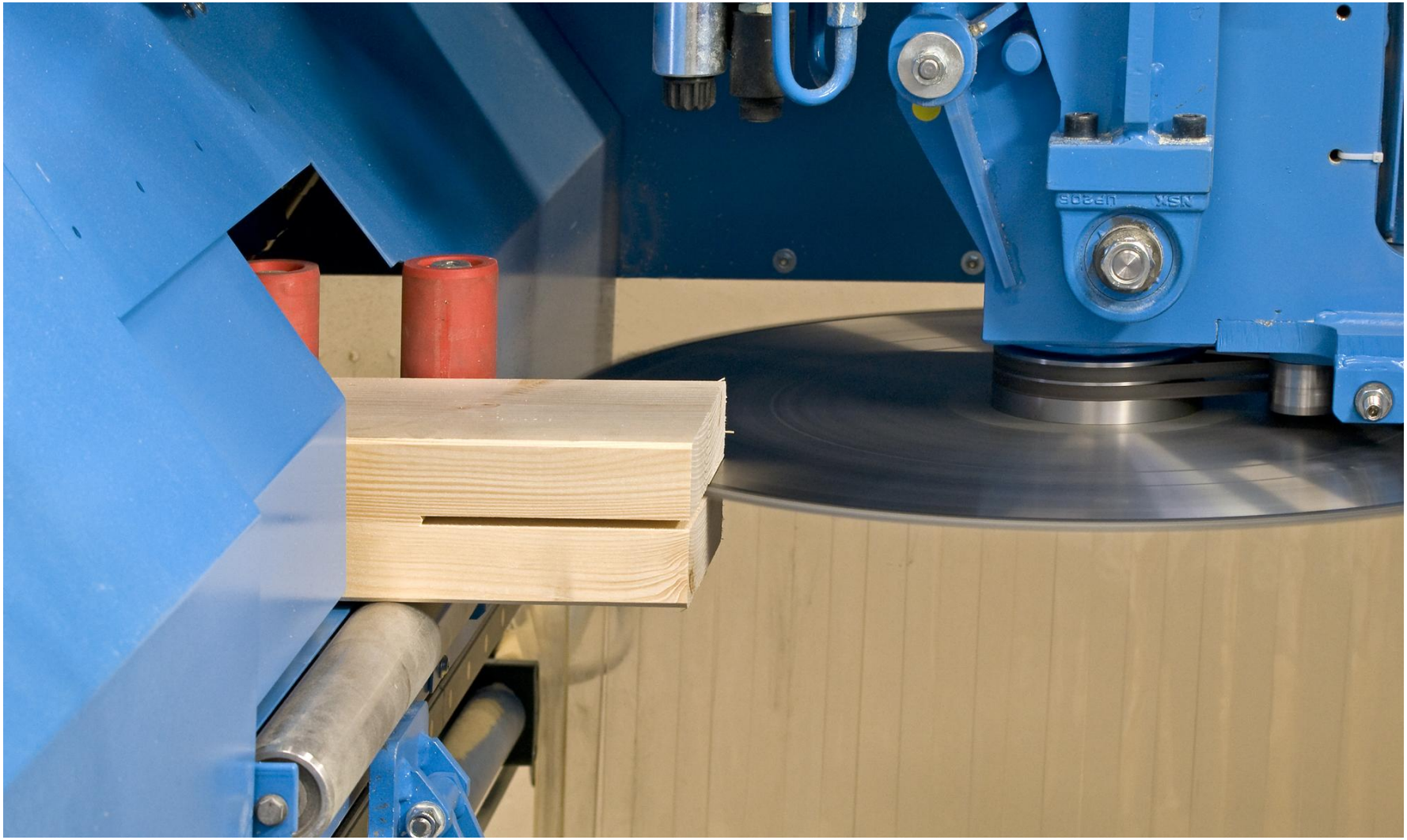
Figure 1.—Experimental model of Princes Risborough stress-grading machine. **1962**

Source: M. Bacher



Source: M. Bacher

Nuove macchine a controllo numerico



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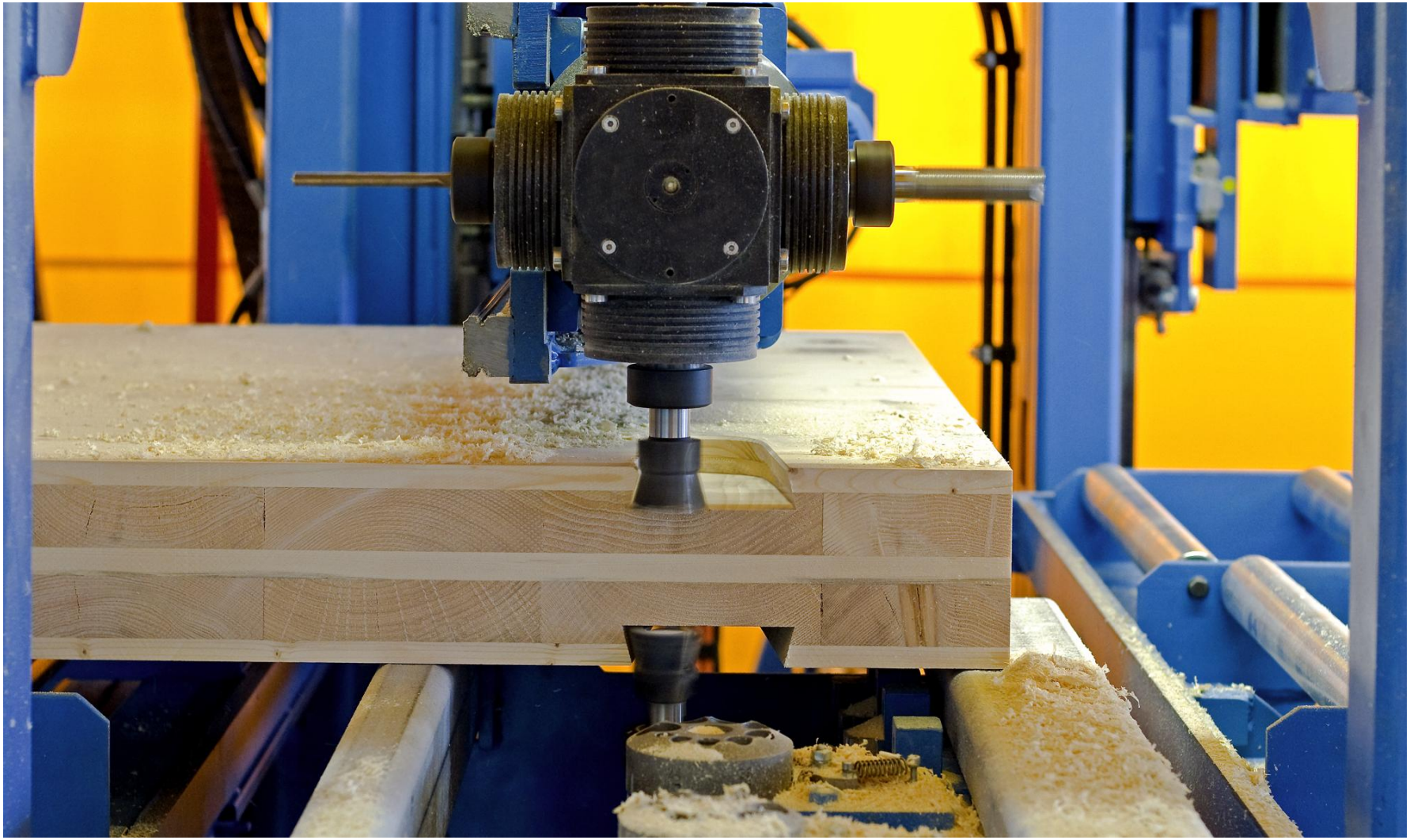

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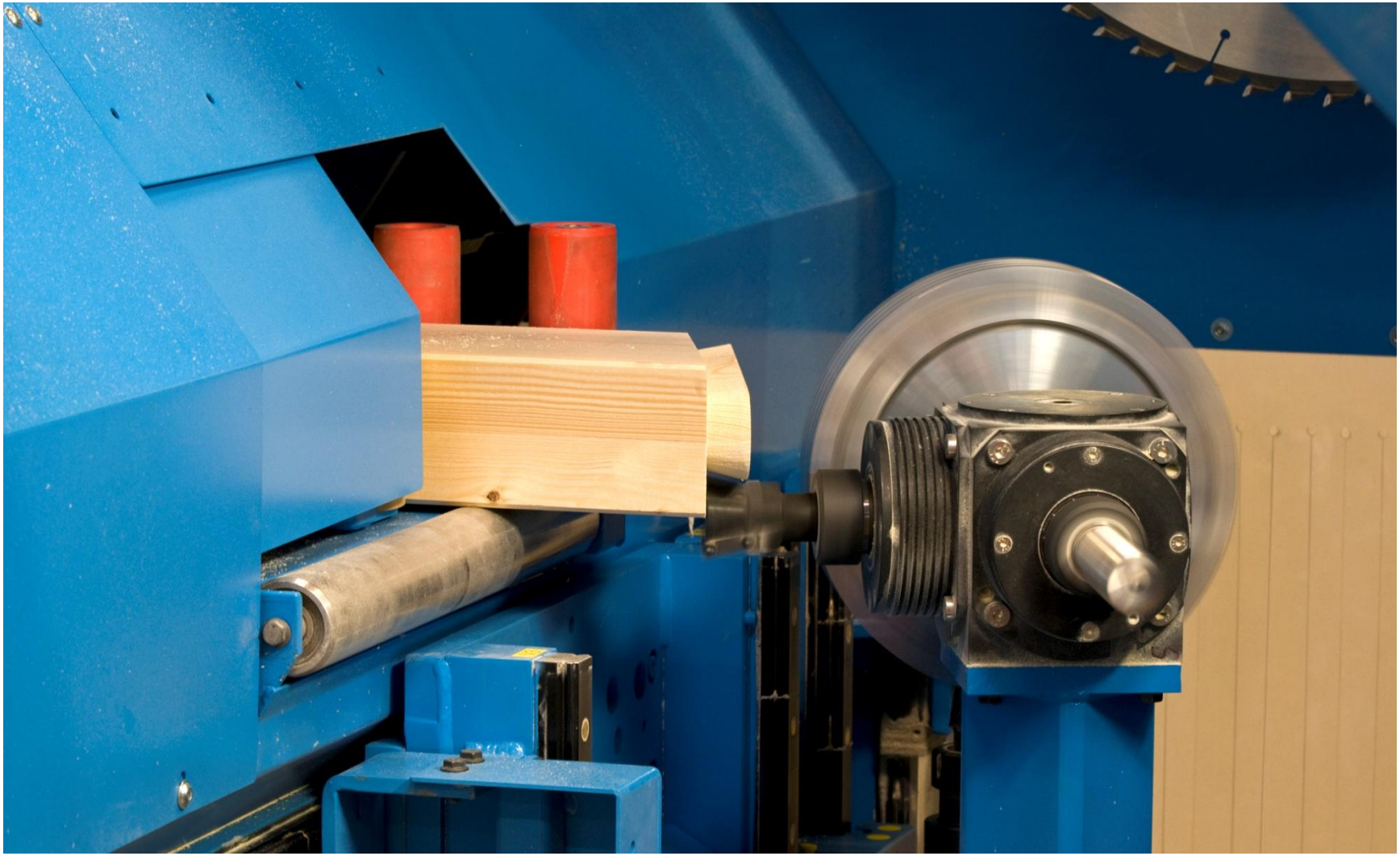

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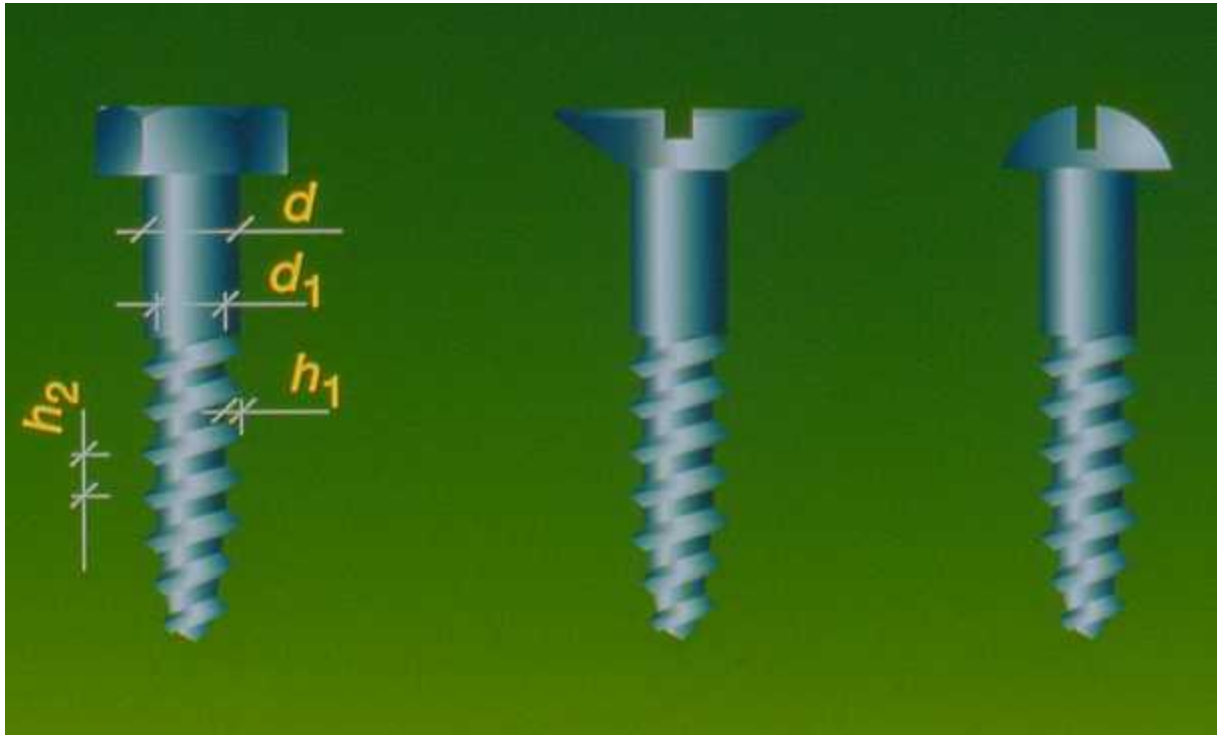
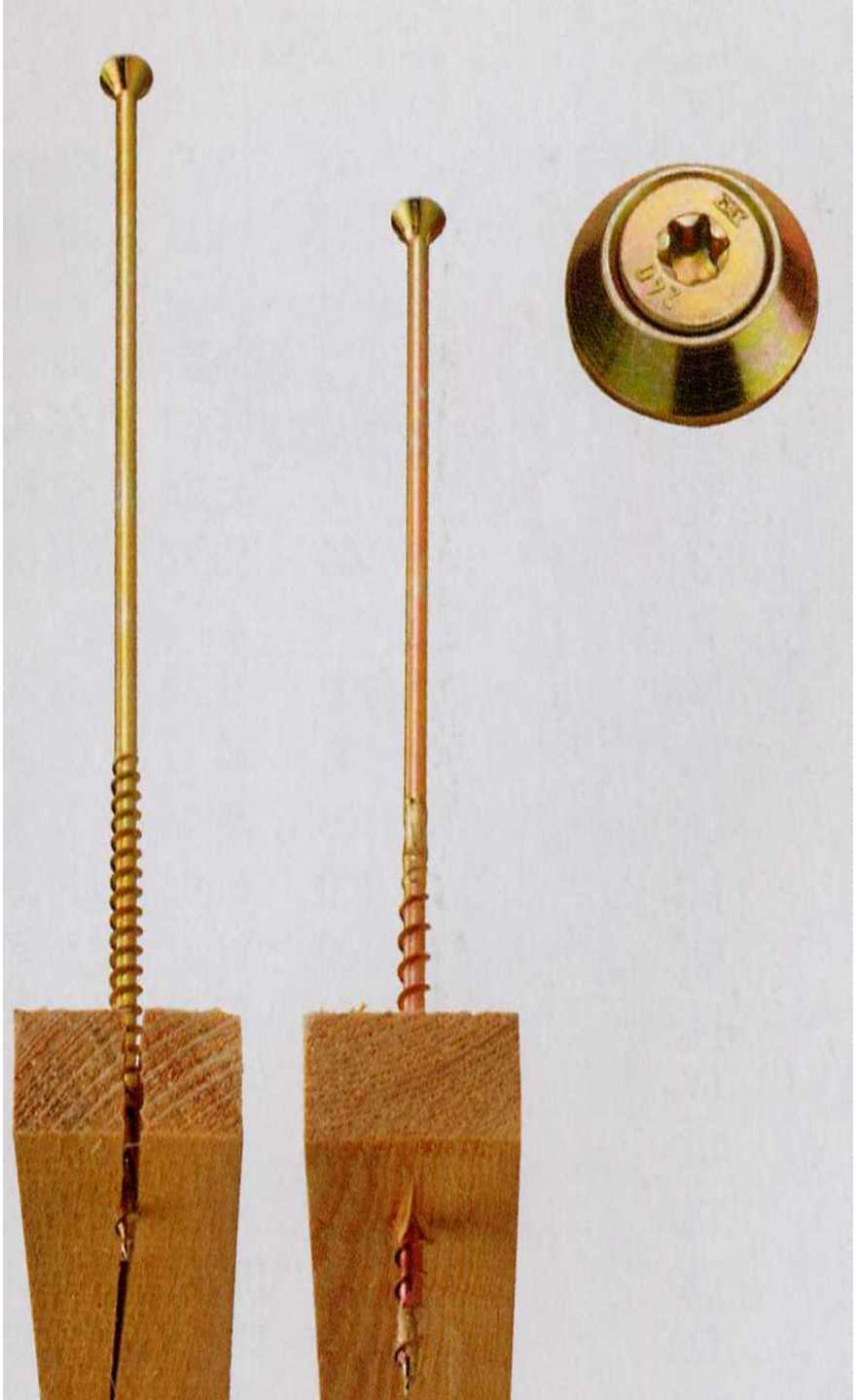
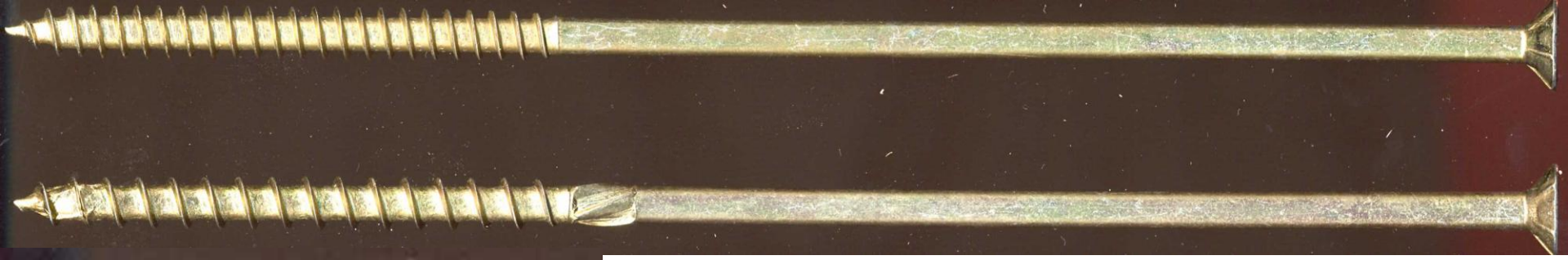
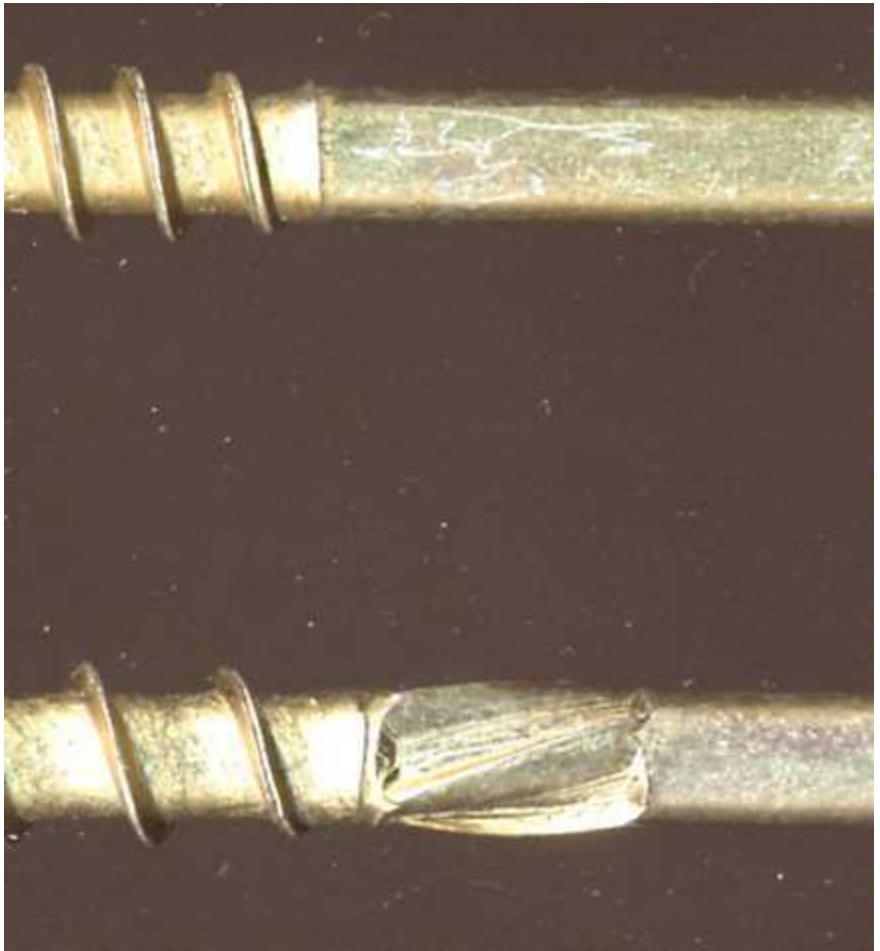
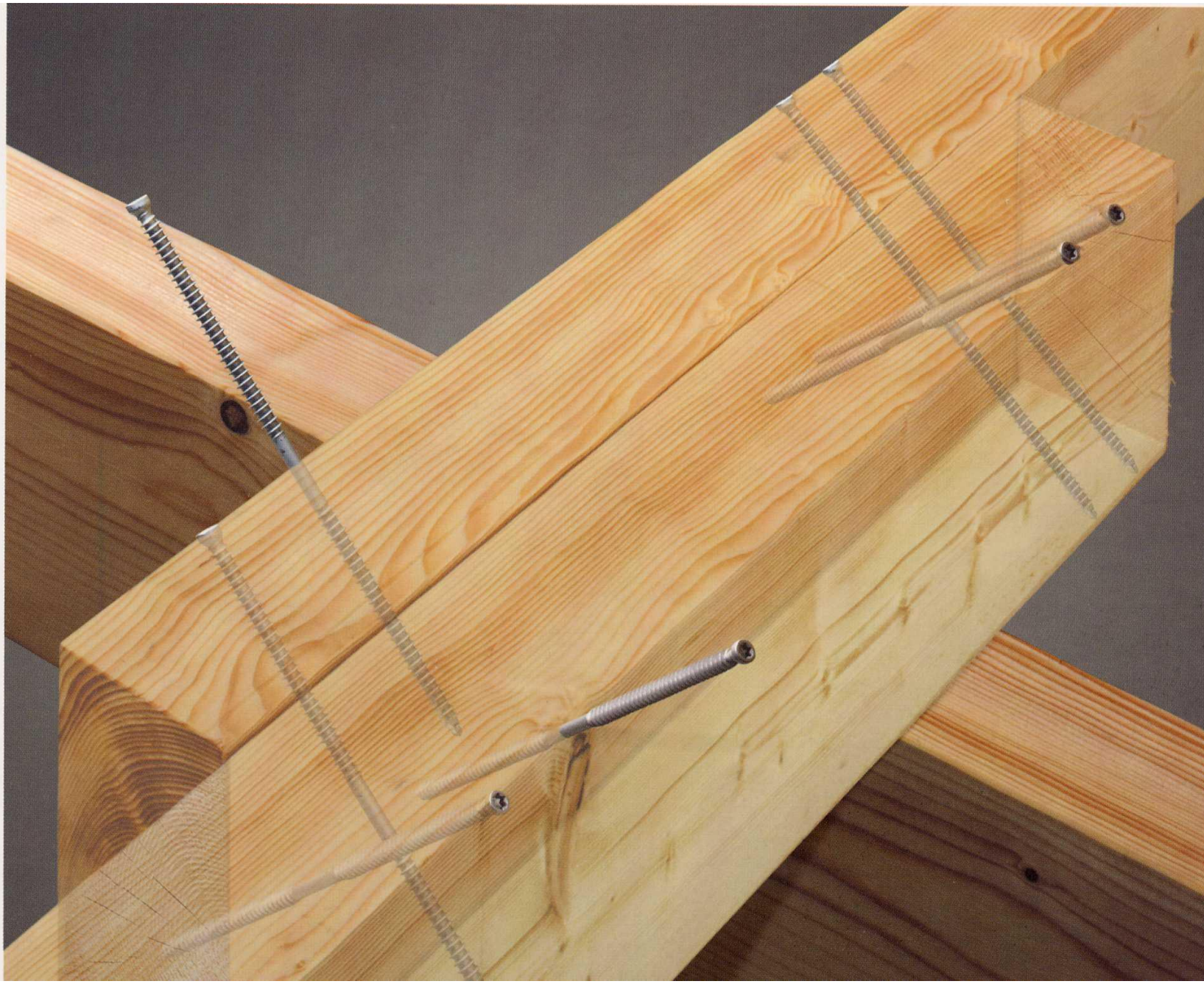
Viti di nuova generazione

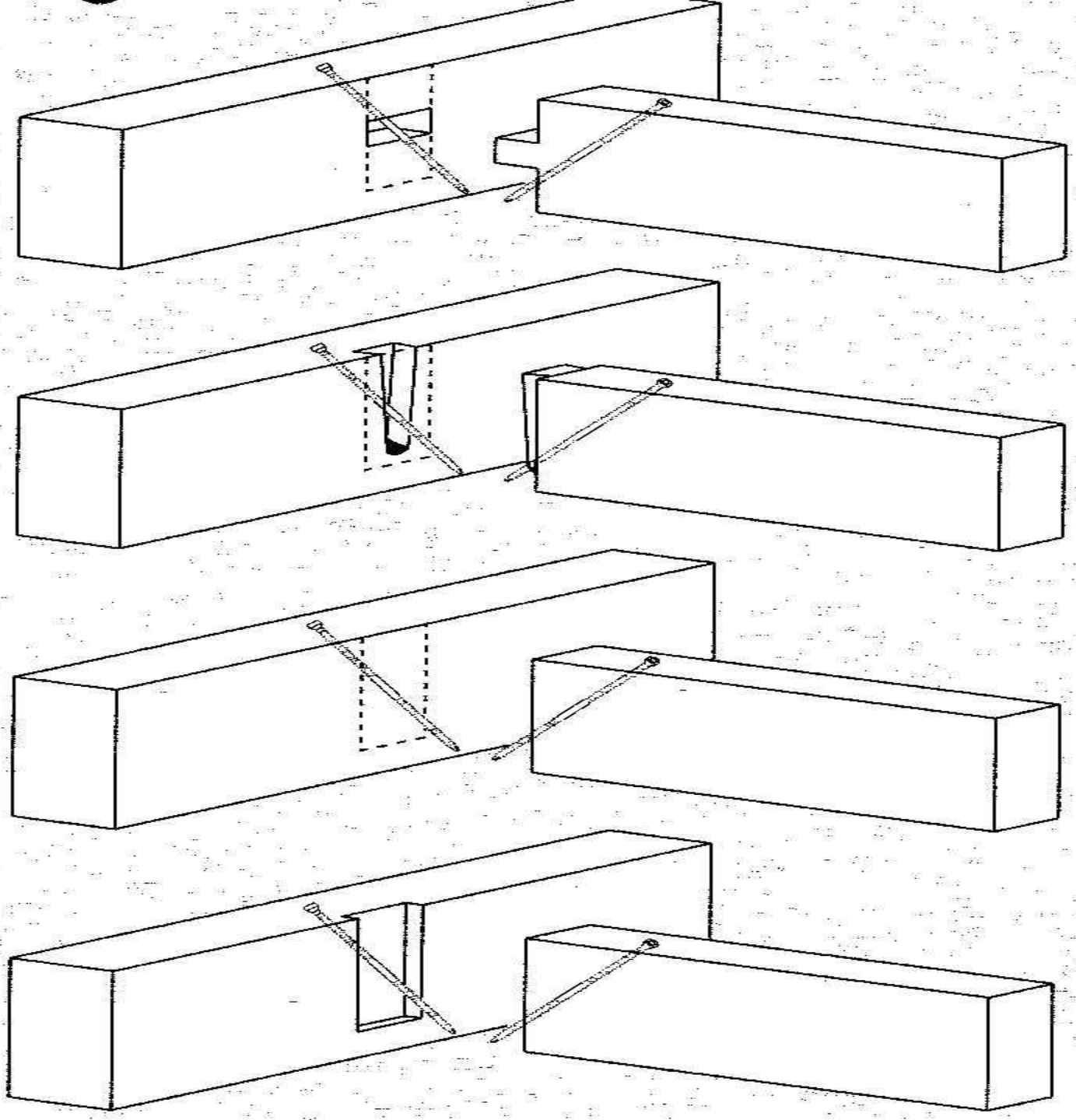

d
d_1
h_1
h_2

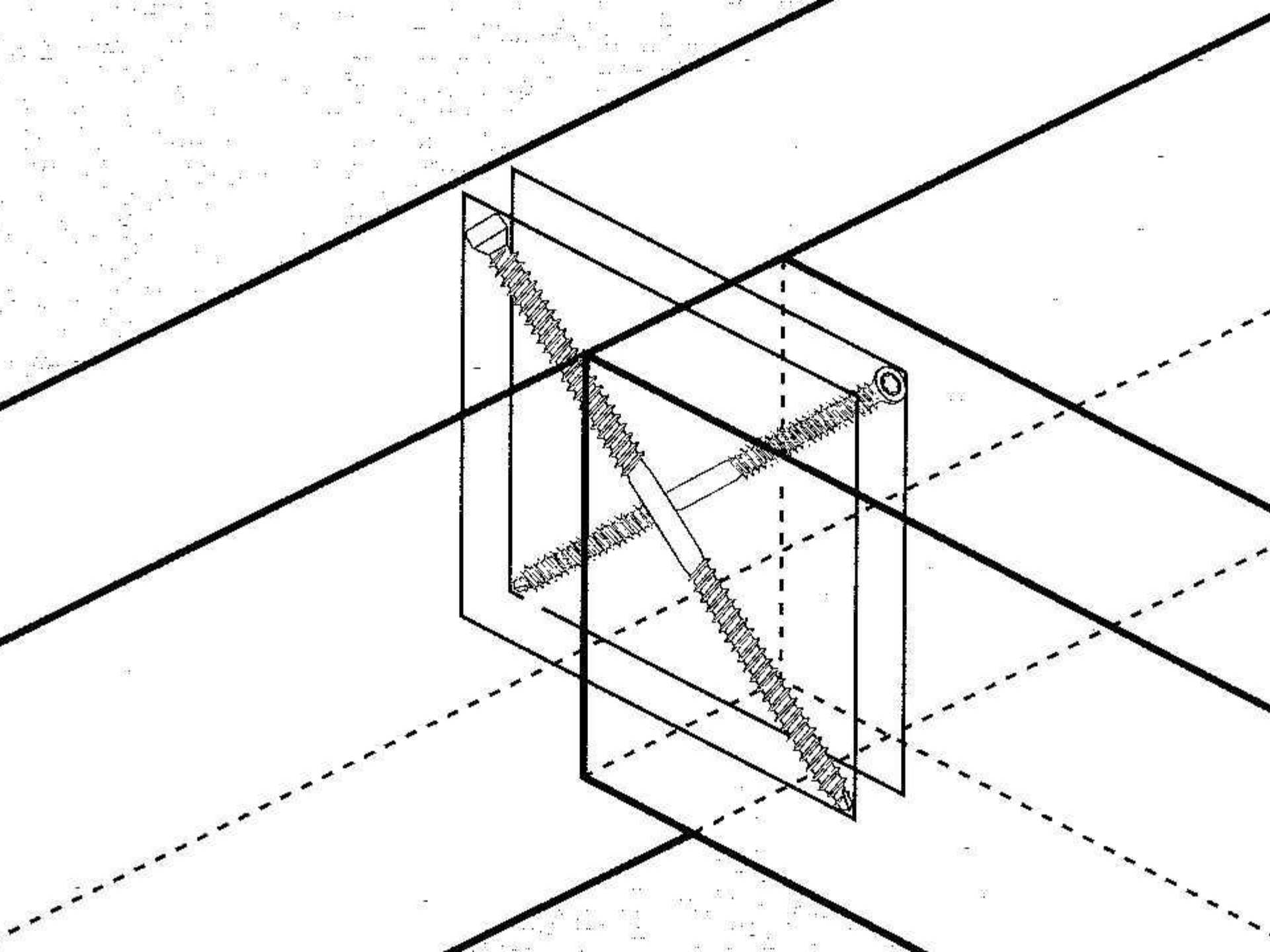


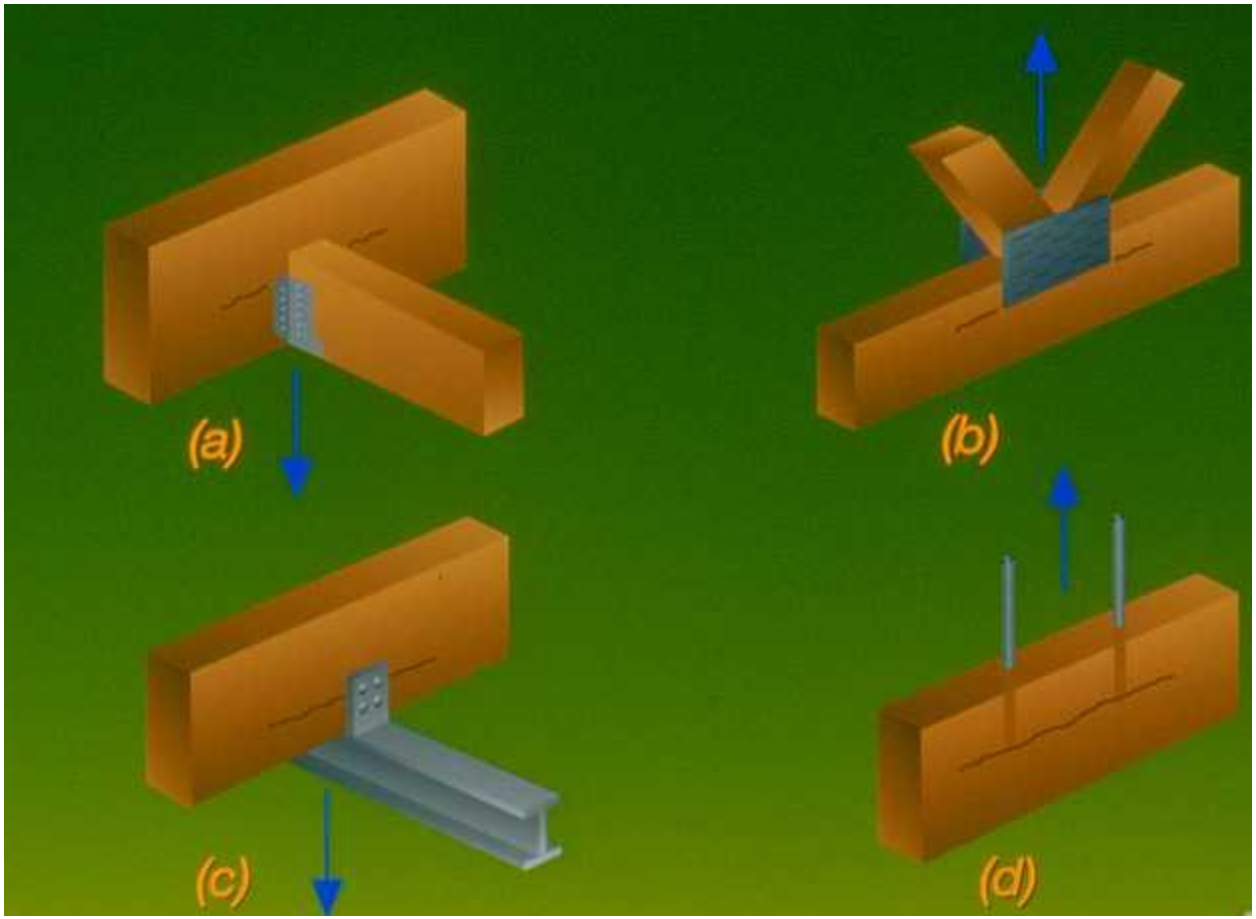


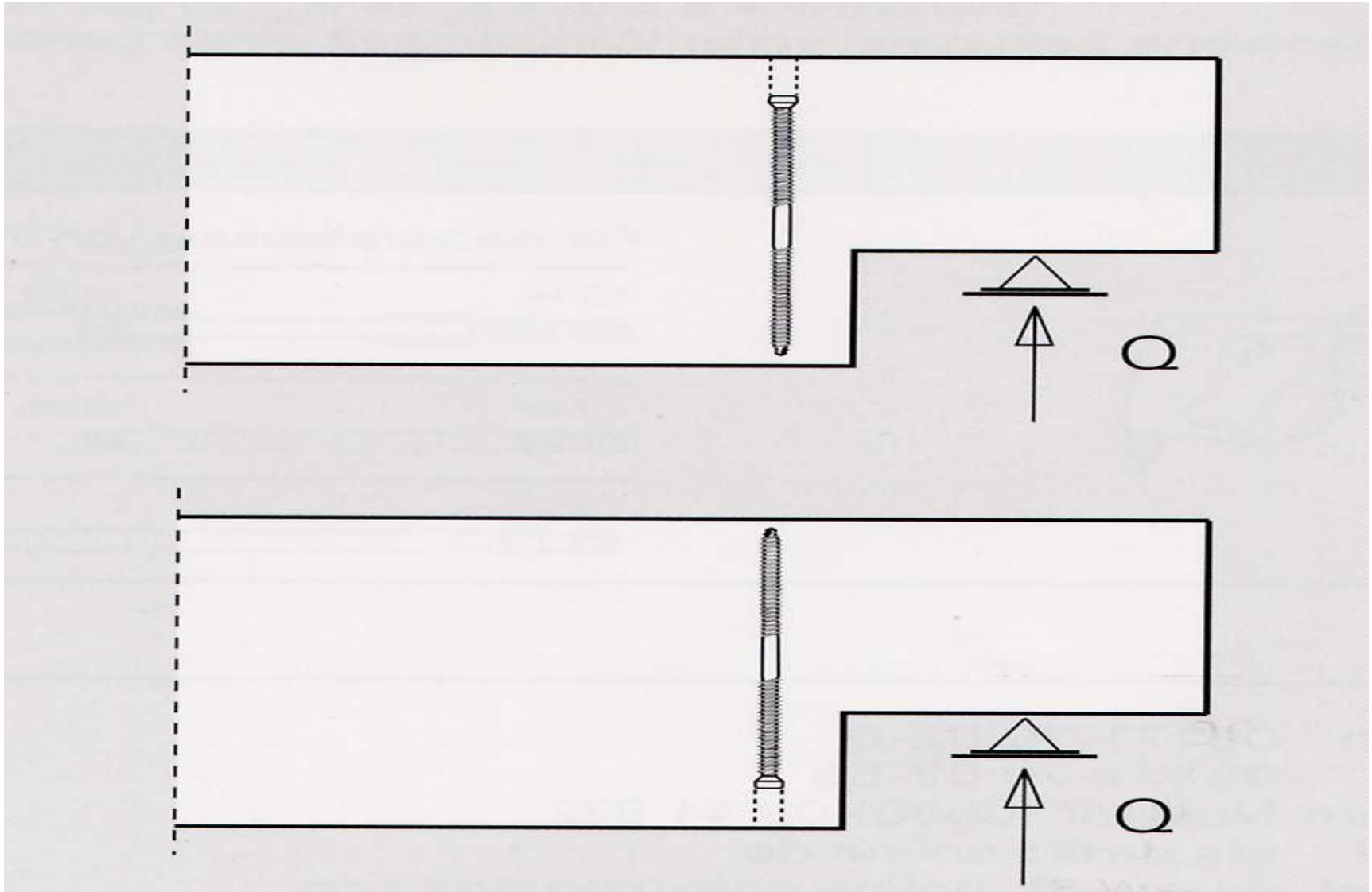









(a)
(b)
(c)
(d)


Q
Q

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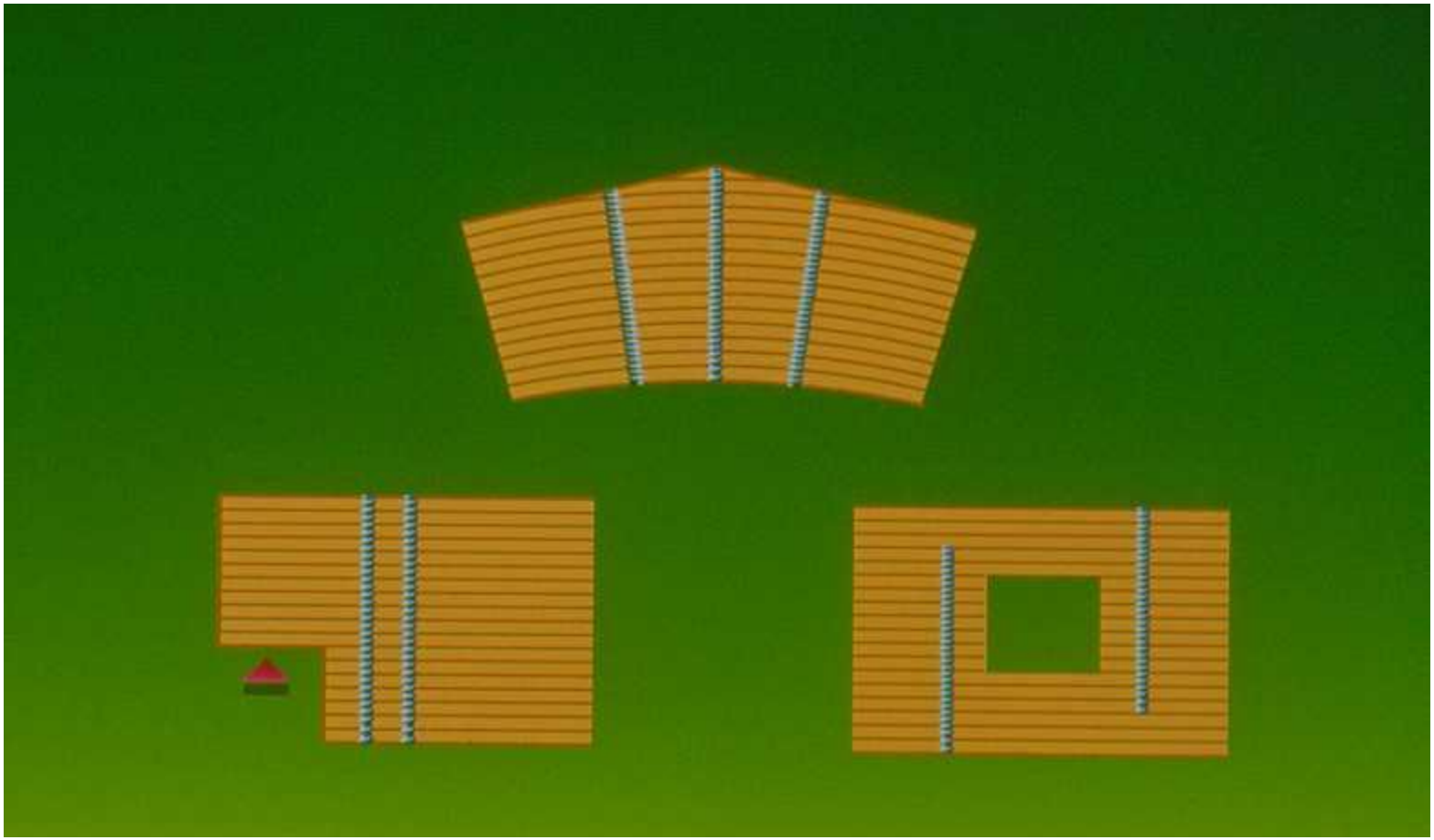
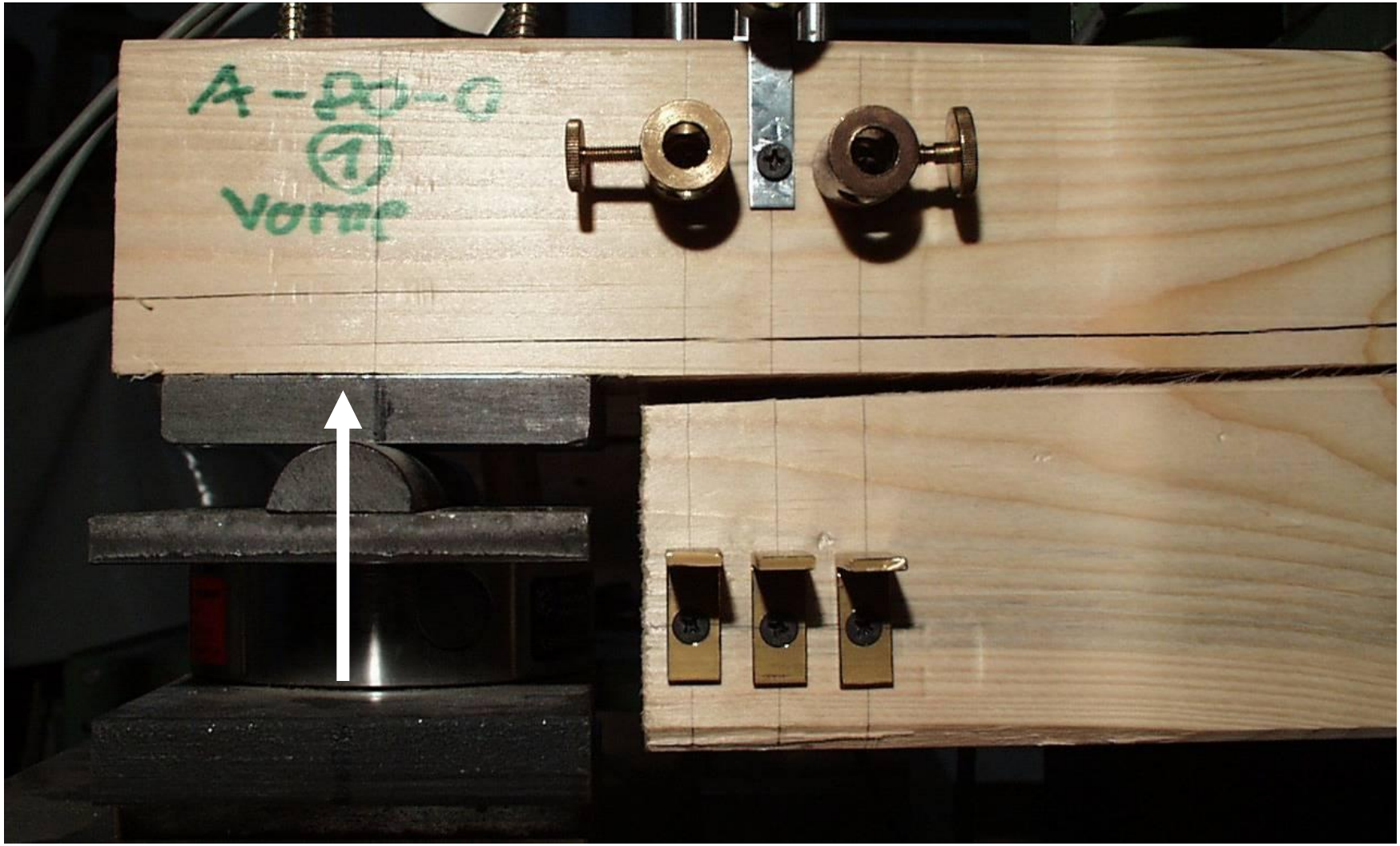
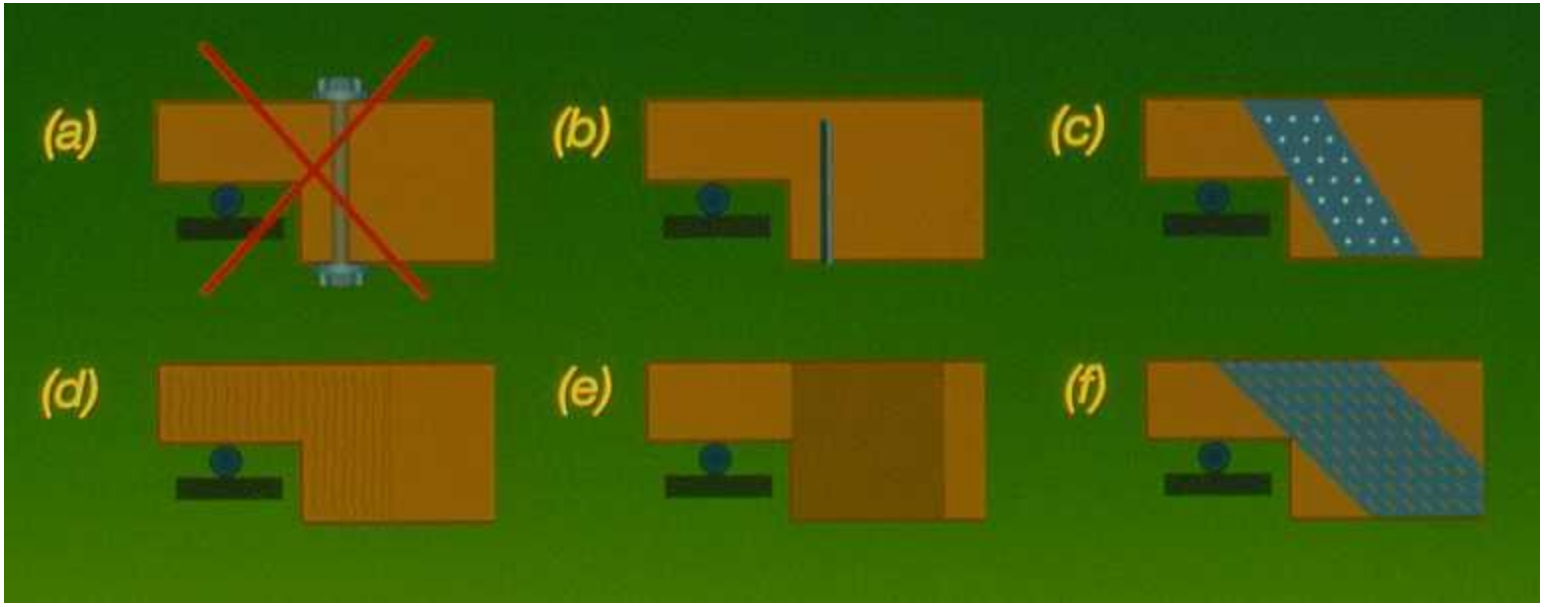
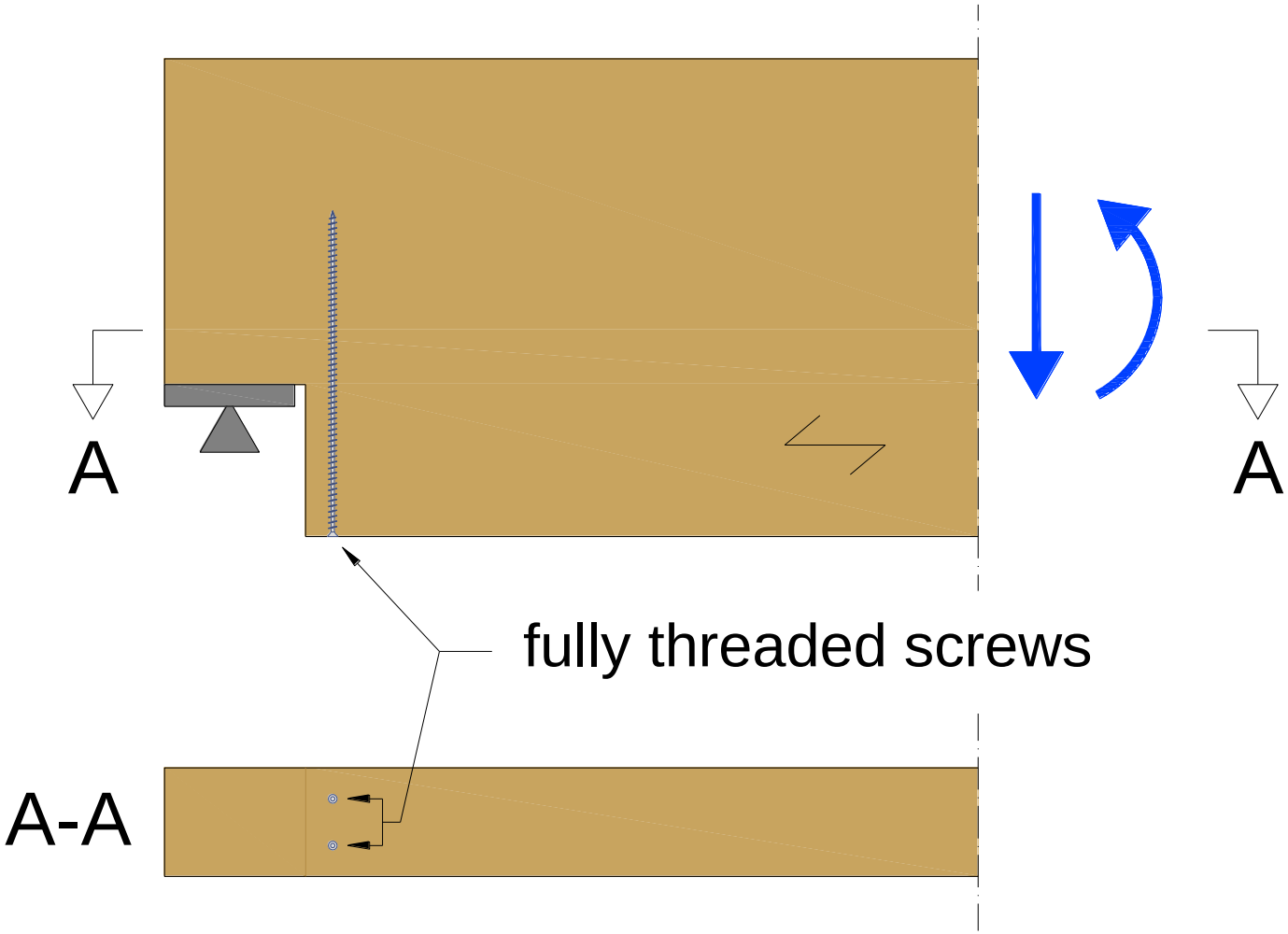



A-
vorn


(a)
(b)
(c)
(d)
(e)
(f)


A
A
fully threaded screws
A-A

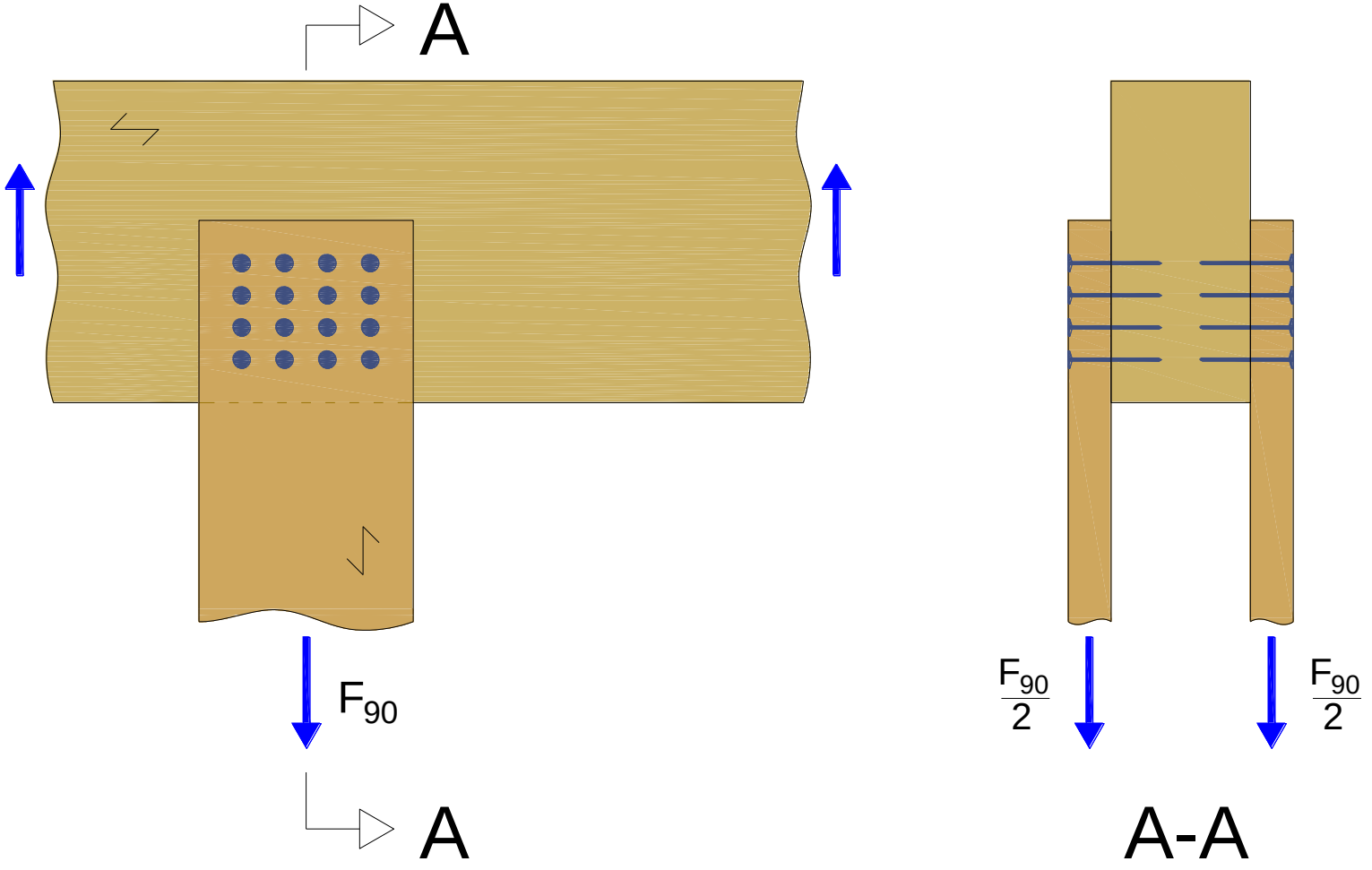

A
F_{90}
A
$\frac{F_{90}}{2}$
$\frac{F_{90}}{2}$
A-A

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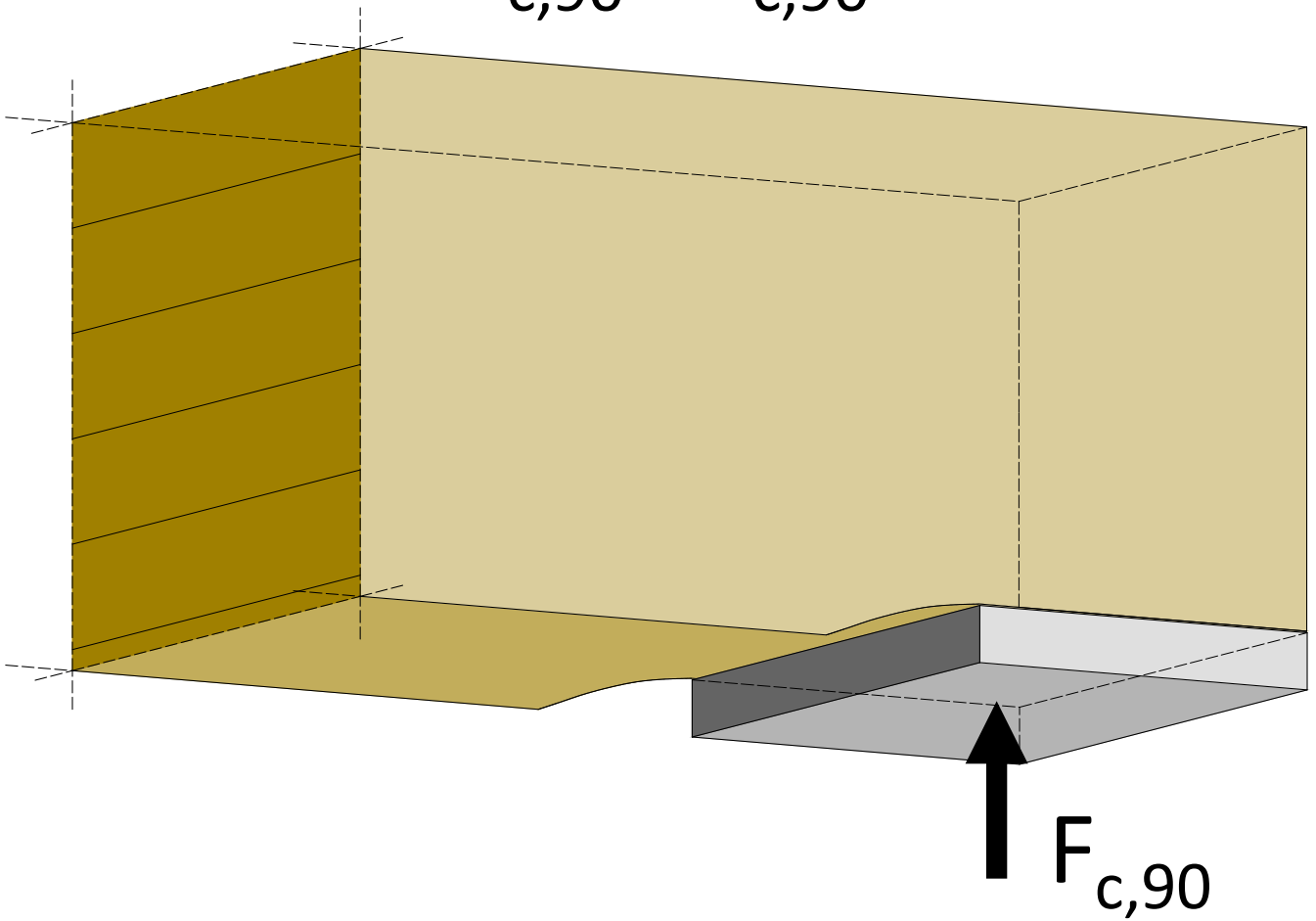
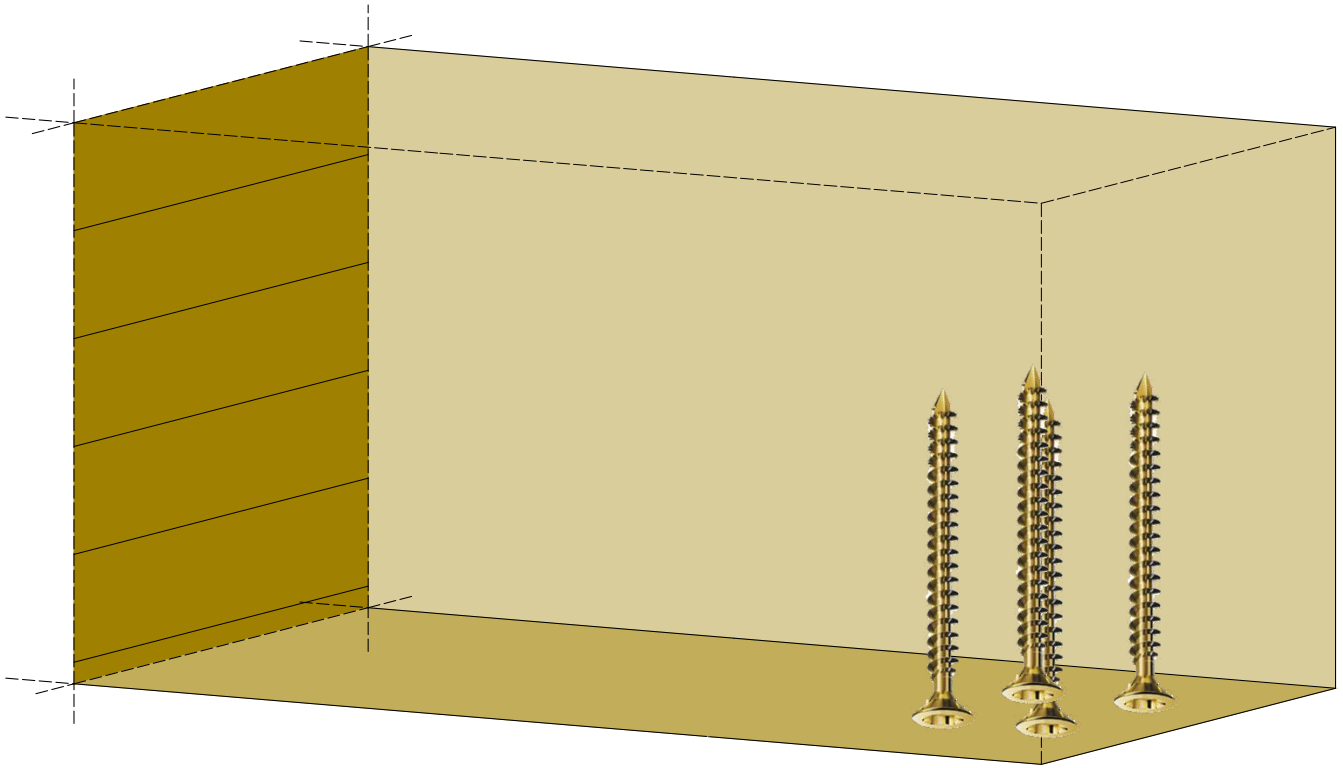
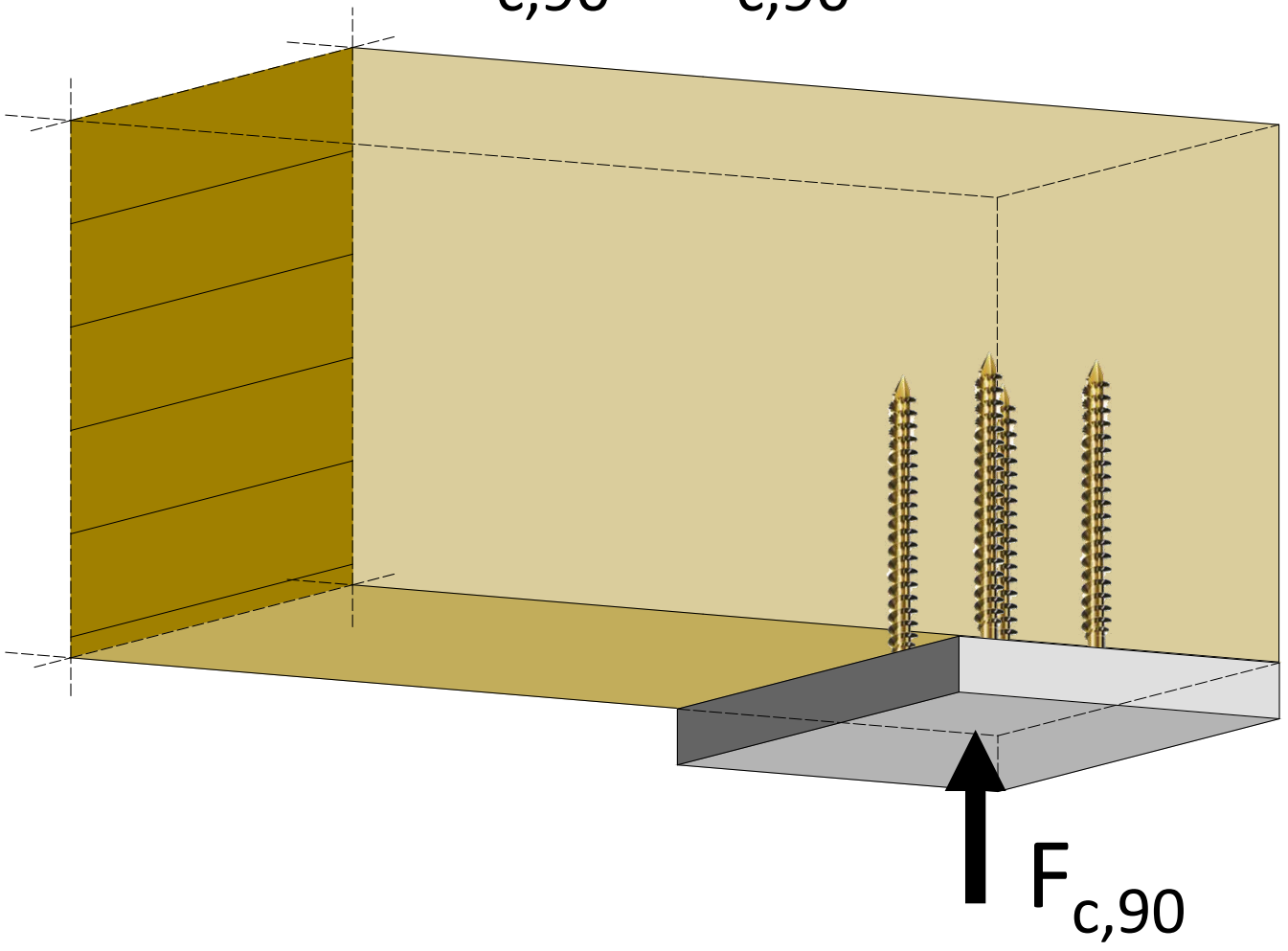
Photo: Kreuzinger

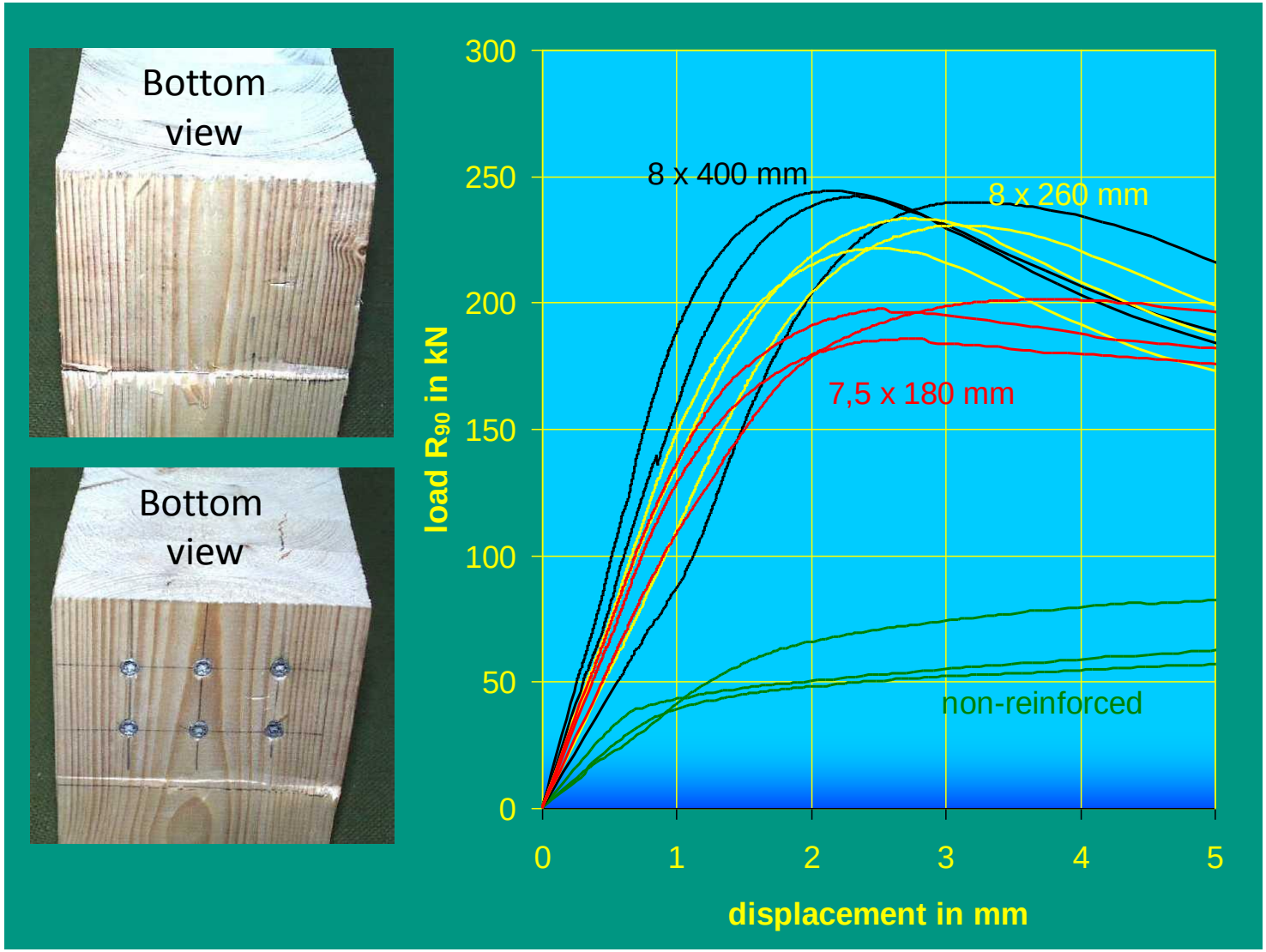
$$\sigma_{c,90} = f_{c,90}$$





$\sigma_{c,90} < f_{c,90}$




Bottom view
Bottom view
300
250
200
150
100
50
0
load R_{90} in kN
8 x 400 mm
8 x 260 mm
7,5 x 180 mm
non-reinforced
0
1
2
3
4
5
displacement in mm

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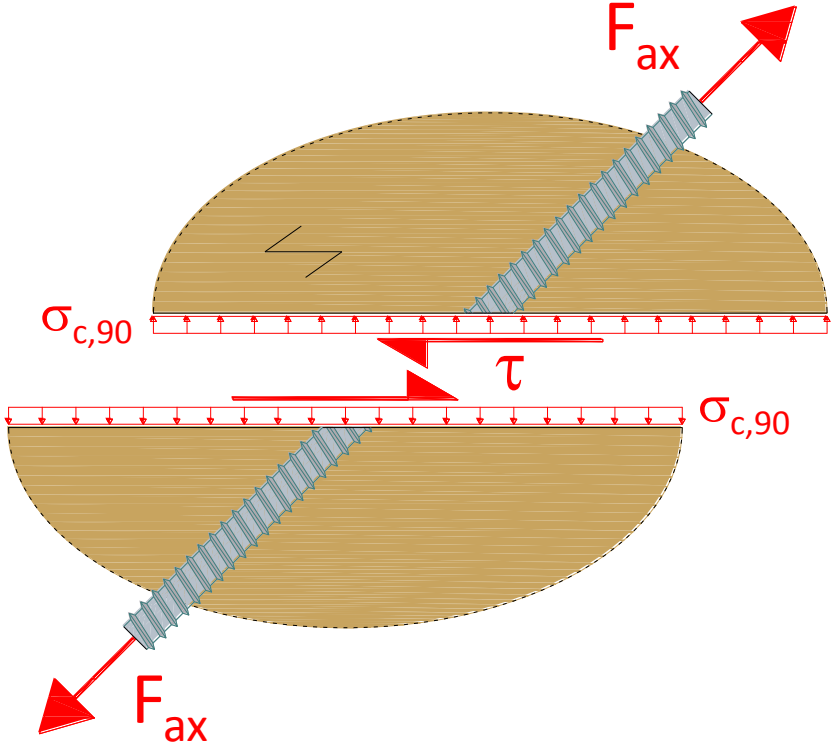
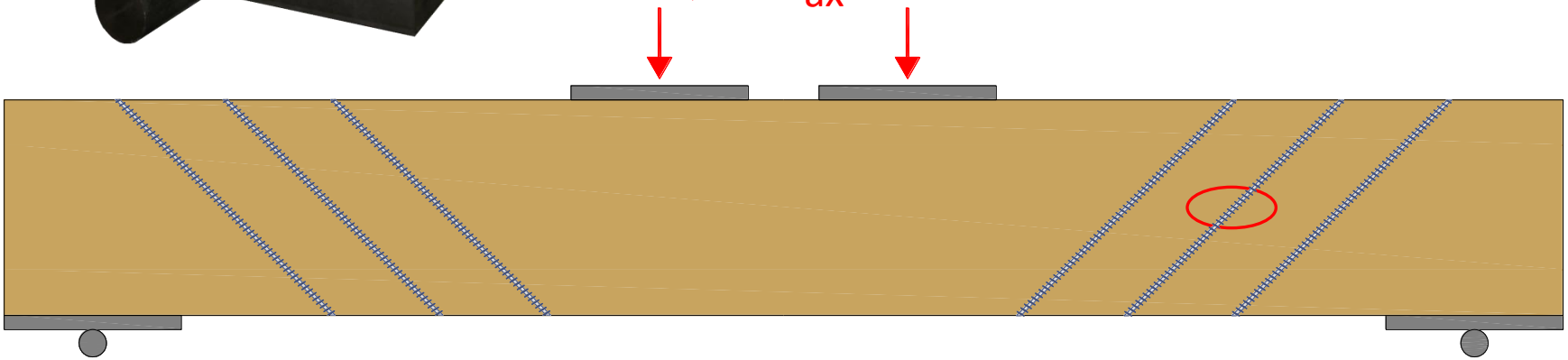
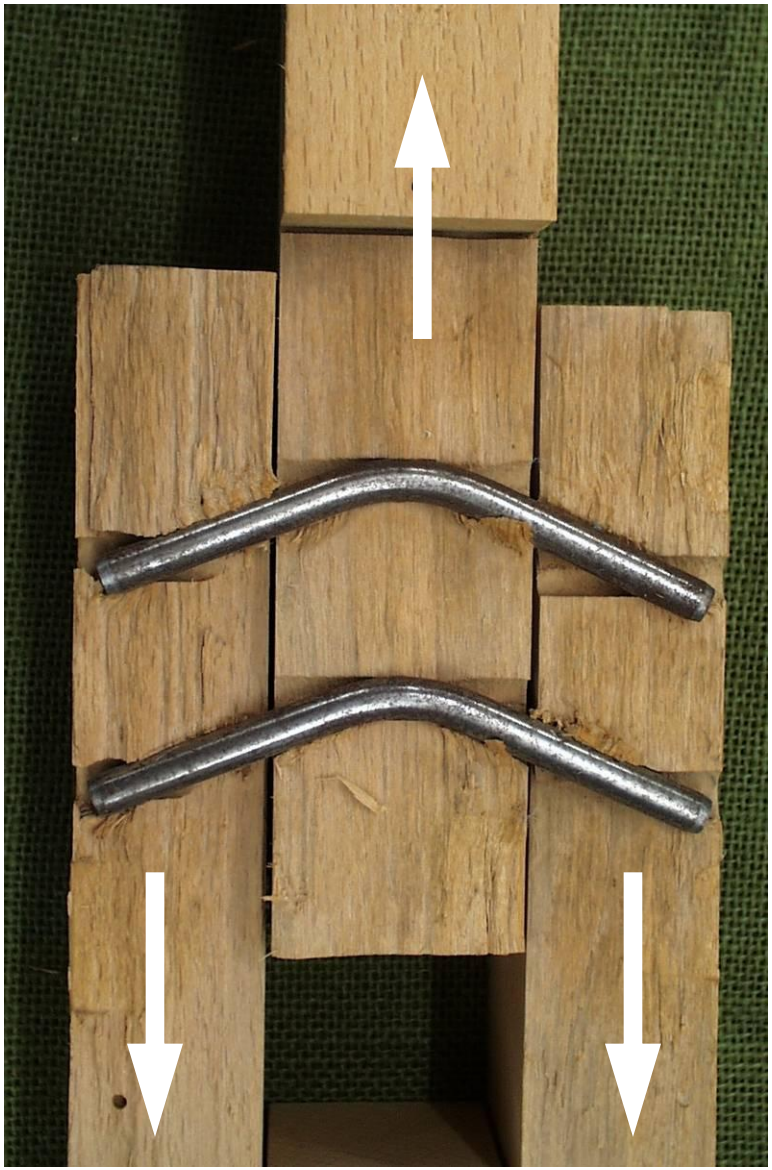
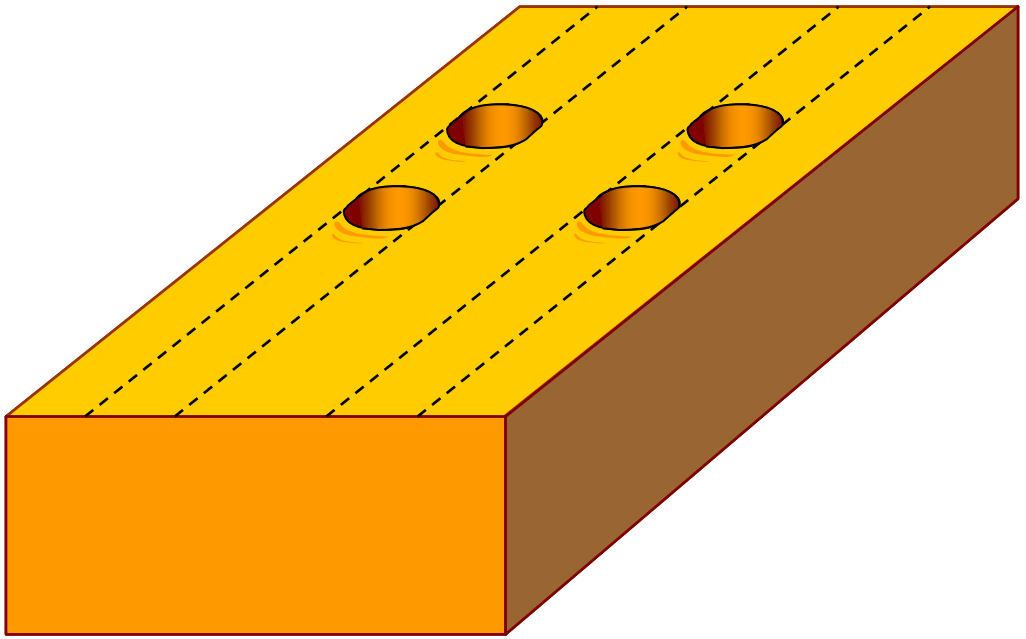
No 13

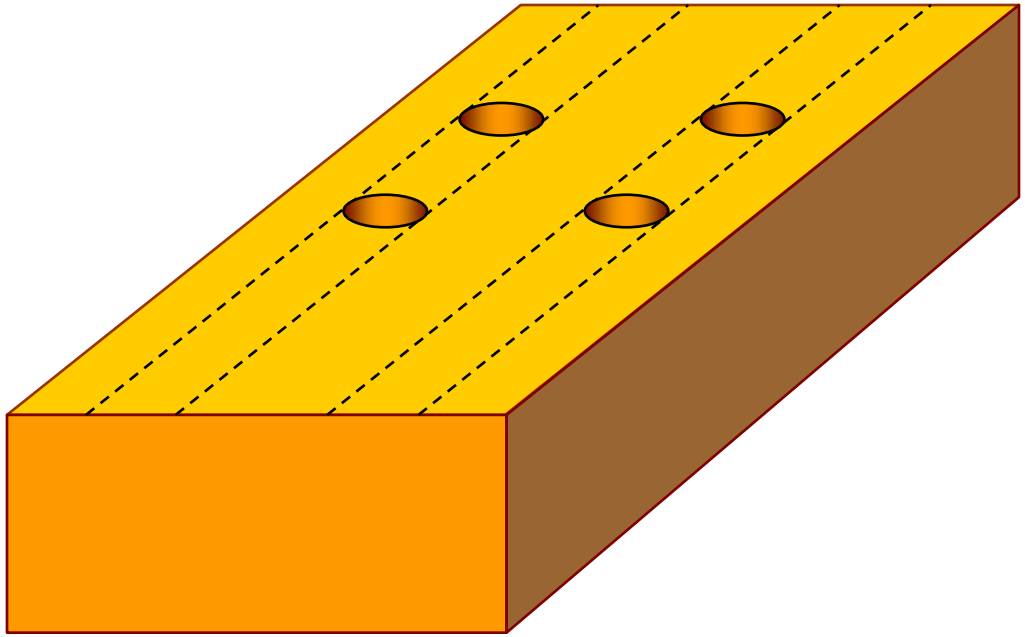

F ax
σ c,90
τ
σ c,90
F ax



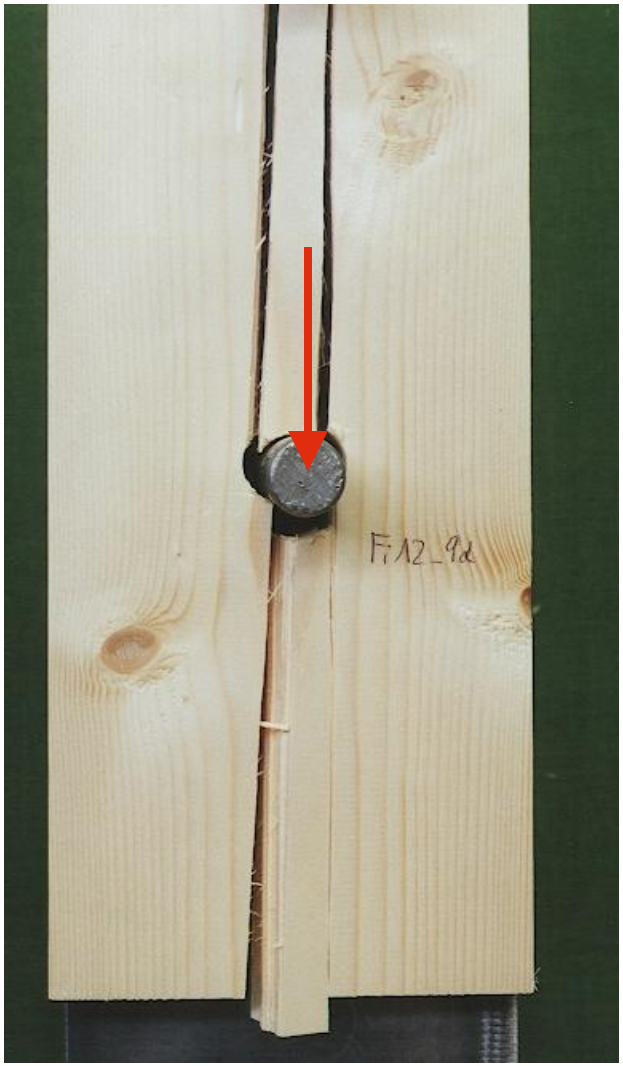
Johansen‘s model

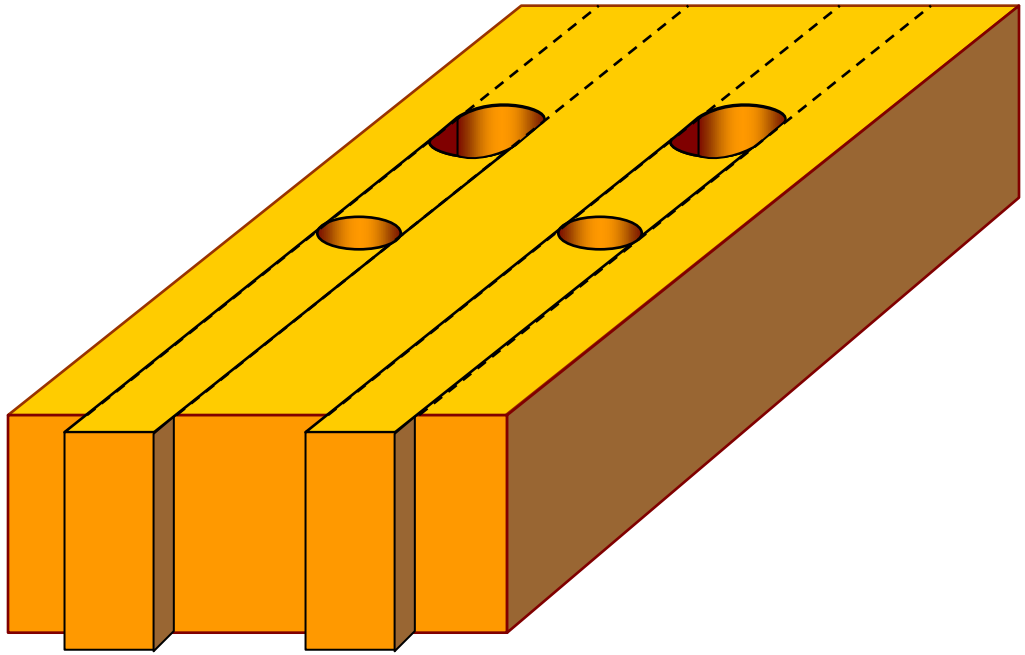


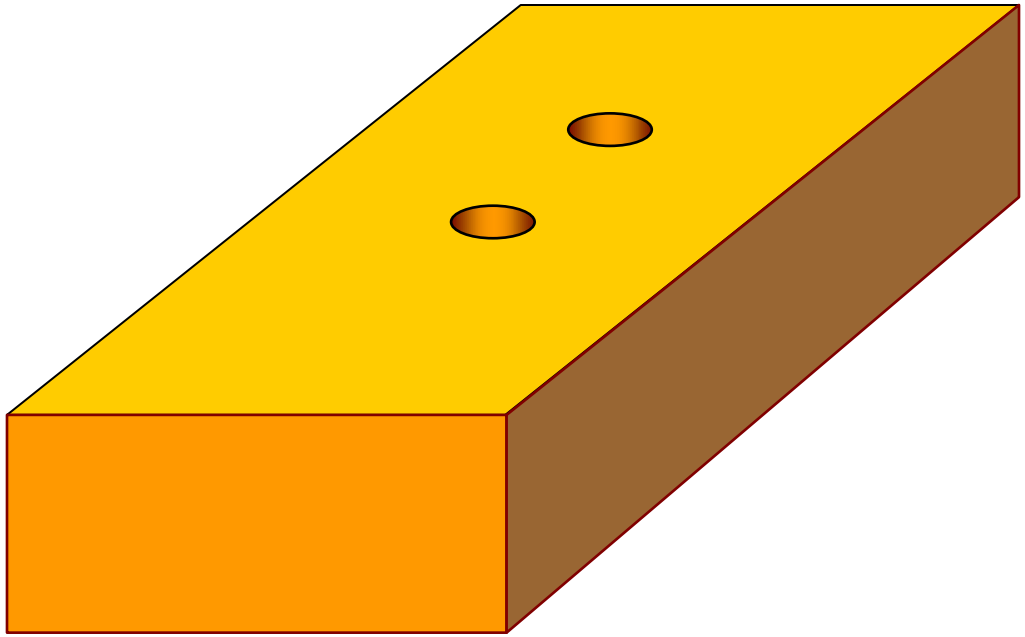




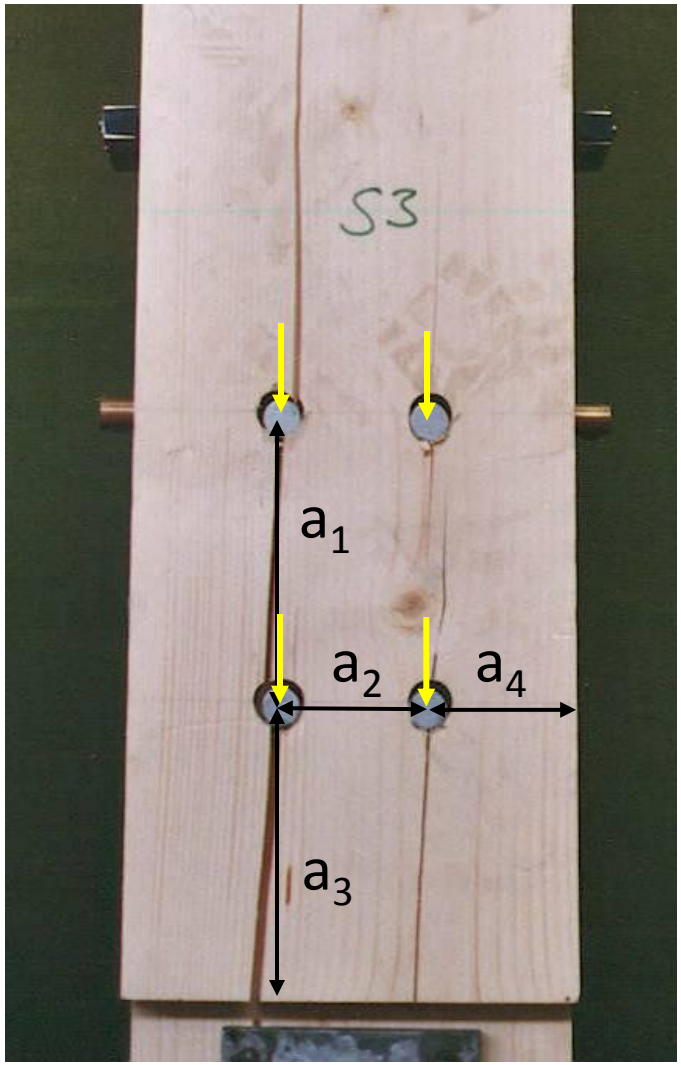
Plug shear

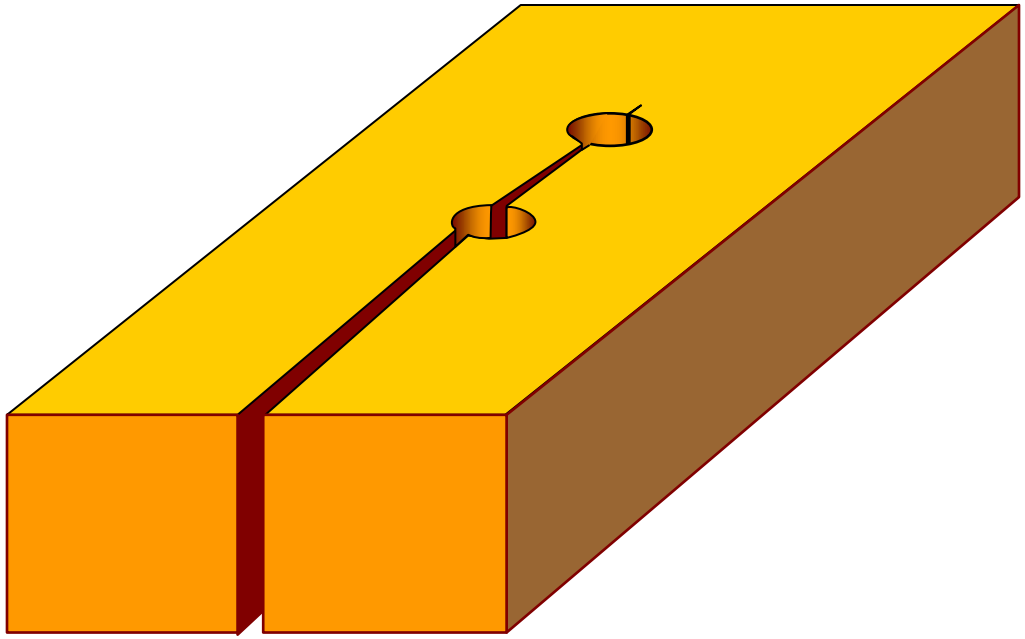


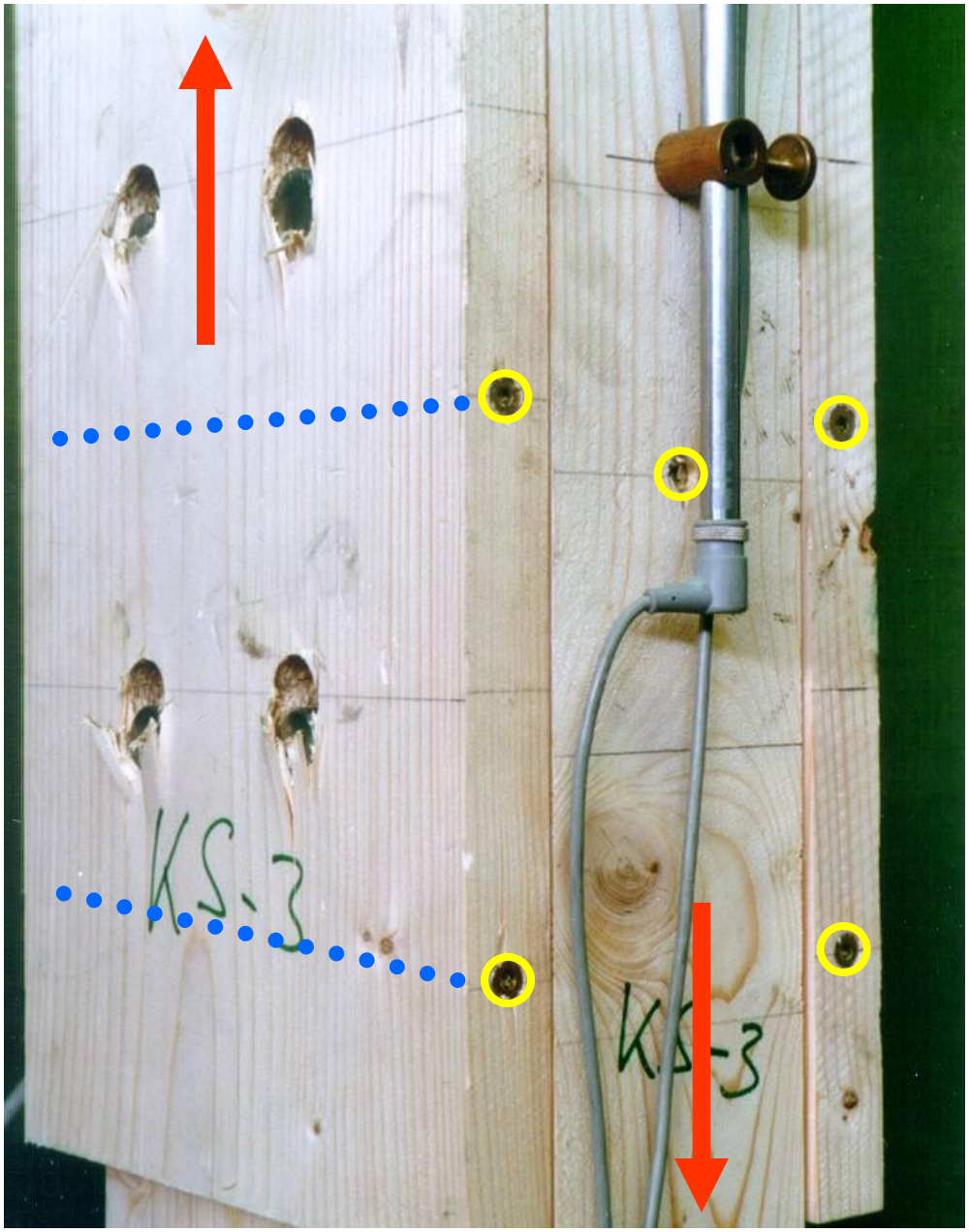




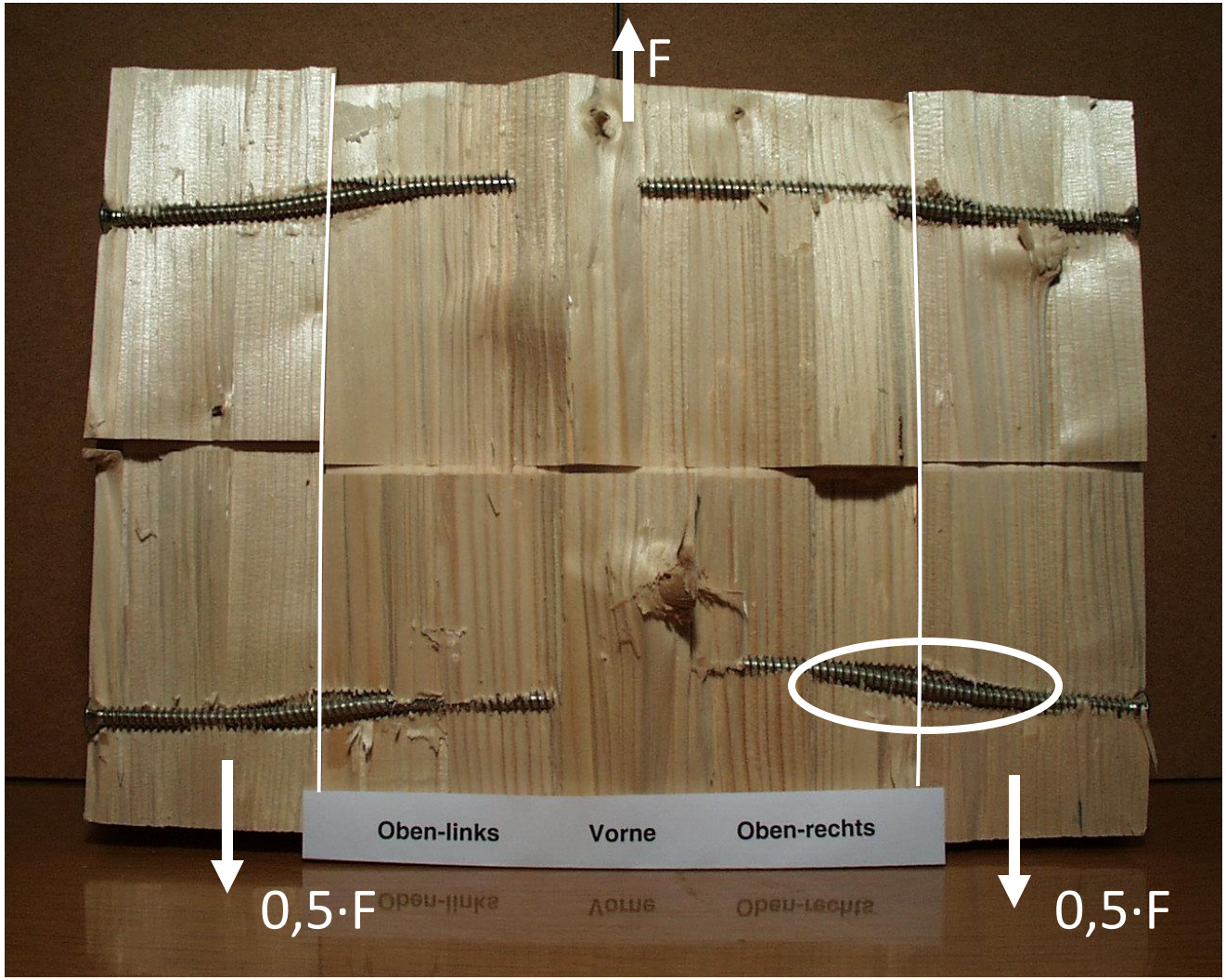
Splitting

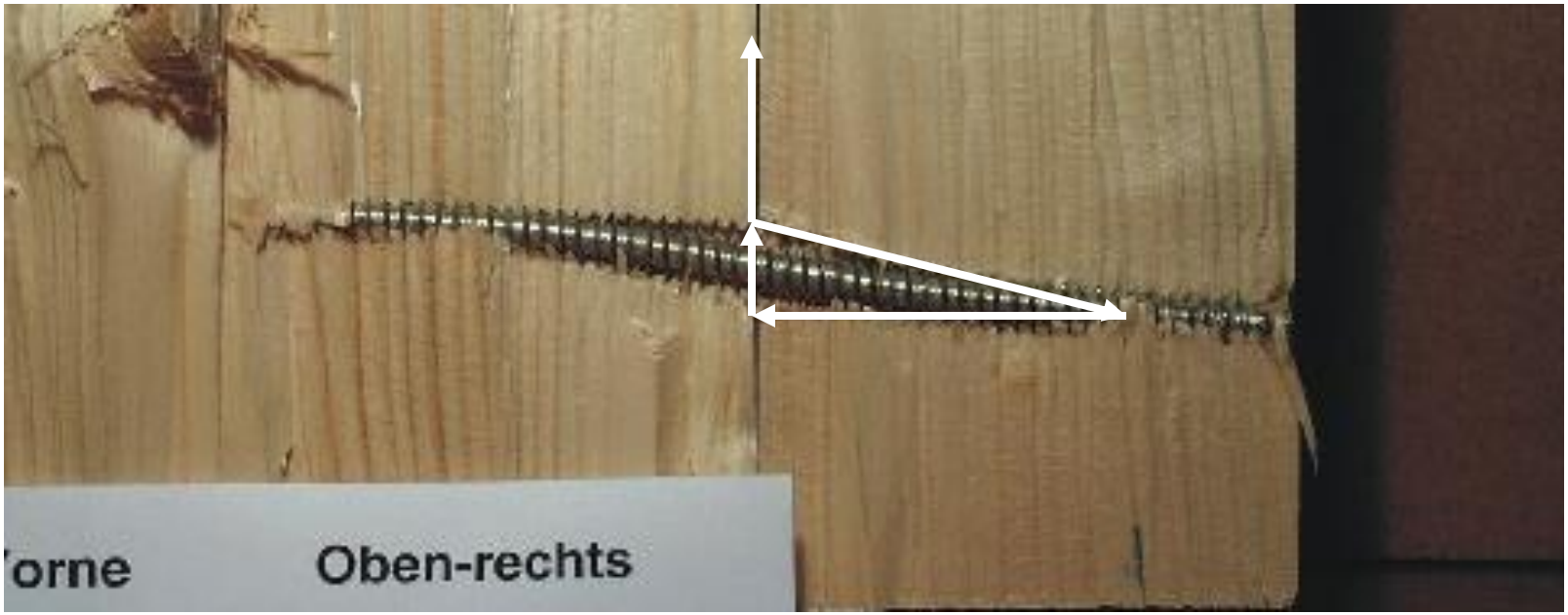




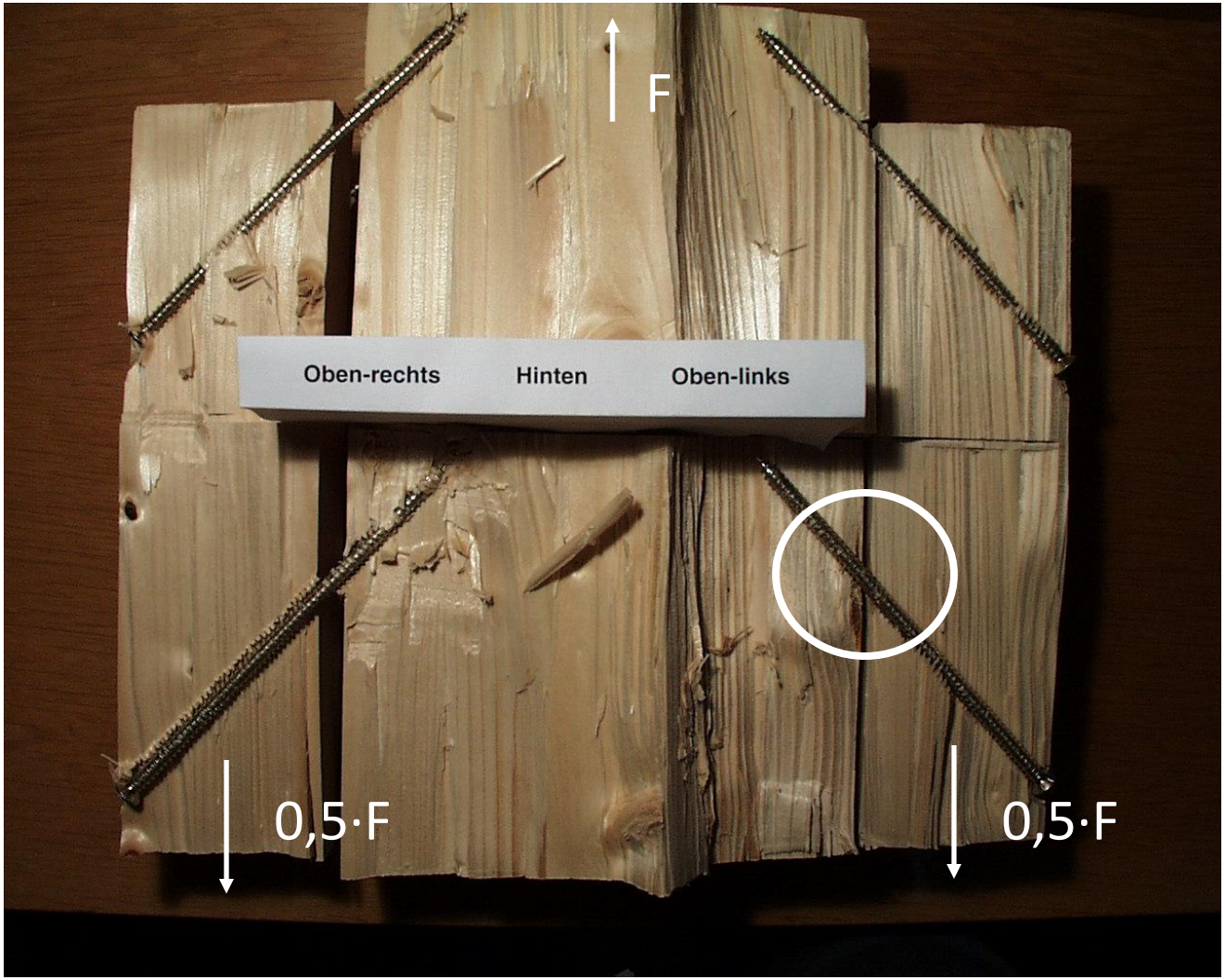

KS-3
KS-3

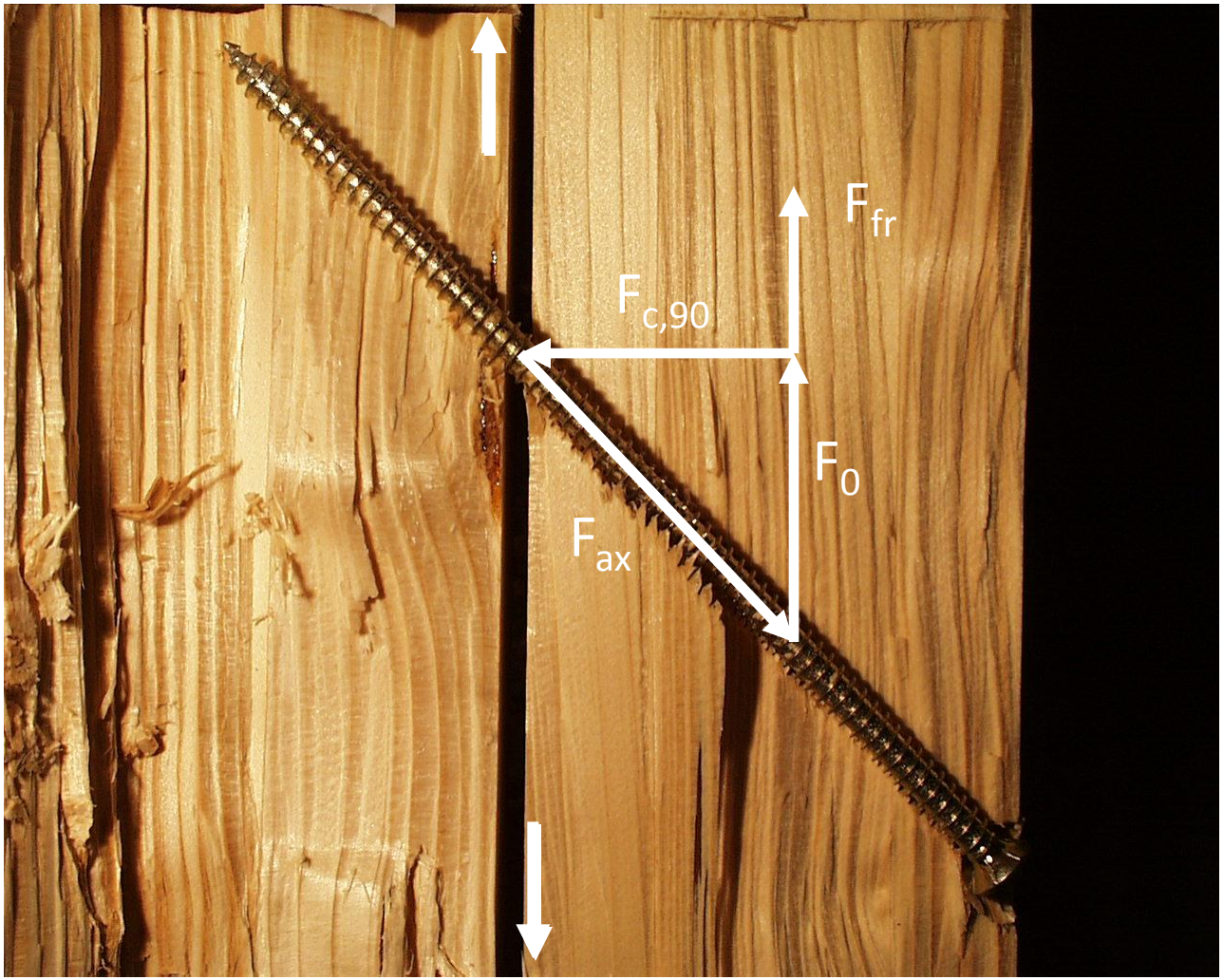
Hans J. Blass


F
Oben-links
Vorne
Oben-rechts
0,5·F
0,5·F


orne
Oben-rechts

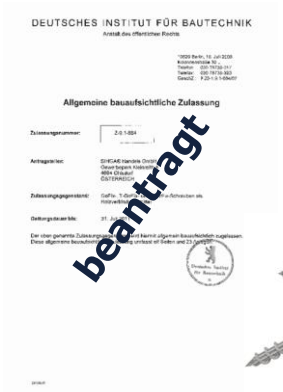
Truss action




F_{fr}
$F_{c,90}$
F_0
F_{ax}

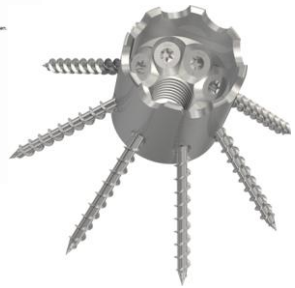
IdeFix - Inovation in mechanical connections

IdeFix® IF

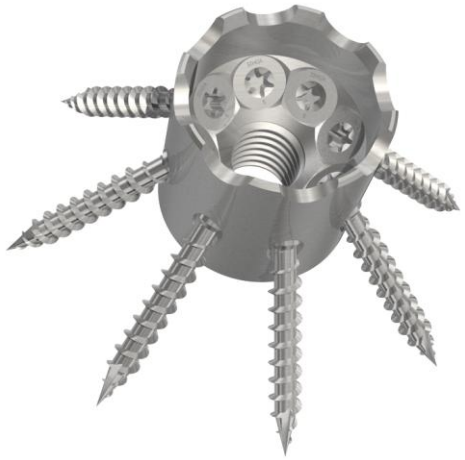

DEUTSCHES INSTITUT FÜR BAUTECHNIK

Allgemeine bauaufsichtliche Zulassung

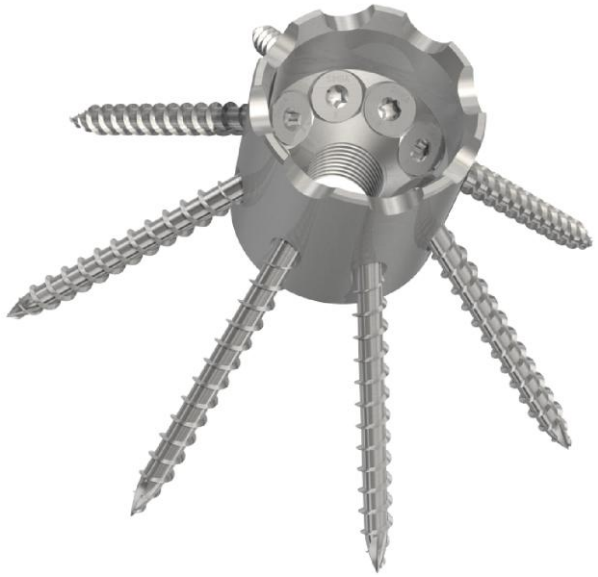
beantragt



Ø 30 mm, M12

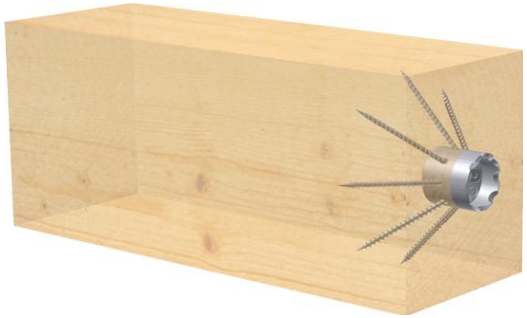


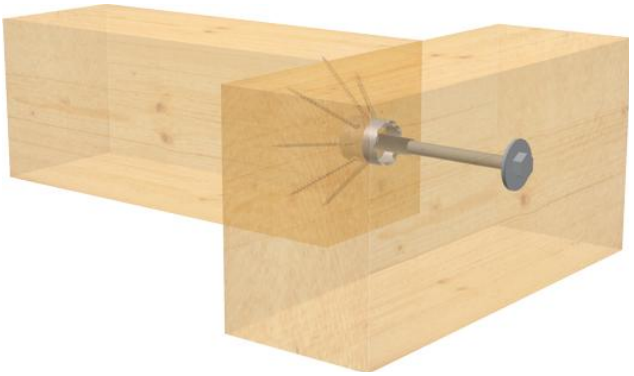
Ø 40 mm, M16

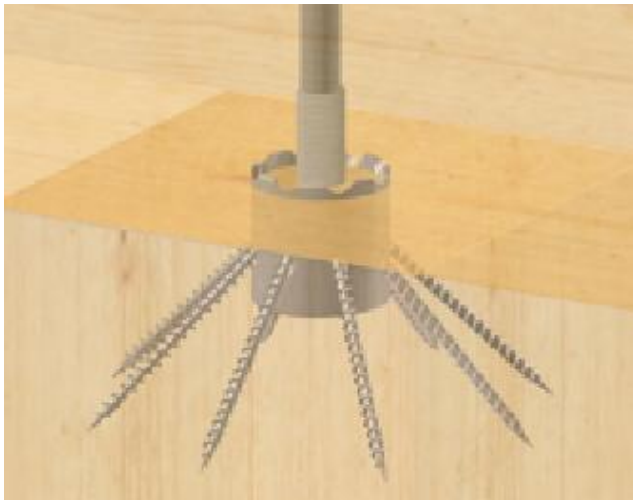


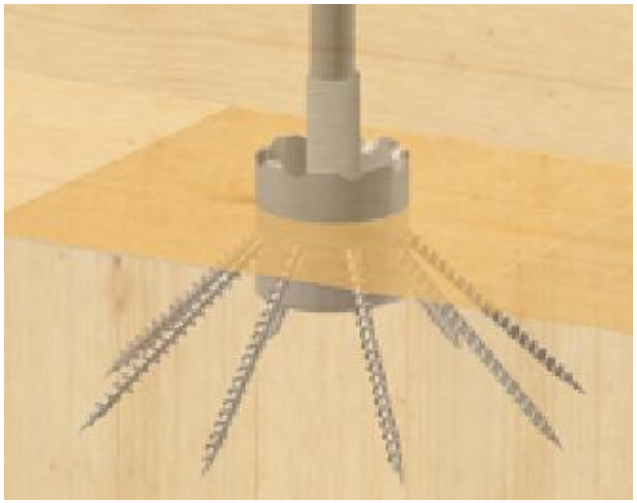
Ø 50 mm, M20

IdeFix assembling in connection

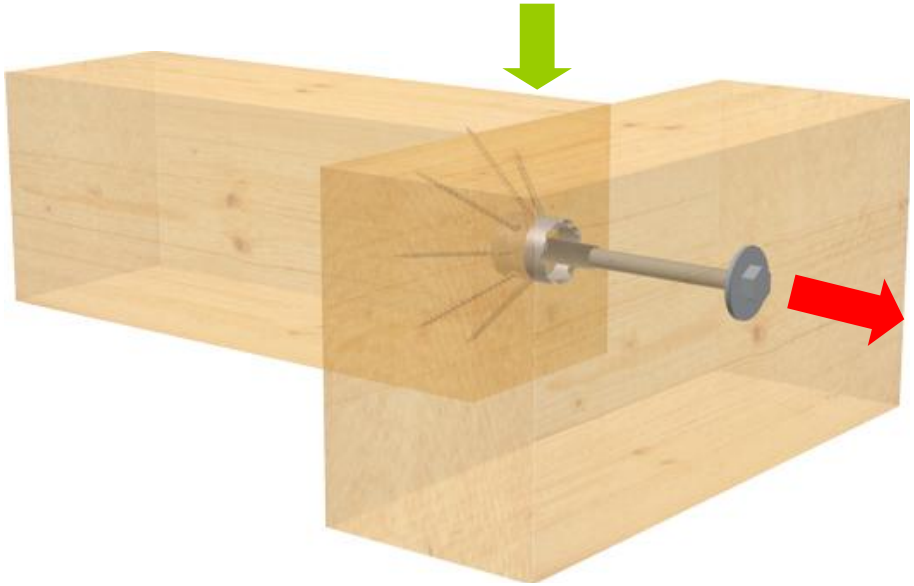








IdeFix load-bearing capacities



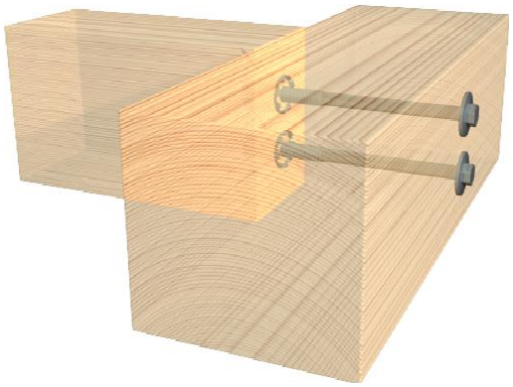
in shear:

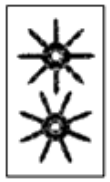
IdeFix® 30	8,94 kN
IdeFix® 40	14,66 kN
IdeFix® 50	21,09 kN

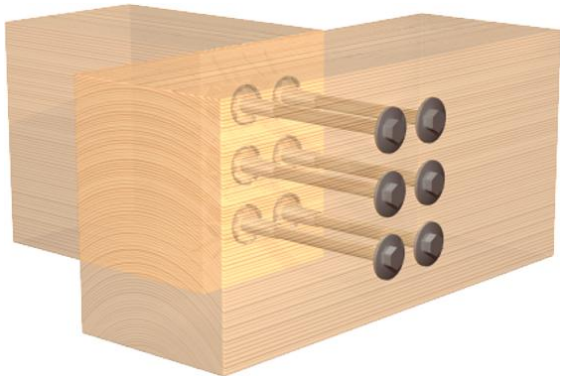
in tension:

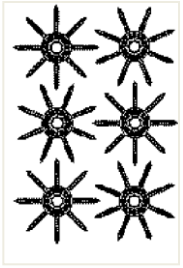
IdeFix® 30	17,30 kN
IdeFix® 40	28,79 kN
IdeFix® 50	47,35 kN

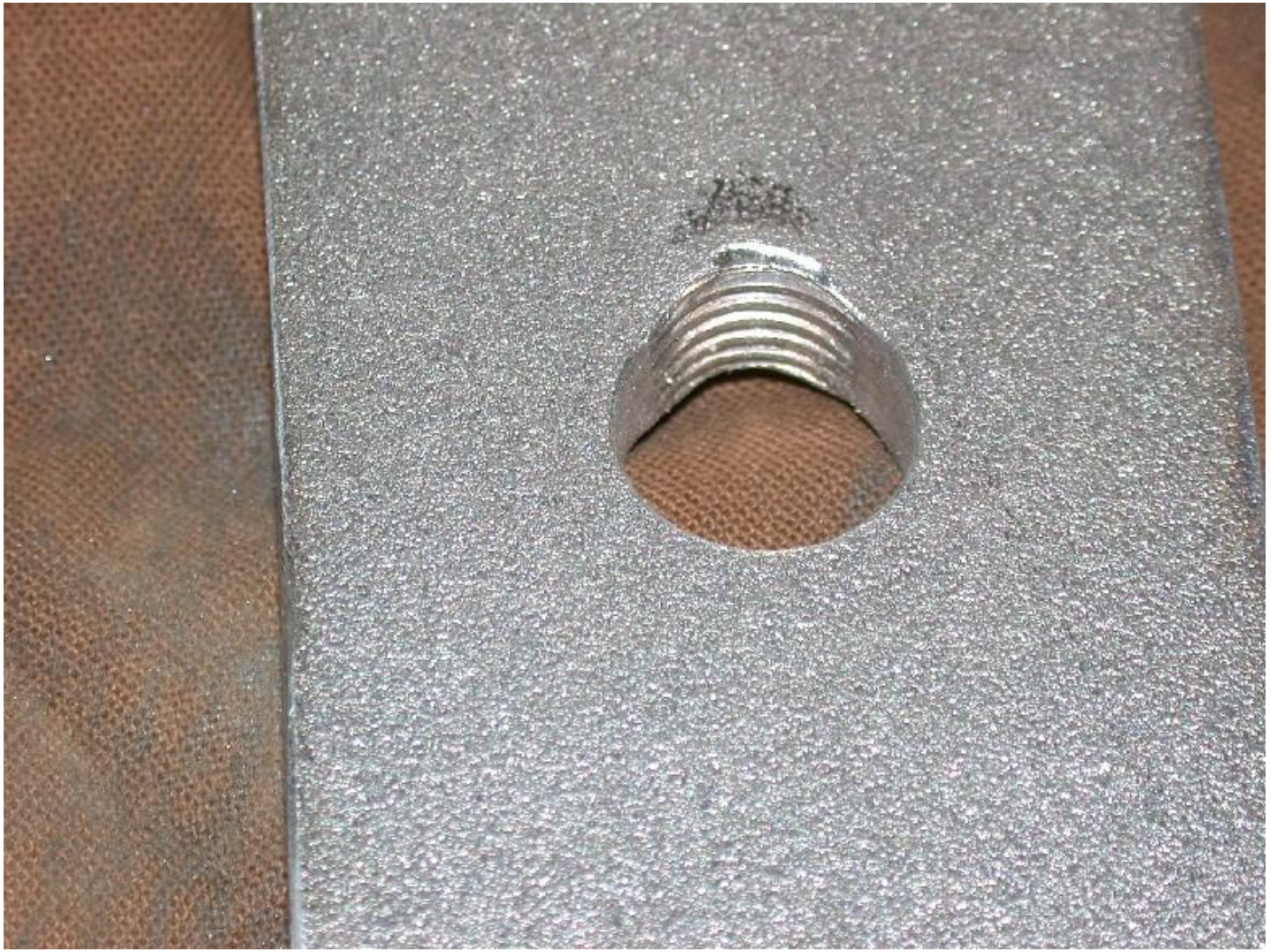
IdeFix set up and application



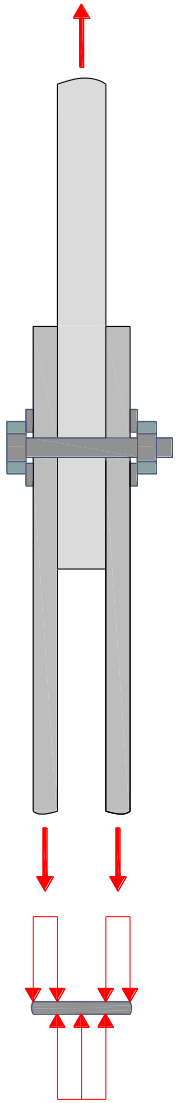


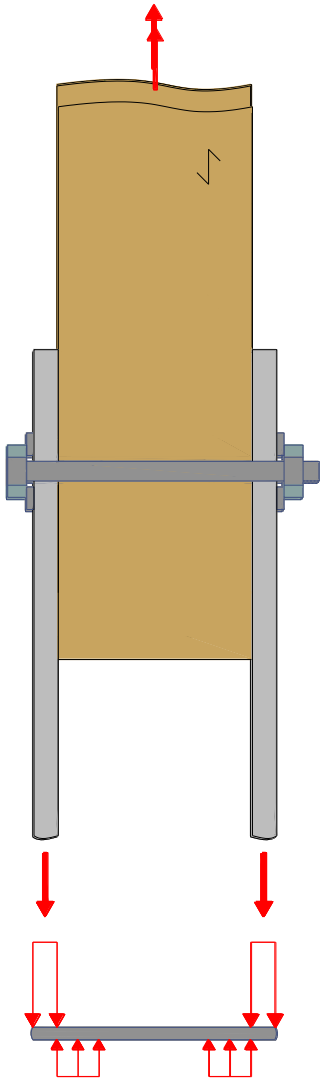


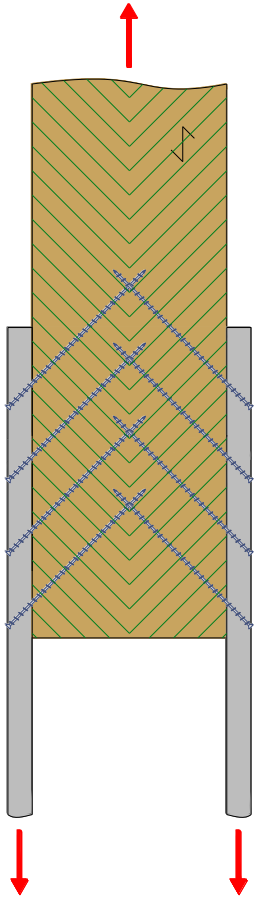




Source:
Project KI-Smile







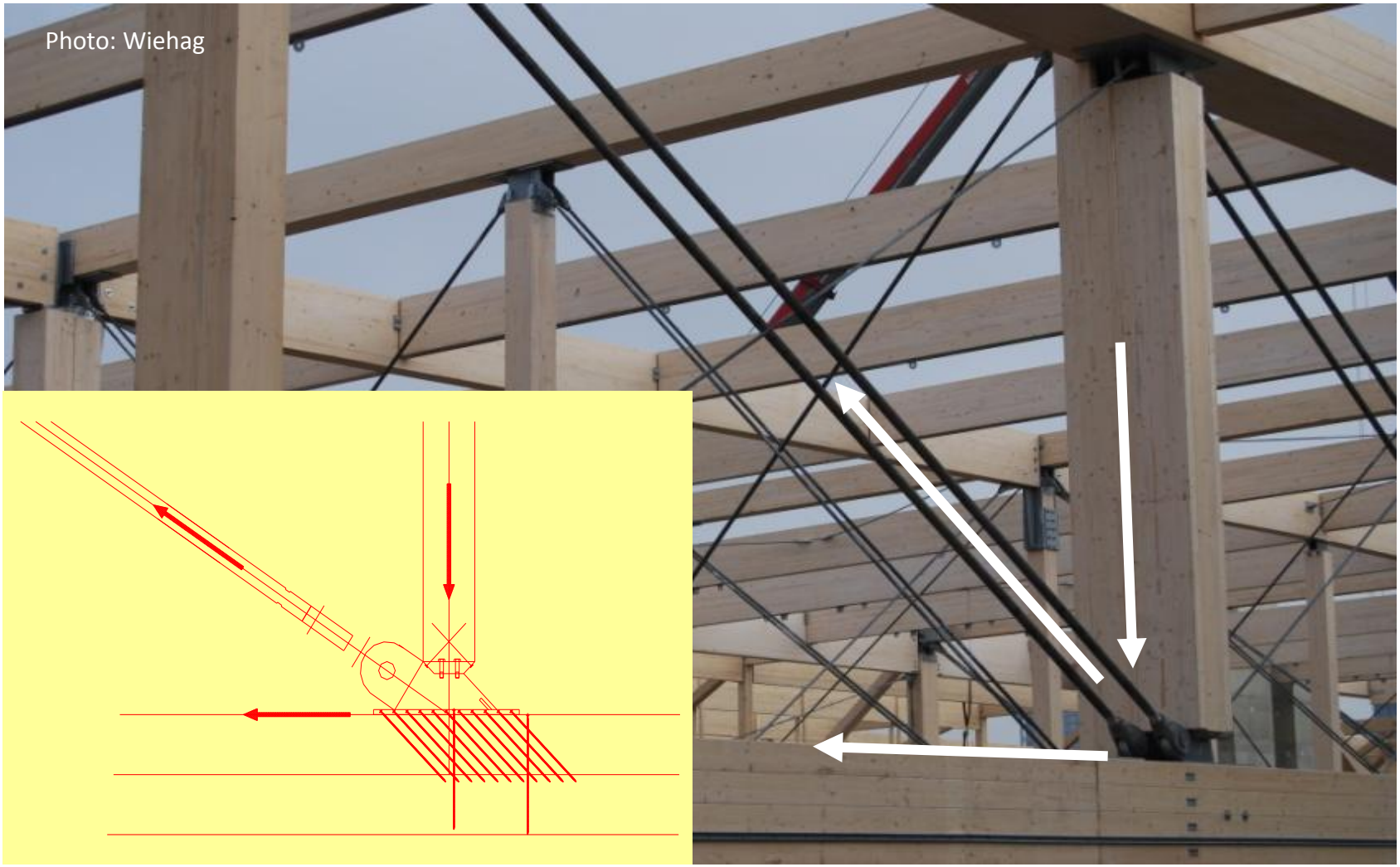


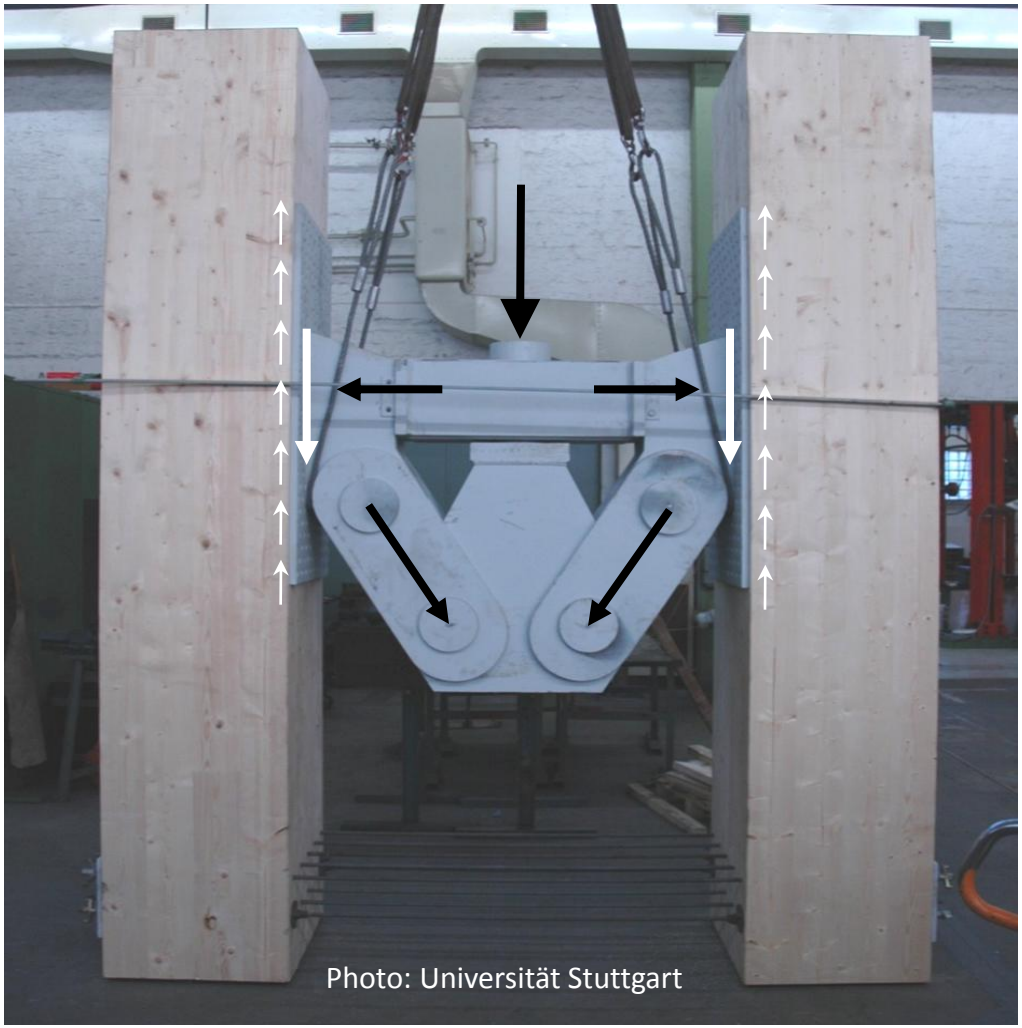
Photo: Wiehag

Photo: Atlas Copco

Photo: Atlas Copco


Photo: Atlas Copco

Connection test Stuttgart University



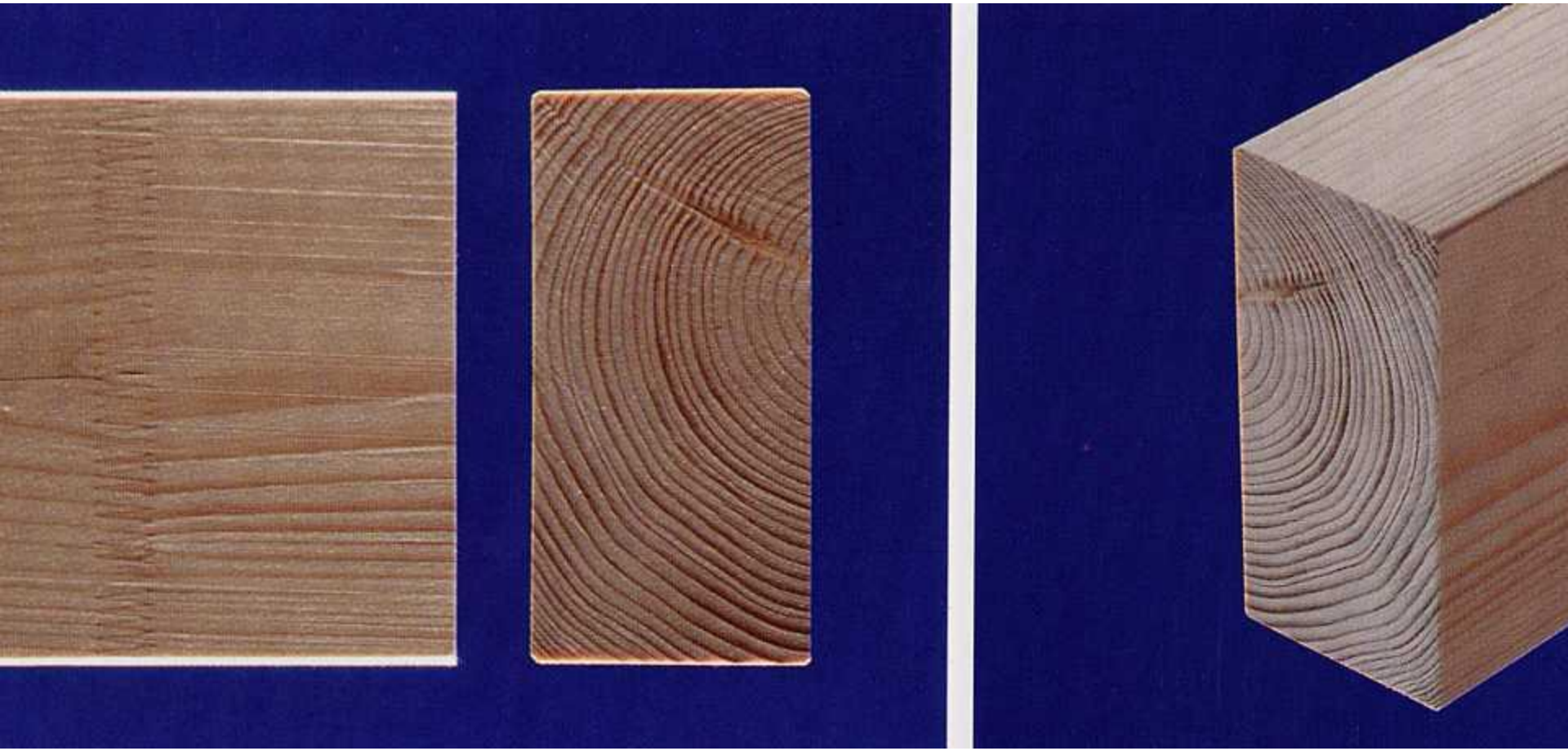
- Ultimate load per shear plane:
  Test 1: F_U = 6200 kN
  Test 2: F_U = 6600 kN

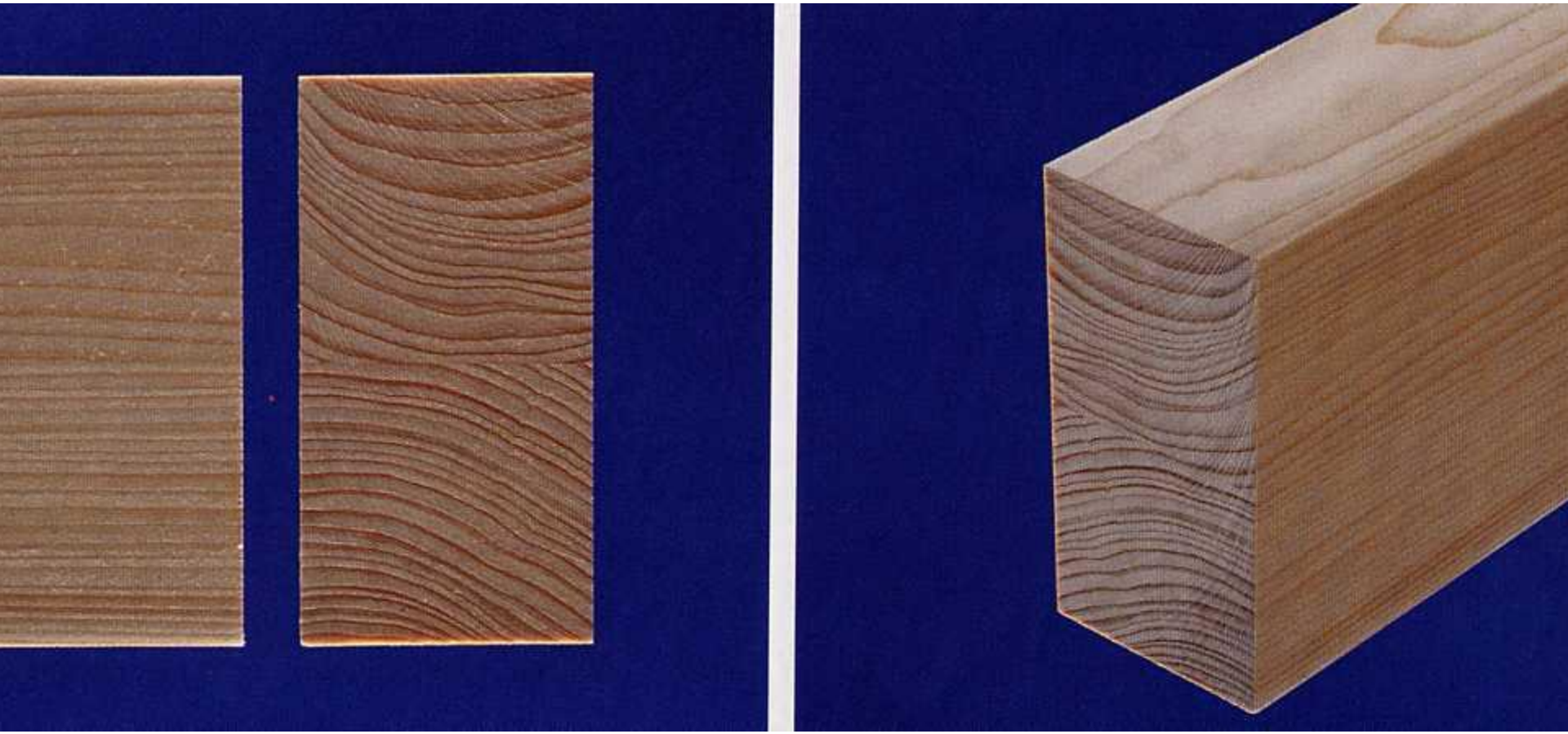

Photo: Universität Stuttgart

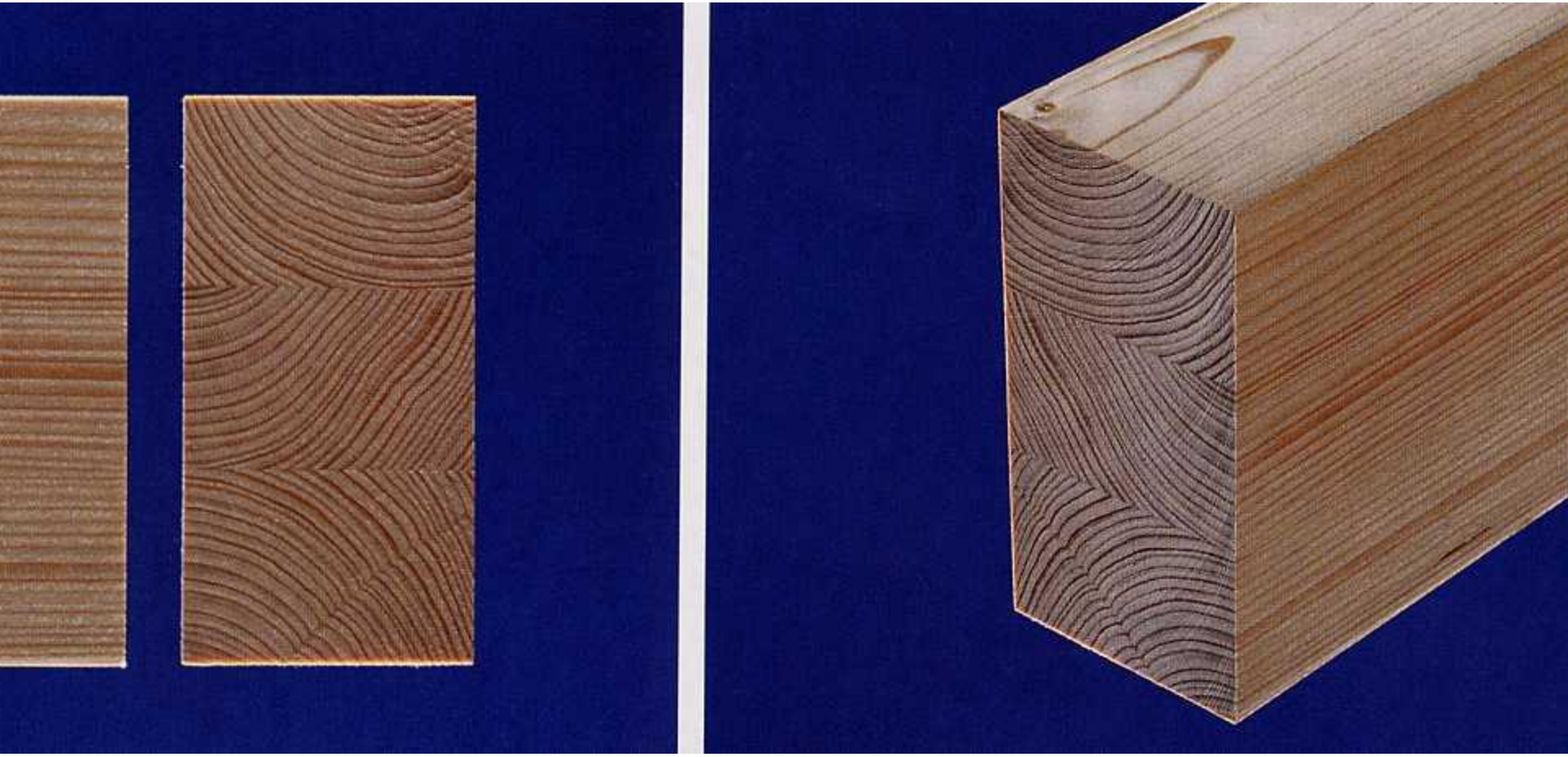

Photo: Universität Stuttgart

Nuovi materiali

- KVH, Bilama, Trilama
- Glulam a doppia curvatura
- X-LAM



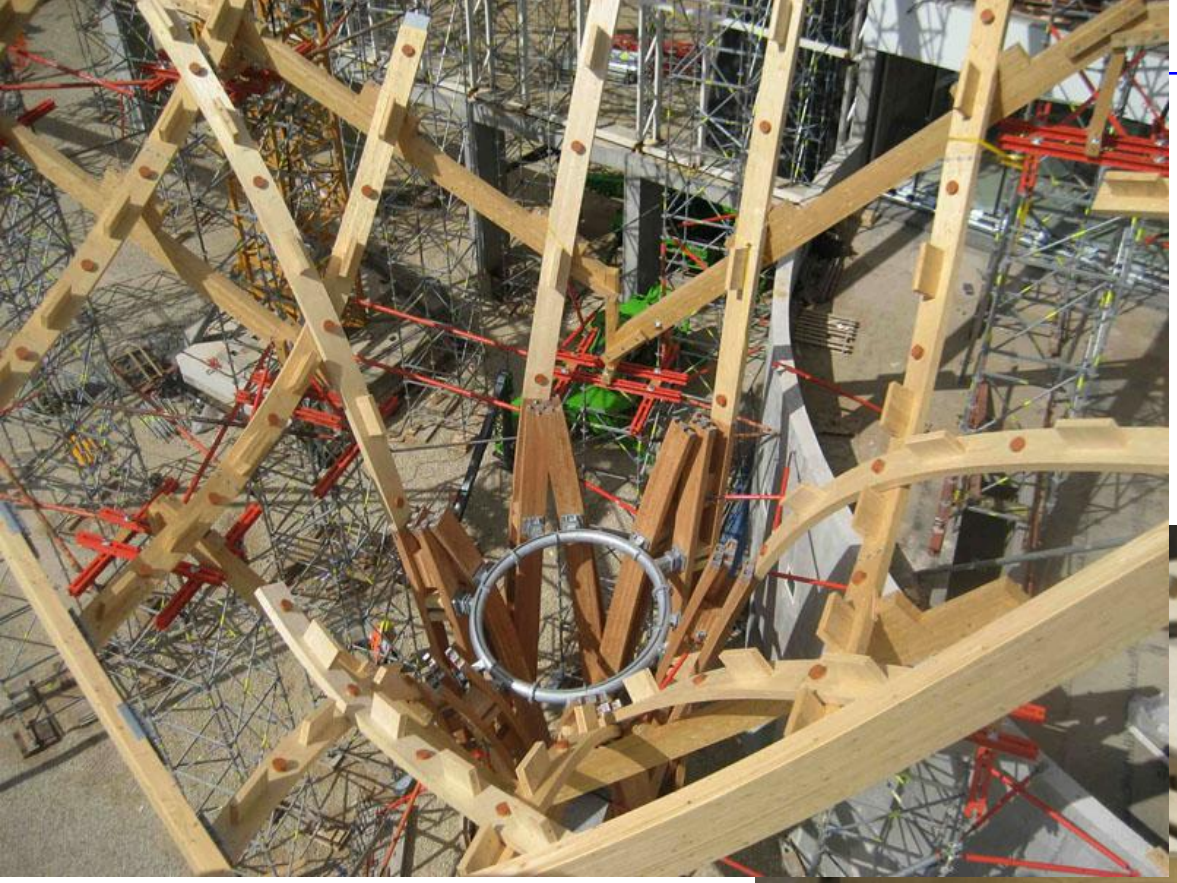




Shigeru Ban's design for the roof of the **Centre Pompidou in Metz**

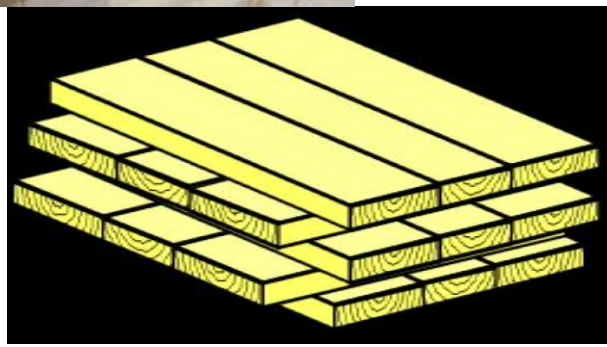
D-P
DESIGNTOPRODUCTION

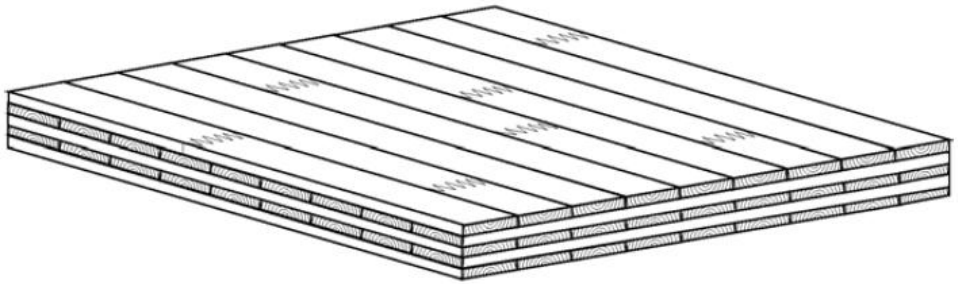
DESIGNTOPRODUCTION



DESIGNTOPRODUCTION

XLAM





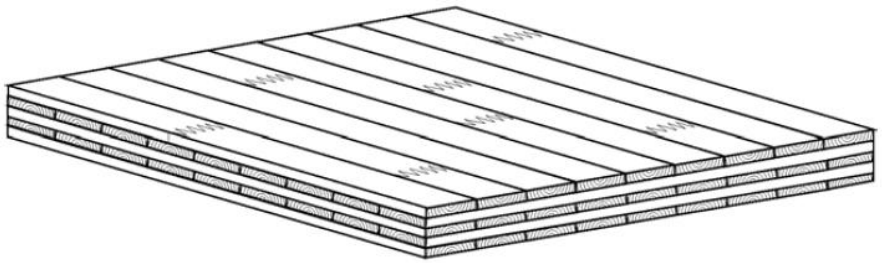
XLAM SYSTEM

Il sistema XLAM (dove XLAM sta per cross-laminated solid timber boards)

è stato sviluppato una dozzina di anni fa in Austria e si è rapidamente esteso a gran parte delle nazioni europee come Germania, Svizzera, Scandinavia, Italia)

XLAM SYSTEM

il XLAM è costituito da tavole, normalmente di abete, incollate fra di loro in maniera incrociata (compensato di tavole) per formare pannelli adatti all'uso come solai e pareti



XLAM SYSTEM : vantaggi

- La disposizione incrociata fornisce un materiale con elevata stabilità dimensionale ed eccellenti prestazioni meccaniche e buon isolamento termico,

- Il sistema XLAM permette la costruzione sia di case unifamiliari che di edifici pluripiano e di edifici non residenziali (scuole, uffici…)

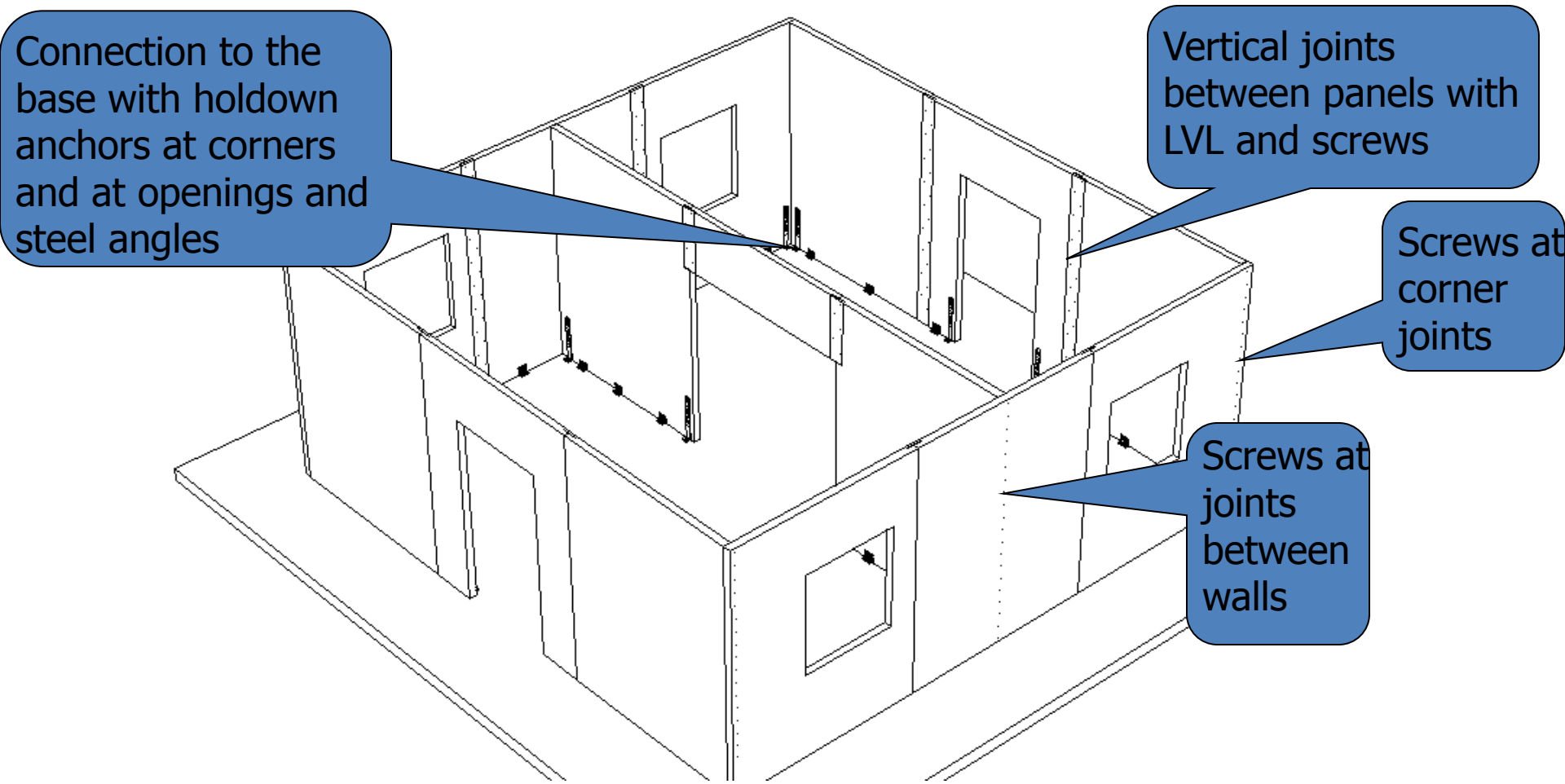
XLAM SYSTEM : vantaggi

- I pannelli XLAM sono estremamente resistenti e rigidi, e consentono l'utilizzo anche di categorie di qualità di legno medio-basse di provenienza locale.

XLAM SYSTEM : vantaggi

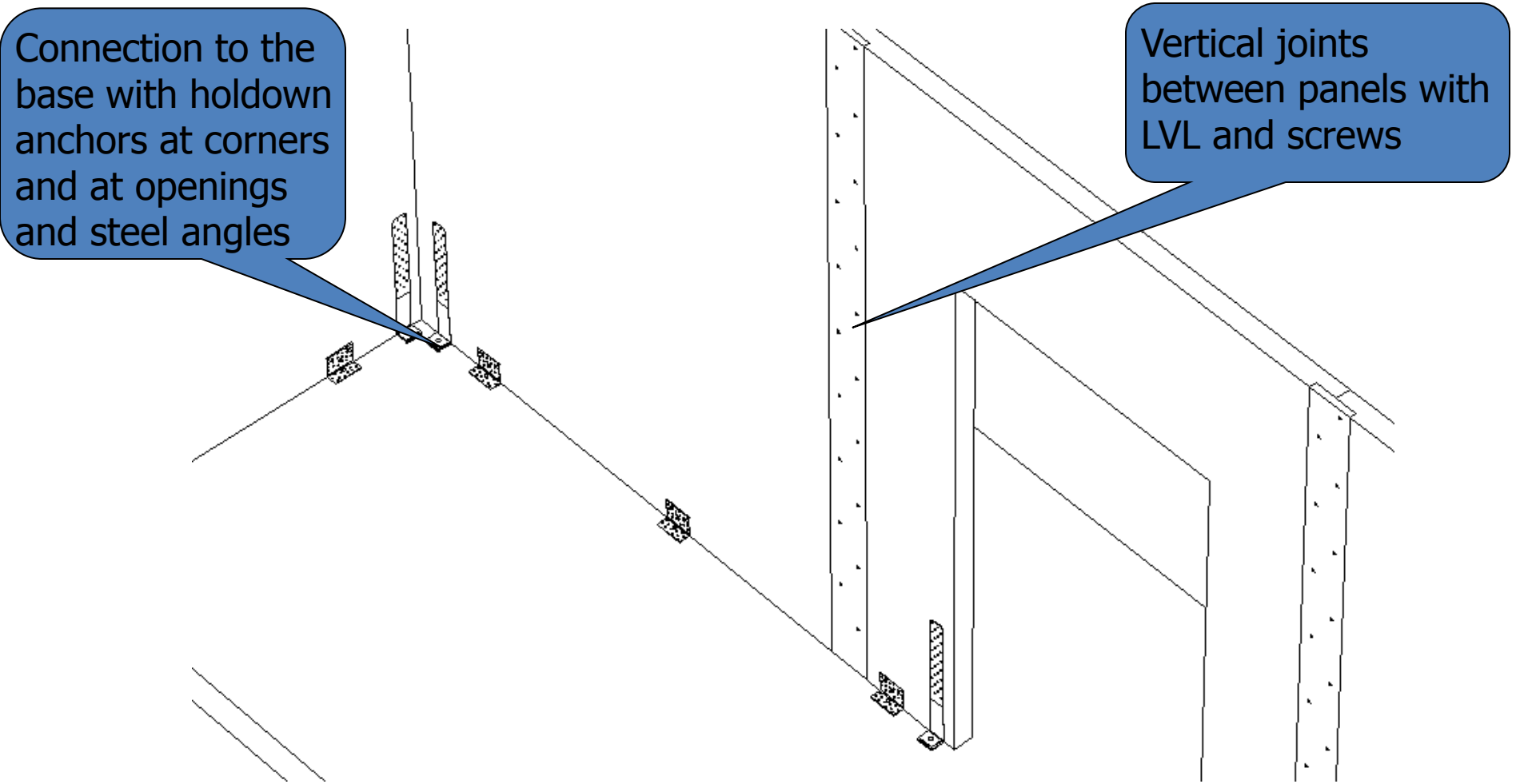
- Ma, sopratXLAM è più attraente per la maggior parte dell'utente europeo, che non vede bene i sistemi leggeri di costruzione che sono spesso percepiti tutto, il sistema adatti solo per costruzioni temporanee o cottages

XLAM SYSTEM : Construction and details

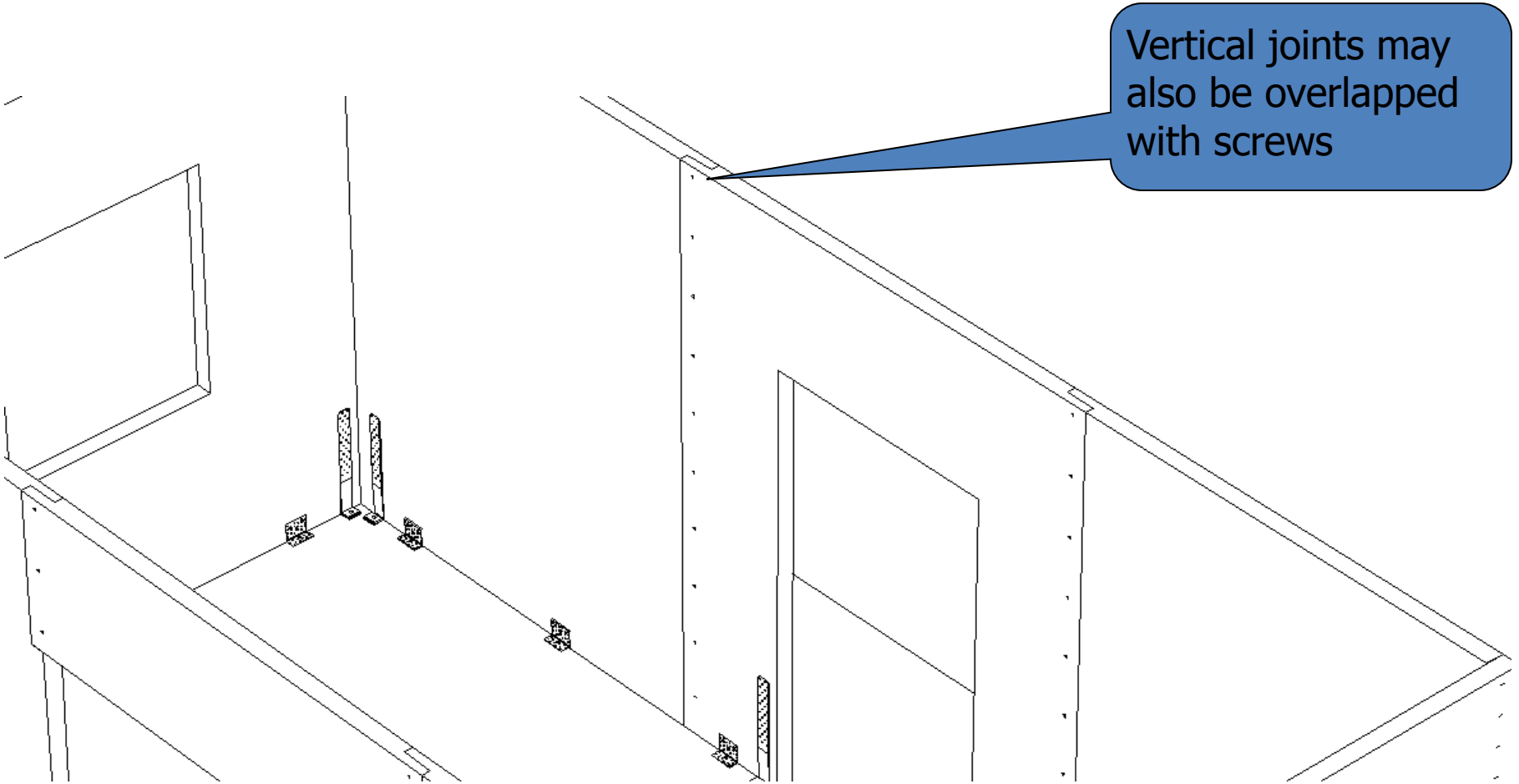


XLAM SYSTEM : Construction and details

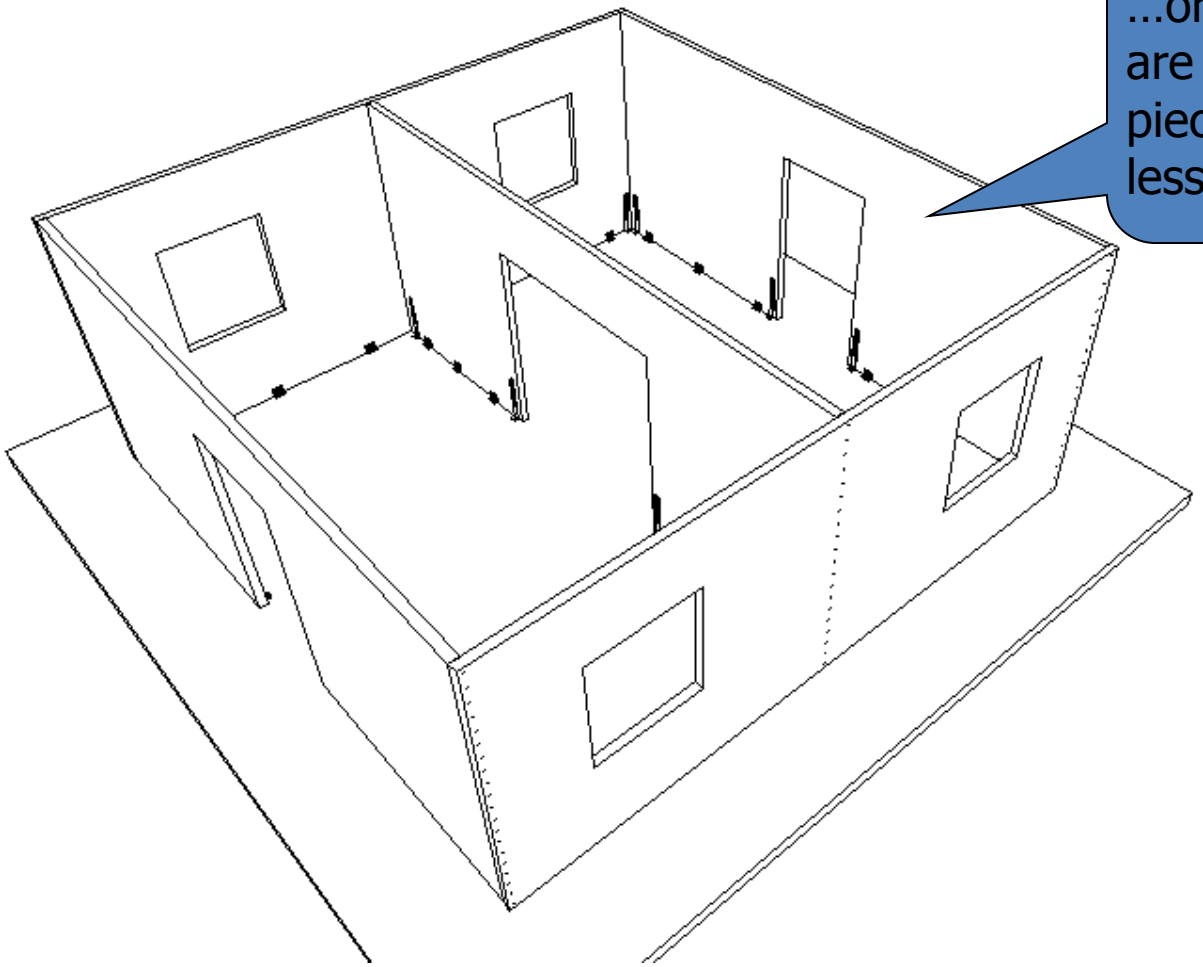
XLAM SYSTEM : Construction and details



XLAM SYSTEM : Construction and details

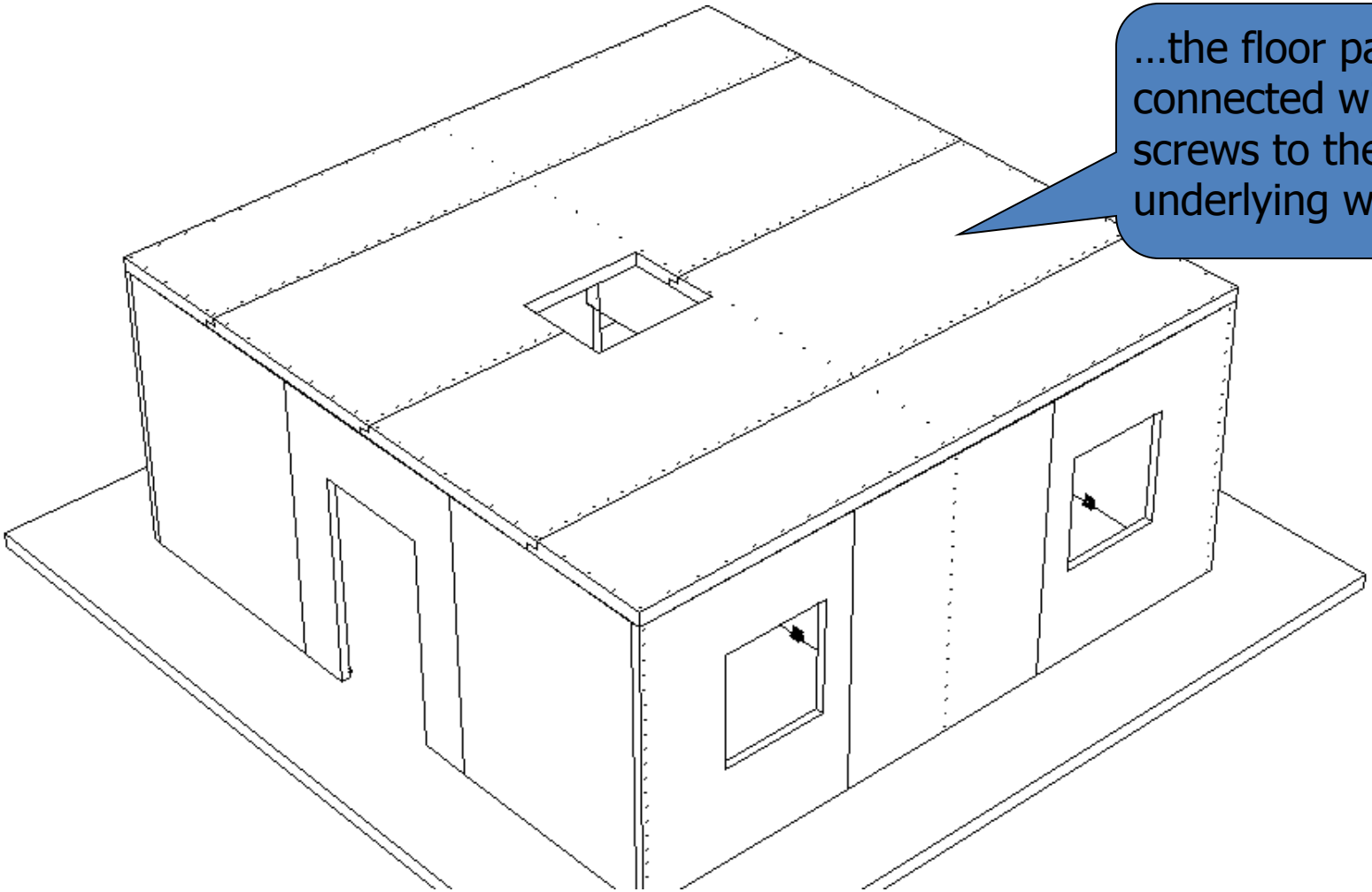


XLAM SYSTEM : Construction and details

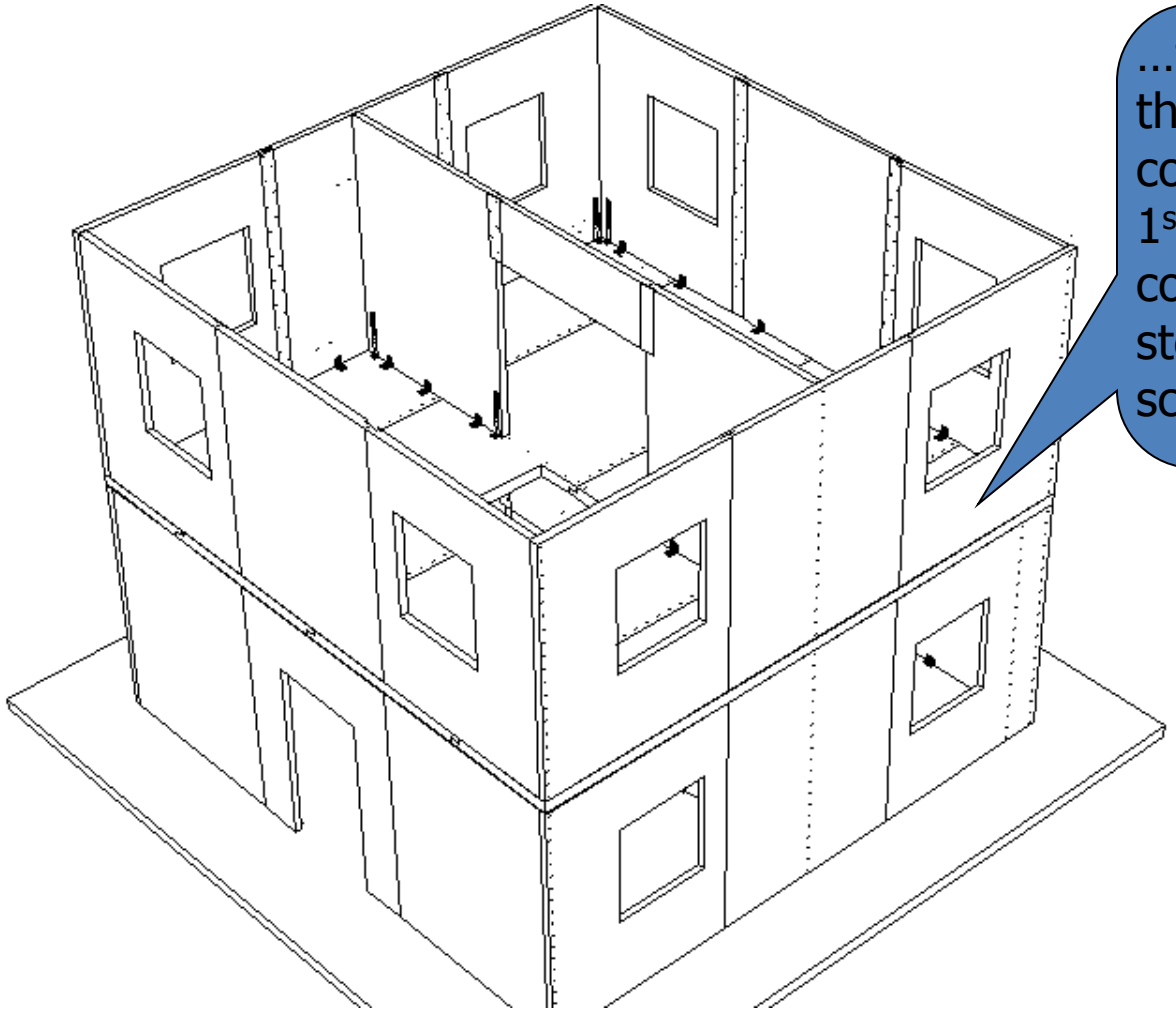


…or more often walls are made of one piece if total length is less than 7-10 m

XLAM SYSTEM : Construction and details

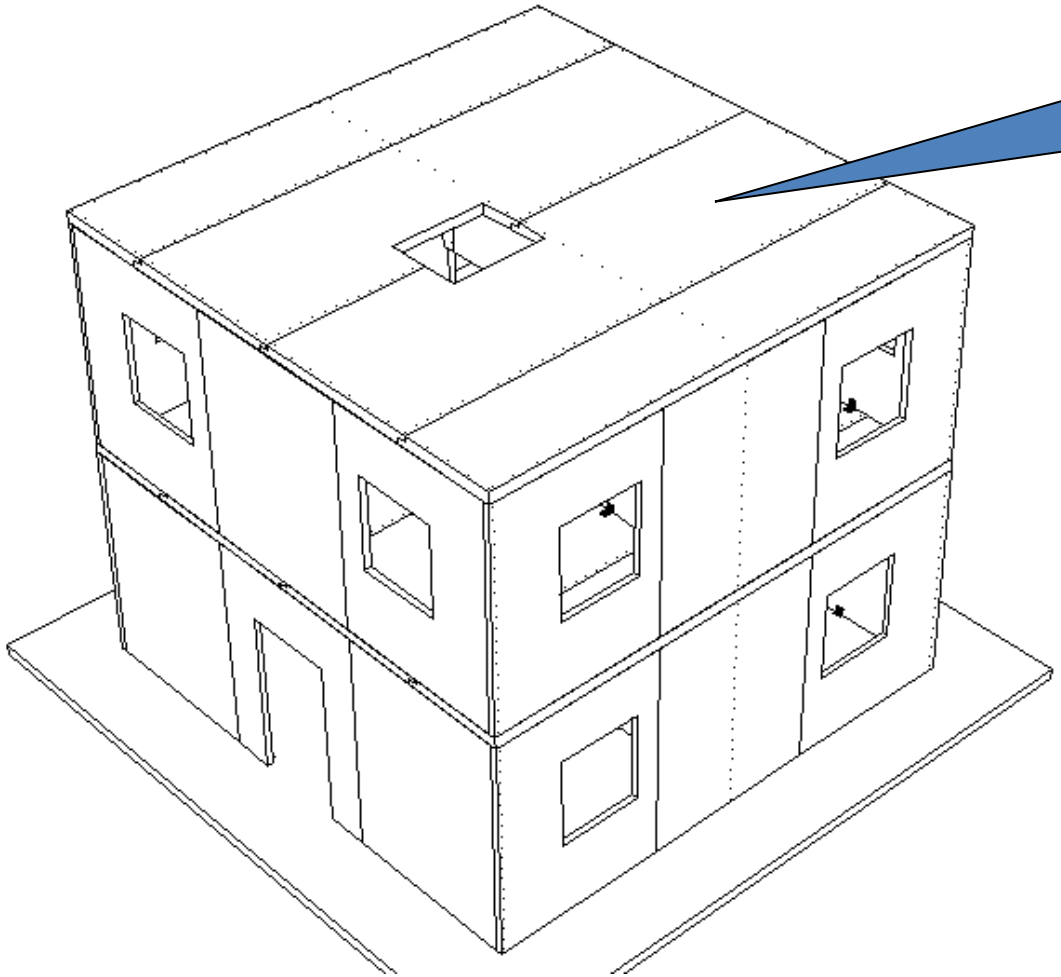


XLAM SYSTEM : Construction and details



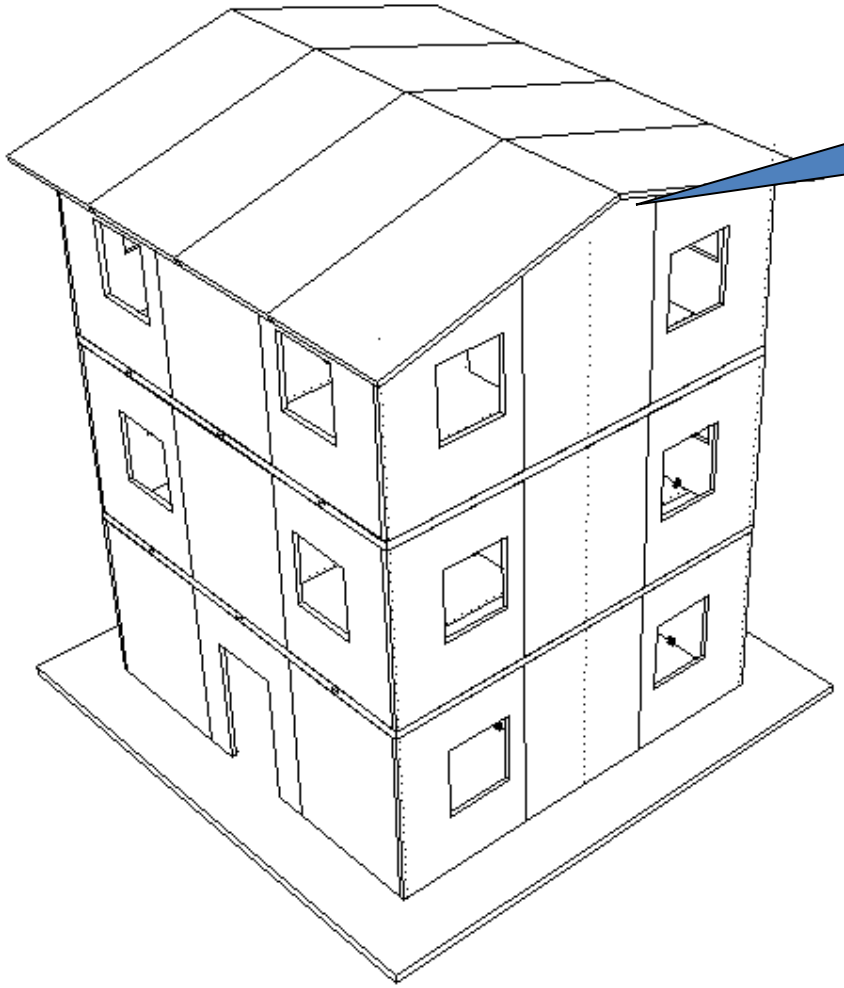
…the wall panels of the second floor are constructed over the 1st floor and connected again with steel connectors and screws

XLAM SYSTEM : Construction and details



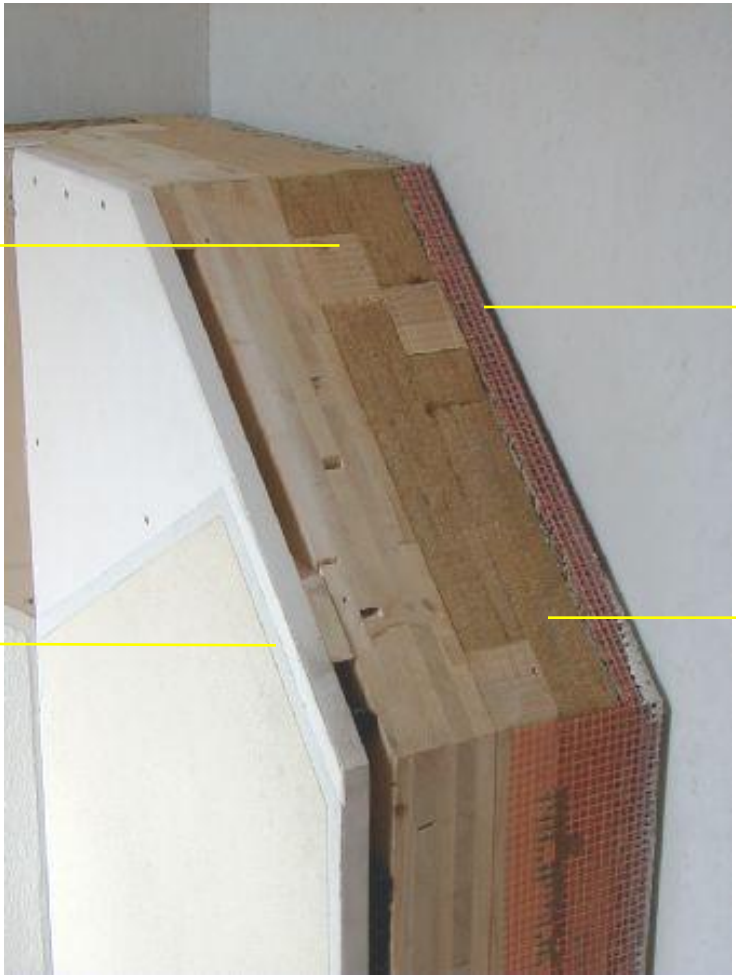
…the 2nd floor is connected in the same way

XLAM SYSTEM : Construction and details



…the contruction is then completed very quickly

XLAM SYSTEM : Construction and details



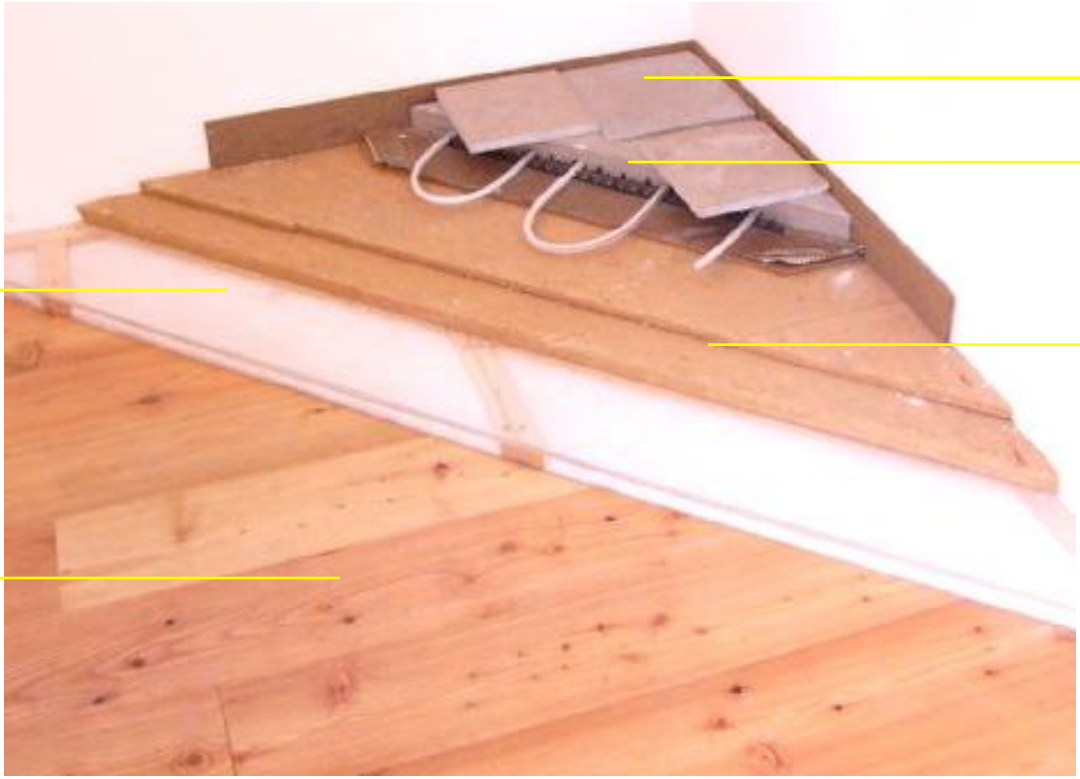
Cross Laminated wall panel

Plaster Board

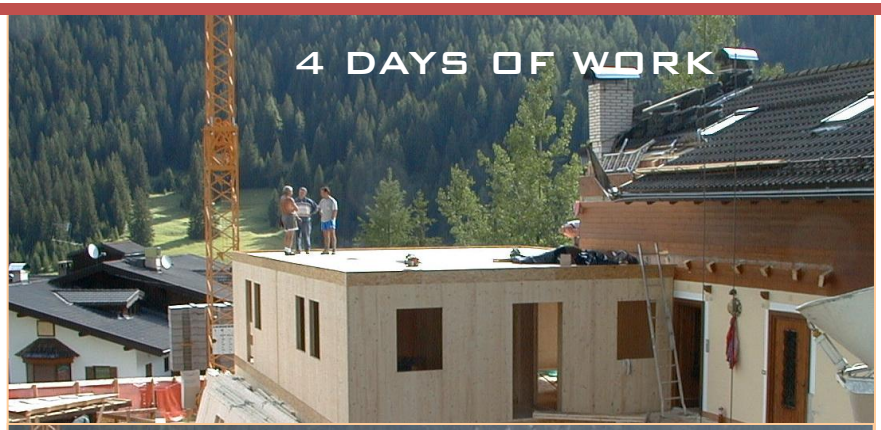
Double Gypsum wall board

Wood fibre

XLAM SYSTEM : Construction and details

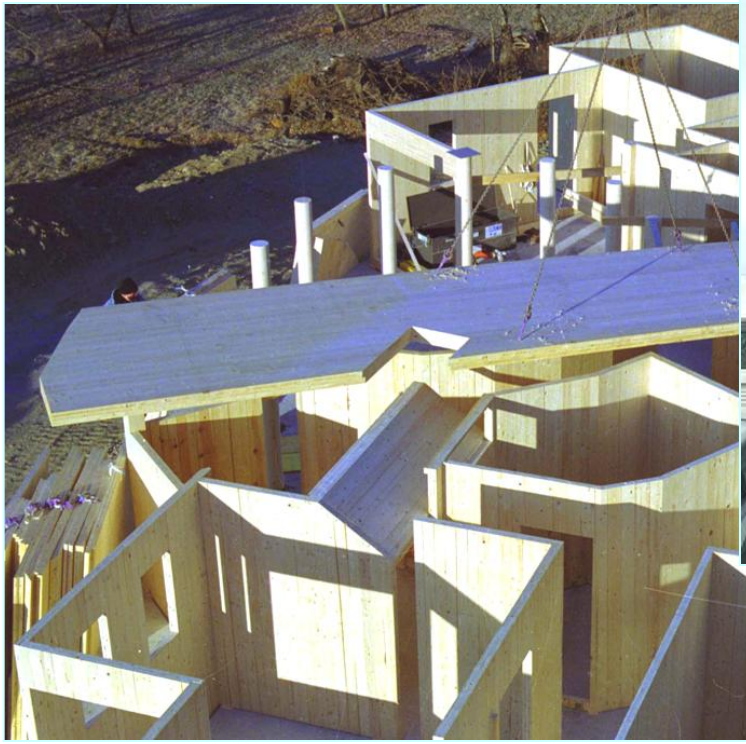


XLAM SYSTEM : Construction and details



XLAM SYSTEM : Construction and details

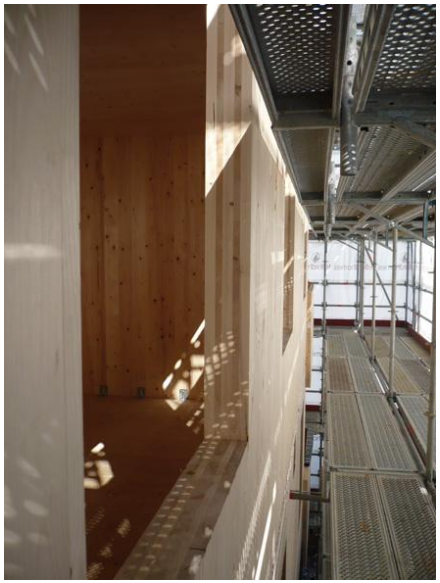
XLAM SYSTEM : Construction and details



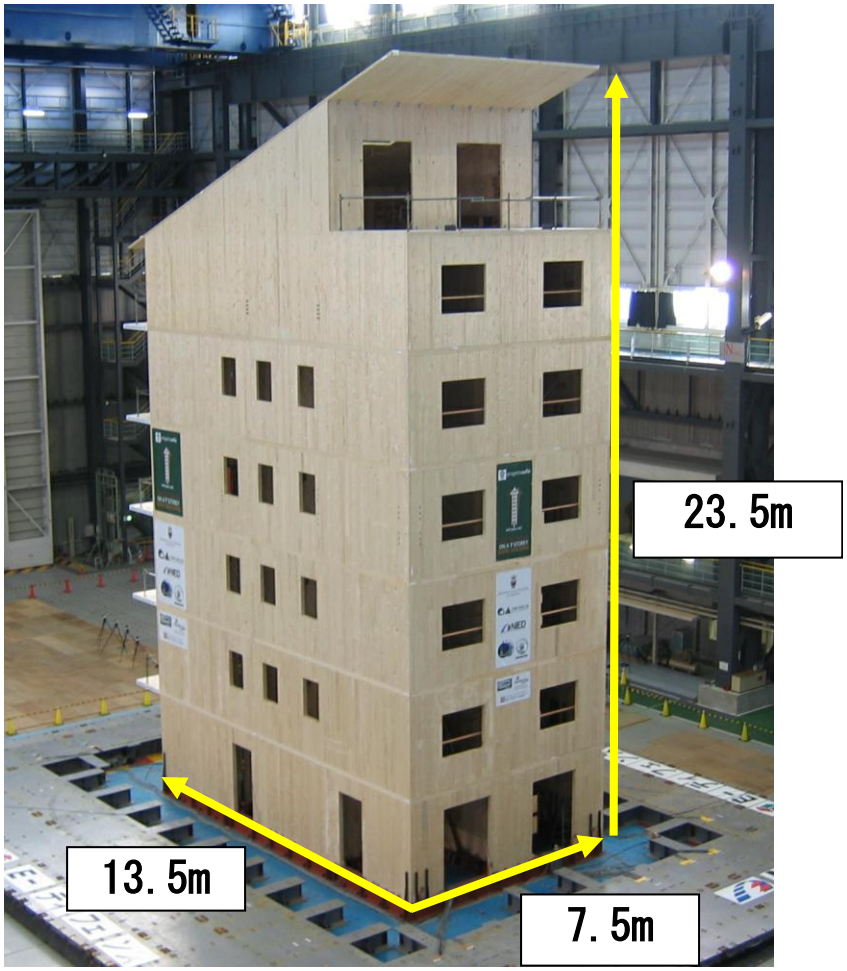
Great Britain

architects Waugh Thistleton

Appartementencomplex Murray Grove London



SEISMIC TEST IN MIKI 2007 OCT 23



Input :

JMA Kobe 3D x,y,z 0.60, 0.82, 0.34 g

1995 JMA Kobe 3D

Prima del terremoto...

Dopo 7 terremoti distruttivi!

progettosofie

Riflessioni dopo il sisma dell'Abruzzo:

- Bisogna cambiare mentalità e pensare di cominciare a costruire i nuovi edifici sia

- per la salvaguardia delle vite umane sia per la salvaguardia del patrimonio edilizio,

- anche per terremoti di forte intensità, e questo non solo per gli edifici strategici (ospedali, caserme etc.), ma anche per gli edifici residenziali...

Il X-LAM si può riusare…

progettosofie


TUTTO È PARTITO DA QUI…