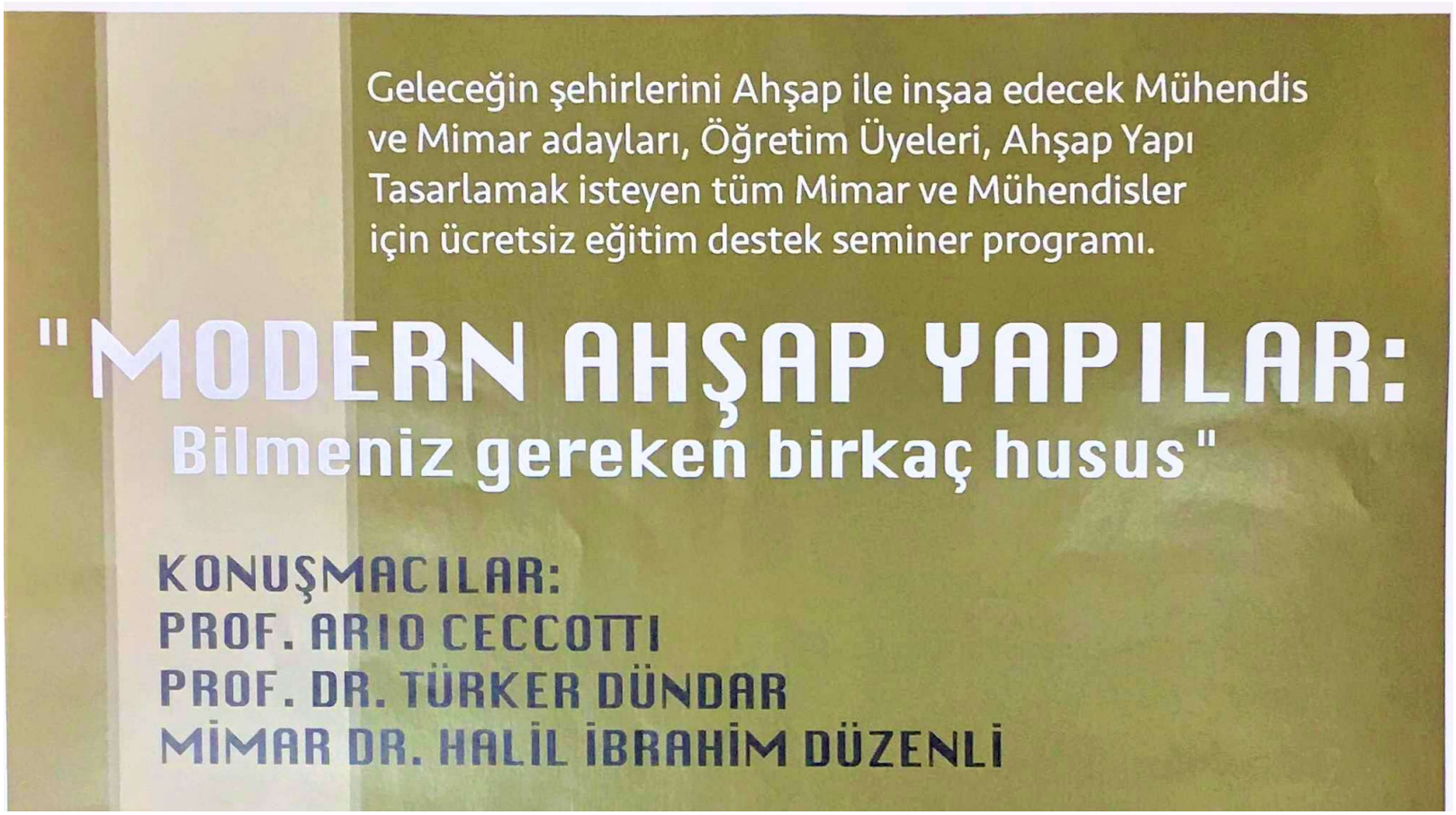


Timber engineering, few things to know

Ario Ceccotti *Boğaziçi University*

List of content

- ***The material.***

Structural wood: technology and physical-mechanical properties of wood products derived from wood for use in load-bearing structures.

- ***The connections***

Joints between elements, glued and mechanical. Materials, devices and their properties.

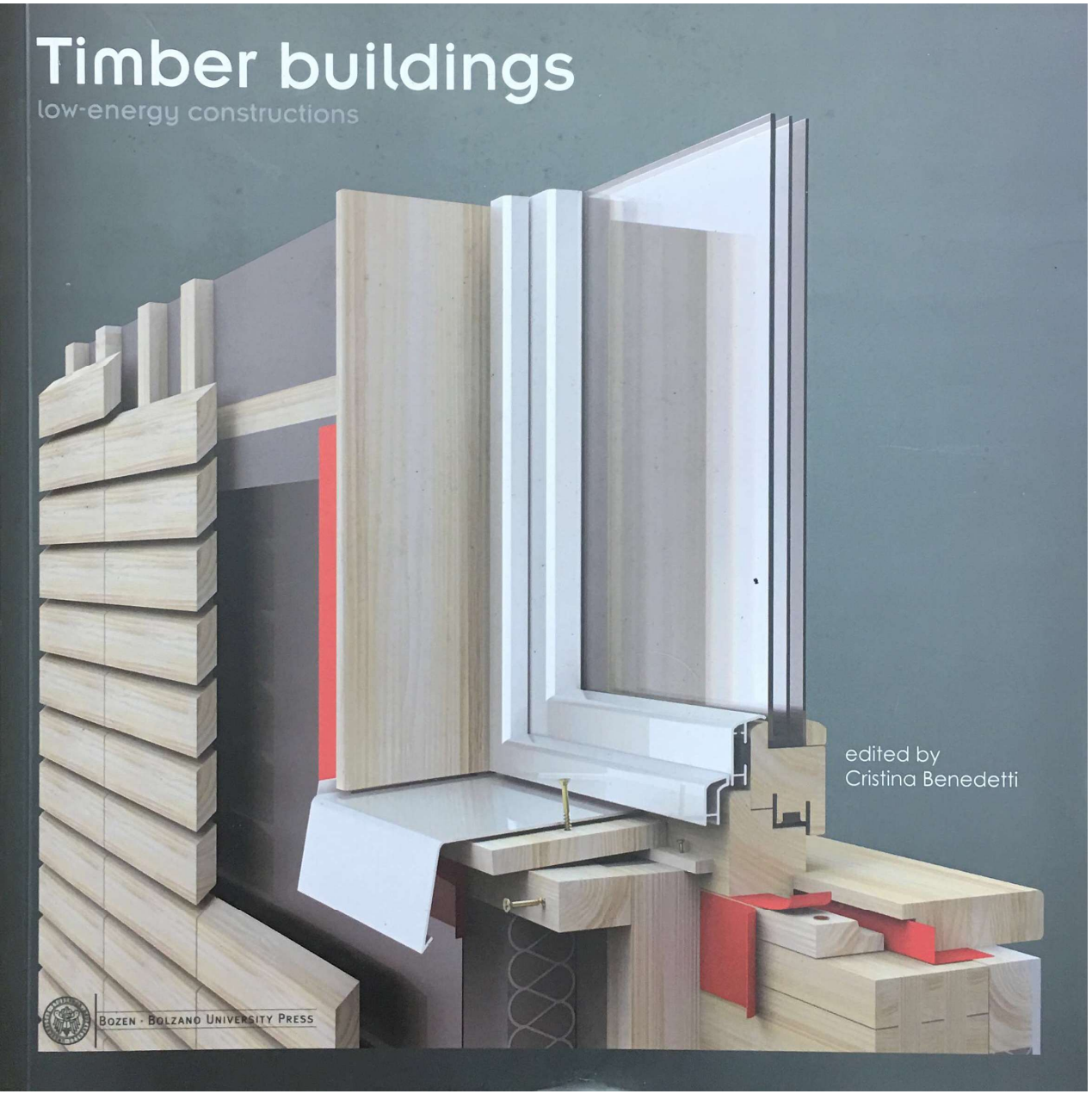
- ***The buildings.***

The main construction types. Frame and partition systems. Durability and resistance. Behavior to seismic actions and to fire.

Hans J. Blass
Carmen Sandhaas

KIT Karlsruhe Institute of Technology
Germany

https://publikationen.bibliothek.kit.edu/1000069616

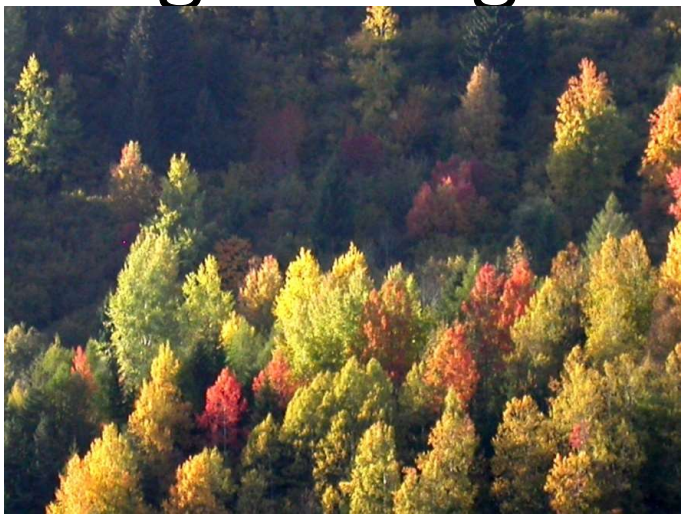


Cristina Benedetti

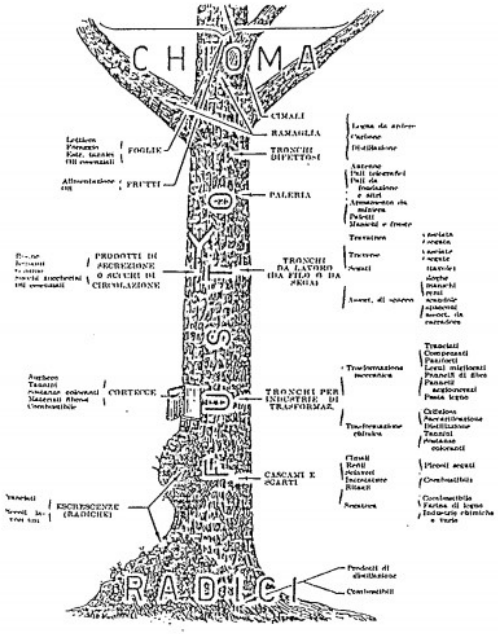
University of Bolzano
Italy

https://bupress.unibz.it/it/timber-buildings.html

Wood is a natural material of biological origin



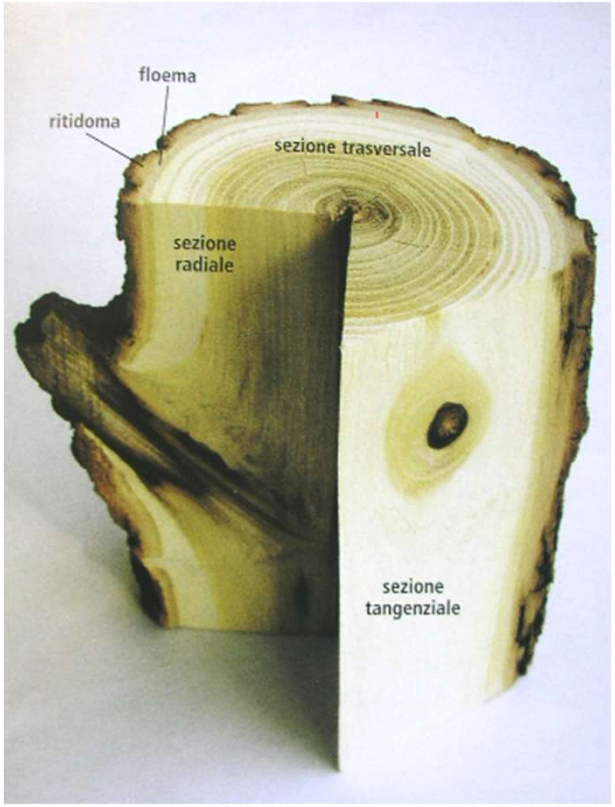
wood is renewable

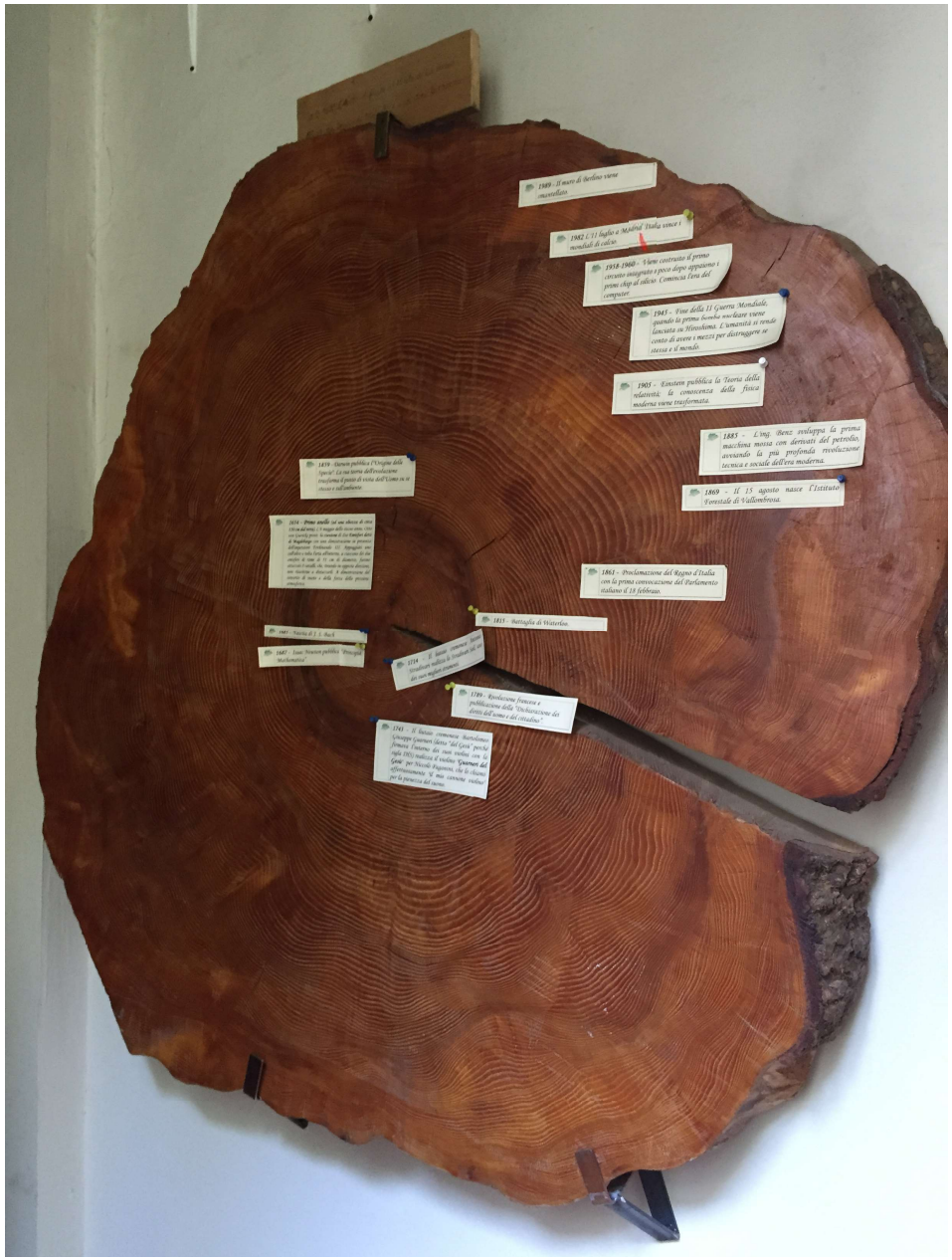


Parti principali dell'albero (da: GIORDANO, 1951)

using wood to save forests!

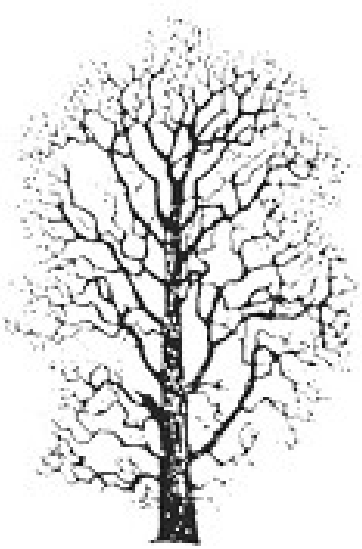
Prof. J. Natterer

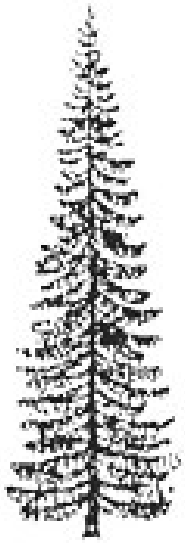

floema
ritidoma
sezione trasversale
sezione
radiale
sezione
tangenziale

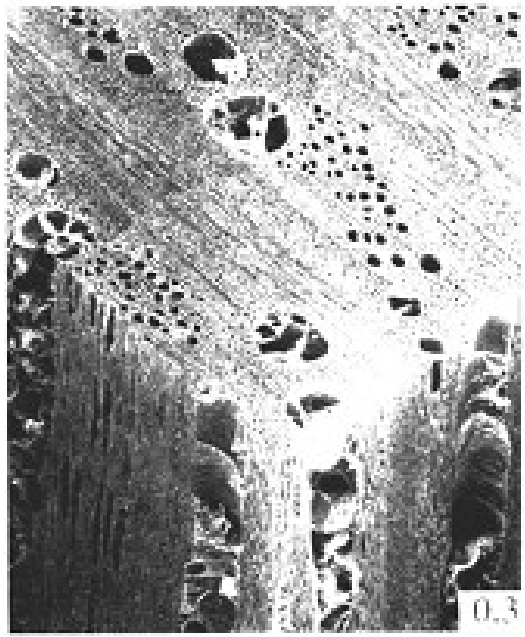


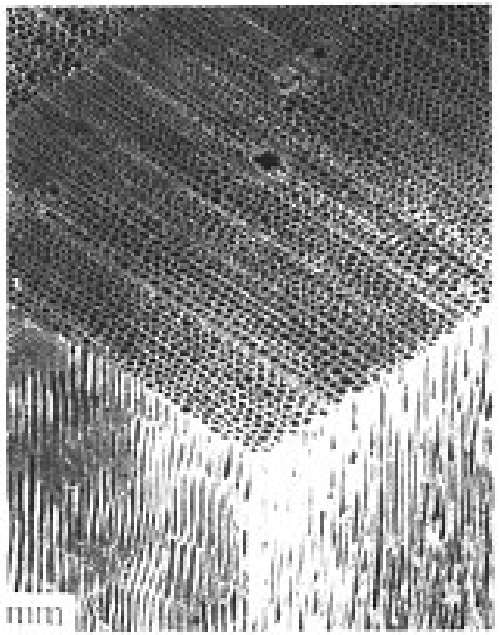
University of Florence DISTAF


nasce
Matteo
1977
nasce
Paolo
1981
nasce
Oscar
2010

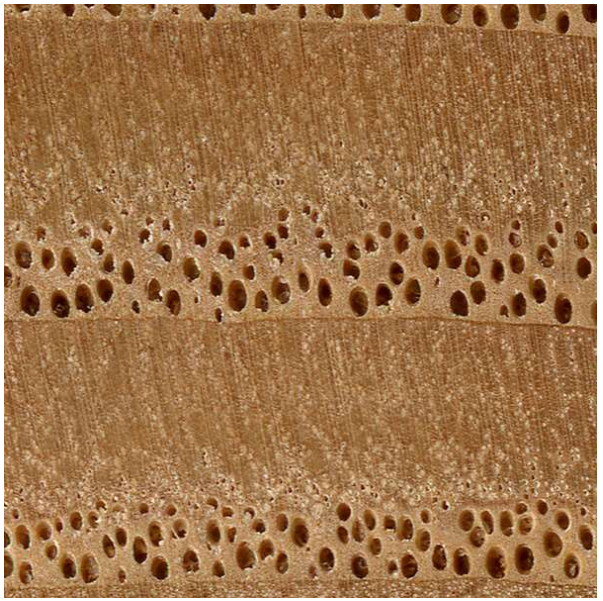





0,3 mm



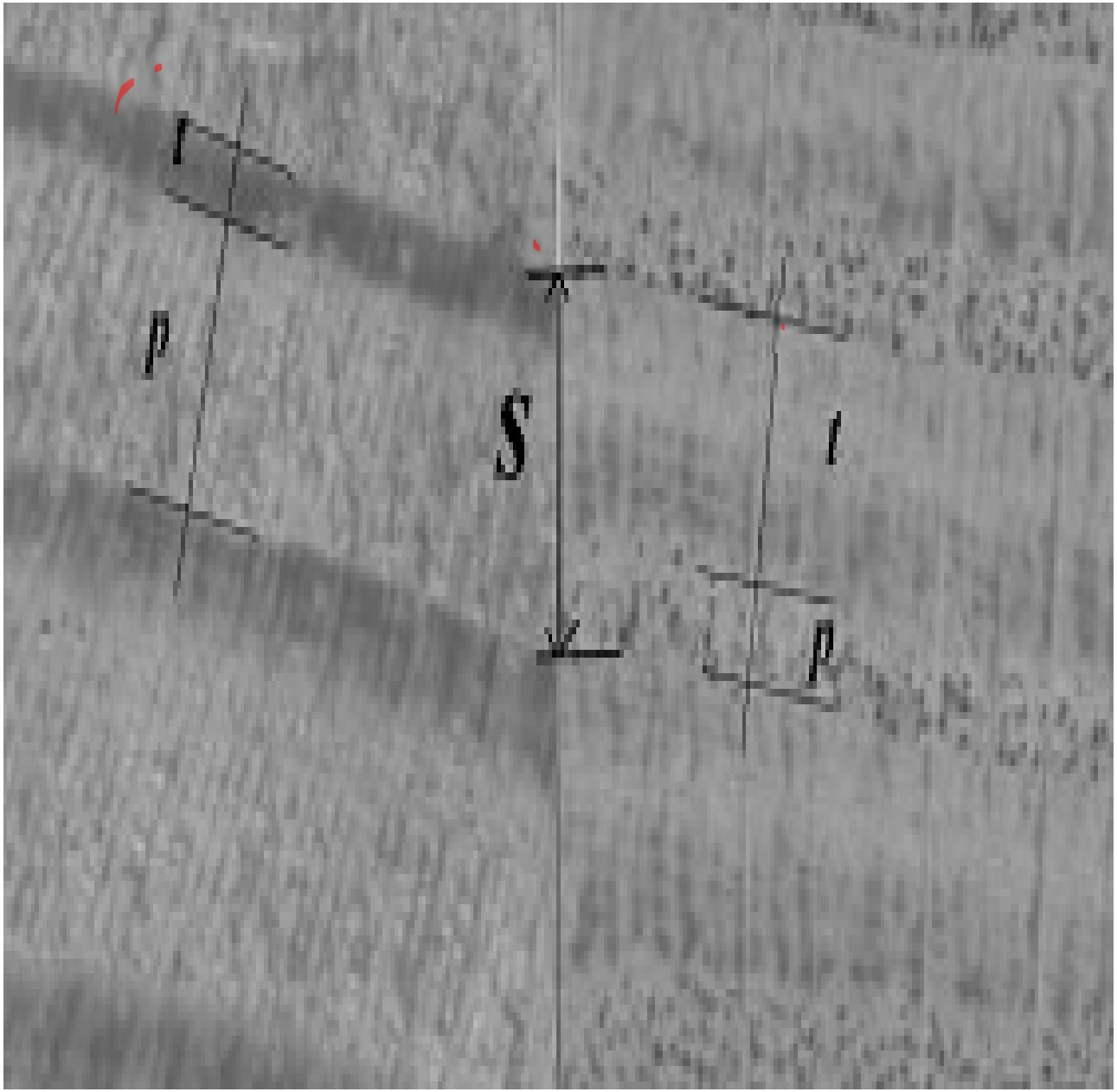
Yapraklı ağaçlar



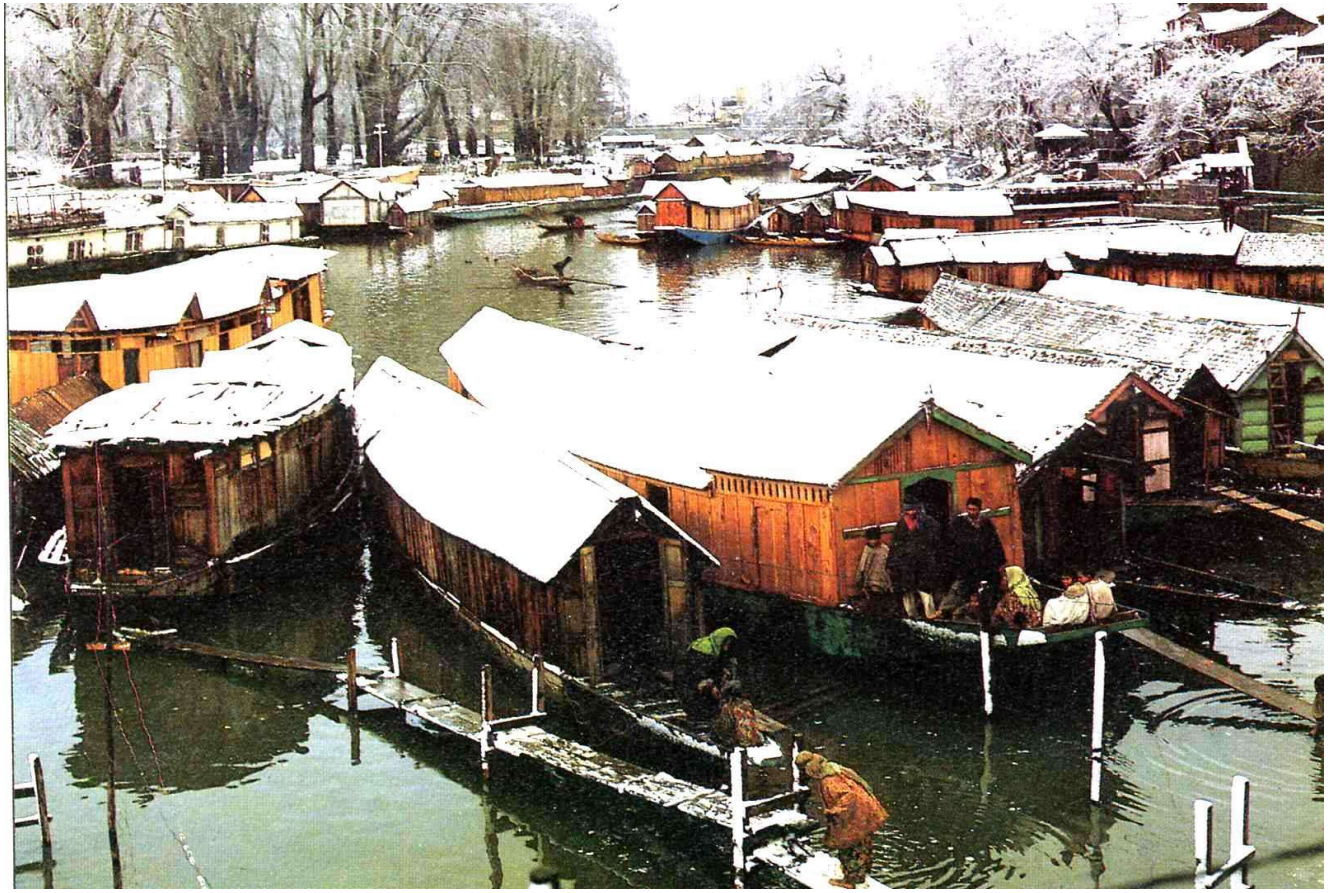
Prof. T. Dündar

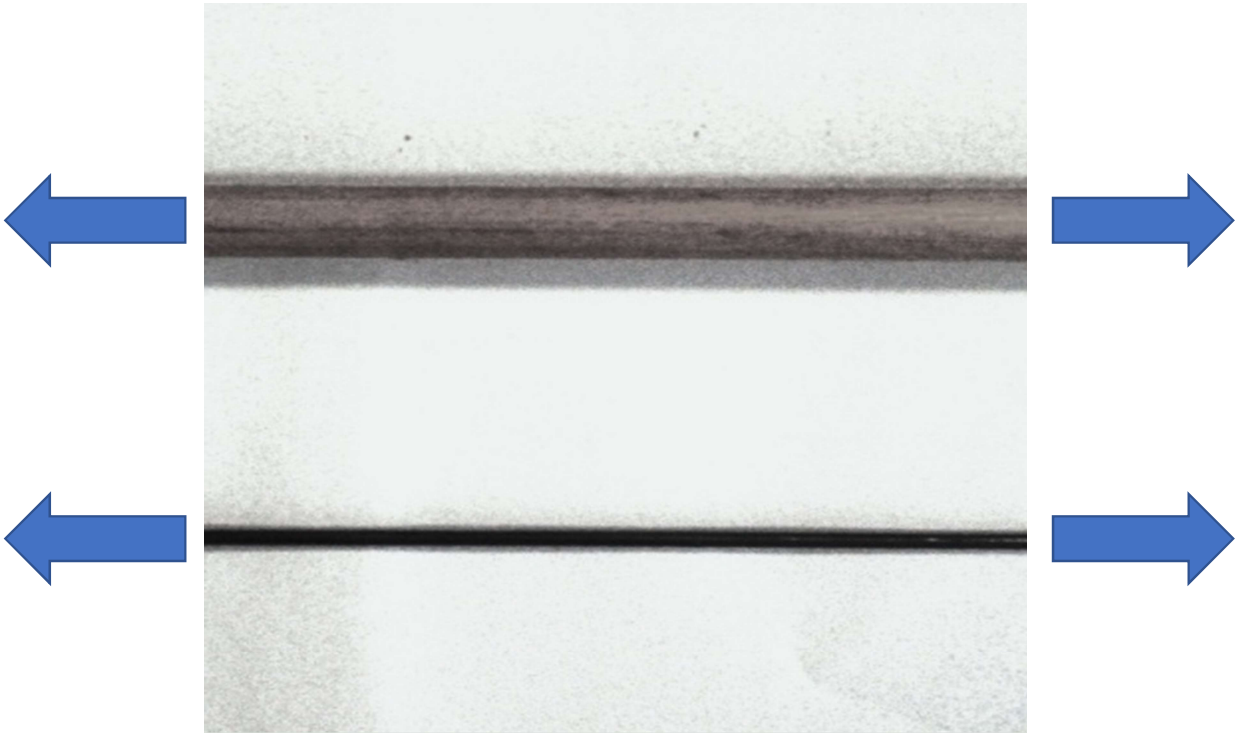
İbreli ağaçlar

Prof. T. Dündar


t
p
S
t
p


Disney · PIXAR
UP






DZ313

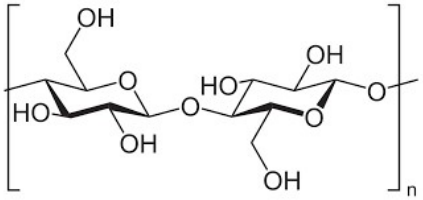
Hughes H-4 Hercules ("Spruce Goose"), 1947

Yoğunluk

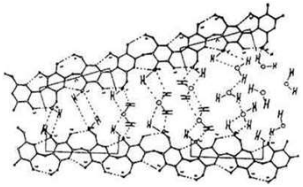
Ağaç Türü	Hava Kurusu Yoğunluk (g/cm^3)	Tam Kuru Yoğunluk (g/cm^3)
Karaçam	0.56	0.52
Sarıçam	0.53	0.50
Kızılçam	0.55	0.51
Ladin	0.45	0.41
Göknar	0.41	0.39
Sedir	0.51	0.48
Melez	0.59	0.55
Ardıç	0.55	0.51

CONIFERE	ABETE ROSSO	450 300 - 620
	ABETE BIANCO	440 310 - 610
	LARICE	650 380 - 930
	PINO SILVESTRE	550 380 - 660
	DOUGLASIA	510 390 - 720
LATIFOGLIE	QUERCIA FAGGIO	760 500 - 1000
	ROBINIA	750 600 - 870
	CASTAGNO	580 370 - 700
	PIOPPO non euroamericano	500 400 - 630

Ahşap-nem ilişkisi

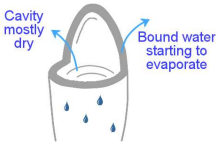


%75-85 Selülozik
%15-25 Lignin



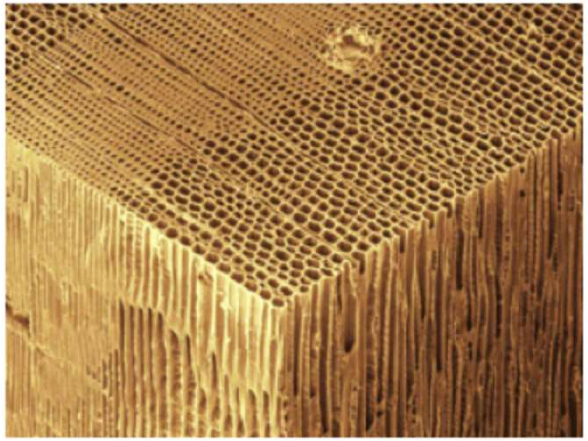
Bağlı su (bound water)

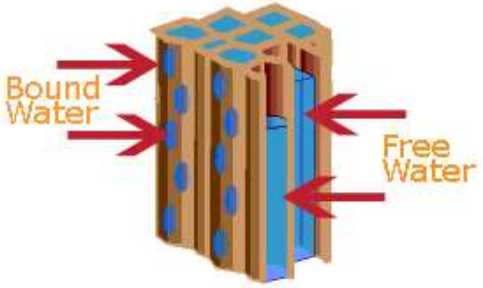
Lif Doygunluğu Noktası- LDN
(Fiber Saturation Point- FSP)



Fibre saturation point

Serbest su (free water)

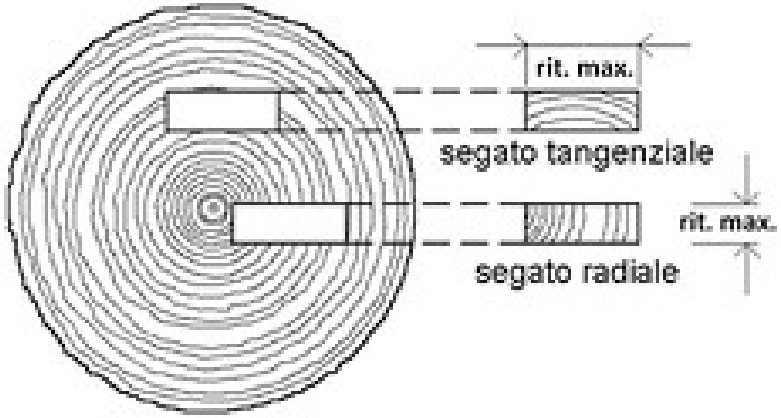


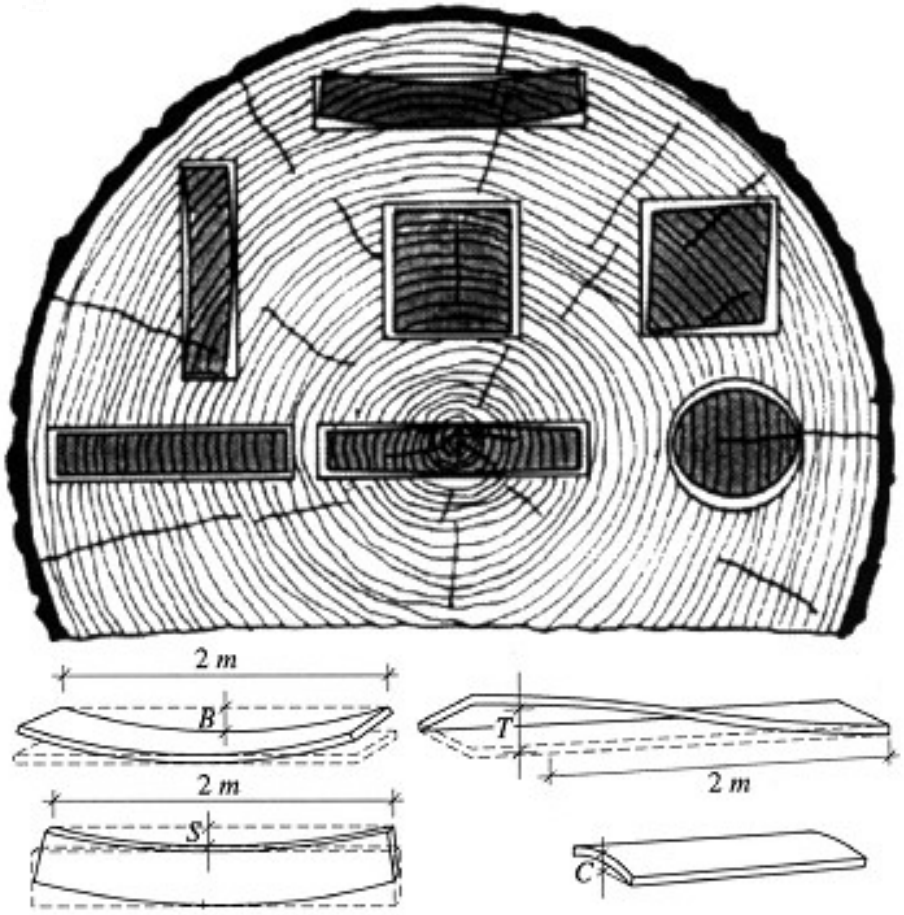


Prof. T. Dündar

moisture content
definition:

$$u\,(\%) = \frac{(\rho - \rho_0)}{\rho_0} \cdot 100$$


rit. max.
segato tangenziale
rit. max.
segato radiale


2 m
B
2 m
S
T
2 m
C

	Tangenziale	Radiale	Longitudinale
Specie Legnosa	α_T	α_R	α_L
Conifere Europee	0.24	0.12	0.01
Quercia e Faggio	0.40	0.20	0.01

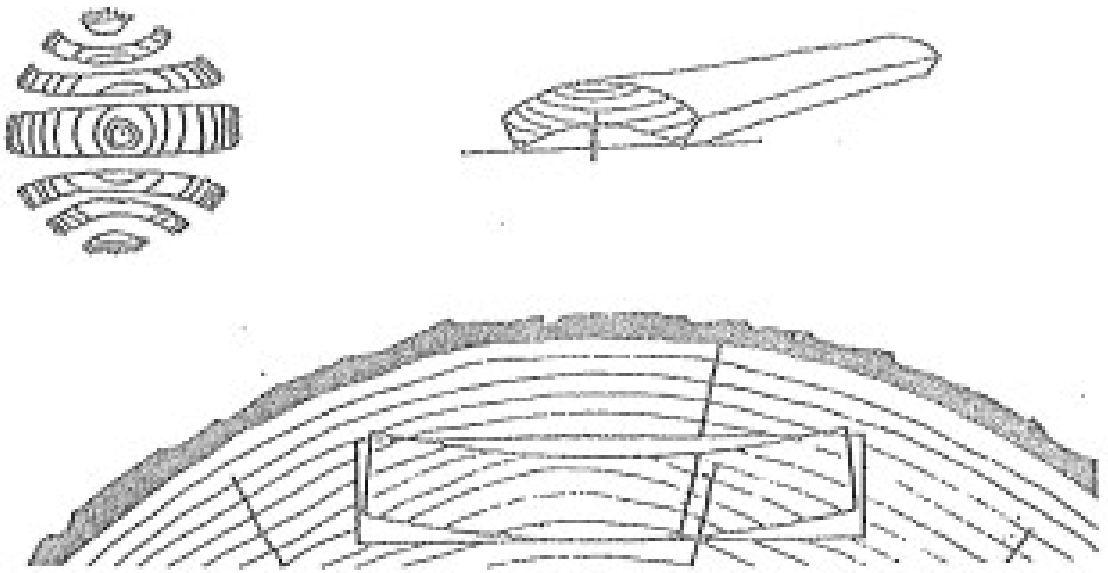


Fig. 4.15- Imbarcamento delle tavole tangenziali

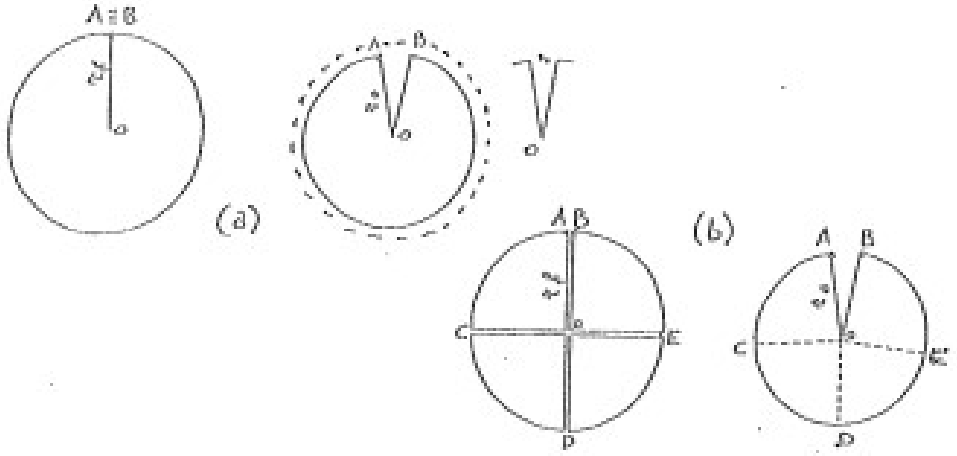
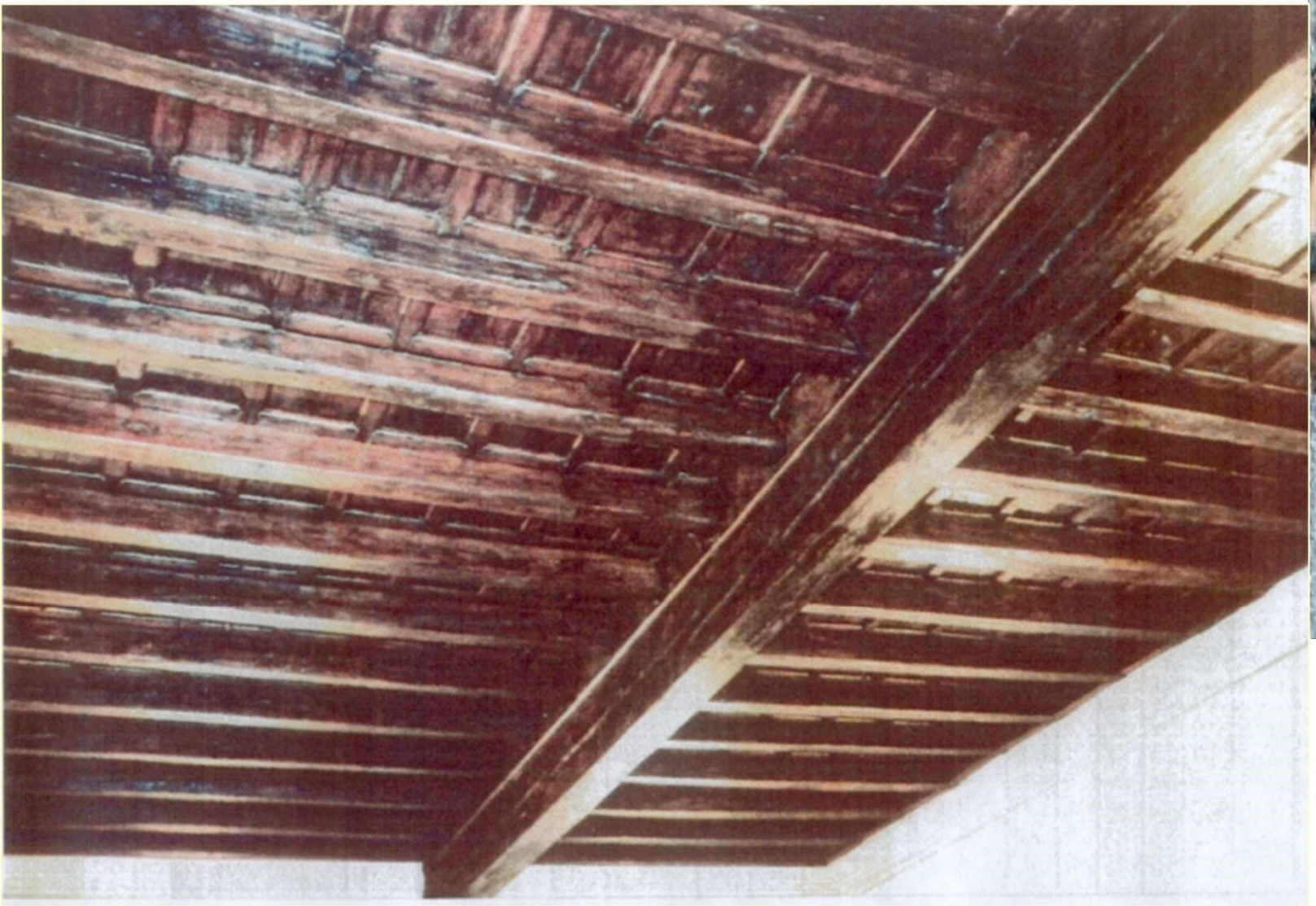
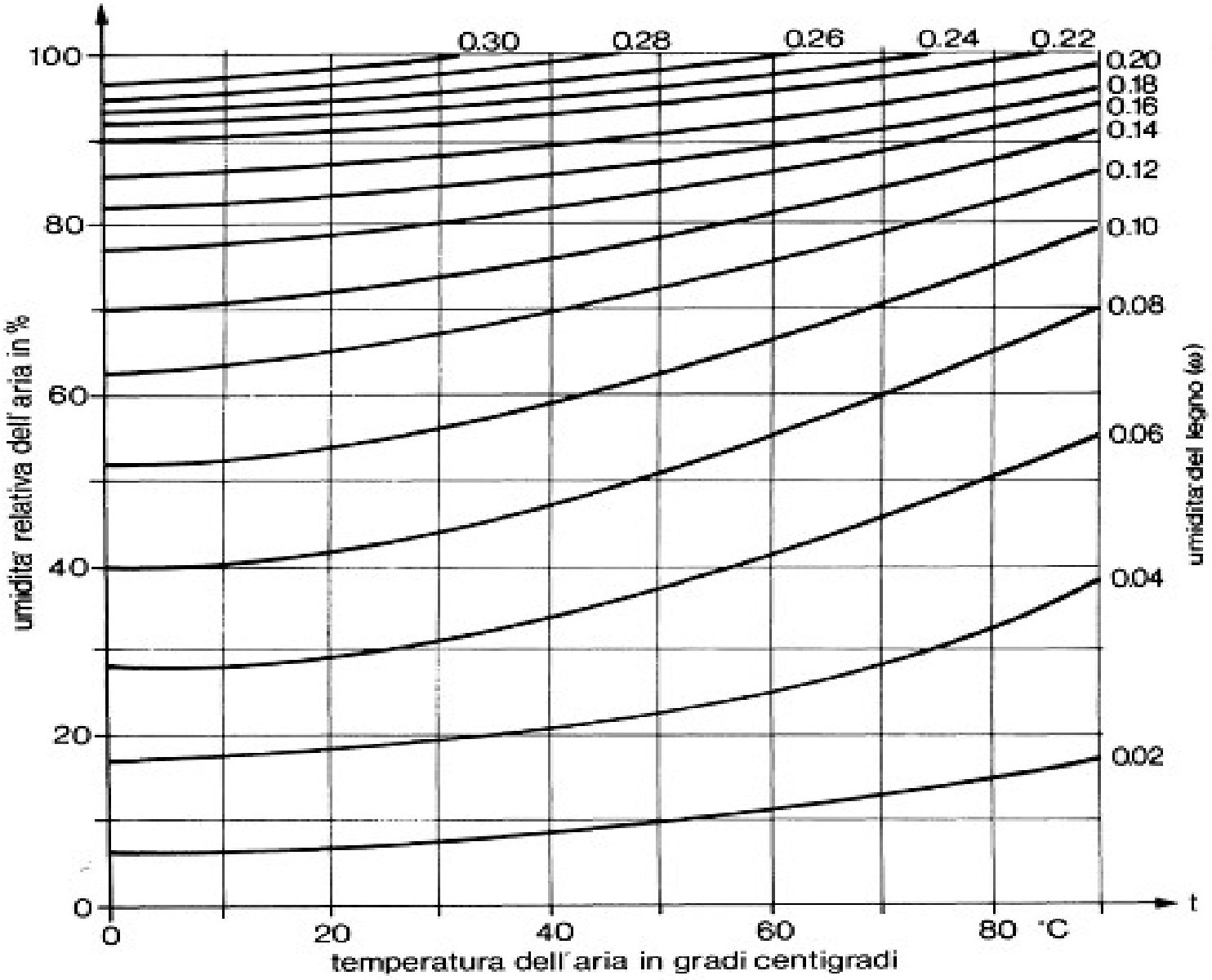


Fig. 4.14- Ritiro angolare: metodo del taglio radiale della rotella (a) e dei 4 quarti (b)




0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
umidità del legno (ω)
100
80
60
40
20
0
umidità relativa dell'aria in %
0
20
40
60
80 °C
t
temperatura dell'aria in gradi centigradi

ELEMENTI PROTETTI CONTRO LE INTEMPERIE		
- in locali ben aerati e ben riscaldati	0,10	±0,02
- in locali ben aerati poco riscaldati in inverno	0,13	±0,02
- in locali ben aerati non riscaldati in inverno	0,15	±0,03
- al riparo, all'aperto	0,17	±0,05
ELEMENTI PARZIALMENTE PROTETTI CONTRO LE INTEMPERIE		
SEZIONI PICCOLE:		
- con forte irraggiamento solare	0,14	±0,05
- con debole irraggiamento solare	0,16	±0,04
SEZIONI MEDIE:		
- con forte irraggiamento solare	0,12	±0,04
- con debole irraggiamento solare	0,15	±0,04
ELEMENTI DIRETTAMENTE ESPOSTI ALLE INTEMPERIE		
SEZIONI GROSSE:		
- mediamente	0,18	±0,06
- in superficie	0,20	±0,08
ELEMENTI UMIDI		
- in locali umidi, mal ventilati	da 0,24 fino a saturazione	
ELEMENTI IMMERSI	oltre la saturazione	


094

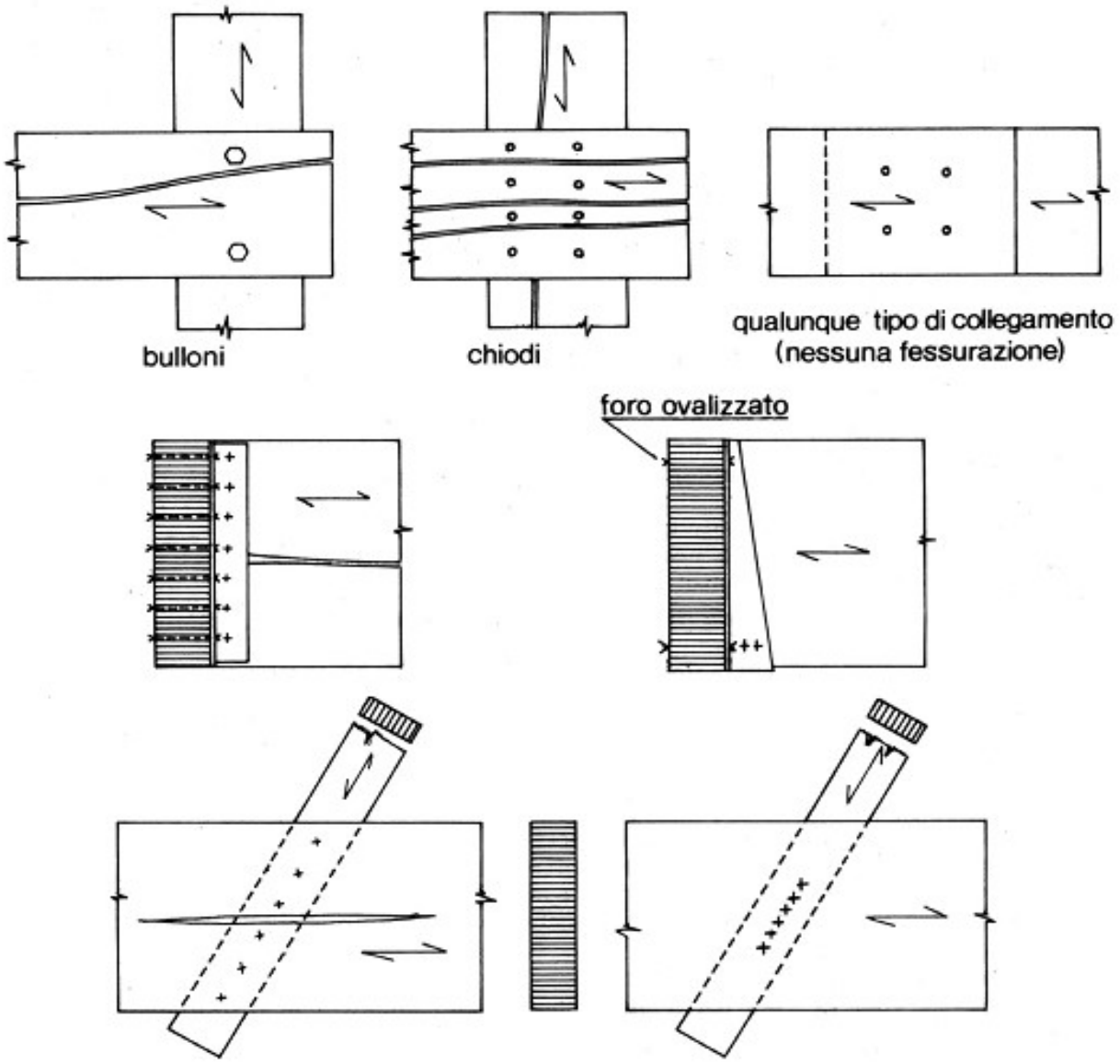
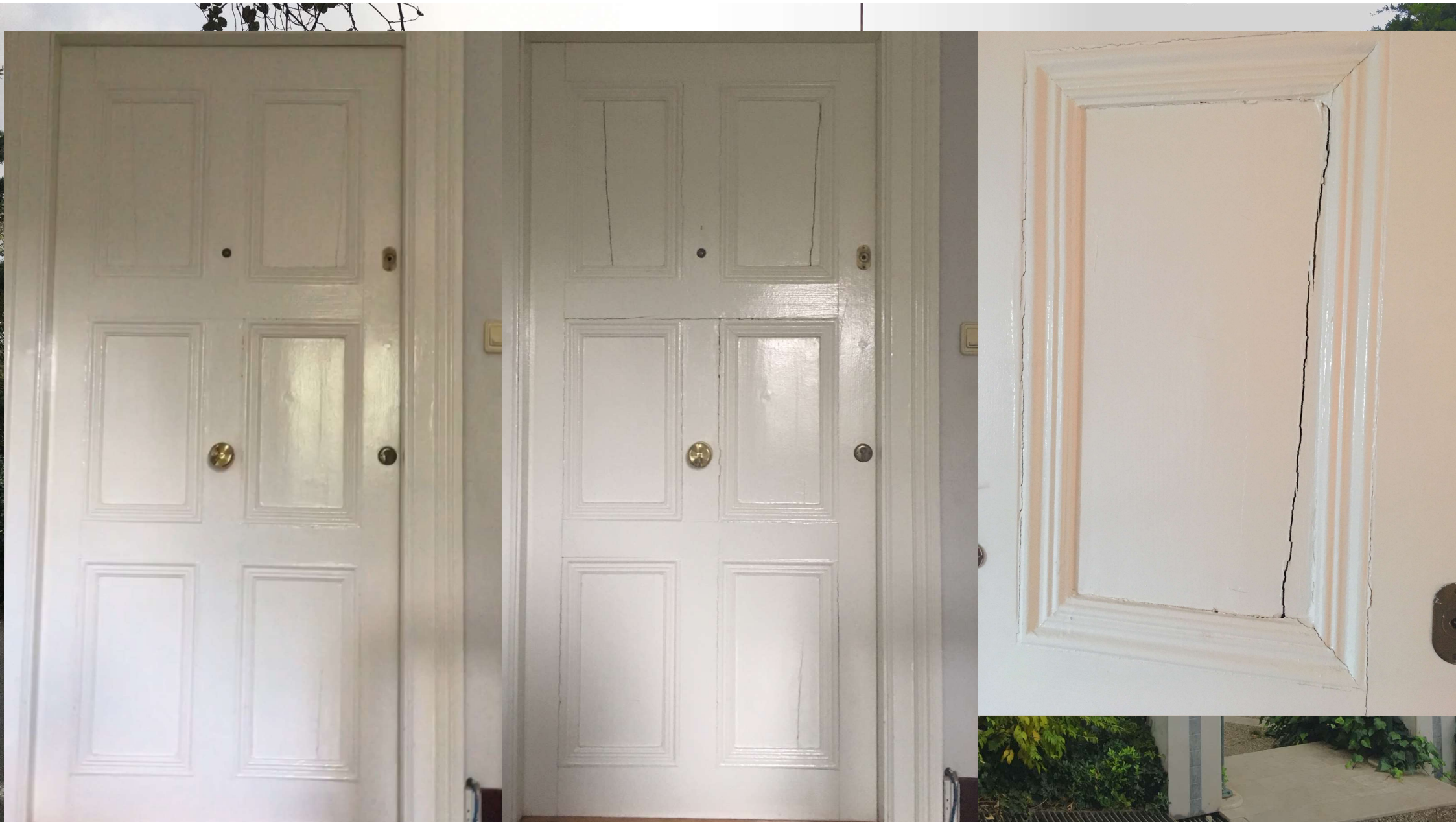


Fig. 12.39 – Collegamenti meccanici e possibilità di fesssurazione



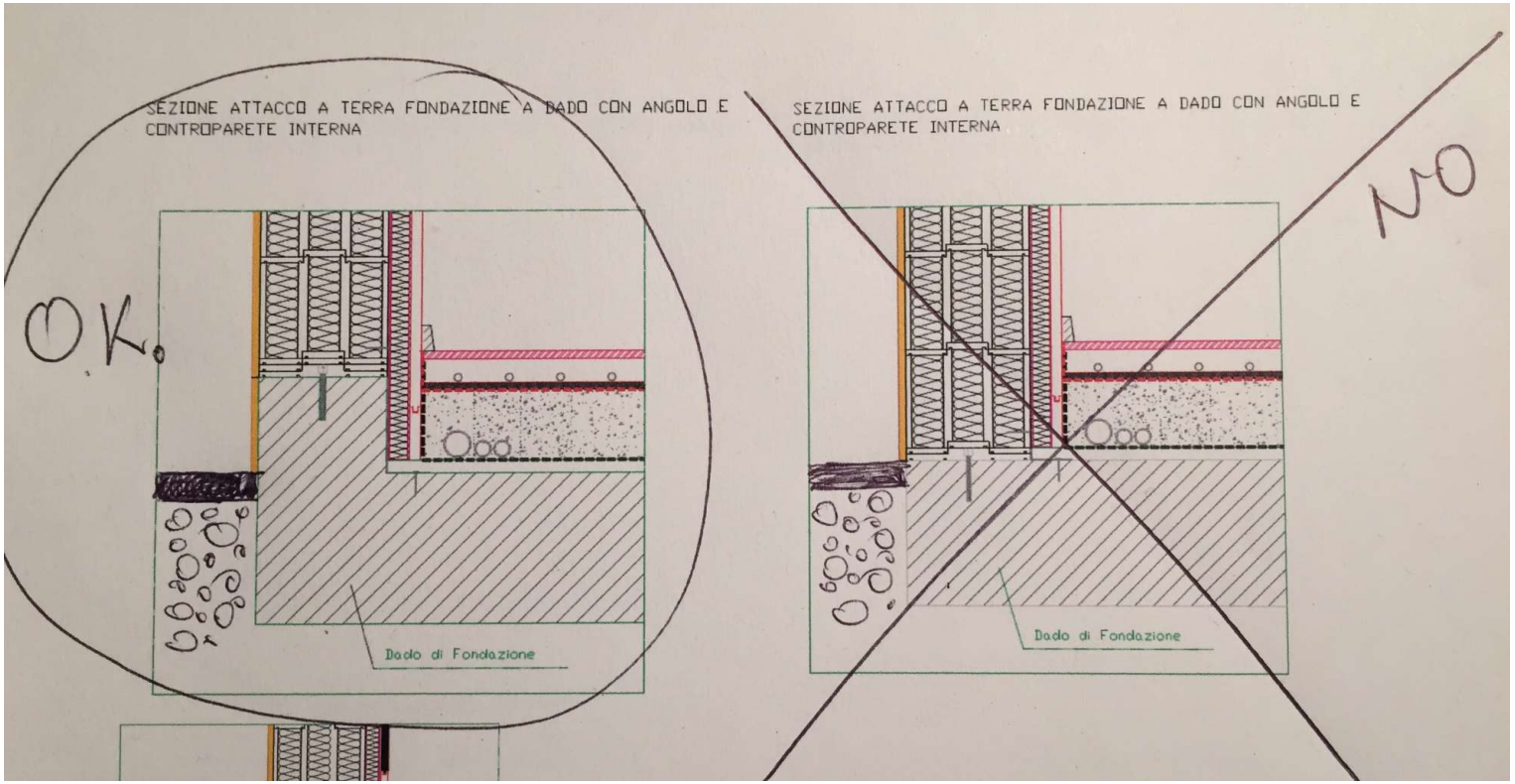
Biyolojik Dayanımı

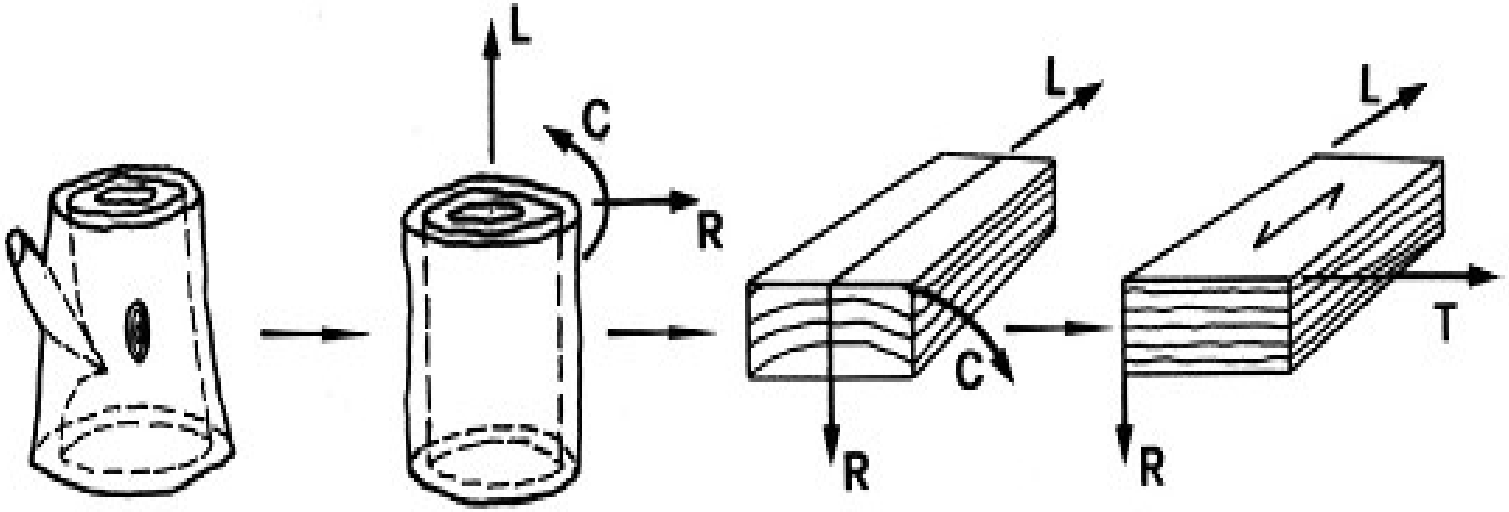
Ahşapta mantarlara karşı doğal dayanım sınıfları (Öz odun ve toprakla temas esas alınmıştır) (TS EN 350-2)		
Sınıf 1	Çok dayanıklı (> 25 yıl)	Yalancı Akasya, Teak, Afzelia, Makore, Okan, Mansonia, Iroko, Bilinga, Green Heart, Afrormosia, Paduk
Sınıf 2	Dayanıklı (15-25 yıl)	Ardıç, Porsuk, Kestane, Saplı Meşe, Anjelik, Kosipo, Sipo, Bosse, Bubinga, Mutenye, Azobe, Iroko, Wenge, Amerikan Maunu
Sınıf 3	Yarı dayanıklı (10-15 yıl)	Sarıçam, Melez, Douglas göknarı, Ceviz, Saçlı Meşe, Tiama, Kosipo, Sapelli, Sipo, Afrika maunu,
Sınıf 4	Az dayanıklı (5-10 yıl)	Göknar, Ladin, Karaçam, Sarıçam, Radiata Çamı, Melez, Douglas göknarı, Karaağaç, Hickory, Kırmızı Amerikan Meşesi,
Sınıf 5	Dayanıksız (< 5 yıl)	Radiata çamı, Akçaağaç, Kızılağaç, Huş, Gürgen, Kayın, Dişbudak, Kavak, Ihlamur

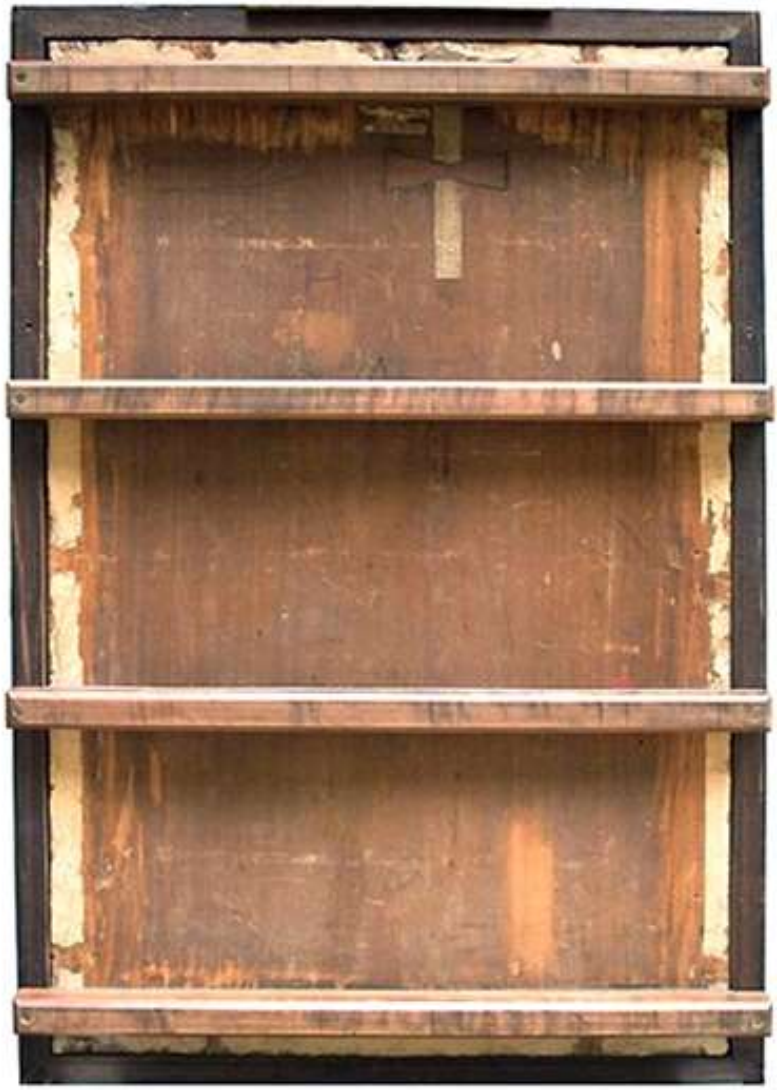
Prof. T. Dündar

Emprenye edilebilirlik (TS EN 350-2)

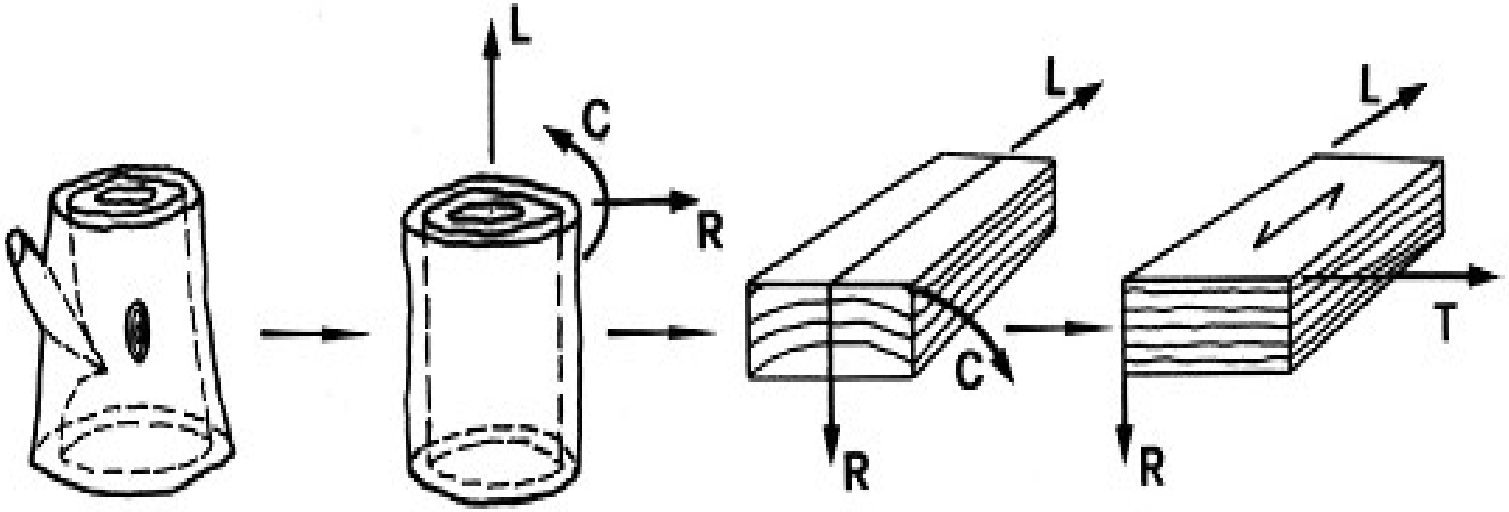
Emprenye edilebilirlik sınıfı	Açıklama	Ağaç Türleri
(1) Kolay emprenye	Kereste basınç altında kolayca tam olarak emprenye edilebilir	Karaçam diriodunu, Sarıçam diriodunu, Akçaağaç, Kızılağaç, Huş, Gürgen, Kavak diriodunu, Meşe diriodunu, Karaağaç diriodunu, Kayın
(2) Yarı kolay emprenye	Tam emprenye mümkün değil, ama 2-3 saat sonra yumuşak odunlarda 6 mm'den fazla nüfuz edilebilir. Sert odunlarda ve özodunda ise daha büyük oranlarda nüfuz etmesi mümkündür.	Göknar, Huş, Kestane diriodunu, Dişbudak, Ceviz diriodunu, Karaağaç özodunu
(3) Zor Emprenye	3-4 saat basınç etkisiyle 3 mm'den 6 mm'ye yanal nüfuz mümkün	Göknar, Ladin, Ceviz özodunu, Kavak özodunu
(4) Çok zor emprenye	3-4 saat basınç altında bırakıldıktan sonra boyuna ve enine çok az miktarda nüfuz mümkün olur.	Melez, Ladin, Karaçam özodunu, Sarıçam özodunu, Douglas göknarı, Kestane özodunu, Meşe özodunu


SEZIONE ATTACCO A TERRA FONDAZIONE A DADO CON ANGOLO E CONTROPARETE INTERNA
O.K.
Dado di Fondazione
SEZIONE ATTACCO A TERRA FONDAZIONE A DADO CON ANGOLO E CONTROPARETE INTERNA
NO
Dado di Fondazione


L
C
R
L
C
R
L
T
R



J. Grill – L. Uzielli


L
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R
L
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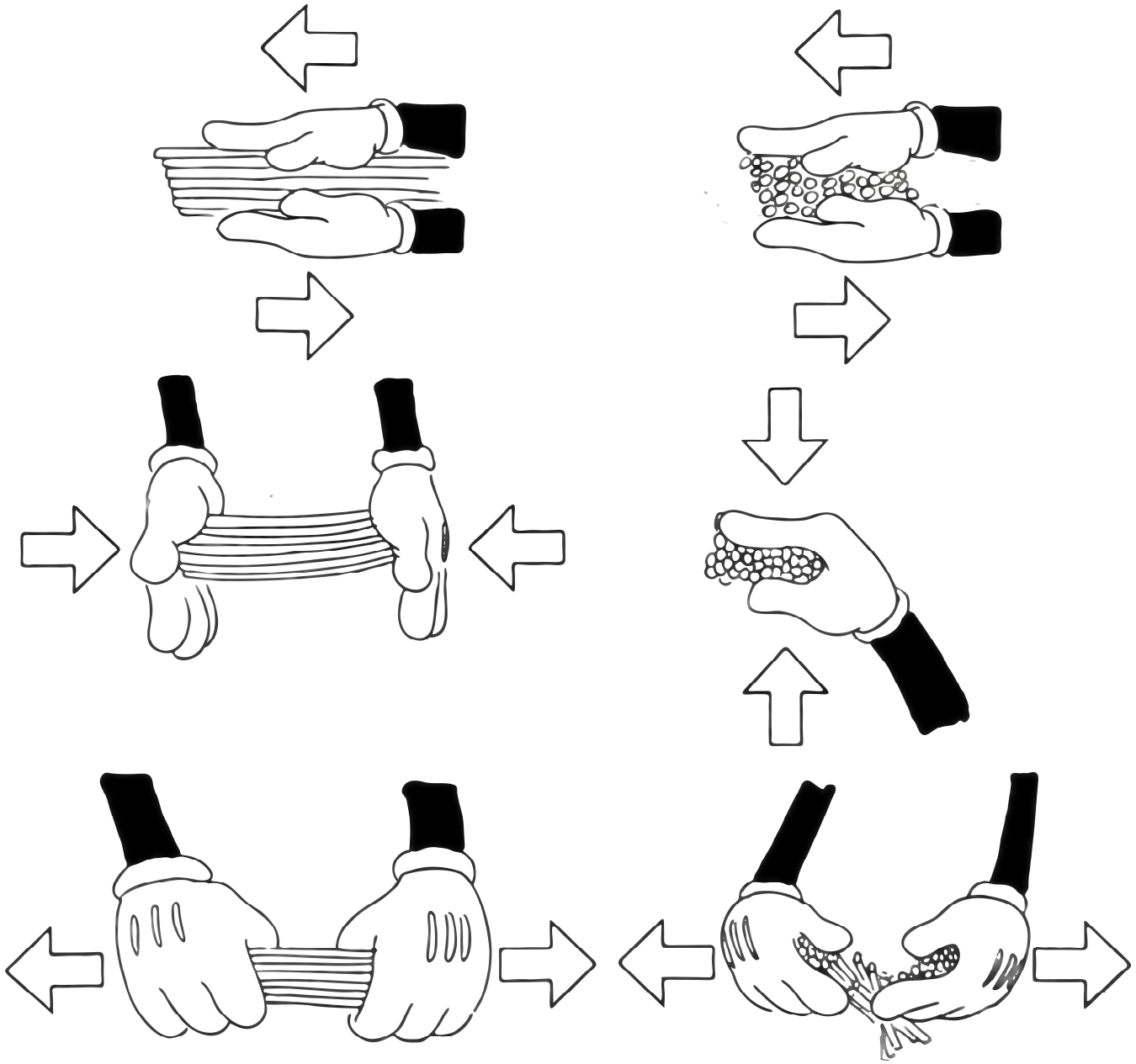
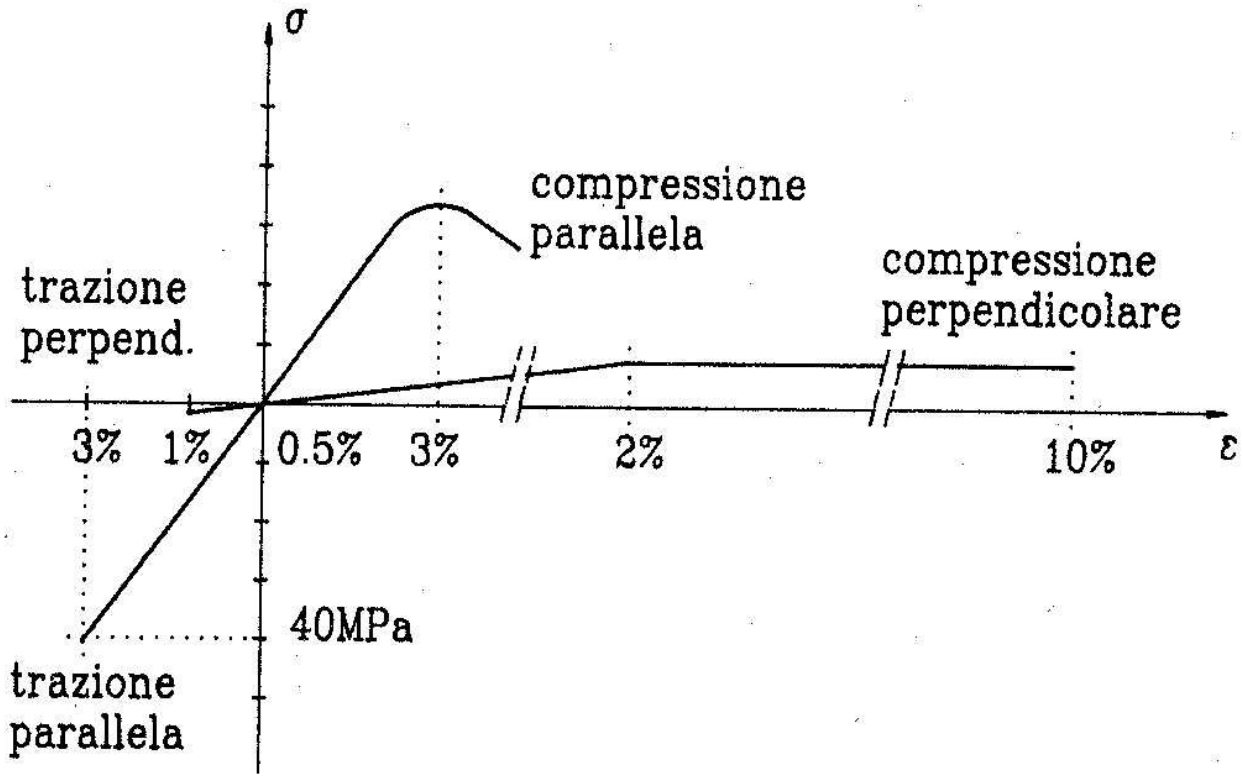
T
R

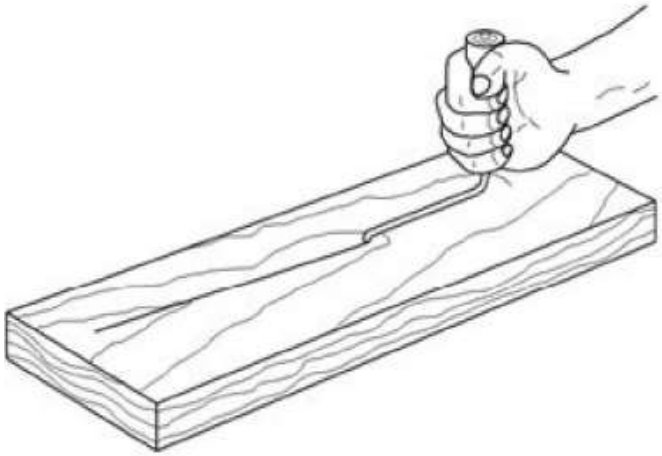


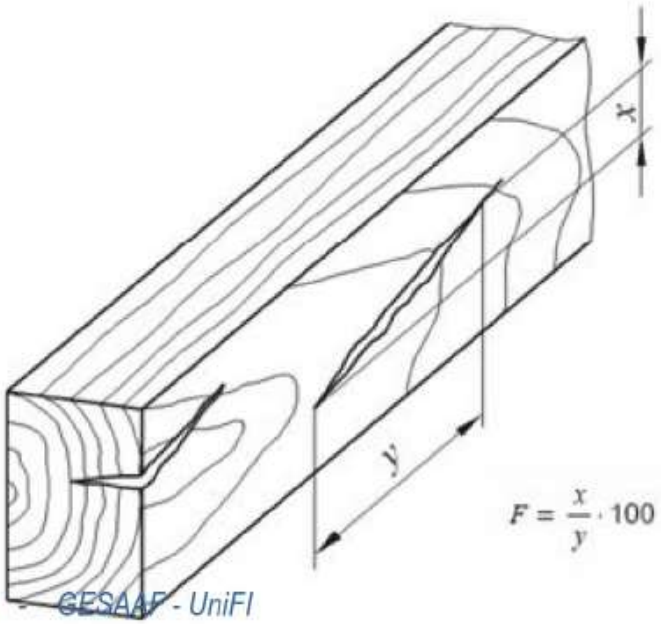
Stress-strain relationship for small clear specimens



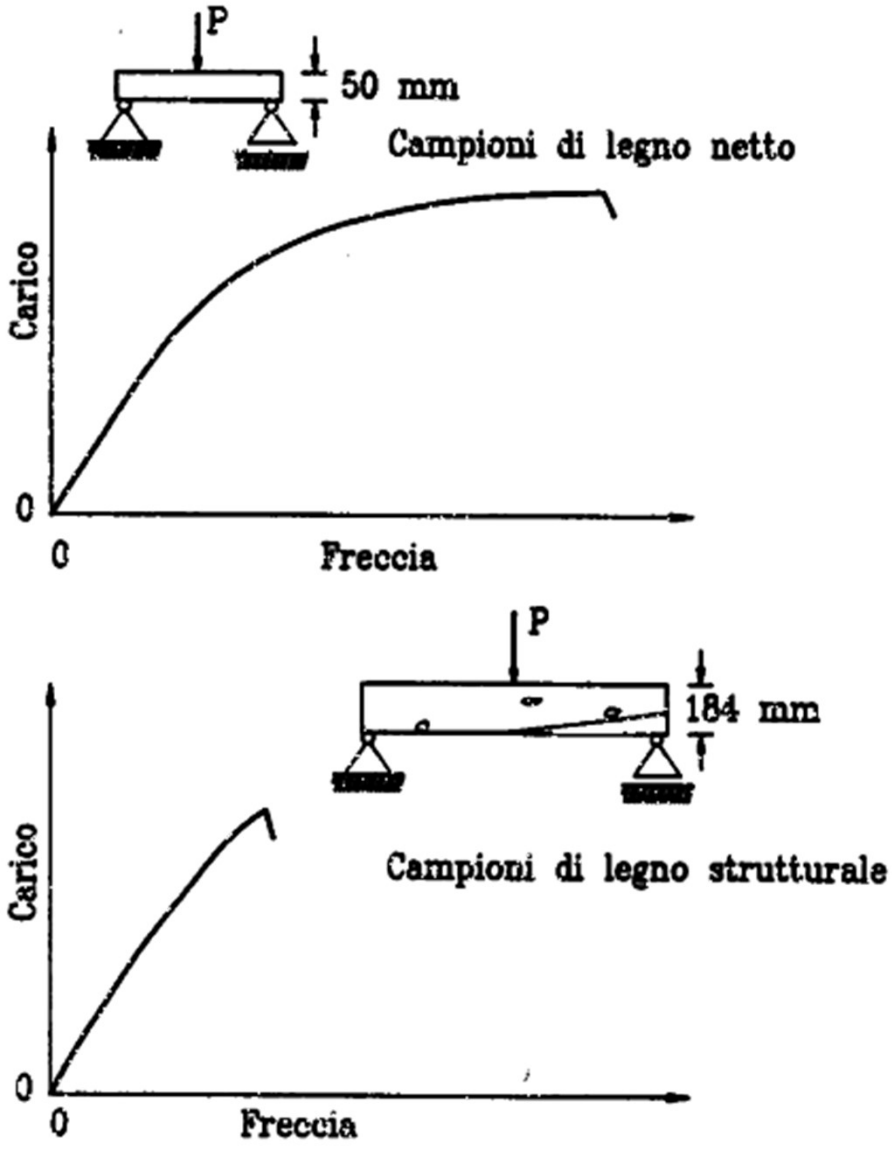
(structural) timber
is material with «defects»

slope of grain



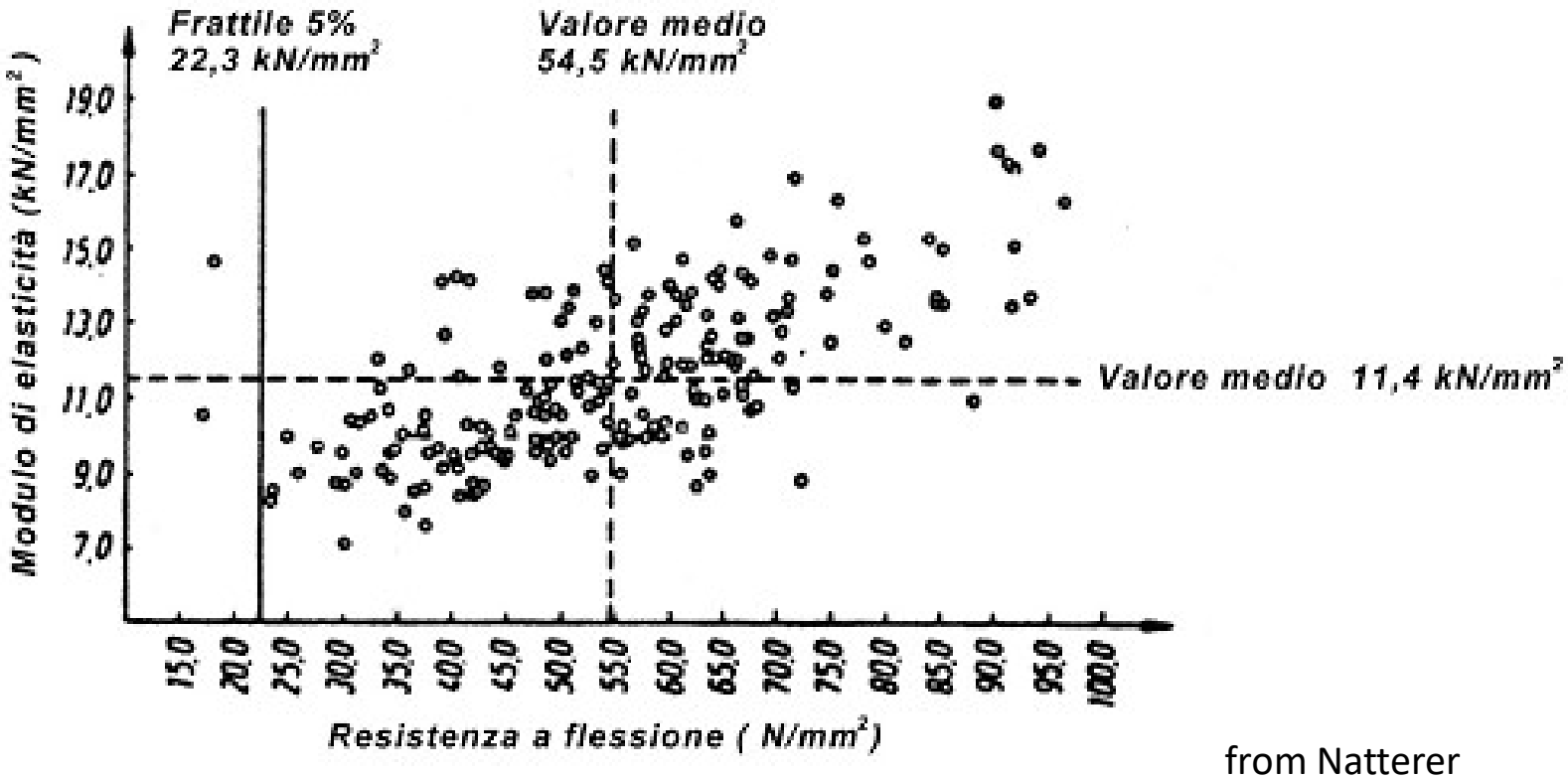


Prof. M. Togni

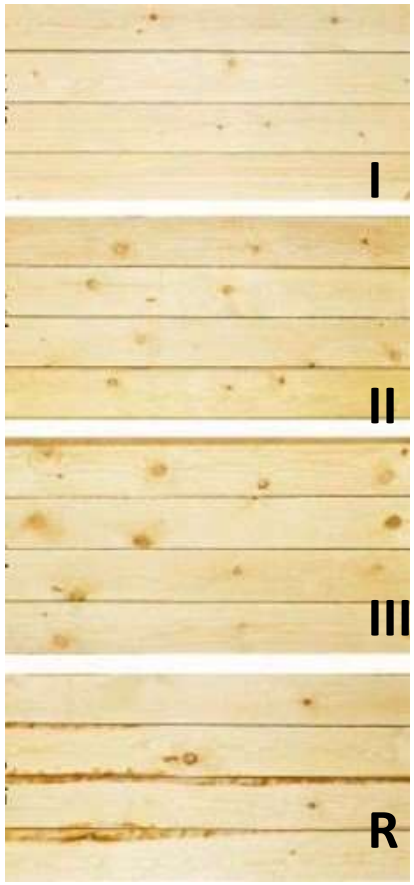


(da Stieda, 1986)

timber is «variable»…



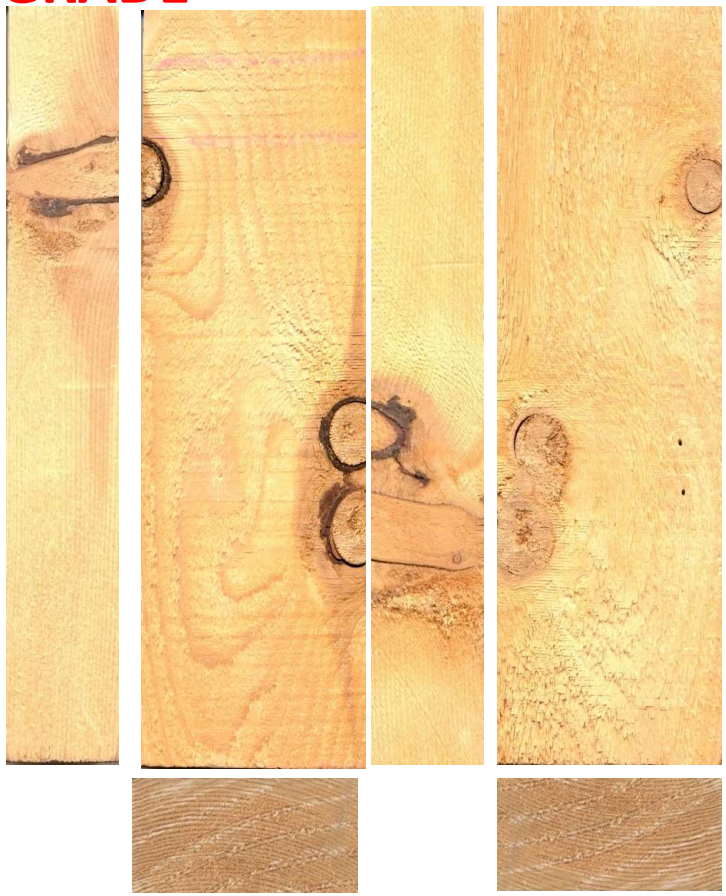
from Natterer



grades

The wood is CLASSIFIED according to resistant quality o

GRADE



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

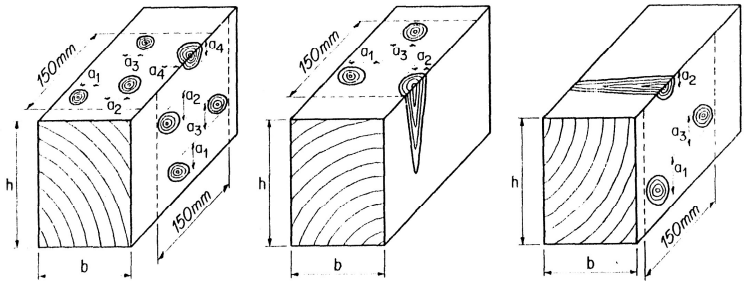
d : diamètre moyen

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

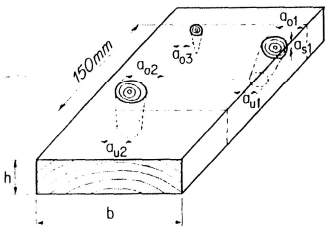


Planche sur dosse

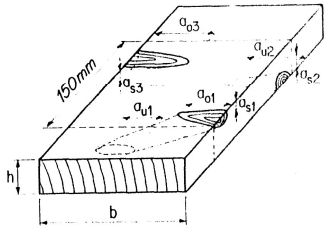


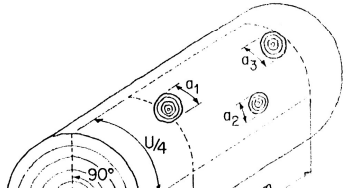
Planche sur quartier

$$q_i = \frac{a_{oi} + a_{ui} + a_{si}}{2b}$$

$$Q = \Sigma q_i$$

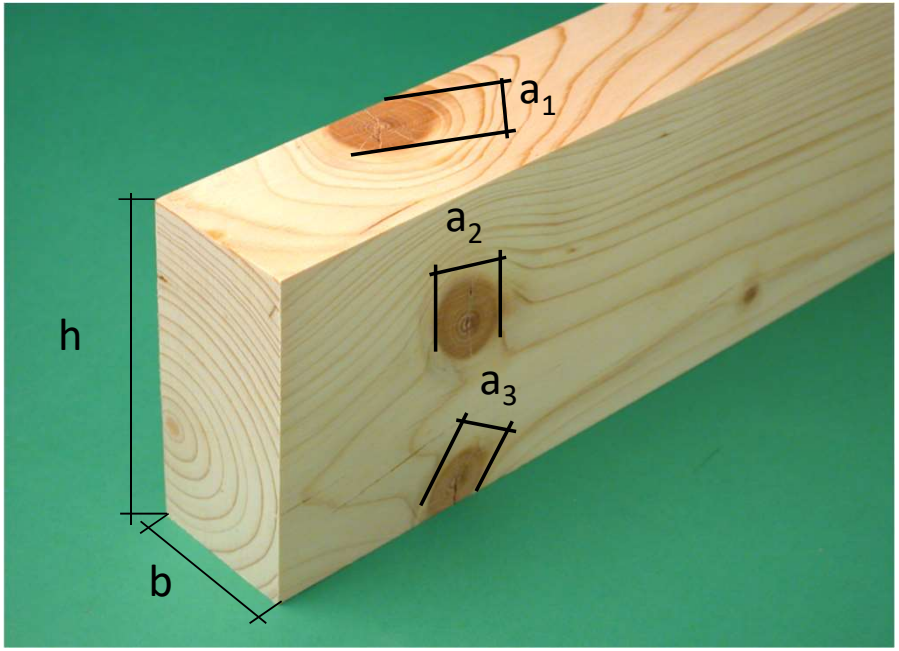
q_i = la plus grande valeur de $\frac{a_{oi} + a_{ui} + a_{si}}{2b}$ ou de $\frac{a_{si}}{2h}$

Figures 28a et 28b Mesure de la nodosité des planches



$$q_i = \frac{a_i}{d}$$

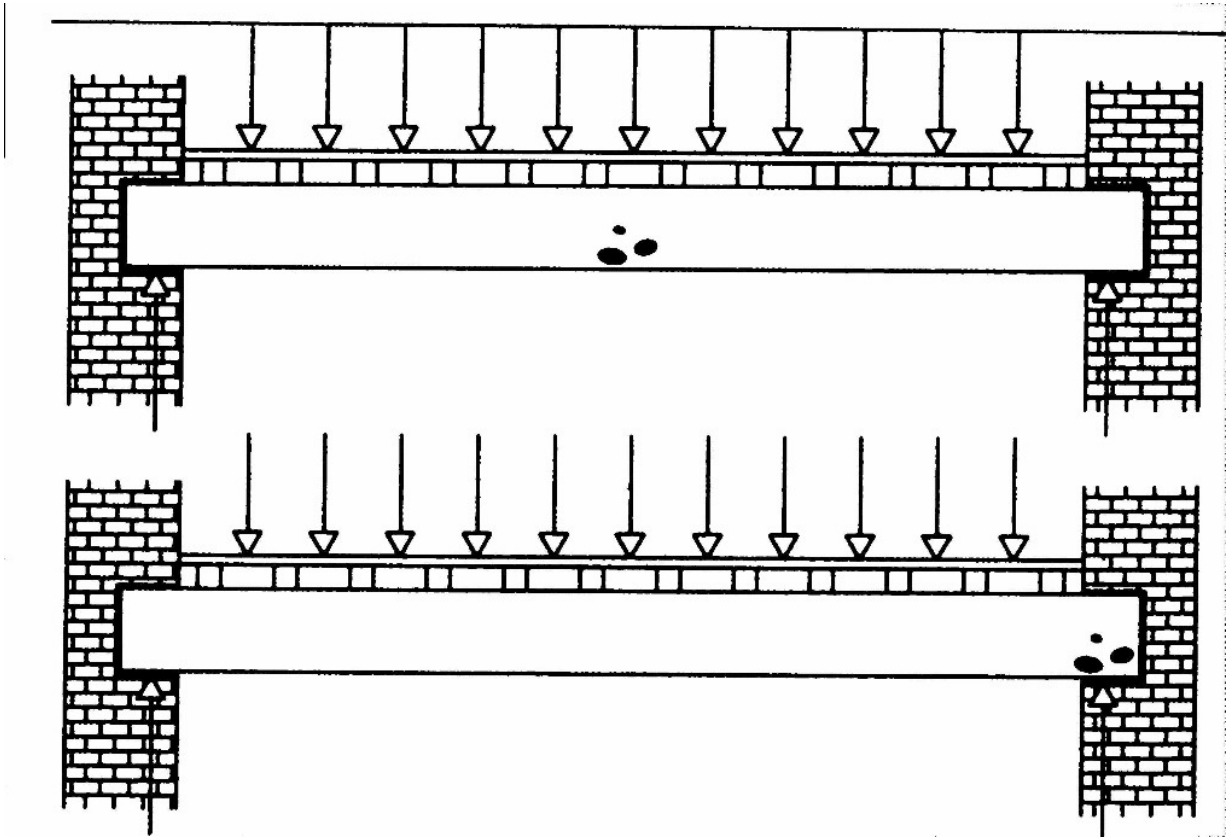
knots– single

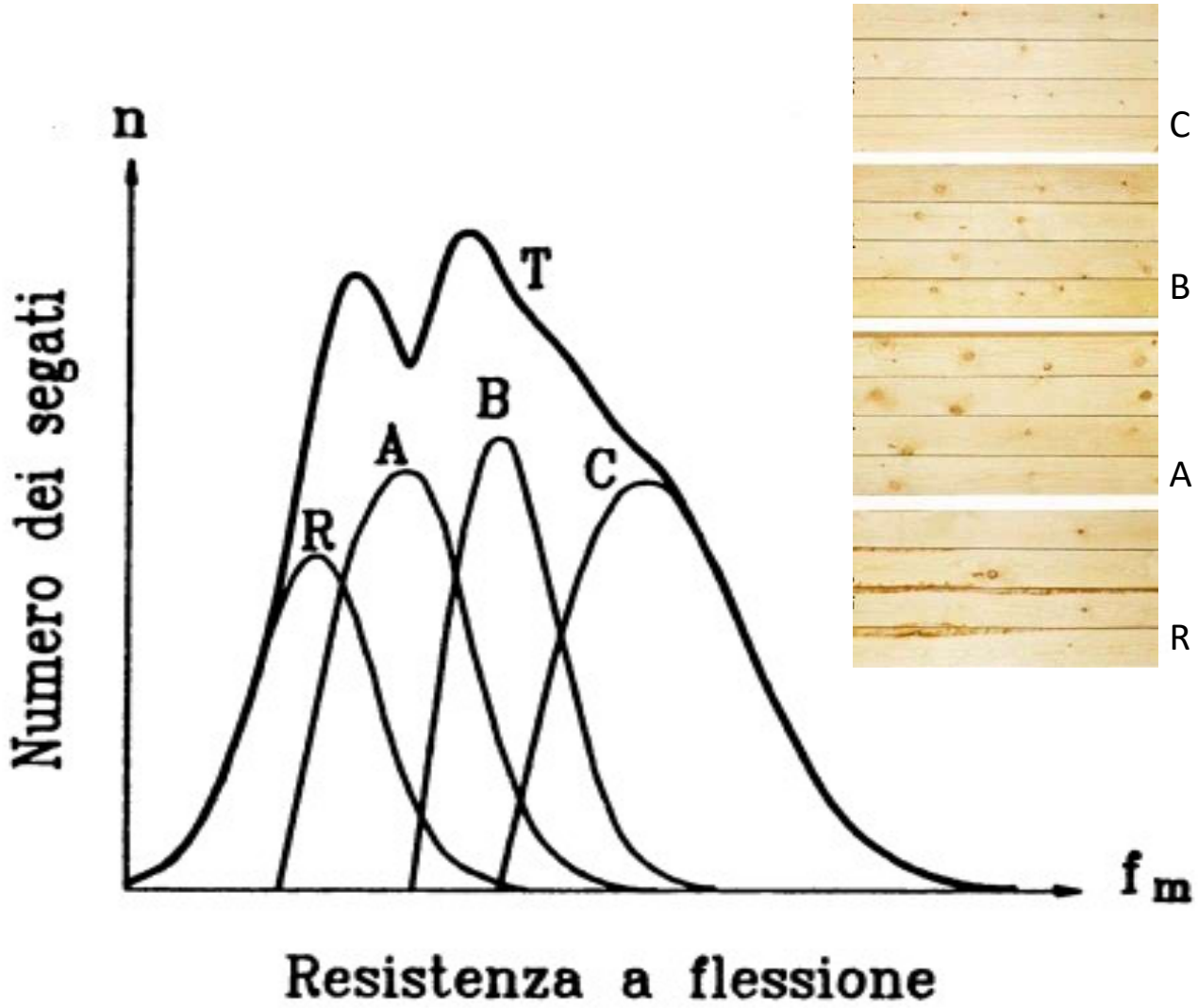


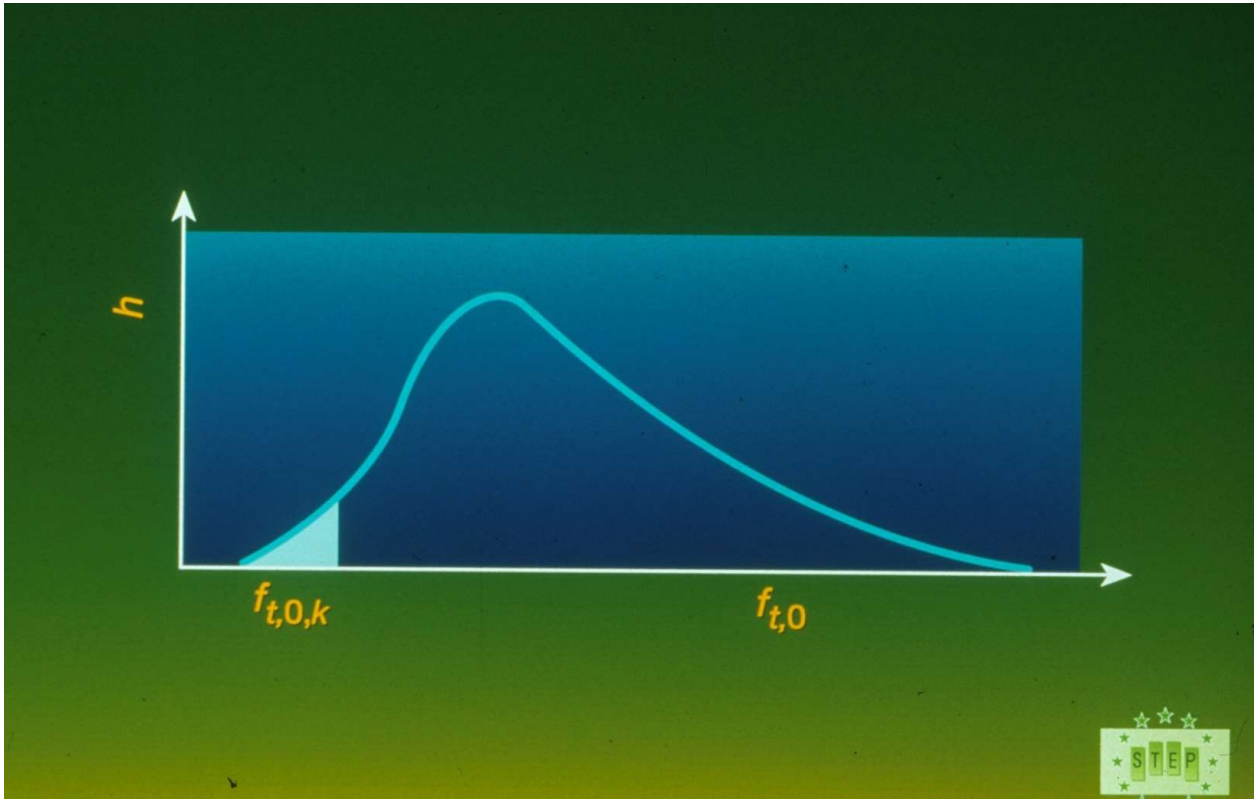
minimum knot diamete/ dimension of the side where it is visible

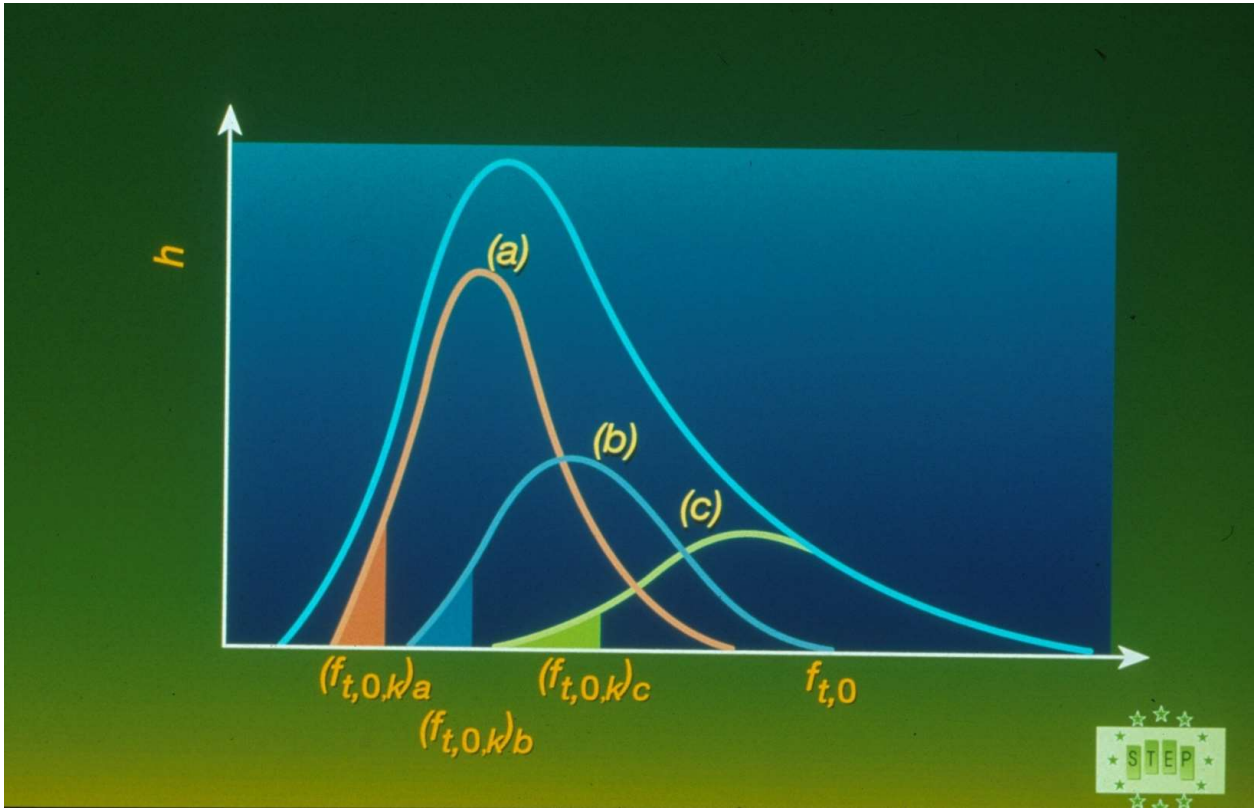
$$A = \max\left(\frac{a_1}{b}; \frac{a_2}{h}; \frac{a_3}{h}\right)$$

!!!




n
Numero dei segati
T
B
A
C
R
f_m
Resistenza a flessione
C
B
A
R


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

Analysis of statistical methods for the determination of characteristic values of Italian red spruce (*Picea abies*)

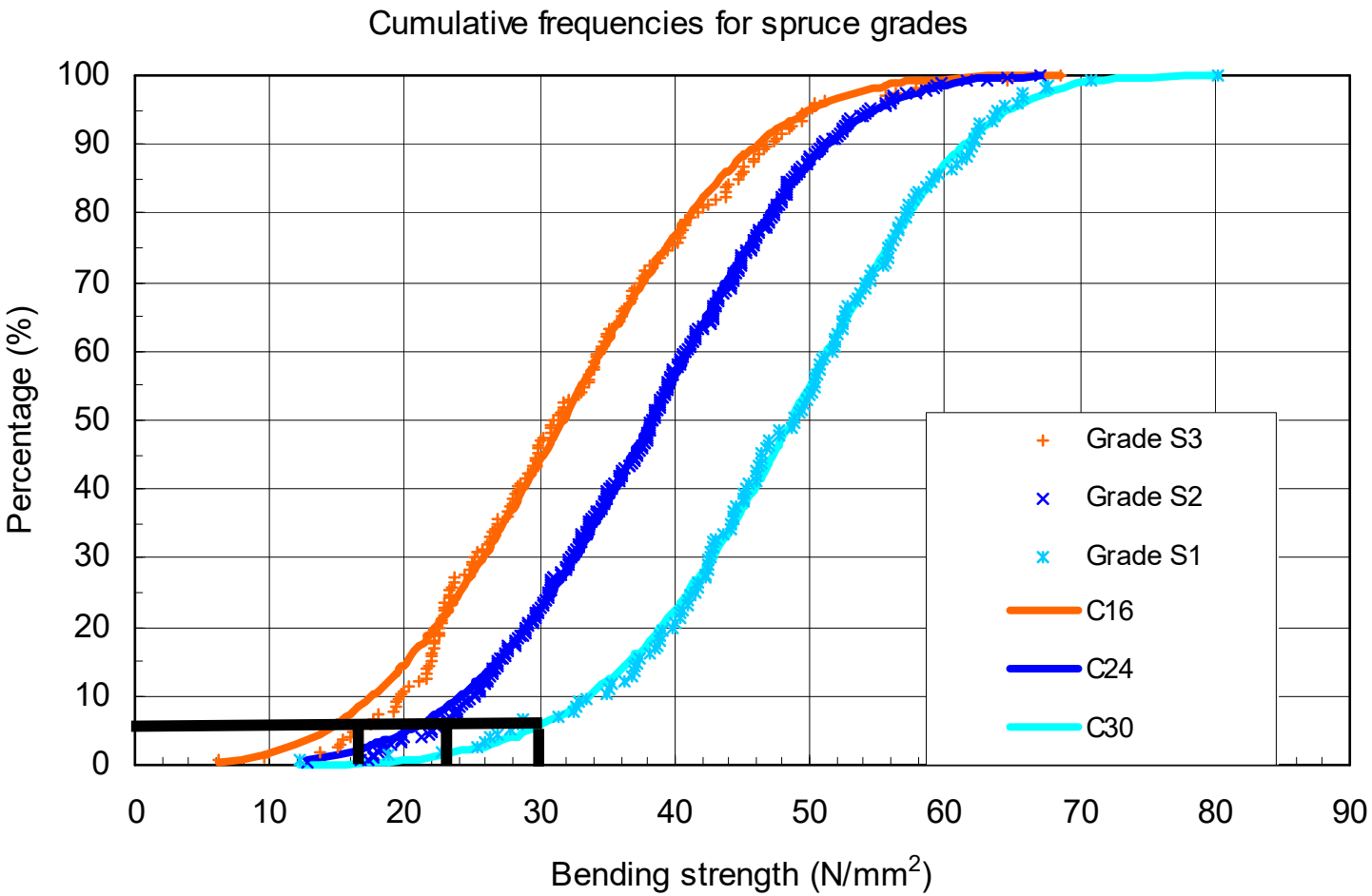
J.W.G. van de Kuilen[1,2], A. Ceccotti[1]
[1]CNR-Ivalsa, San Michele all'Adige, Italy,
[2]Delft University of Technology, Delft, the Netherlands

Table 1. Samples of Italian spruce over 13 year span.

Sample	Year	No.	Sizes			
			width	depth	length	test length
1	1993	215	90	150	4000	2700
2	2003	45	45	70	1400	1260
3	2003	50	45	70	2000	1260
4	2003	45	70	110	2200	1980
5	2003	45	85	150	3000	2700
6	2004	45	90	150	2200	2100
7	2004	45	90	145	2200	2100
8	2004	42	90	145	2200	2100
9	2004	24	125	260	4000	3800
10	2004	78	75	200	4200	3800
11	2004	72	90	250	4200	3800
12	2005	48	60	150	3000	2700

Table 2 Visual grades and yield for each subsample.

Sample				S1	S2	S3	Reject	Total
No.	width	depth						
1	90	150	n.	67	117	28	1	215[1)]
			%	*31.2*	*54.4*	*13.0*	*0.4*	*100*
2	45	70	n.	10	17	11	7	45
			%	*22.2*	*37.8*	*24.4*	*15.6*	*100*
3	45	70	n.	10	11	24	5	50
			%	*20.0*	*22.0*	*48.0*	*10.0*	*100*
4	70	110	n.	15	20	6	4	45
			%	*33.3*	*44.4*	*13.3*	*8.9*	*100*
5	85	150	n.	15	24	4	2	45
			%	*33.3*	*53.3*	*8.9*	*4.4*	*100*
6	90	150	n.	9	26	9	0	44
			%	*20.4*	*59.2*	*20.4*	*0*	*100*
7	90	145	n.	3	25	17	0	45
			%	*6.7*	*55.5*	*37.7*	*0*	*100*
8	90	145	n.	8	14	15	0	37
			%	*21.6*	*37.8*	*40.5*	*0*	*100*
9	120	260	n.	4	12	4	3	23
			%	*18.2*	*54.5*	*17.3*	*13.6*	*100*
10	75	200	n.	3	21	23	25	72
			%	*4.2*	*29.2*	*31.9*	*34.7*	*100*
11	90	250	n.	0	30	13	27	71
			%	*0*	*42.8*	*18.5*	*38.6*	*100*
12	60	150	n.	10	17	16	5	48
			%	*20.8*	*35.4*	*33.3*	*10.4*	*100*


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

Timber population:

- species
- source
- grade

Yapısal ahşabın sınıflandırılması

		Softwood species												Hardwood species							
		C14	C16	C18	C20	C22	C24	C27	C30	C35	C40	C45	C50	D18	D24	D30	D35	D40	D50	D60	D70
Strength properties (in N/mm^2)																					
Bending	$f_{m,k}$	14	16	18	20	22	24	27	30	35	40	45	50	18	24	30	35	40	50	60	70
Tension parallel	$f_{t,0,k}$	8	10	11	12	13	14	16	18	21	24	27	30	11	14	18	21	24	30	36	42
Tension perpendicular	$f_{t,90,k}$	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Compression parallel	$f_{c,0,k}$	16	17	18	19	20	21	22	23	25	26	27	29	18	21	23	25	26	29	32	34
Compression perpendicular	$f_{c,90,k}$	2,0	2,2	2,2	2,3	2,4	2,5	2,6	2,7	2,8	2,9	3,1	3,2	7,5	7,8	8,0	8,1	8,3	9,3	10,5	13,5
Shear	$f_{v,k}$	3,0	3,2	3,4	3,6	3,8	4,0	4,0	4,0	4,0	4,0	4,0	4,0	3,4	4,0	4,0	4,0	4,0	4,0	4,5	5,0
Stiffness properties (in kN/mm^2)																					
Mean modulus of elasticity parallel	$E_{0,mean}$	7	8	9	9,5	10	11	11,5	12	13	14	15	16	9,5	10	11	12	13	14	17	20
5 % modulus of elasticity parallel	$E_{0,05}$	4,7	5,4	6,0	6,4	6,7	7,4	7,7	8,0	8,7	9,4	10,0	10,7	8	8,5	9,2	10,1	10,9	11,8	14,3	16,8
Mean modulus of elasticity perpendicular	$E_{90,mean}$	0,23	0,27	0,30	0,32	0,33	0,37	0,38	0,40	0,43	0,47	0,50	0,53	0,63	0,67	0,73	0,80	0,86	0,93	1,13	1,33
Mean shear modulus	G_{mean}	0,44	0,5	0,56	0,59	0,63	0,69	0,72	0,75	0,81	0,88	0,94	1,00	0,59	0,62	0,69	0,75	0,81	0,88	1,06	1,25
Density (in kg/m^3)																					
Density	ρ_k	290	310	320	330	340	350	370	380	400	420	440	460	475	485	530	540	550	620	700	900
Mean density	ρ_{mean}	350	370	380	390	410	420	450	460	480	500	520	550	570	580	640	650	660	750	840	1080

STRENGTH CLASSES

NOTE 1 Values given above for tension strength, compression strength, shear strength, 5 % modulus of elasticity, mean modulus of elasticity perpendicular to grain and mean shear modulus, have been calculated using the equations given in Annex A.
NOTE 2 The tabulated properties are compatible with timber at a moisture content consistent with a temperature of 20 °C and a relative humidity of 65 %.
NOTE 3 Timber conforming to classes C45 and C50 may not be readily available.
NOTE 4 Characteristic values for shear strength are given for timber without fissures, according to EN 408. The effect of fissures should be covered in design codes.

CLASS

EN 1912: Structural Timber. Strength classes. Assignment of visual grades and species

GRADE

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

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.


CE
1234
ABC LEGNAMI srl
12
UNI EN 14081-1:2005 + A1 2011
LEGNO A SEZIONE RETTANGOLARE
CLASSIFICATO AD USO STRUTTURALE
WPCA
Lotto N.358/2013
DIN 4074-1 – S10
Classe di resistenza meccanica (EN 1912+EN 338)
C24
Reazione al fuoco
D-s2, d0
Classe di durabilità naturale ai funghi (solo durame)
4
Umidità
NOT DRY GRADED (FRESCO)
X
DRY GRADED (SECCO)
MARCHIO CE
IDENTIFICATIVO DELL'ENTE NOTIFICATO
STABILIMENTO DI PRODUZIONE
ANNO DI PRIMA APPOSIZIONE DEL MARCHIO CE
NORMA ARMONIZZATA DI RIFERIMENTO
CODICE UNIVOCO DI IDENTIFICAZIONE DEL PRODOTTO – TIPO
LOTTO DI PRODUZIONE
INFORMAZIONI SULLA NORMA DI CLASSIFICAZIONE A VISTA
INFORMAZIONI RELATIVE AI REQUISITI PRESTAZIONALI


C 24
C 24
C 24
C 24
C 24
C 24
C 24
C 24


SKP 005D H CEC16 KD FPD
SKP 005D H CEC16 KD FPD
SKP 005D H CEC16 KD FPD


SKP 005D H CEC16 KD FPD
SKP 005D H CEC16 KD FPD

GL 24h Yapısal Lamine Ahşap

Teknik Bilgiler	GL 24 h
Birleştirme	Homojen
Ağaç Cinsi	Ladin
Üretim	EN 386 ve EN 14080'e Uygun Olarak
Kurtağzı Birleştirme	EN 385'e Uygun Olarak
Rutubet Oranı	12 ± % 2
Mekanik Derecelendirme	EN 14081 ve EN 4074'e Uygun Olarak
Derecelendirme Sınıfı (EN14081 'e göre)	L 25 L 30 L 36 L 40
Lamel Kalınlıkları	40 mm
Tutkallama	MUF Melamin Üre Formaldehit
Yüzey Kalitesi	Dört tarafı planyalanmış, dört köşesi pahlanmış, en yüksek derecede görsel yüzey kalitesi
Harici Denetleme	Malzeme Test Enstitüsü Stuttgart Üniversitesi (MPA Stuttgart, Otto-Graf-Institut (MSSF)
Yanma Davranışı	0.7 mm/dakika
Emisyon Sınıfı	E1
Ölçü Toleransları	Genişlik Toleransı ±2 mm Yükseklik Toleransı ±2 mm Uzunluk Toleransı ±5 mm
Malzeme Kategorisi (DIN 4102'ye göre)	B2 Normal Olarak Yanıcı
Yangın Davranış Sınıfı	D - S2, d0
Kabarma ve Büzülme	Eksenel olarak: % 0.01-0.02
Nem Miktarı Değişimi %	Radyal olarak: % 0.019 Teğetsel olarak: % 0.34
Isı İletkenliği	0.13W/(mK)
Su Buharı Dayanım Katsayısı	40

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ASMAZ

AHŞAP A.Ş.

200 mm X 280 mm

CE

Yurt dışından ithal edilmiştir.

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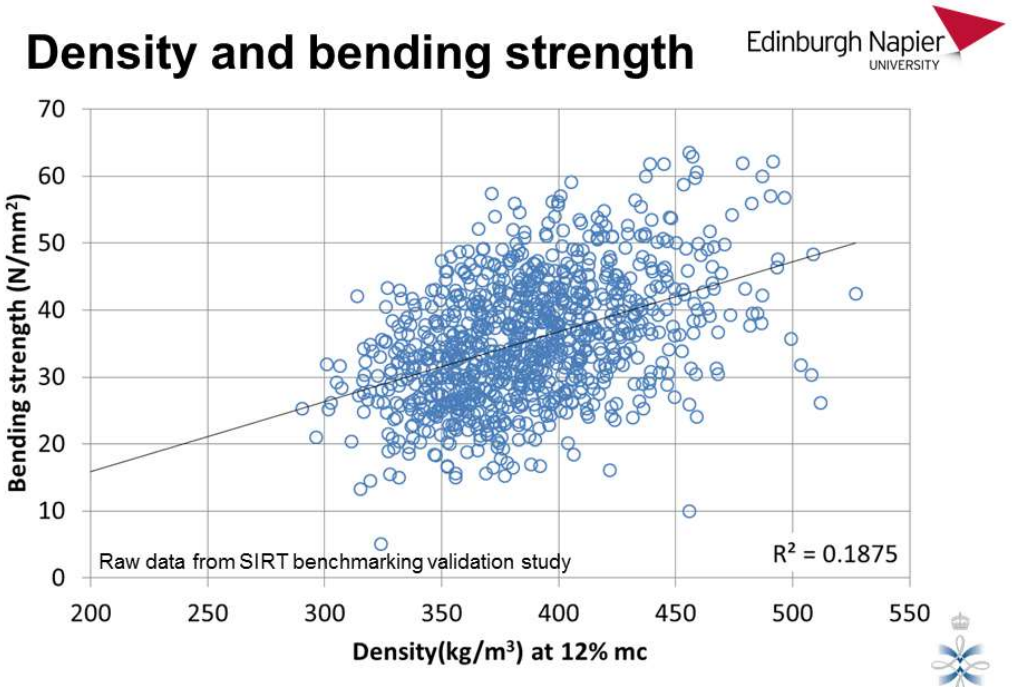
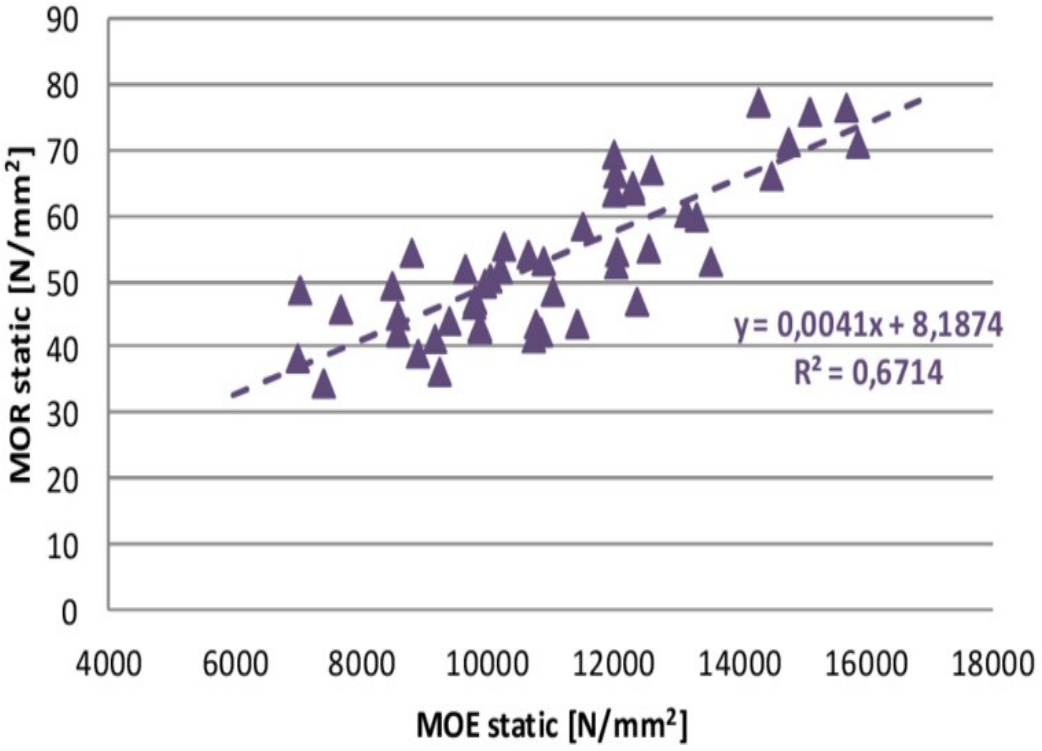
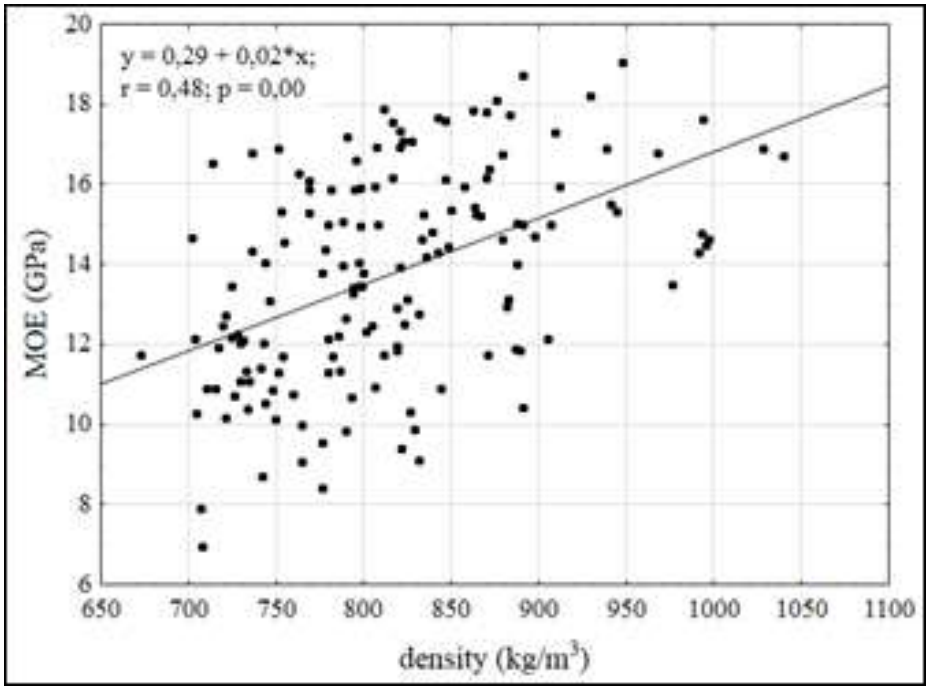
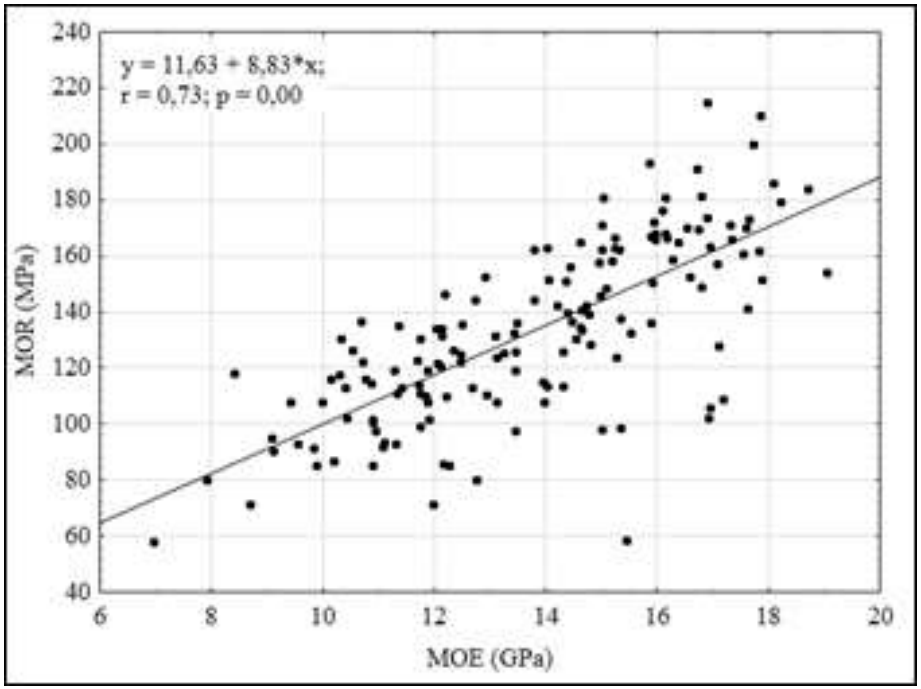
correlations between mechanical properties





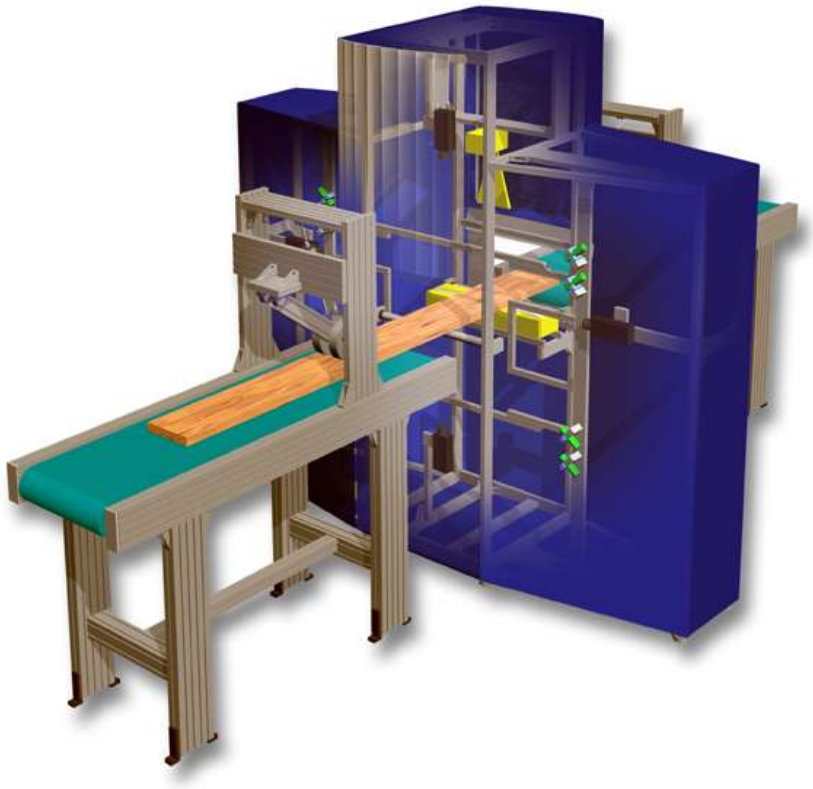

y = 0,29 + 0,02*x;
r = 0,48; p = 0,00
MOE (GPa)
density (kg/m3)
20
18
16
14
12
10
8
6
650
700
750
800
850
900
950
1000
1050
1100

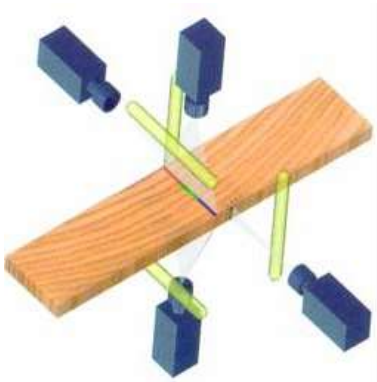

y = 11,63 + 8,83*x;
r = 0,73; p = 0,00
MOR (MPa)
MOE (GPa)
240
220
200
180
160
140
120
100
80
60
40
6
8
10
12
14
16
18
20

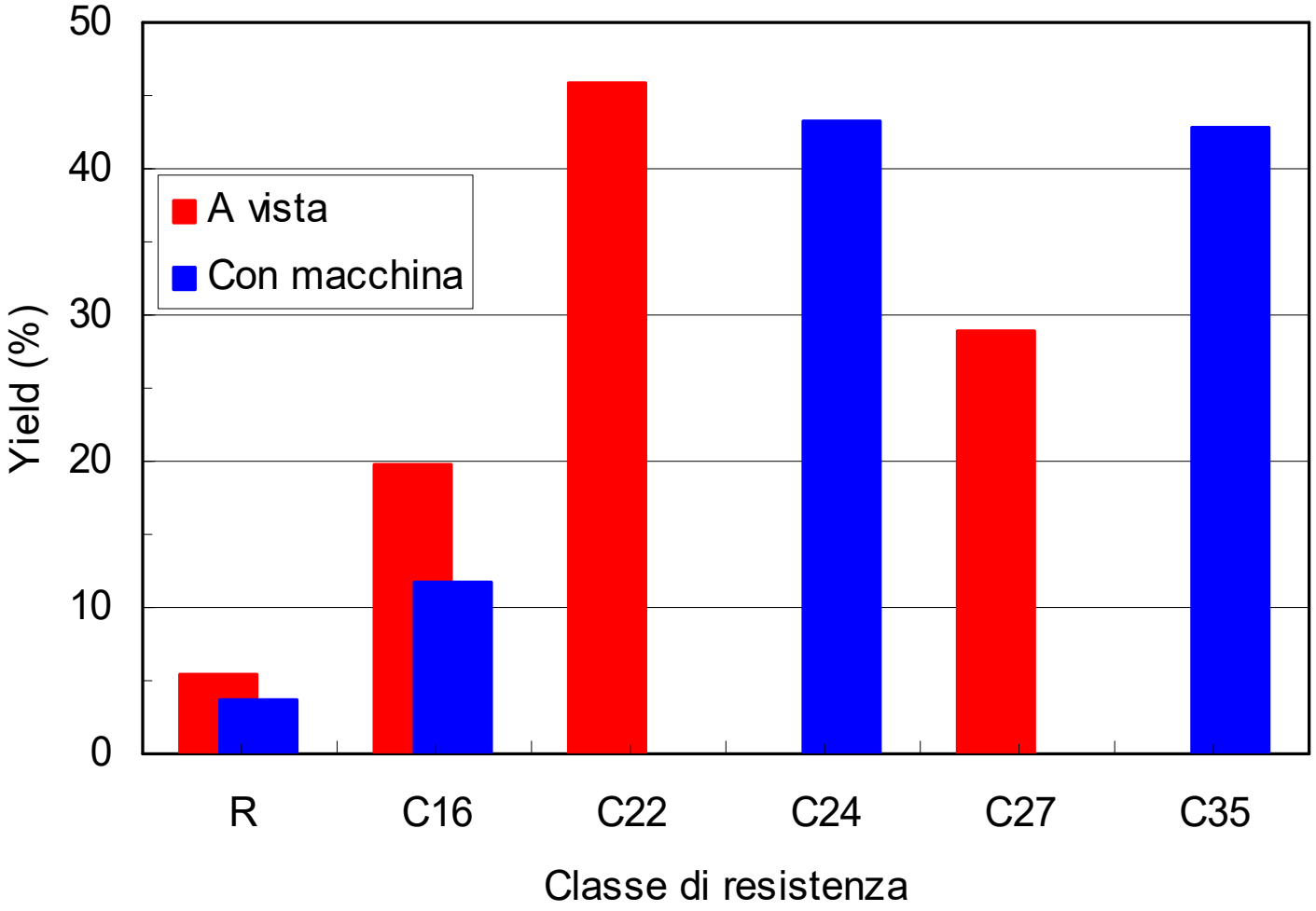
Grading parameter	Correlation with		
	f_m	$f_{t,0}$	$f_{c,0}$
Knots	0,5	0,6	0,4
Slope of grain	0,2	0,2	0,1
Density	0,5	0,5	0,6
Ring width	0,4	0,5	0,5
Knots + ring width	0,5	0,6	0,5
Knots + density	0,7 - 0,8	0,7 - 0,8	0,7 - 0,8
Modulus of elasticity E	0.7 - 0,8	0,7 - 0,8	0.7 - 0,8
E + density	0,7 - 0,8	0,7 - 0,8	0,7 - 0,8
E + knots	> 0,8	> 0,8	> 0,8

Table 1 ***Correlation coefficients between possible grading characteristics and strength properties according to Glos (1993). Species: European spruce.***

strength grading machines







Prof. J-W van de Kuilen

to be continued…