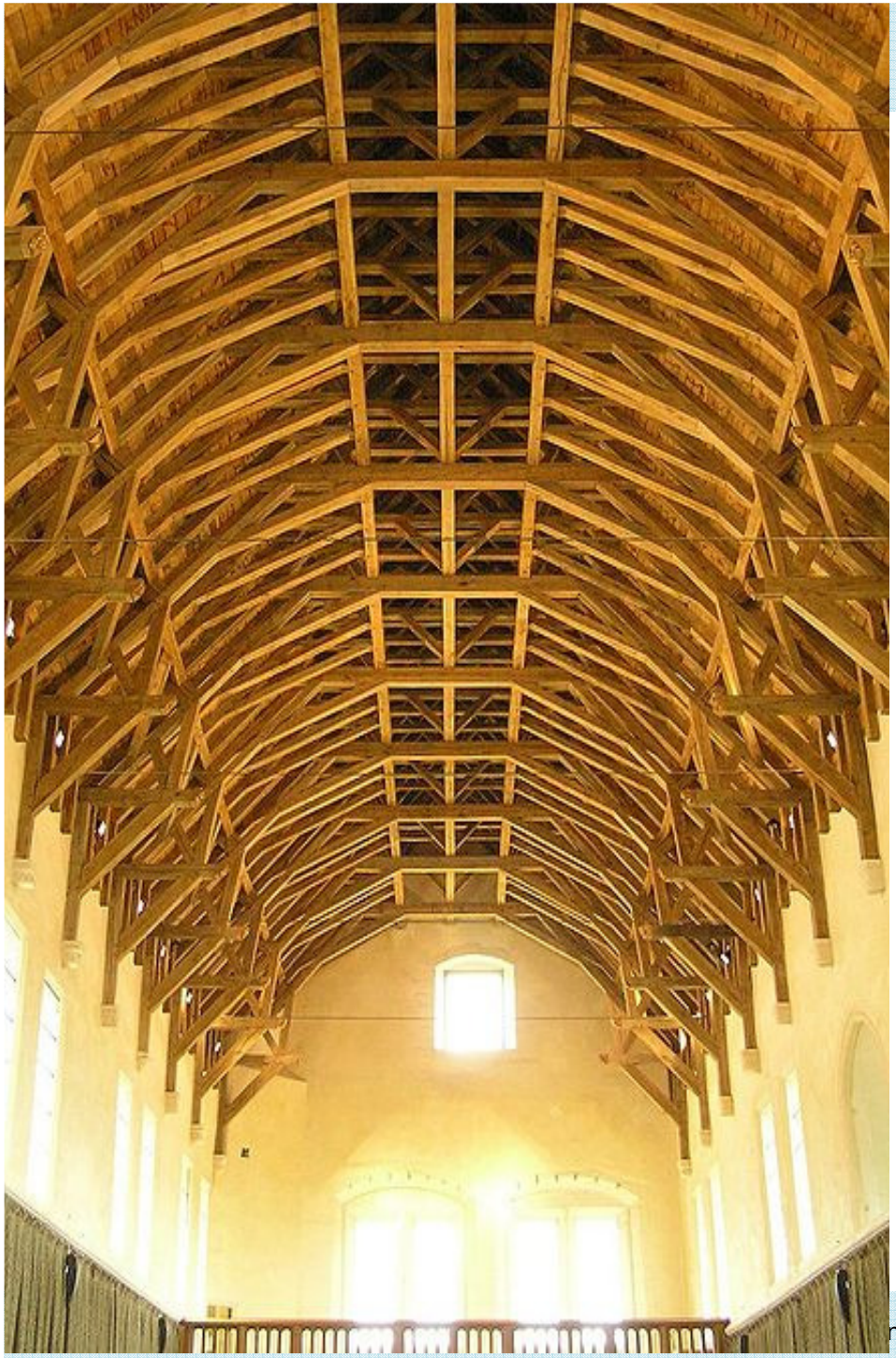
MPA STUTTGART
Otto-Graf-Institut
Materials Testing Institute University of Stuttgart

EU Hardwoods
Meeting 18.12.2014
Stuttgart

EU Hardwoods
Partner 2: MPA Uni Stuttgart

Gerhard Dill-Langer




Yesterday…


Today…


Tomorrow ?

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- Tasks of MPA, Collaboration with partners
- Review of glued solid products
  made of hardwoods in Europe today
- Timetable
- Costs

Task	2014				2015				2016				P1	P2	P3	P4	P5	P6	P7	P8	P9
0													x	x	x	x	x	x	x		
1.1															x	x	x	x			
1.2															x		x	x			
1.3																	x				
2.1													x		x	x					x
2.2													x		x	x					
2.3													x								
3.1														x	x						
3.2													x	x	x						
4.1														x	x	x				x	
4.2													x	x	x					x	
5.1														x					x		
5.2														x					x		
5.3														x					x		
6													x	x	x	x	x	x	x		

MPA:
funding
1.8.2014 – 30.9.2016

Task	2014		2015				2016				P1	P2	P3	P4	P5	P6	P7	P8	P9
0											x	x	x	x	x	x	x		
1.1													x	x	x	x			
1.2													x		x	x			
1.3															x				
2.1											x		x	x					x
2.2											x		x	x					
2.3											x								
3.1				Adhesives								x	x						
3.2											x	x	x						
4.1					Glulam							x	x	x				x	
4.2											x	x	x					x	
5.1	Cross-											x					x		
5.2												x					x		
5.3			Lam									x					x		
6											x	x	x	x	x	x	x		

WP 3 Adhesives

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Adhesives for structural hardwood bonding

3.1: general: species dependent adhesive types,
product dependent integrity tests designed for hardwoods,
quality procedures adapted to hardwoods.

3.2: finger-joints: consolidate finger-joint data in solid wood and laminations, investigate influence of size and finger-joint type for the different species with accomplishing test if necessary (associating bending and tension tests), influence of moisture content and curing process

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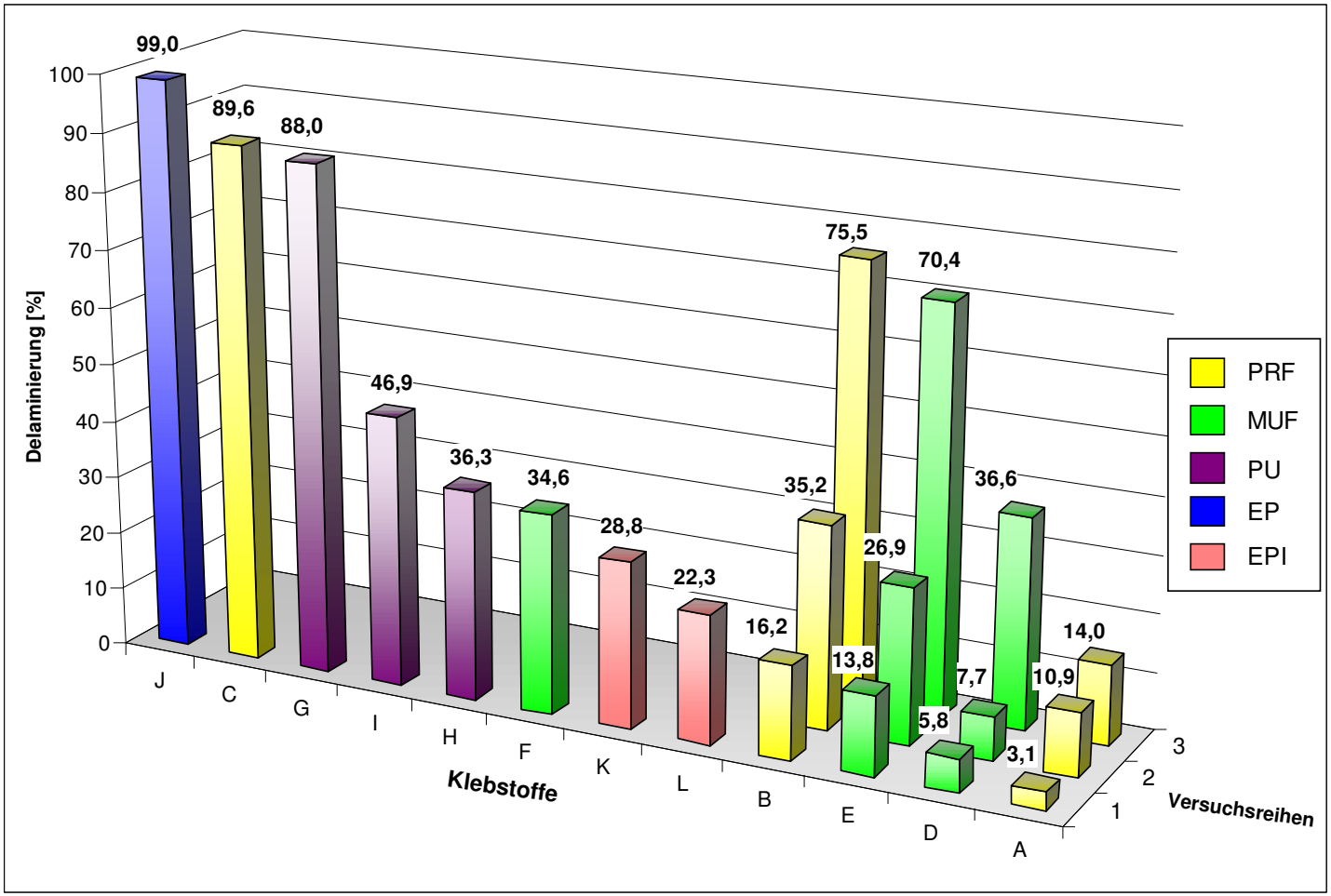
Adhesives for structural hardwood bonding

3.1: general.

Delamination test results with oak (source: Germany and Tchech rep.)



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Adhesives for structural hardwood bonding

3.1: general.

Positively tested acc. to EN 302-2

PRF:

- Momentive PF 1993 / 2003: Beech
- Dynea PRF 4040 / 5839: Beech
- Dynea 4535 / 5035: Sweet Chestnut

MUF:

- Casco Grip Pro Design (Z-9.1-807): Beech, Oak, Birch, sweet Chestnut
- Casco 1247 / 2526: Sweet Chestnut

PU (with primer):

- Purbond HBS 309 (with primer)

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Glued laminated timber and finger joints made of following species:

- Beech
- Oak
- Sweet Chestnut

Formwork (I-) Beams made of

- Birch / spruce (poplar) hybrid

Todays Use of different hardwood species for the bulding sector

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Type of hardood product	Species	General Use	Special use (product)
joists boards	Oak	Structural engineering, bridges	beams, braces, planks
	Basralocus, Greenhart	Hydraulic engineering	dolphins, shore enclosures, espacially for SC 3 – conditions, heavily loaded.
	Bongossi, Kapur, Bangkirai	bridges	beams, braces, planks
	Robinie	Road construction	noise protection walls
Lamellas for glued products	Oak, Sweet chestnut, beech, ash Meranti (dark red)	Structural engineering	glulam
	birch		Formwork (I-) beams
veneers	beech	Structural engineering	plywood, LVL
	Poplar, birch		plywood
Chips, Particles	beech, poplar	Structural engineering	Chip boards

Glulam products: Approvals

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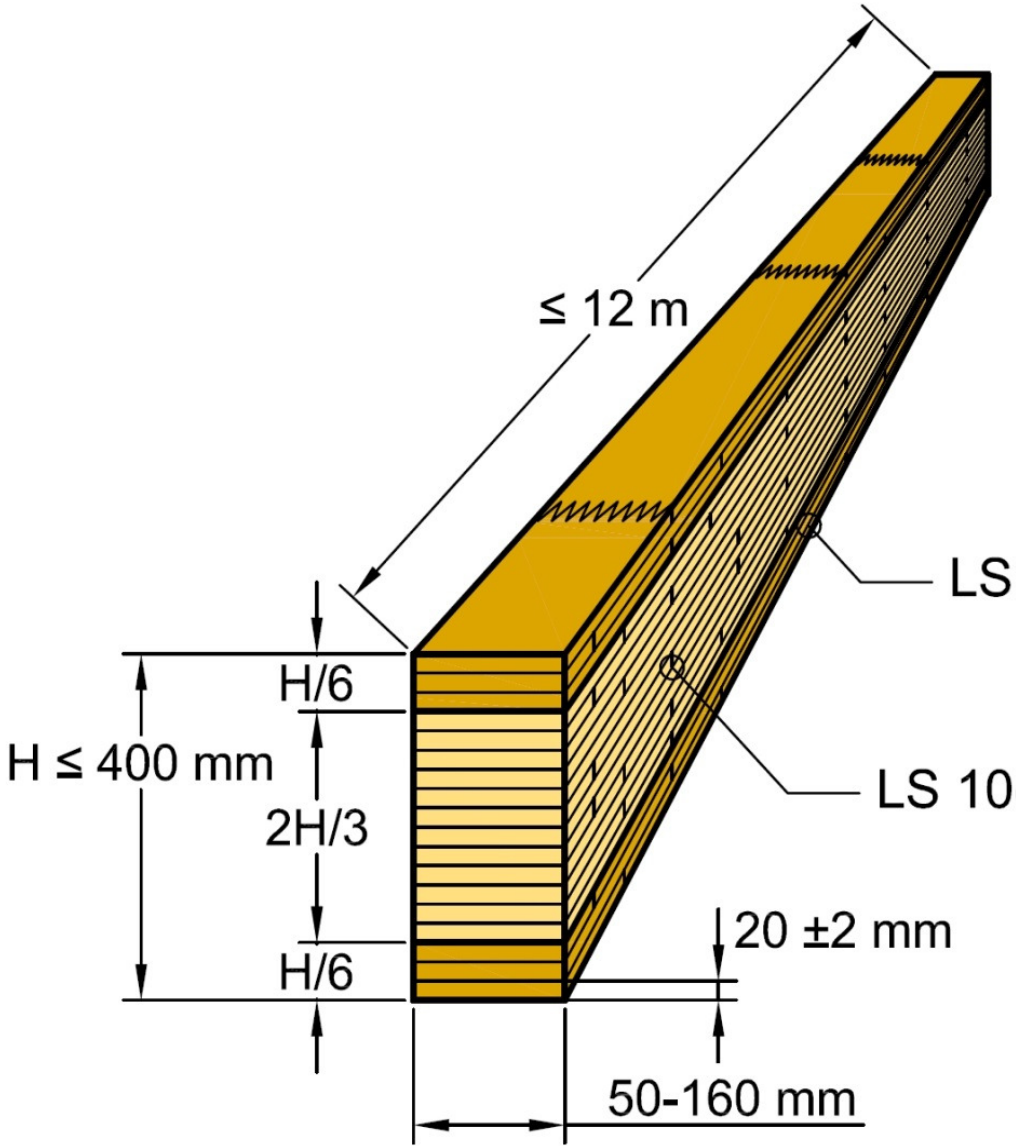
First year of approval	Approval		Species	Service Class	Holder of Approval
	German ABZ Z-9.1-…	European Technical Approval ETA			
2004	577	-	Dark Red Meranti	1, 2	Enno Roggemann, Bremen
2008 – 2012	Approvals in a single case (Germany)		Oak (Germany. Tchech Rep.)	1	Different holders
2009	679	-	Beech and Beech Spruce hybrid	1	Studiengemeinschaft Holzleimbau, Wuppertal
2012 2013	704 -	- 13/0642	Oak (France)	1, 2	Elaborados y Fabricados Gamiz, S.A., Spanien
2013	821	-	Oak	1, 2	Holz Schiller GmbH, Regen
2013	-	13/0644	Sweet Chestnut	1, 2	SIEROLAM SA., Spanien
2013 2014	837 -	- 14/…..	LVL made of beech	1, 2	Pollmeier Furnierwerkstoffe GmbH, Creuzburg

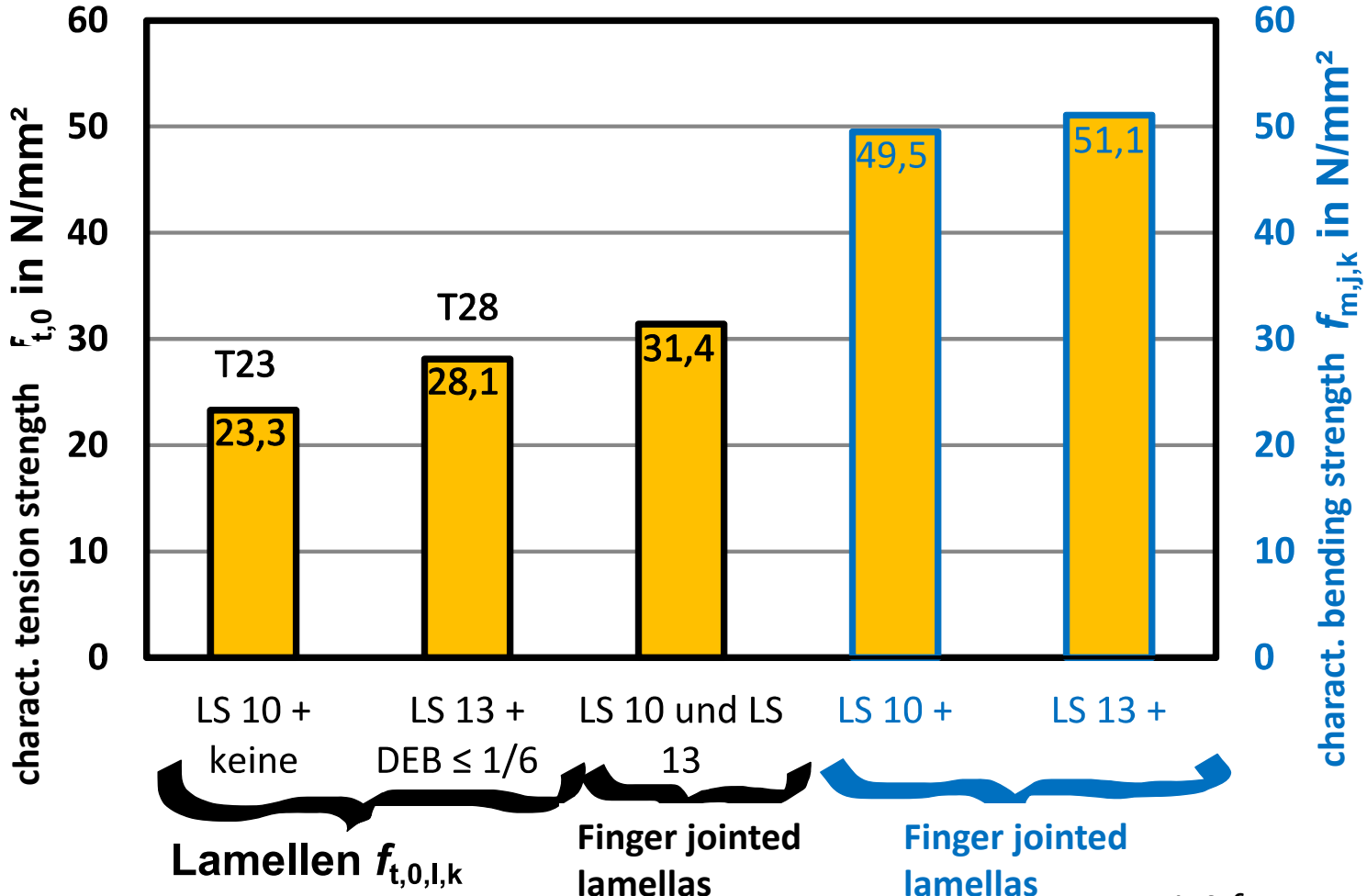
Oak glulam of Gamiz, Spanien



Mean length of boards: 1,2m

Oak
(Quercus robur, Quercus petraea)
Source: France

Oak glulam of Gamiz, Spanien



$$1{,}4\, f_{t,0,l,k} \leq f_{m,j,k} < 1{,}4\, f_{t,0,l,k} + 12$$

LS 10: 32,2 < 49,5 < 44,2 — no

LS 13: 39,2 < 51,1 < 51,2

Tension strength classes of „Gamiz“ oak lamellas

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Tension strength of boards T-classes	Visual grade	Respective bending strength class C or D-class ≈ L-Klasse	charact. tension strength [N/mm²]	MOE [N/mm²]	charact. raw density [kg/m³]
T 14	S 10	24	14	11	350
T 18		30	18	12	380
T 21	S 13	35	21	13	390
T 22		36	22	13	390
T 23	LS 10		23	13	690
T 26		40	26	13,5	410
T 27		45	27	15	410
T 28	LS 13	47	28	14,5	690
T 30		50	30	15,5	430

Glulam strength grade of „Gamiz“ oak glulam

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species	Glulam strength grade	Lamellas at the edges			Lamellas near mid-height		
		T-class -	percentage of height [%]	Bending strength of finger joints [N/mm²]	T-class -	percent age of height [%]	Bending strength of finger joints [N/mm²]
SW	GL 24 h	T 14	100	30	T 9	-	-
	GL 24 c	T 14	2 x 33	31	T 14	34	19
	GL 28 c	T 21	2 x 17	36	T 14	66	26
	GL 30 c	T 22	2 x 17	41	T 14	66	28
	GL 32 c	T 26	2 x 17	45	T 14	66	26
HW Oak	GL 33,5 c	T 28	2 x 17	51	T 23	66	49

Comparison: „Gamiz Oak Glulam“ vs. SW-glulam GL32c

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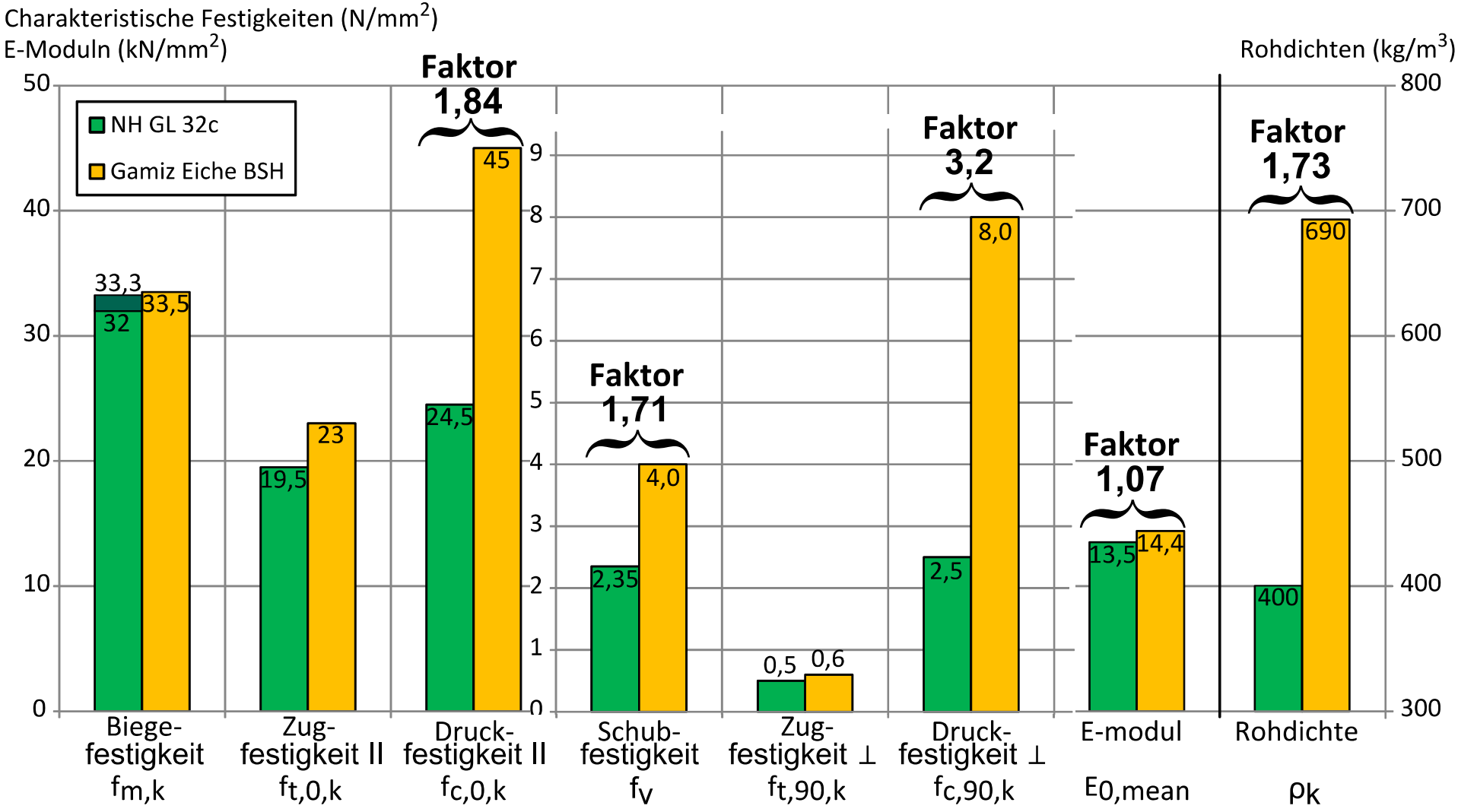
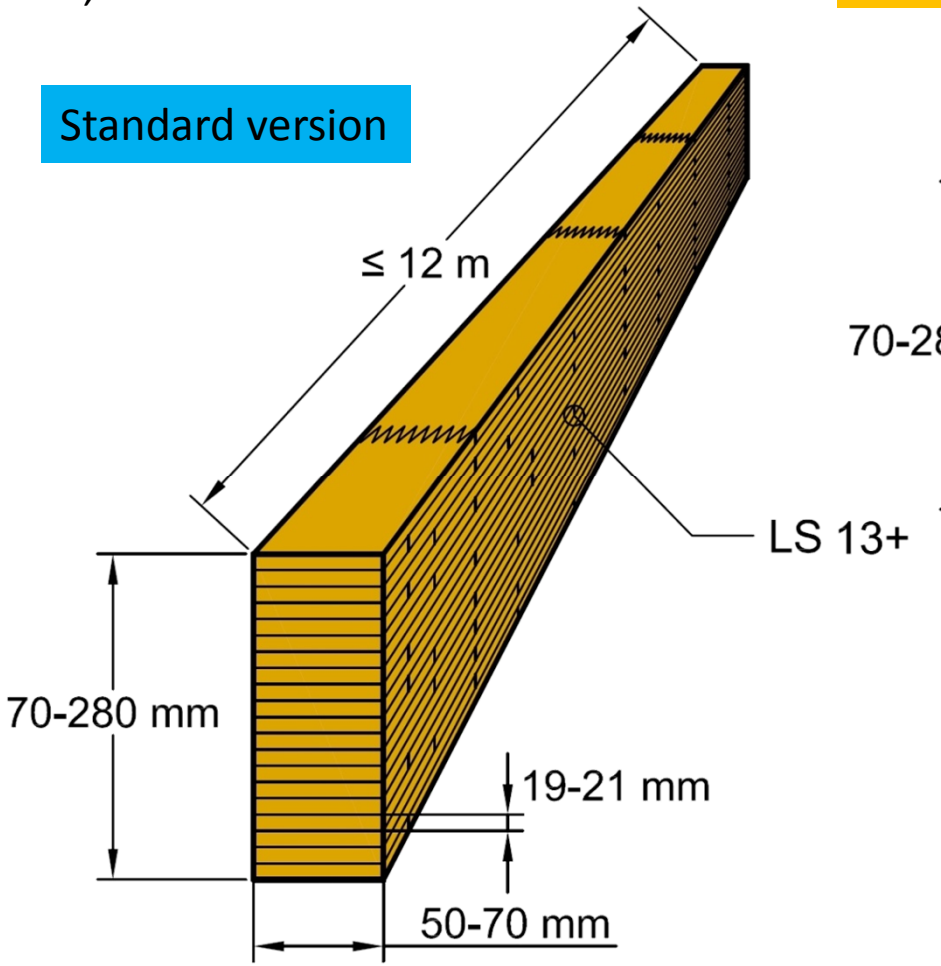
Reference height
h = 400mm



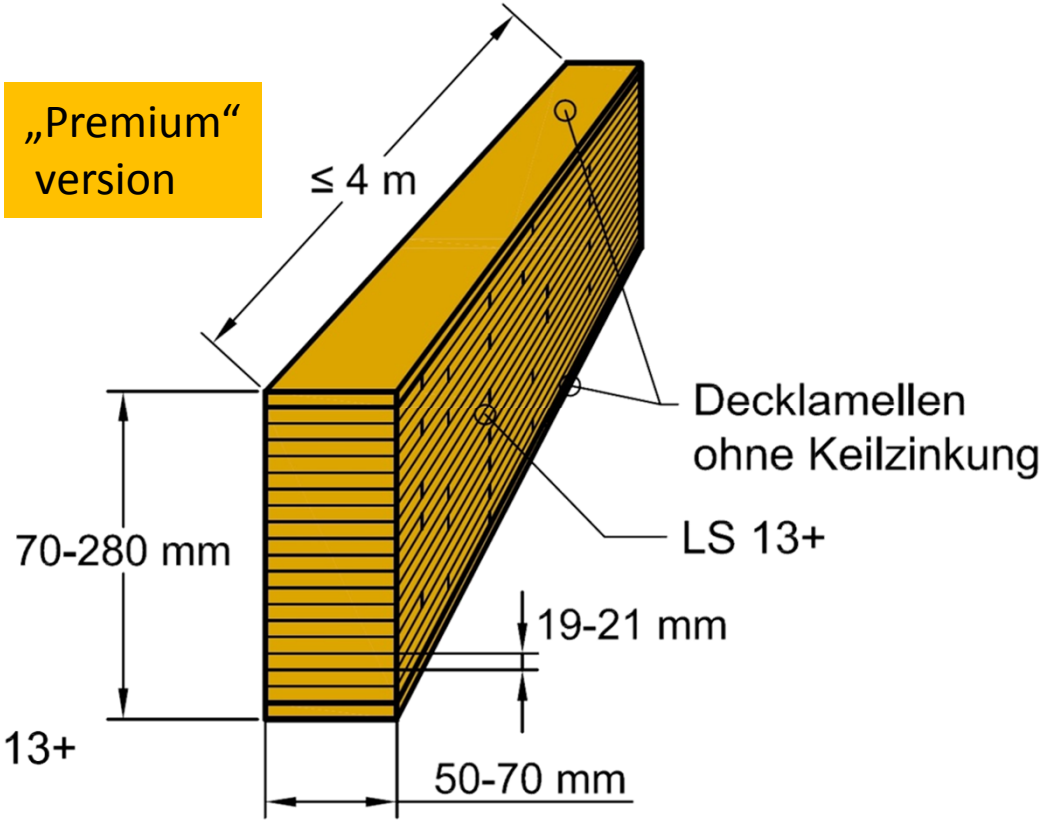
Oak Glulam „Schiller“

Mean length of lamellas:
0,6m

Standard version

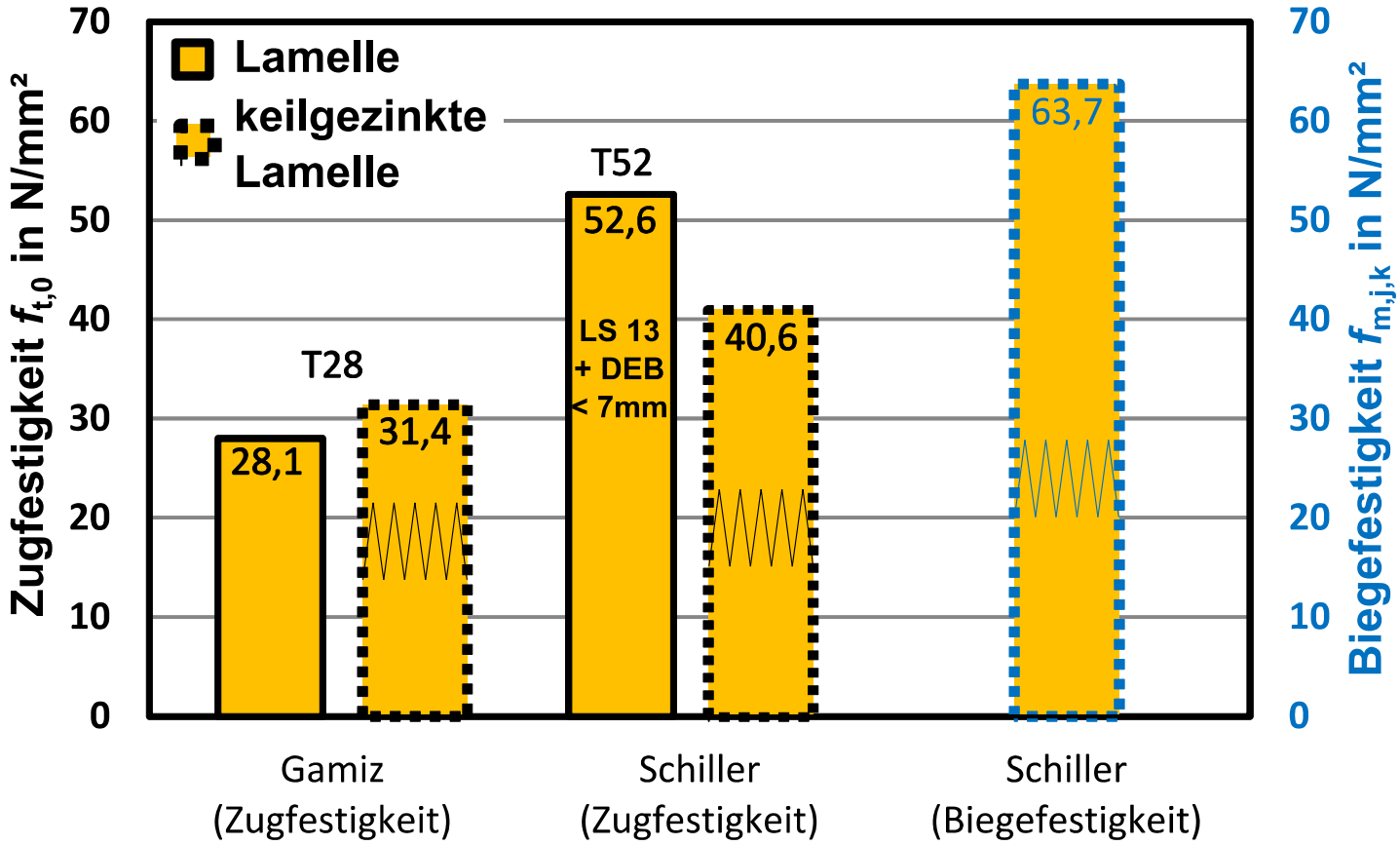


„Premium“ version



Oak
(Quercus robur, Quercus petraea)
Source: Germany, Tchech rep.

Strength of Schiller LS13+ lamellas



$$1{,}4\, f_{t,0,l,k} \leq f_{m,j,k} < 1{,}4\, f_{t,0,l,k} + 12$$

LS 13+: 72,8 $\overset{\text{no}}{\leq}$ 63,7 < 84,8

T-classes of „Schiller“ oak lamellas

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Tension strength of boards T-classes	Visual grade	Respective bending strength class C or D-class ≈ L-Klasse	charact. tension strength [N/mm²]	MOE [N/mm²]	charact. raw density [kg/m³]
T 14	S 10	24	14	11	350
T 18		30	18	12	380
T 21	S 13	35	21	13	390
T 22		36	22	13	390
T 23	LS 10 (Gamiz)		23	13	690
T 26		40	26	13,5	410
T 27		45	27	15	410
T 28	LS 13 (Gamiz)	47	28	14,5	690
T 30		50	30	15,5	430
T 52	LS 13 +	-	52	14,0	650

Comparison: Glulam made of oak

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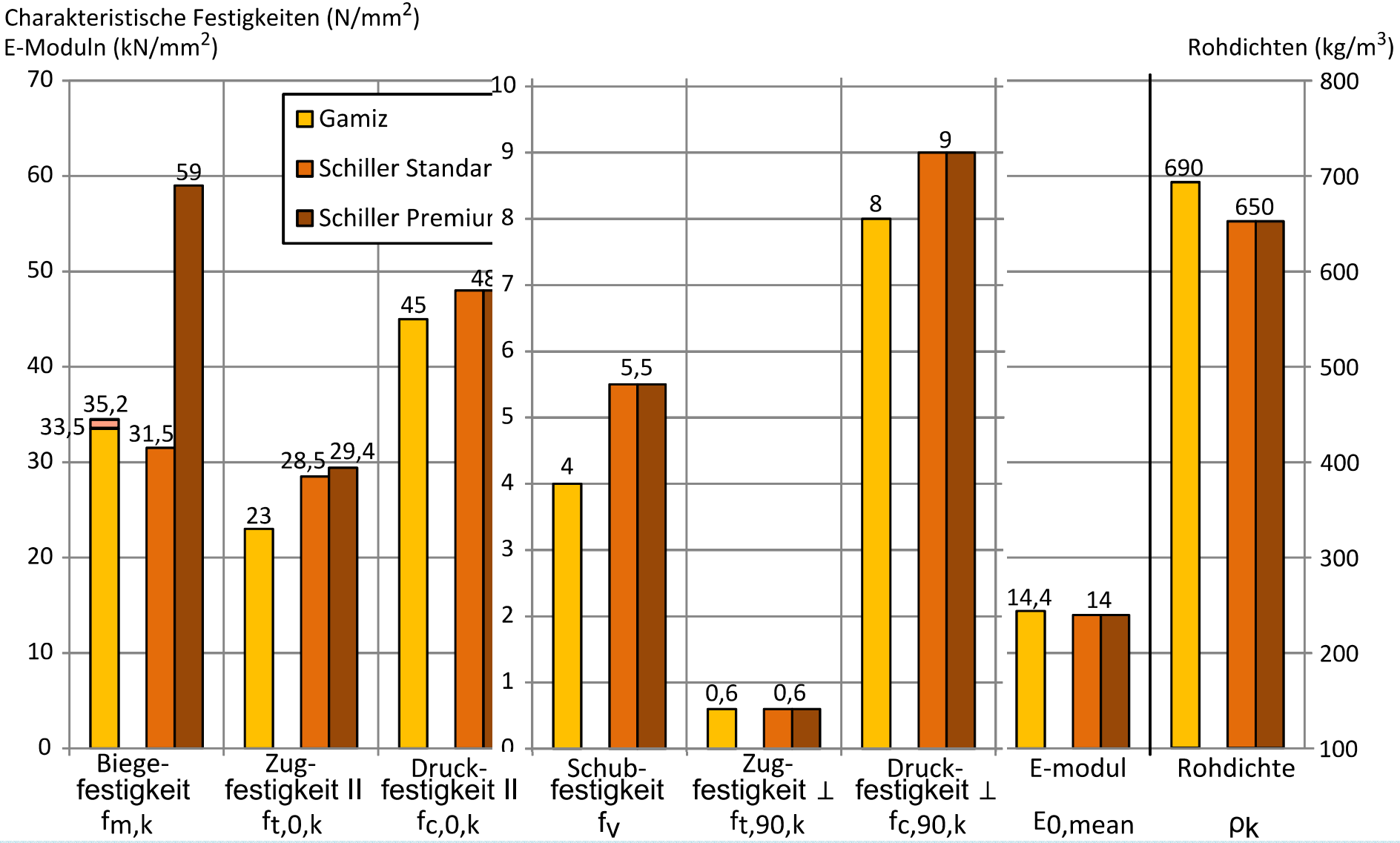
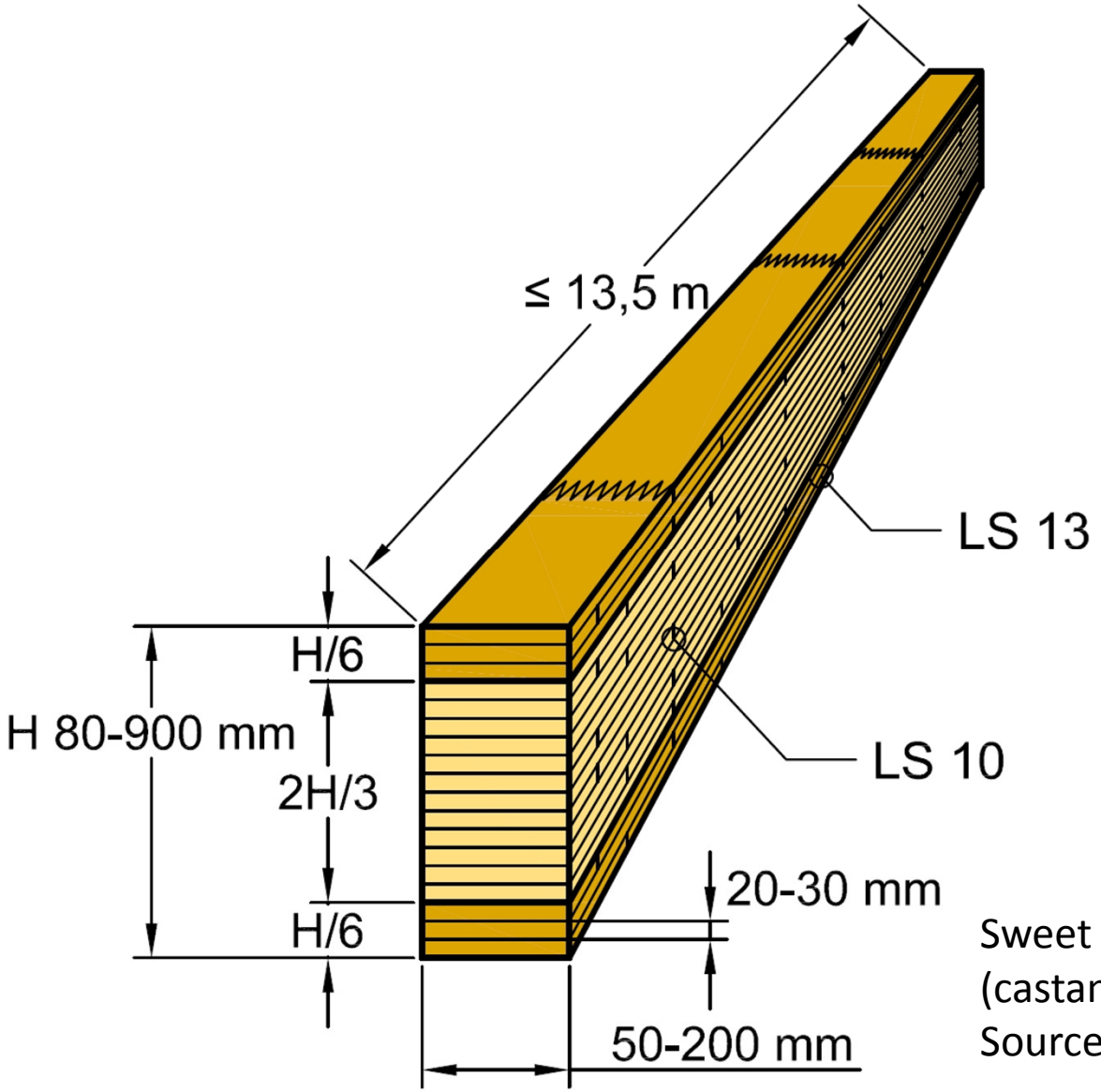
Höhen bezogen
h = 280 mm



Sweet Chestnut glulam, Sierolam, Spain



Mean length of lamellas: 1,0m

Sweet chestnut
(castanea sativa)
Source: North of Spain

T-classes of „Sierolam“ sweet chestnut lamellas

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Tension strength of boards T-classes	Visual grade	Respective bending strength class C or D-class ≈ L-Klasse	charact. tension strength [N/mm²]	MOE [N/mm²]	charact. raw density [kg/m³]
T 14	S 10	24	14	11	350
T 17	LS 10	-	17	12,5	520
T 18	-	30	18	12	380
T 21	S 13	35	21	13	390
T 22		36	22	13	390
T 22	LS 13	-	22	13	520
T 23	LS 10 (Gamiz)		23	13	690
T 26		40	26	13,5	410
T 27		45	27	15	410
T 28	LS 13 (Gamiz)	47	28	14,5	420
T 30		50	30	15,5	430
T 52	LS 13 + (Schiller)	-	52	14,0	650

Vergleich: Sierolam-Kastanien-BSH bzgl. Gamiz/Schiller-Eiche-BSH

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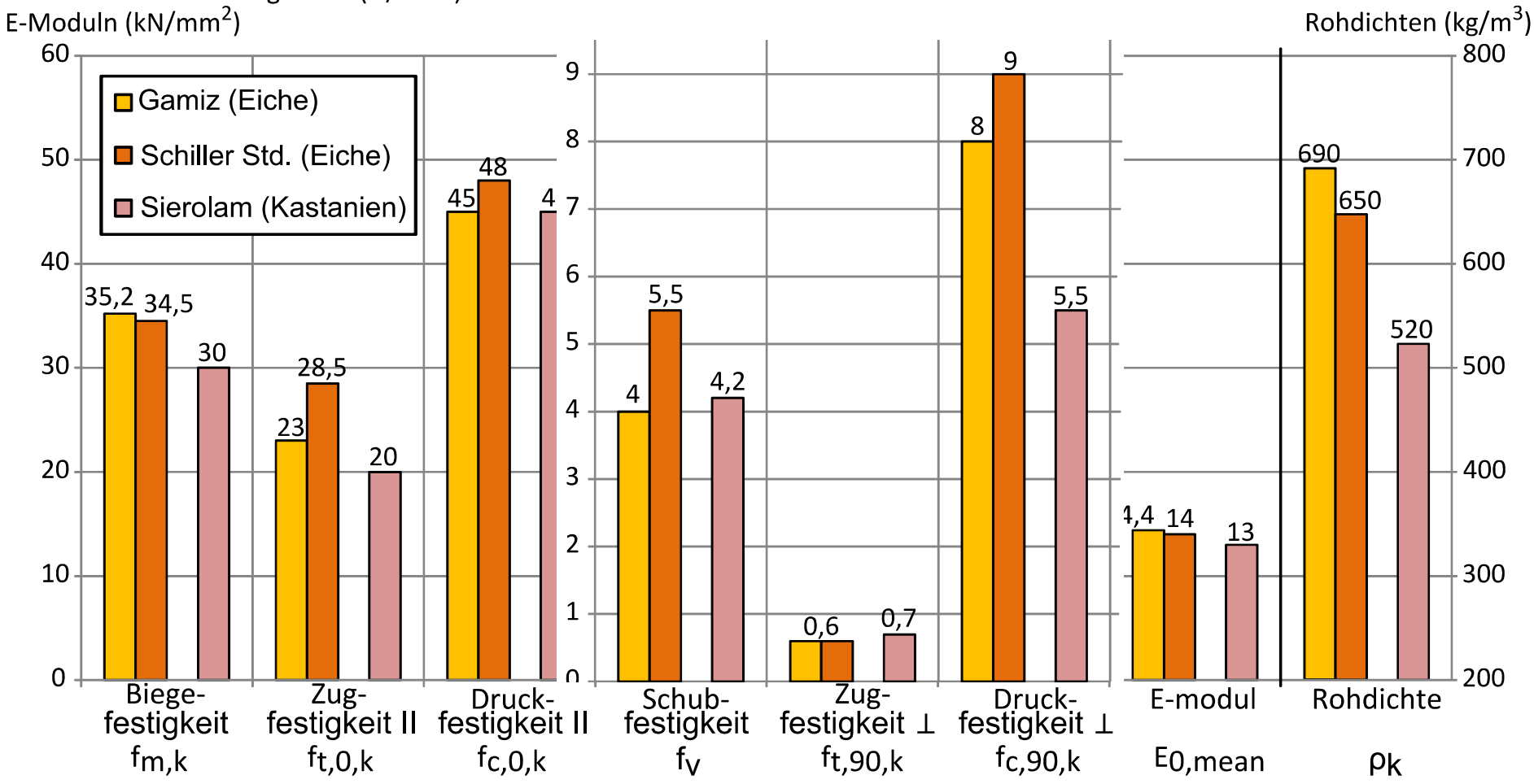
Höhen bezogen
h = 280 mm



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Sortierkriterien und Grenzwerte der Buchenholzlamellen

Bezeichnung	Sortierkriterien nach DIN 4074-5	Zusätzlich Ästigkeit	Elastizitätsmodul (N/mm²)
LS 10	LS 10		
LS 10 + E13	LS 10		13000 < Edyn
LS 10 + E14	LS 10		14000 < Edyn
LS 13	LS 13		
LS 13 + A	LS 13	DEB ≤ 0,04	
LS 13 + E14	LS 13		14000 < Edyn
LS 13 + E15	LS 13		15000 < Edyn
LS 13 + A + E15	LS 13	DEB ≤ 0,04	15000 < Edyn
DEB = Ästigkeit A für den Einzelast nach DIN 4074-5			

Lay-ups of beech-gluam made acc. to Z-9.1-679

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	GL 28h	GL 32c	GL 36c	GL 40c	GL 44c	GL 48c
Requirements for outer lamellas (> H/6 per outer edge)						
Sortierung	**LS 10**	**LS 13**	**LS13 + A**	**LS13 + E14**	**LS13 + E15**	**LS13 + A + E15**
E_{dyn}	**-**	**-**	**-**	**>14000**	**>15000**	**>15000**
Requirements for inner lamellas						
Sortierung	**LS 10**	**LS 10**	**LS 10**	**LS 10+E13**	**LS 10+E14**	**LS 10+E14**
E_{dyn}	**-**	**-**	**-**	**>13000**	**>14000**	**>14000**
Charact. Bending strength of finger joints						
$f_{m,j,k}$	**≥ 47**	**≥ 55**	**≥ 58**	**≥ 62**	**≥ 65**	**≥ 69**

Mechanische Kennwerte von Buche-BSH (Z-9.1-679)

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Festigkeitsklasse		GL 28h	GL 32c	GL 36c	GL 40c	GL 44c	GL 48c
		Festigkeitskennwerte (N/mm²)					
Biegefestigkeit	$f_{m,g,k}$	28	32	36	40	44	48
Zugfestigkeit	$f_{t,0,g,k}$	21					
	$f_{t,90,g,k}$	0,5					
Druckfestigkeit	$f_{c,0,g,k}$	25					
	$f_{c,90,g,k}$	8,4					
Schubfestigkeit	$f_{v,g,k}$	3,4					
		Steifigkeitskennwerte (N/mm²)					
Elastizitätsmodul	$E_{0,g,mean}$	13500	13500	13500	14300	15100	15100
	$E_{0,g,05}$	12700	12700	12700	13700	14700	14700
	$E_{90,g,mean}$	690					
	$E_{90,g,05}$	550					
Schubmodul	$G_{g,mean}$	1000					
	$G_{g,0,05}$	800					
		Rohdichtekennwert (kg/m³)					
Rohdichte	$\rho_{g,k}$	650					


VH1_L
Teil 2
Delam 2

Tension strength of European Hardwood Lamellas

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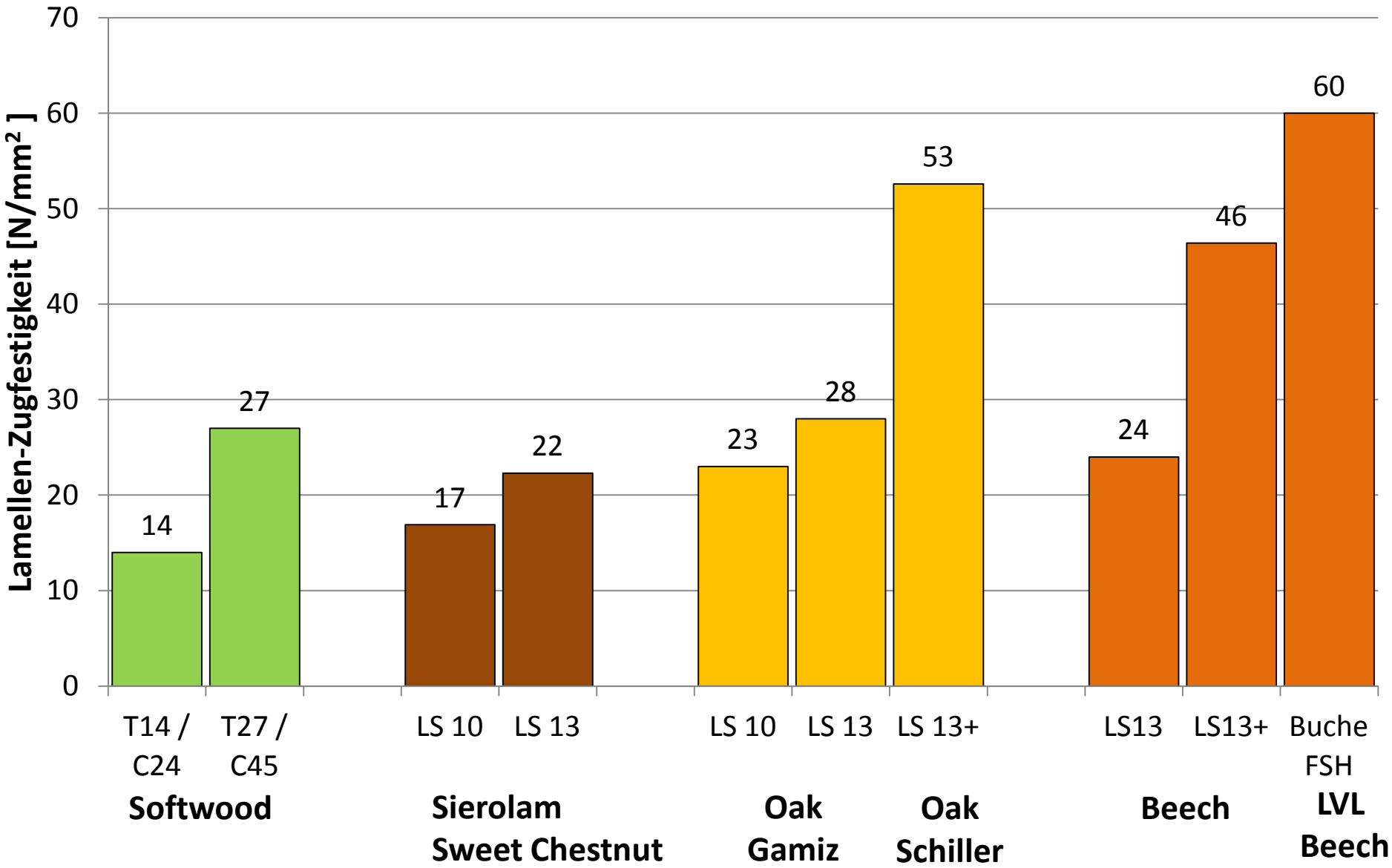

Innovative „Doka“ High strength (Hardwood)-Formwork Beam

Innovative high strength formwork beam

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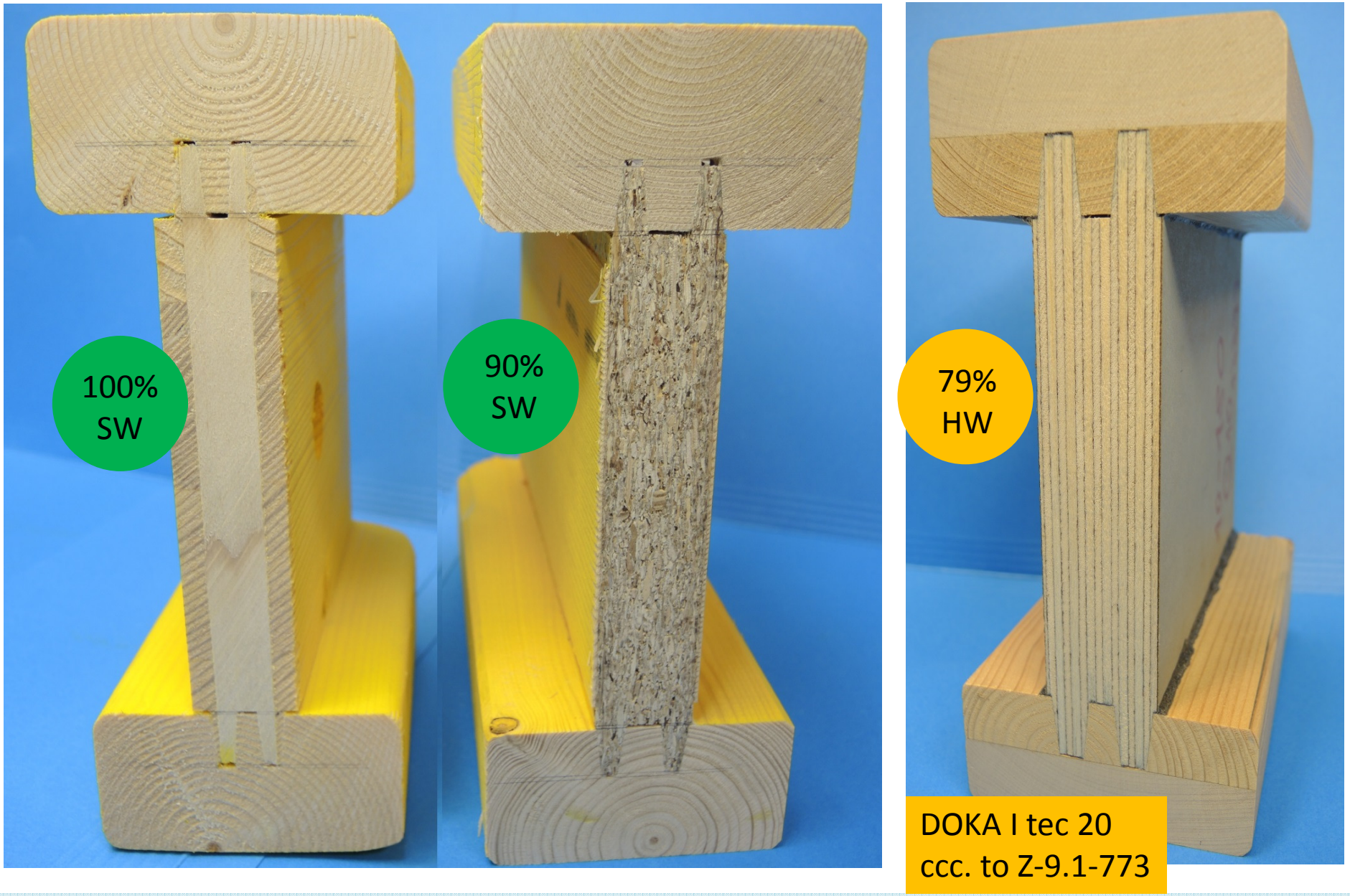

Innovative high strength formwork beam

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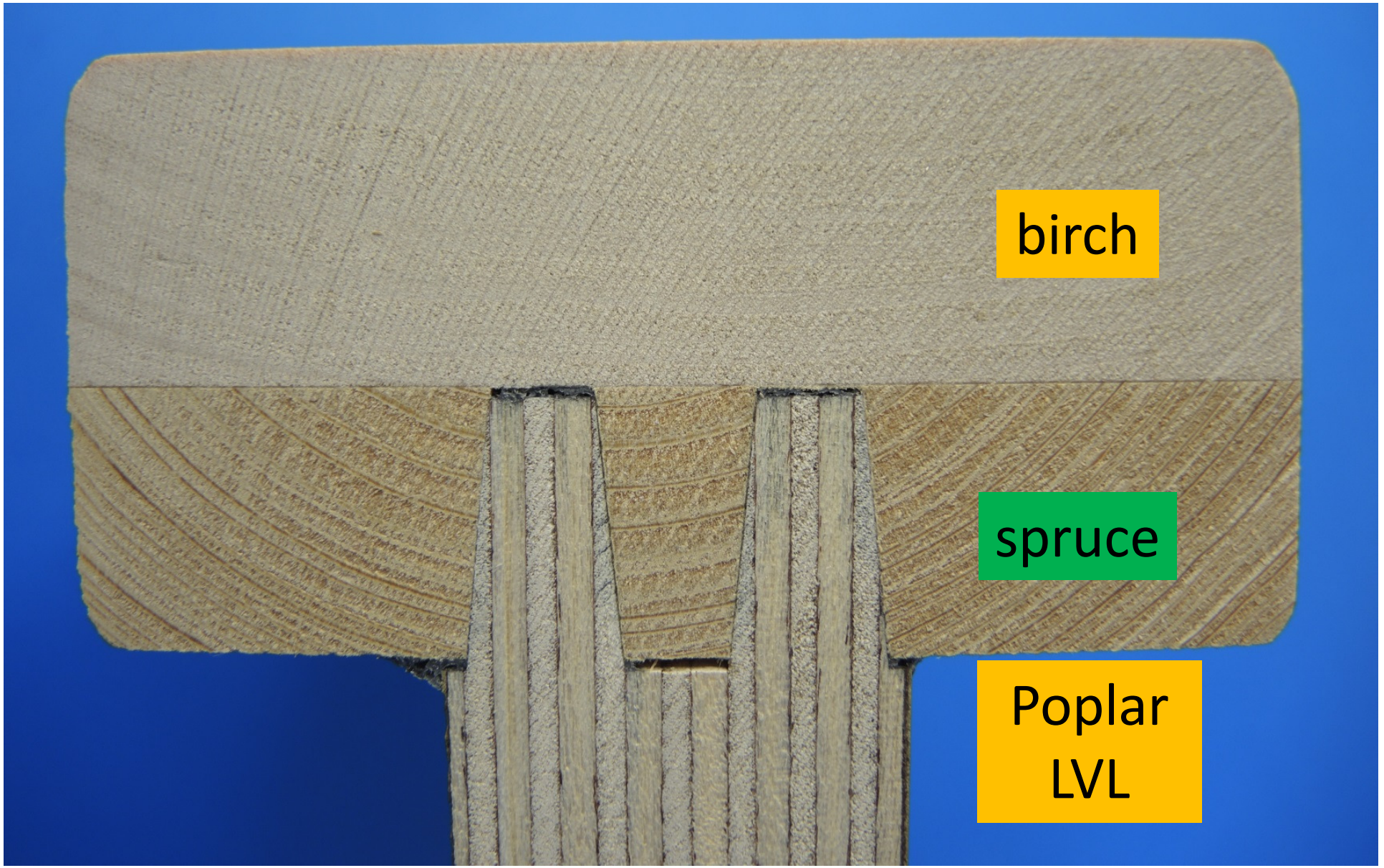
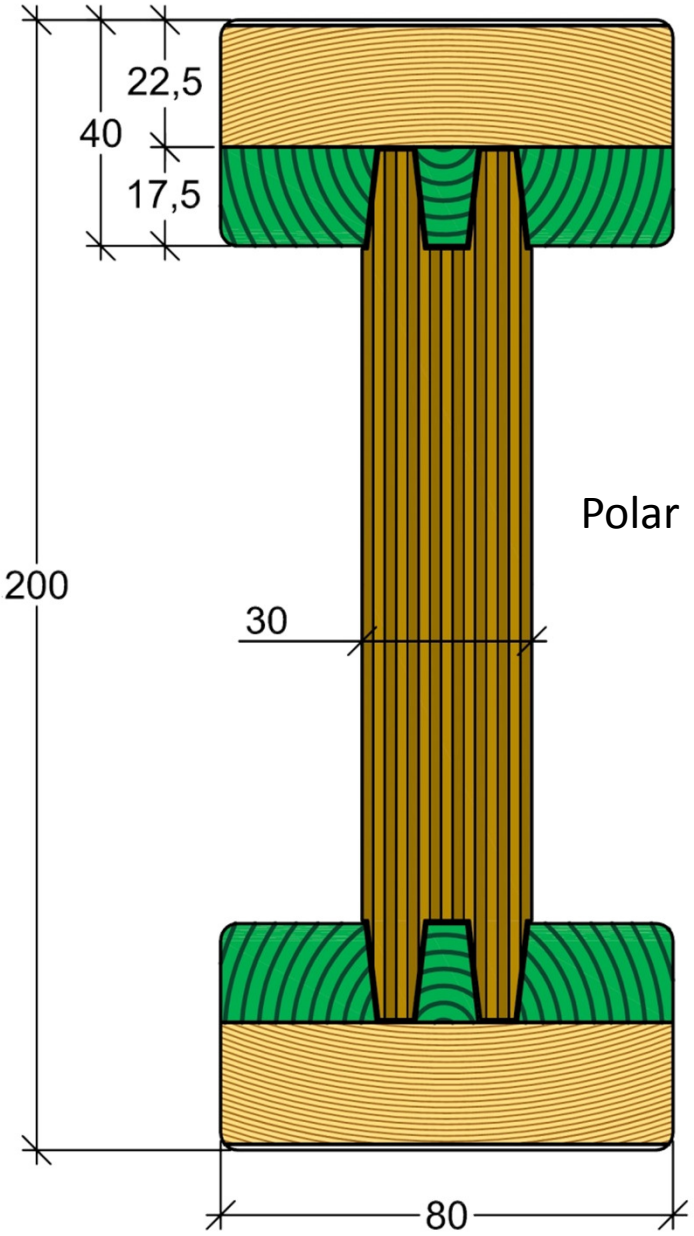


Innovative high strength formwork beam



Flange - requirements

$f_{m,k}$ ≥ 63 N/mm²

(birch in the tension zone)

web - requirements

$f_{m,0,k}$ ≥ 26,4 N/mm²

$f_{m,90,k}$ ≥ 20,8 N/mm²

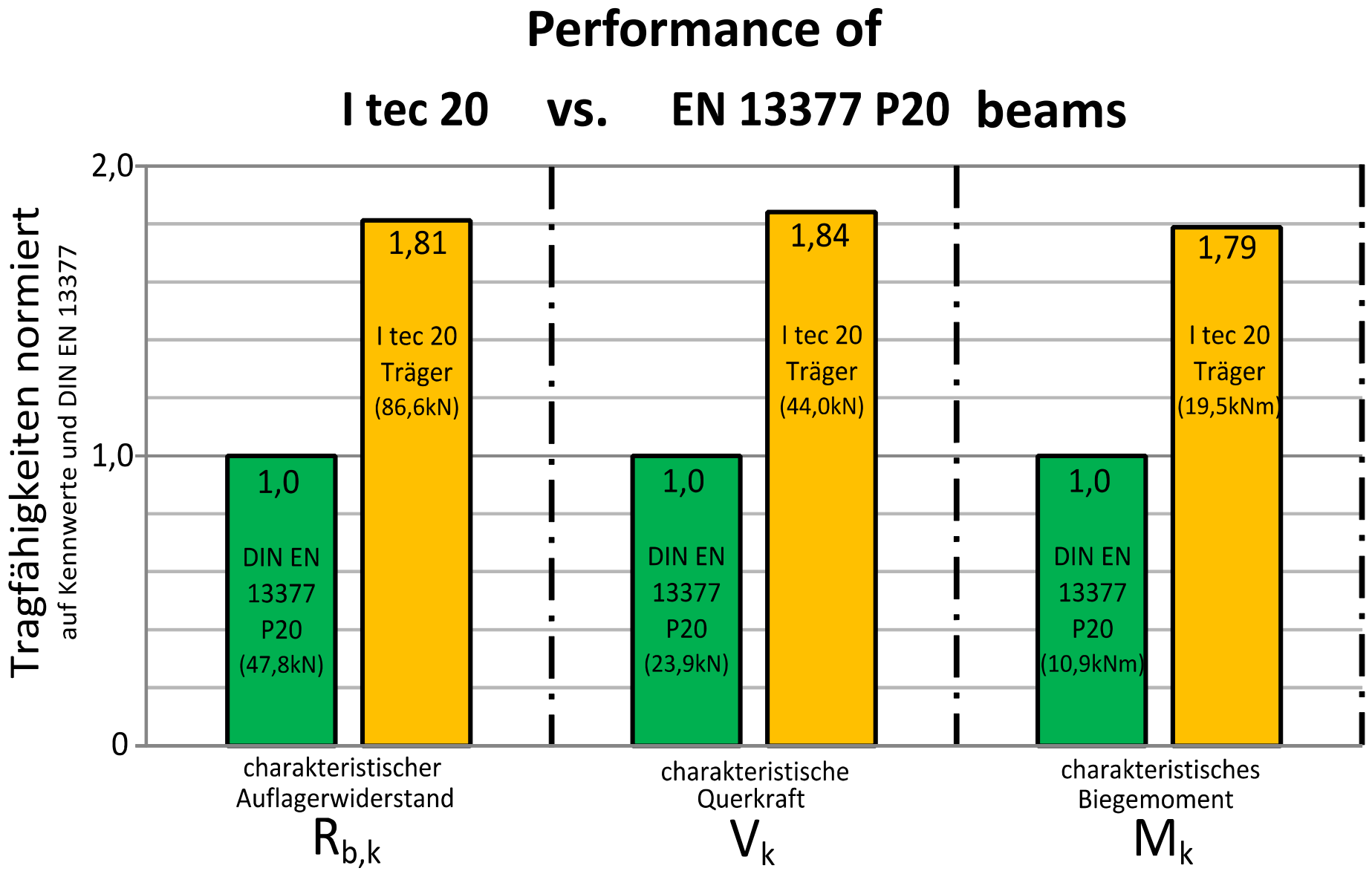
$E_{m,0,mean}$ ≥ 6.000 N/mm²

→ F30 / F20

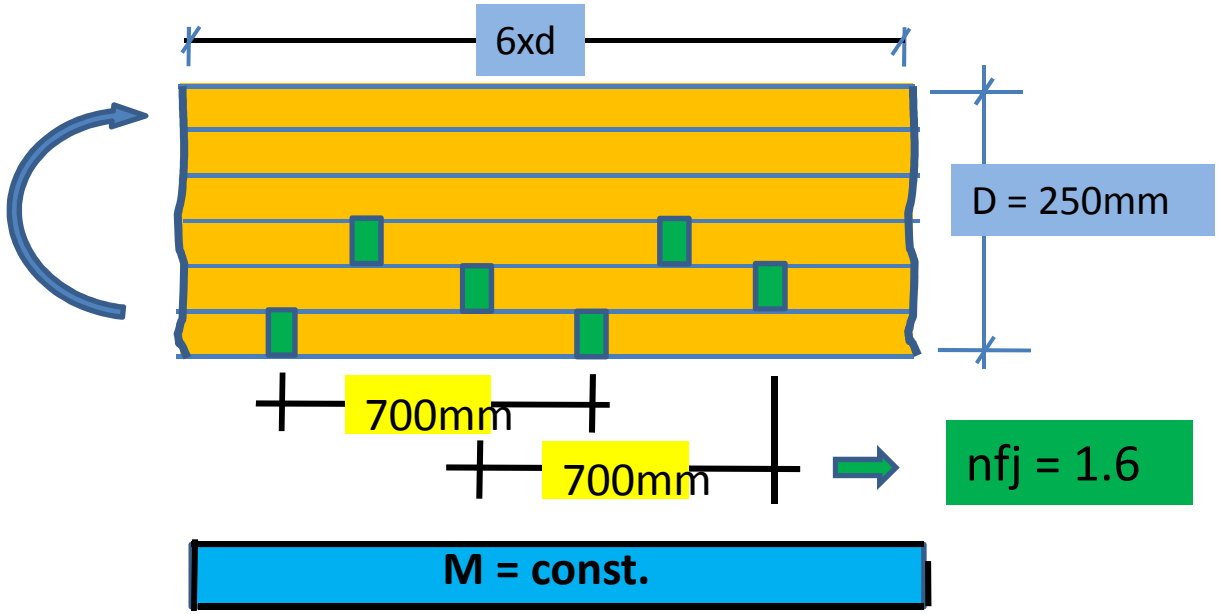
→ E60 / 35

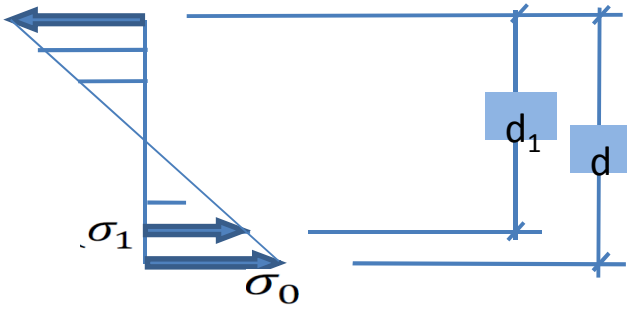
DOKA I tec 20
Acc. to Z-9.1-773

Innovative high strength formwork beam



WP 4: Modelling





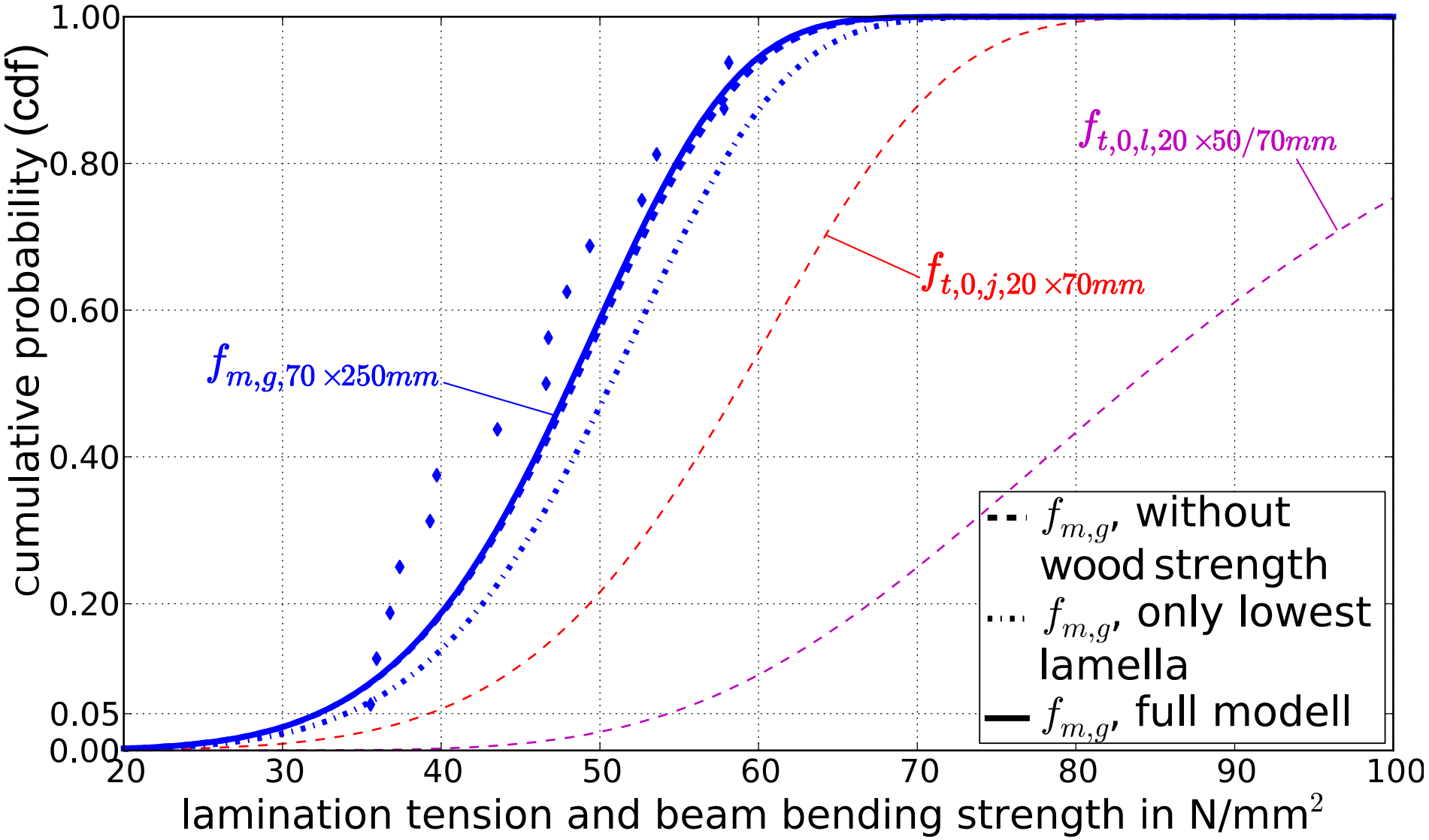
$$F_g = 1 - \left[(1 - F_{wood})e^{\left\{-n_{fj,eff}\left(\sigma/\lambda\right)^m\right\}}\right]$$

$$d = 250 \text{ mm}: \qquad n_{fj,eff} = n_{fj} \cdot [1 + 0.83^{6.4} + 0.68^{6.4}] = 2.5 \cdot 1.39 = 3.48$$

Weibull parameters λ = 62.3 MPa, m = 6.4

➡ $f_{m,k}$ = 32.6 MPa; experimental $f_{m,k}$ = 31.8 MPa

WP 4 Modelling



WP 3 and 4

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- **Schedule to be discussed**
- **Close interrelation of bonding / finger joints with glulam tests**
- **DOL tests with adhesives (if necessary) parallel to glulam tests**
- **Person (from March 2015): M. Hirsch**

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- Test not yet started
- collaboration with two companies arranged:

  - Decker (producer of cross-lam with two different types of presses)
    letter of intent for co-operation

  - Keck (saw mill for beech laminations)
    informal aggreement

5.1: out-of plane loading (e.g. floors)

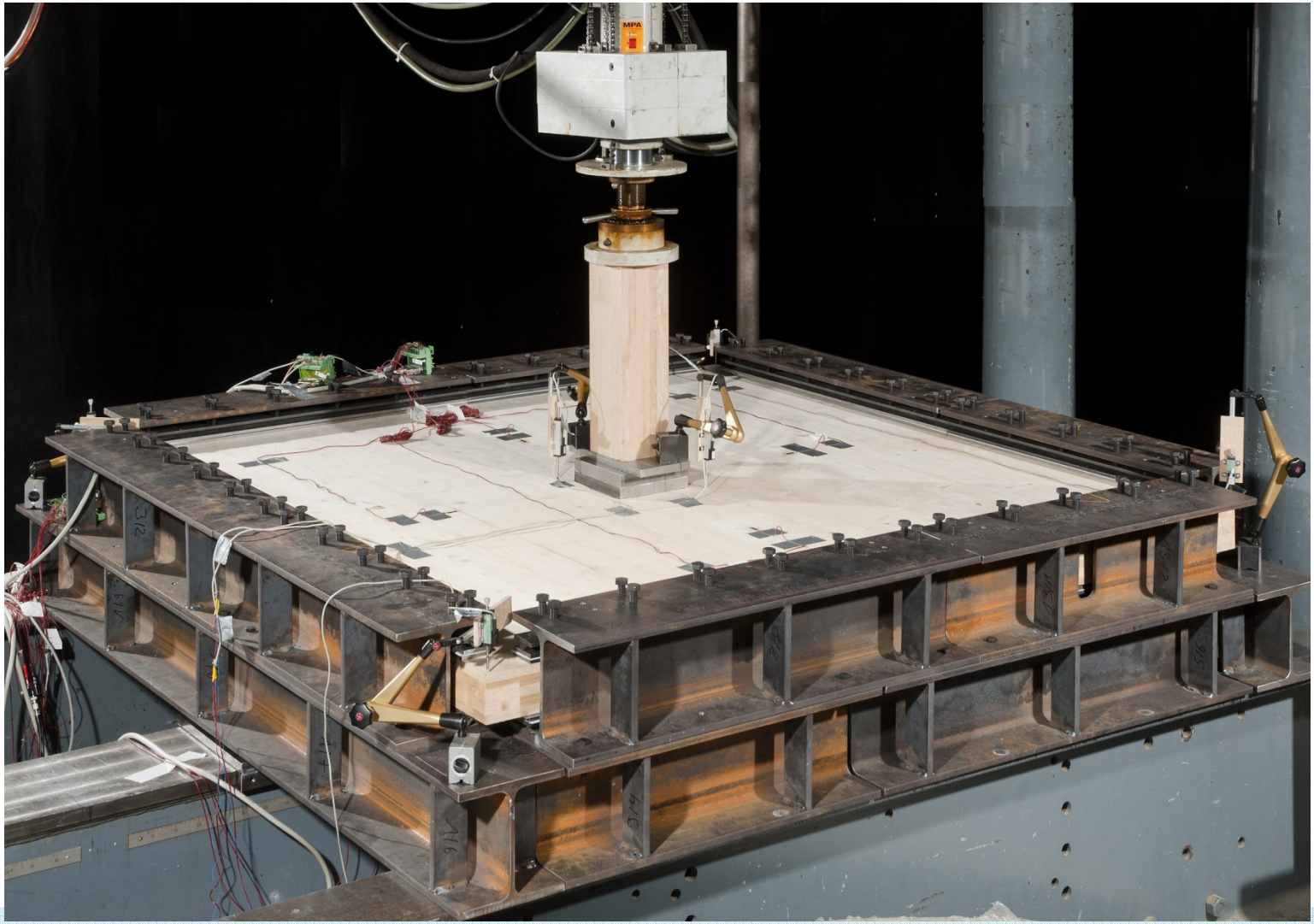
- Testing facilities:

  - bending tests of large elements (up to about 1,8 m * 6 m)
  - 8 * 200 kN loading
  - deformation, strain gauges, photogrammetry

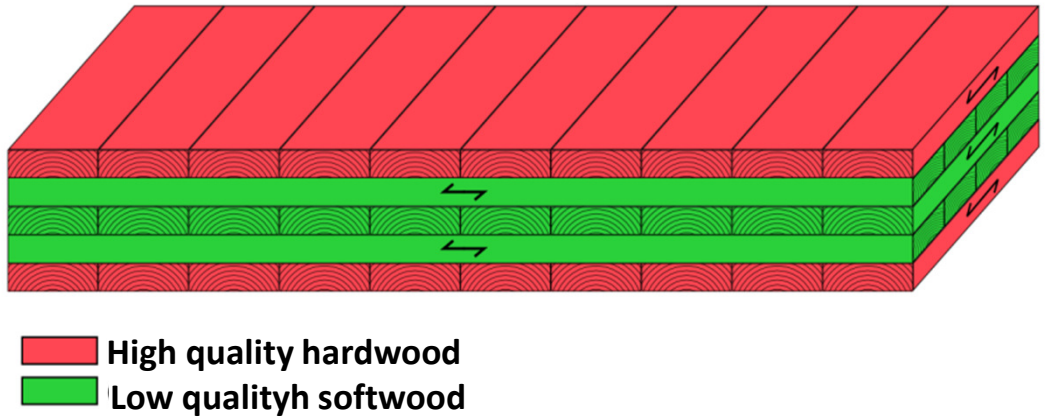
- Budged:
  - about 15 tests with full scale specimens

  - plus accompanying tests (shear strength etc.)

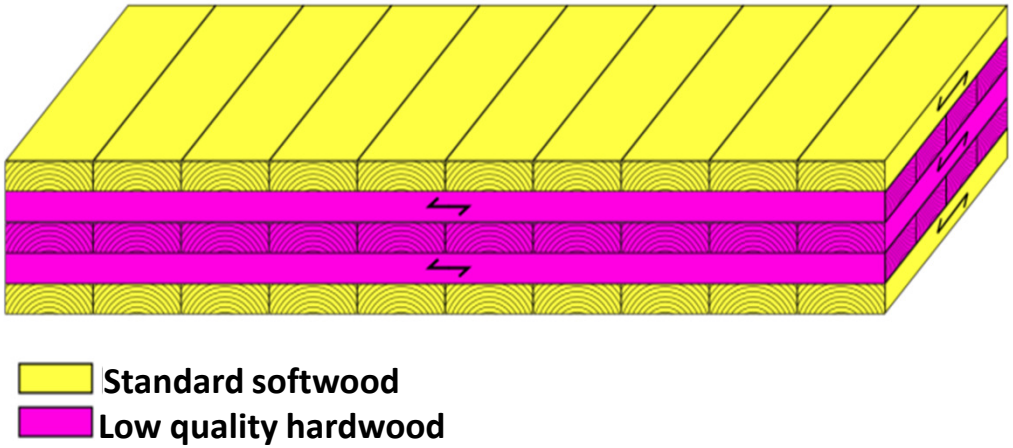
5.1: out-of plane loading (e.g. floors)



5.1: out-of plane loading (e.g. floors)



- high strength
- high aestetic quality



- standard strength
- low cost
- better noise insulation

5.2: in plane loading (walls)

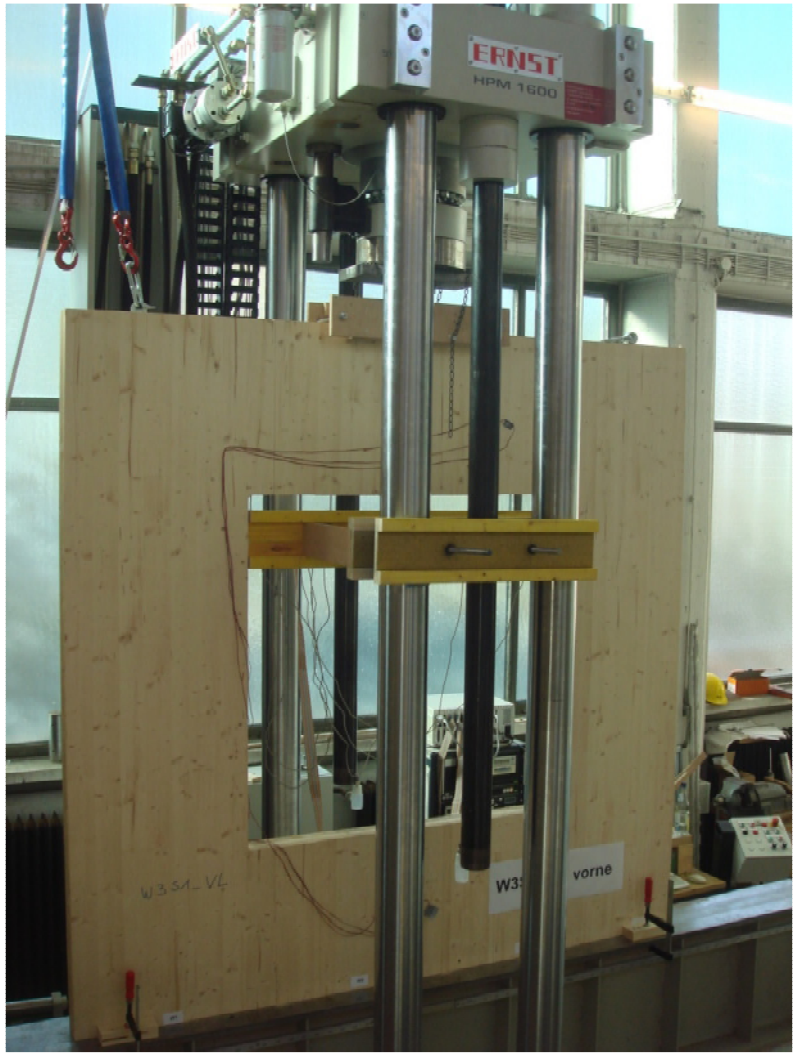
- Testing facilities:

  - In-Plane loading up to about 1400 kN
  - strain gauges, deformation measurements

- Budged:
  - about 15 tests with full scale specimens

  - plus accompanying tests (concentrated loads)

5.1: in plane loading (walls)



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Schedule:

- Arrangements with industry (done)
- Co-operation with CBD acc. to lay-ups (01-03.2015)
- Plans for specimens (02./03.2015)
- Production of specimens I (04.2015)
- Test of specimens I (05-07.2015)
- Evaluation / modelling (06.-08.2015)
- Production of specimes II (09.2015)
- Test of specimens II (10-12.2015)
- Evaluation / modelling (01.2016- …)
- Responsible Person:
  Mr. Tapia (from April 2015), until March: G. Dill-Langer