SIRT

Strategic Integrated Research in Timber

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Current UK timber grading & engineered wood products

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2015

Issues

- Water
- “Figure” and “Defects”
- Anisotropy
- Inhomogeneity
- Variation and uncertainty

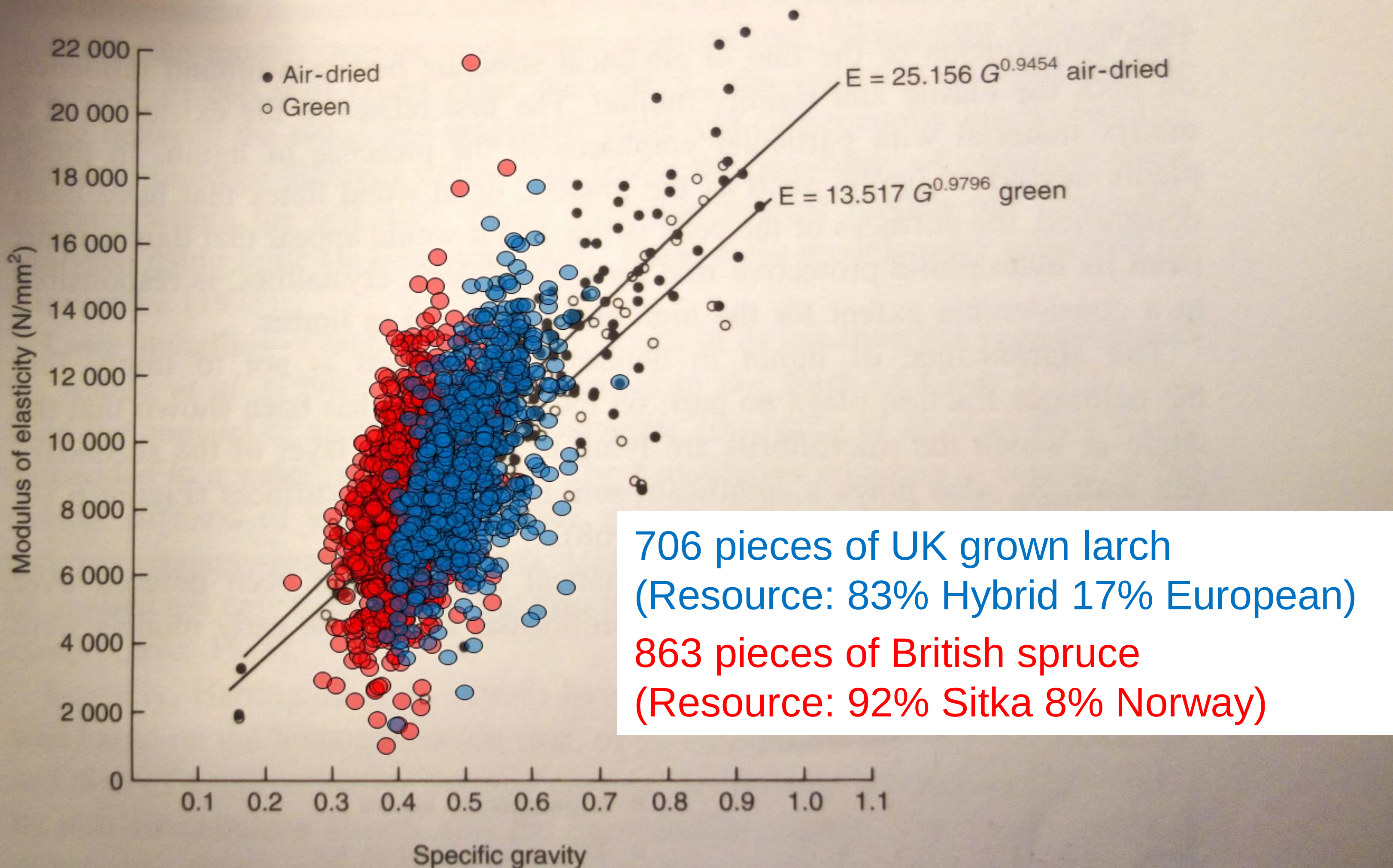

Figure 6.9 Effect of specific gravity on the longitudinal modulus of elasticity for over 200 species of timber tested in the green and dry states. (© BRE.)

Variation

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- From species to species
- Within species / species group
  - Between countries
  - Within countries
  - Within a forest
  - Within a stand
  - Between trees in a stand
  - Within a tree
  - Within a board
  - Depending on how the board is loaded

Variation of properties & correlation between properties

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Structural engineering design

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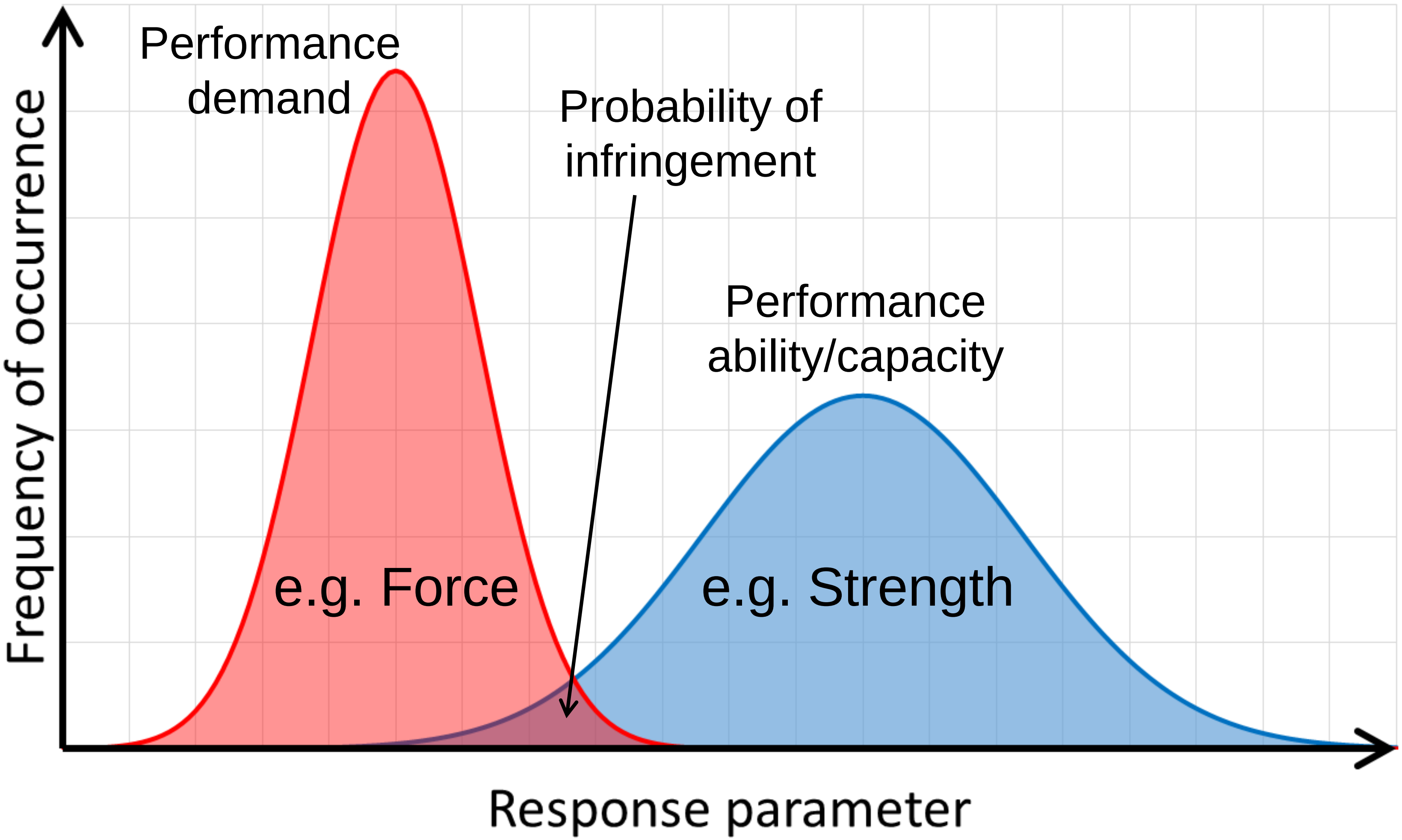
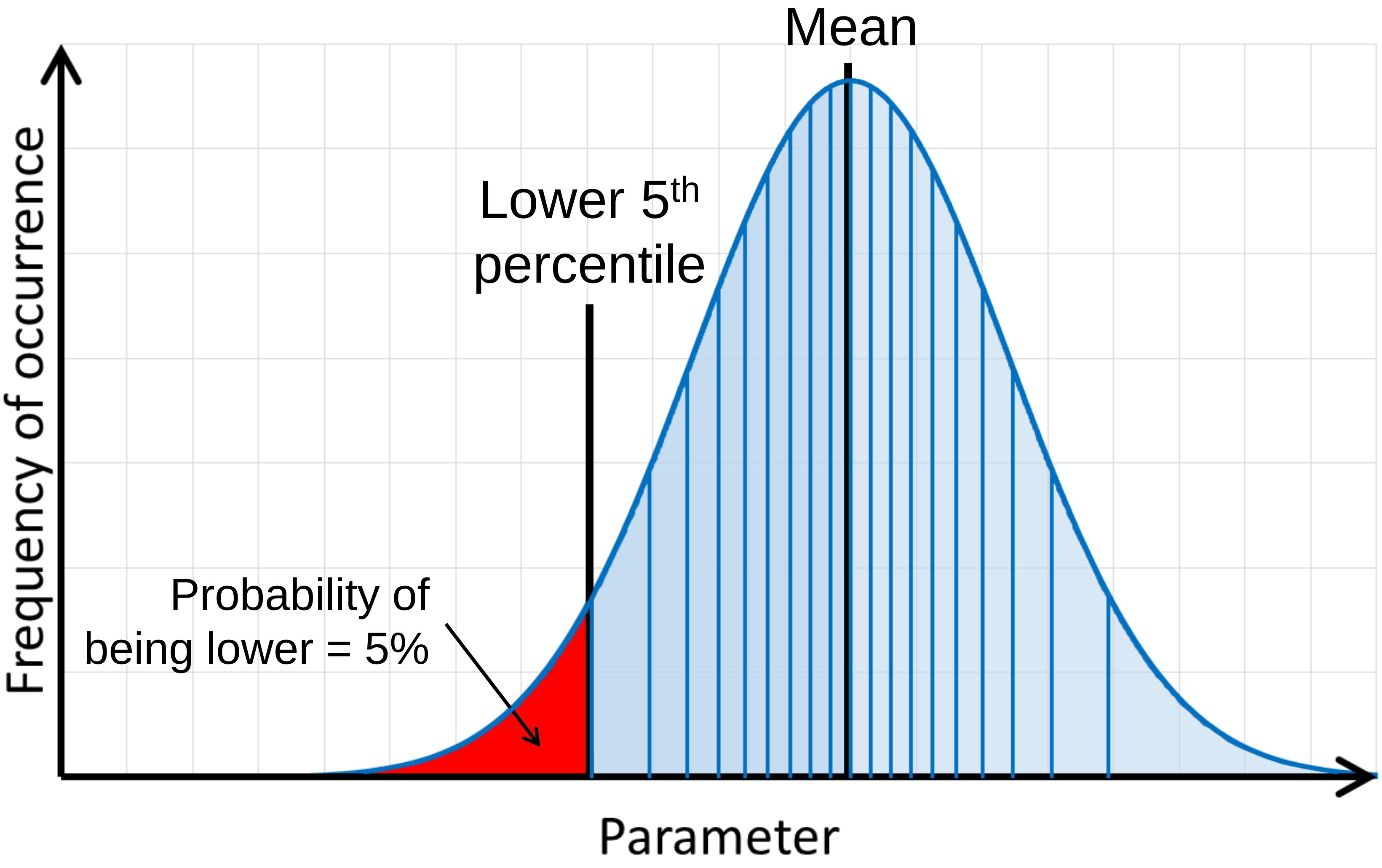
- About buildings
  - Staying safe
  - Staying fit for use
- Dealing with uncertainty
  - Of material
  - Of the actions on a structure
  - Of analysis and construction
- <u>True irrespective of the material</u>

(There is always some uncertainty)

Dealing with uncertainty



Characteristic values



Grade-determining properties

- Strength
  - Usually major axis bending strength
- Stiffness
  - Usually major axis bending stiffness
- Density
  - Also an indirect measure of strength in some elements of timber design
- All the other strength class properties are derived from these 3 main properties
  (By conservative relationships. Equations are in EN 338, but will be moved to EN 384)

EN338:2009		Softwood species										
		C14	C16	C18	C20	C22	C24	C27	C30	C35	C40	C45
Strength properties (in N/mm^2)												
Bending	$f_{m,k}$	14	16	18	20	22	24	27	30	35	40	45
Tension parallel	$f_{t,0,k}$	8	10	11	12	13	14	16	18	21	24	27
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
Compression parallel	$f_{c,0,k}$	16	17	18	19	20	21	22	23	25	26	27
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
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
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
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
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
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
Density (in kg/m^3)												
Density	ρ_k	290	310	320	330	340	350	370	380	400	420	440
Mean density	ρ_{mean}	350	370	380	390	410	420	450	460	480	500	520

Critical property

- To comply with the grade, characteristic values must be met (at least*)
- For a species and grade combination usually one property is limiting
  - Strength
  - Stiffness
  - Density
- So strength grading isn't *always* about predicting strength

* subject to adjustments

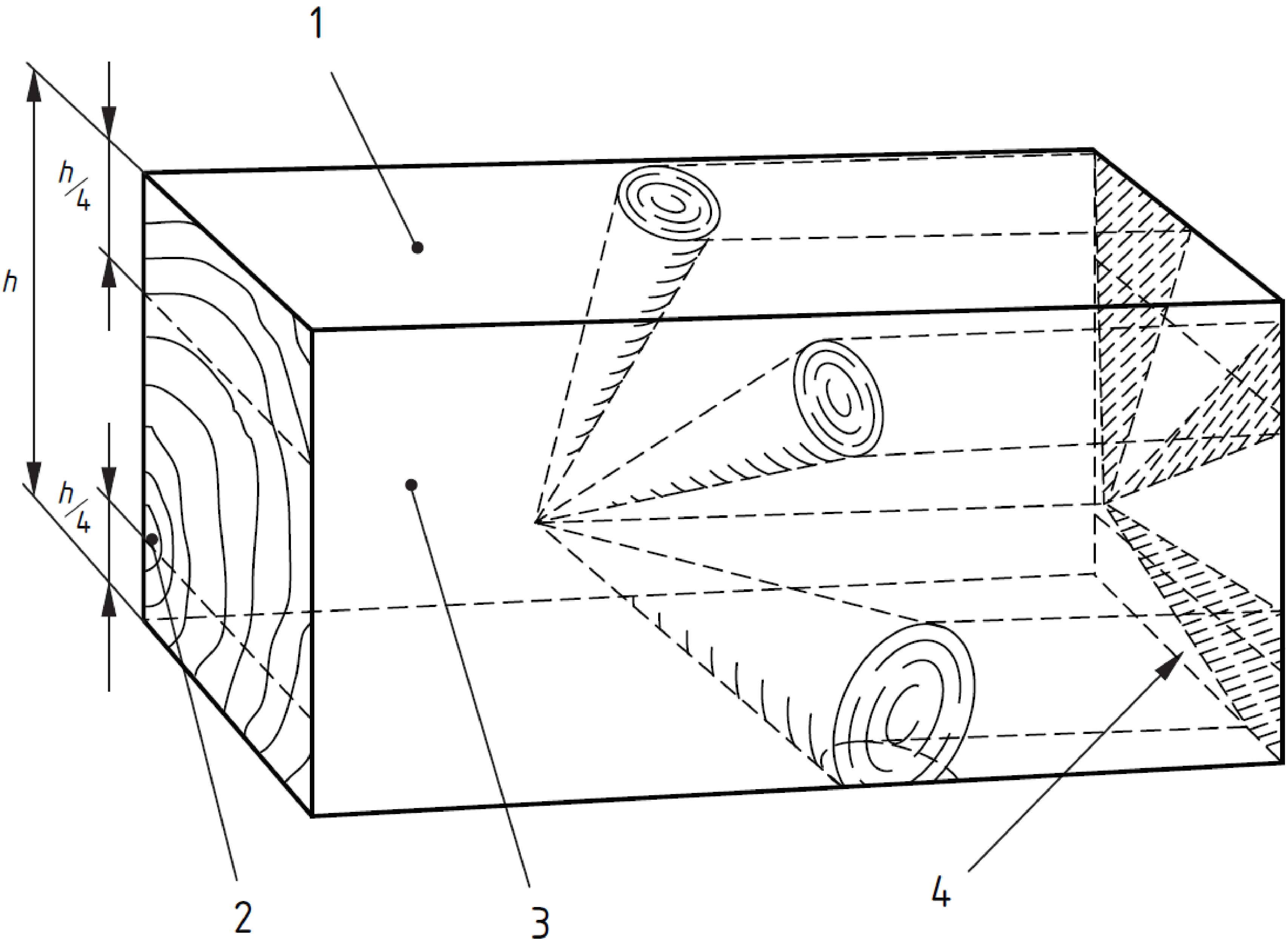
Grading methods for timber

- Visual strength grading
  - (not the same as appearance grading)
- Machine strength grading
  - Machine control
  - Output control

Visual strength grading

- Manual inspection (can be machine assisted)
- Based only on what we can see (and infer)
- Of limited accuracy…
  …due to the parameters being measured
  …and the human element
  …so assignment to grades is more conservative
- A slow process using trained people
  - But can be assisted…perhaps even done…by machine
- Still very common in Europe even for softwoods

Visual grading



Visual strength grading

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- Visually grade
  - e.g. SS, GS (softwoods to BS 4978)
- Assign to strength class based on grading standard, species and origin
  (all three must match)
  - EN 1912
    - e.g. British spruce SS → C18
    - e.g. British spruce GS → C14
  - Somewhere else (not in conflict with EN 1912)
- Based on testing and analysis to EN 384
  - Not supposed to rely on long standing practice any more …need test data

Machine strength grading

- Machine grading
  - Relates an ‘indicating parameter’ to the critical grade-determining parameter(s)
  - Better accuracy than visual grading…
    …due to the parameters being measured
    …and the automation
    …so assignment to grade is less conservative
  - Fast but expensive equipment (but getting cheaper)

So how do we machine grade?

- Now many types of grading machines
  - Bending stiffness
    - Bending about the minor axis
  - Dynamic (acoustic/vibration)
    - Essentially a measure of stiffness
    - May or may not include density
  - X-rays
    - A combination of knots and density
    - Perhaps with optical camera
  - Assessment of slope of grain
  - Mixtures of the above

Bending graders

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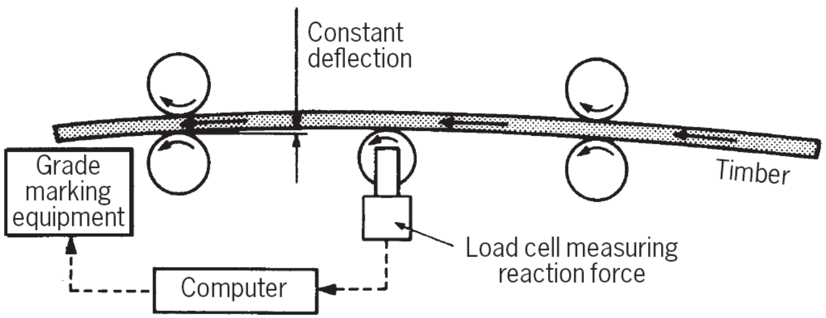
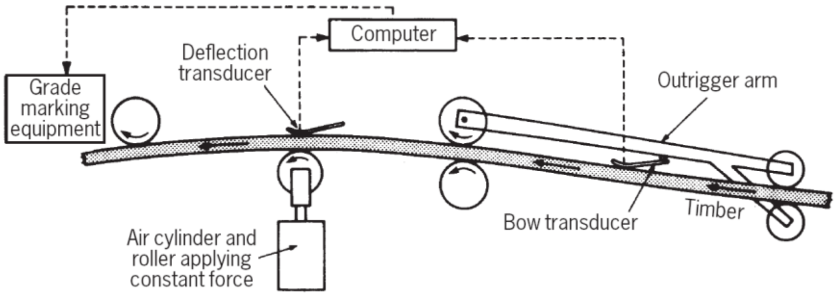
- Measure mechanical stiffness
  - Through application of defined load
  - or defined deflection
  - Minor axis
  - Accounting for pre-existing bow
- Relatively slow (with dynamic errors)
- Limited by cross-section
- Cannot measure the whole piece
- Older technology (hard to link to computers)

Bending graders

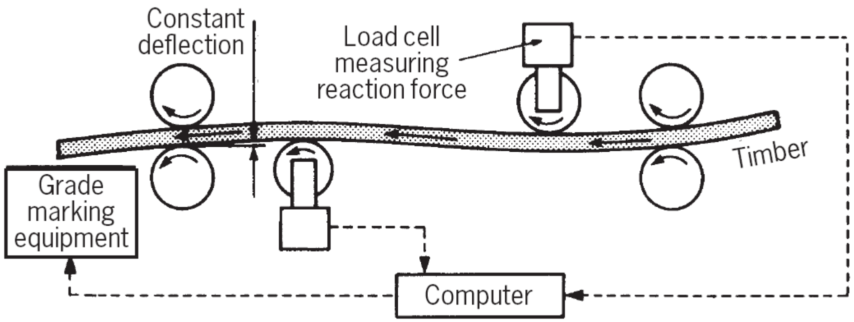
Cook-Bolinder



Computermatic



Timgrader



Figures from BRE Digest 476 “Guide to machine strength grading of timber”

Acoustic graders

- Measure acoustic velocity
  - Through axial or transverse vibration
  - Or time of flight (including ultrasonic)
  - May or may not include density ($MoE_{dyn} = \rho v^2$)
- Fast
- Can be hand-held
- Measure the whole piece
- …but all at once

Acoustic graders

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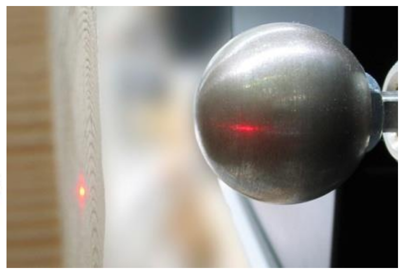
ViSCAN (MiCROTEC)



MTG (Brookhuis)

Precigrader (Dynalyse AB)

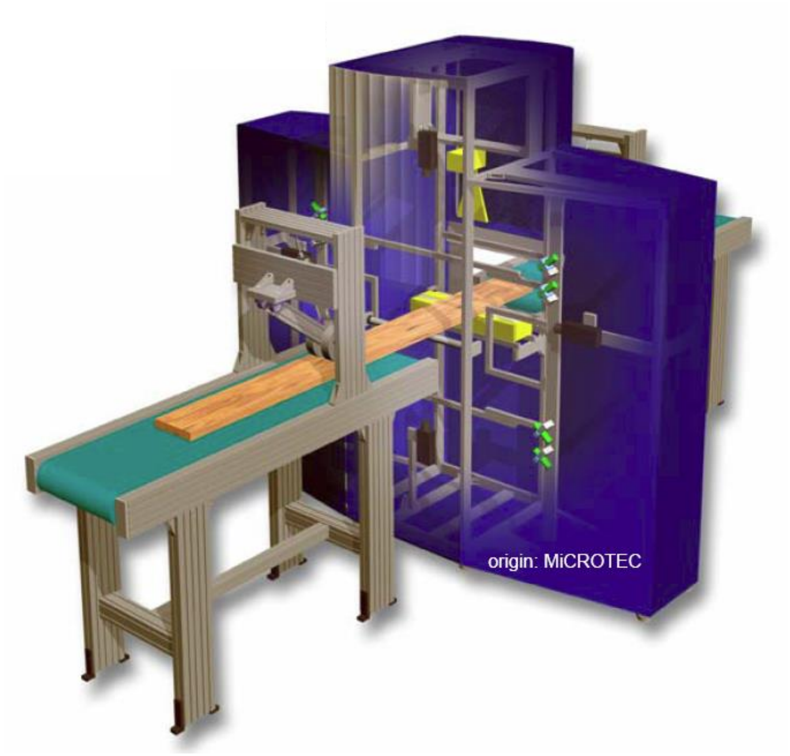
Triomatic (CBS-CBT)

X-ray graders

- Measure
  - Clear wood and average density
  - Knot size and location
- Very fast (and permit board splitting)
- …but big and expensive
- Measure the whole piece
- …and all parts of it individually
- But not great at predicting stiffness

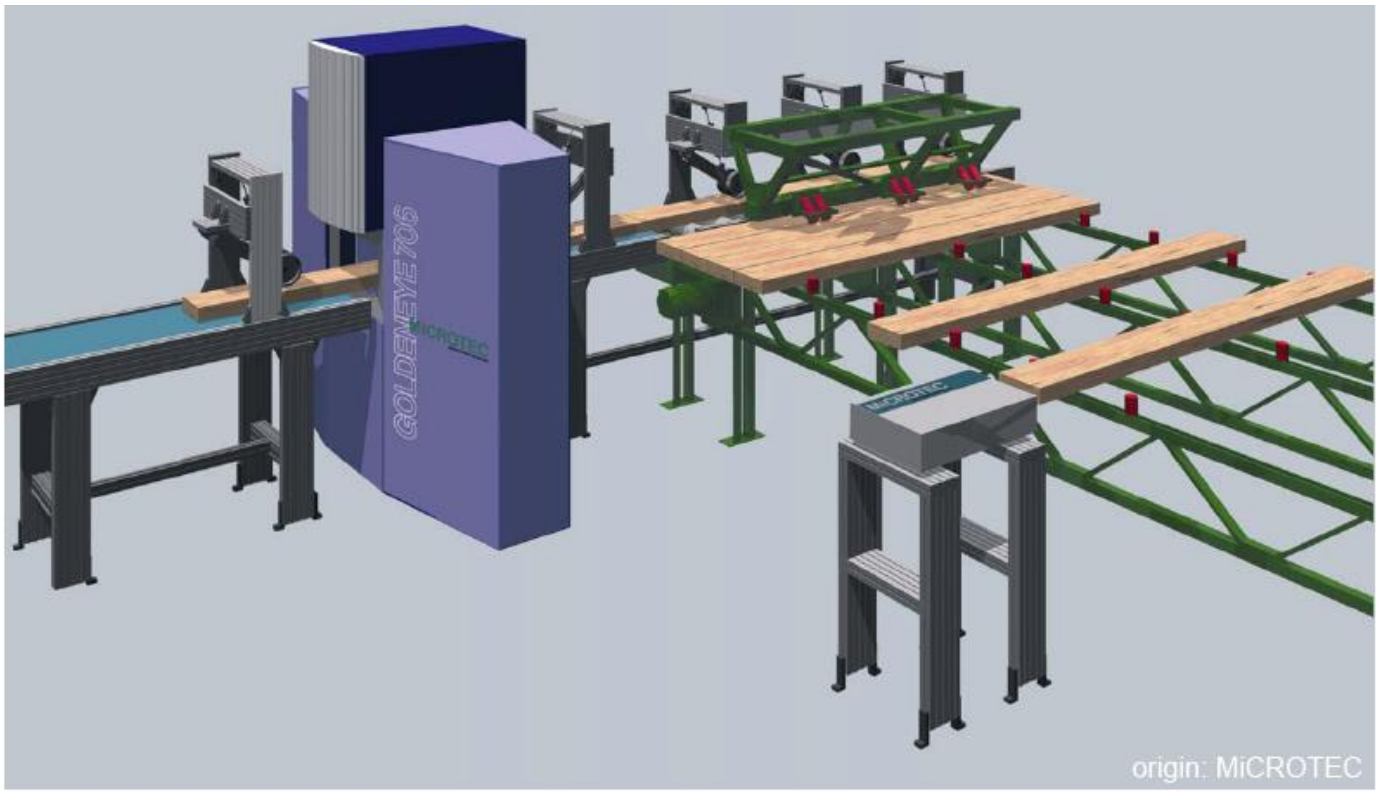
X-ray graders

GOLDENEYE 702 (MiCROTEC)



Combination graders

GOLDENEYE 706 (MiCROTEC)



Two types of machine grading

As things currently stand

- Output control
  - Periodic testing of output
  - Testing element is costly
  - But adapts the machine settings to optimise yield
  - Idea: some initial testing + continuous testing
- Machine control
  - Can be done without need for testing of output
  - Relies on strict assessment and control of machines
  - No regular fine adjustment of machine settings
  - Idea: large initial testing programme

Output control

As things currently stand

- Initial settings
  - Random sample of 60 pieces per grade
- Regular proof testing
  - ~ 5 pieces per grade per shift
- Adjust settings accordingly (by "CUSUM")
  - Reduce pass rates when quality falls
  - Increase pass rates when quality rises

Machine control

As things currently stand

- Initial testing
  - Representative sample of > 450 pieces
  - Covering the whole growth area
- Report produced for CEN TC124 WG2 TG1
  - Assessed
  - If approved,
    settings made available by machine manufacturer and passed to SG18 (Notified bodies)

Settings for UK timber

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Machine name	Operation	Species
Brookhuis Micro-Electronics [& LuxScan]		
MTG 920 [and ESCAN]	Longitudinal frequency	British spruce, UK larch
MTG 960 [and ESCAN]	Longitudinal frequency & density (mass & volume)	British spruce, UK larch
Dynalyse AB		
Precigrader	Longitudinal frequency (microphones) & density (mass & volume)	British spruce
MPC		
Computermatic	Bending	British spruce, British larch, British pine
Cook-Bolinder	Bending	British spruce, British larch, British pine
MiCROTEC		
ViSCAN	Longitudinal frequency (laser vibrometer)	British spruce, UK larch
ViSCAN-Compact	Longitudinal frequency (laser vibrometer) & density (mass & volume)	British spruce, UK larch
ViSCAN-Plus	Longitudinal frequency (laser vibrometer) & density (X-ray)	British spruce, UK larch
ViSCAN-portable	Longitudinal frequency (laser vibrometer) &, optional, density (mass & volume)	UK larch
GOLDENEYE GE702	X-ray (knots & density)	British spruce, UK larch
GOLDENEYE GE706	X-ray (knots & density) & longitudinal frequency (laser vibrometer)	British spruce, UK larch

= Done by Edinburgh Napier University

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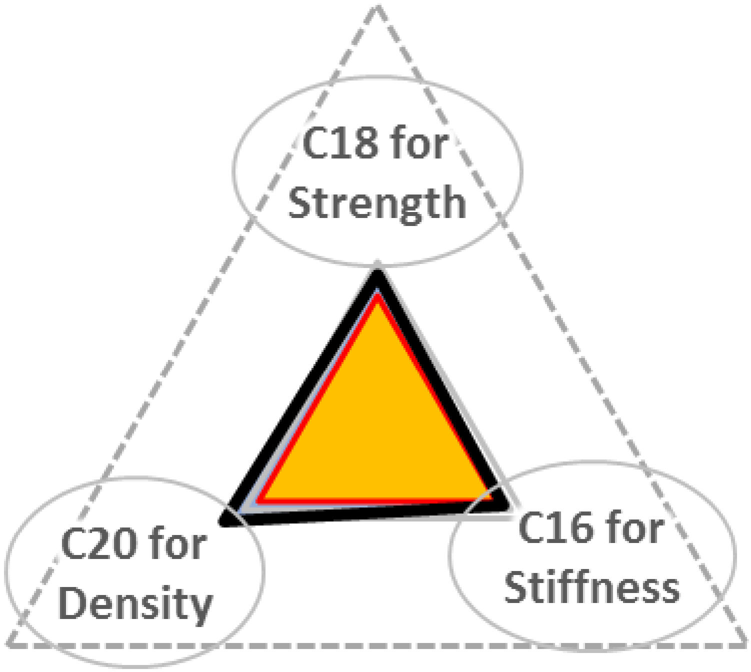
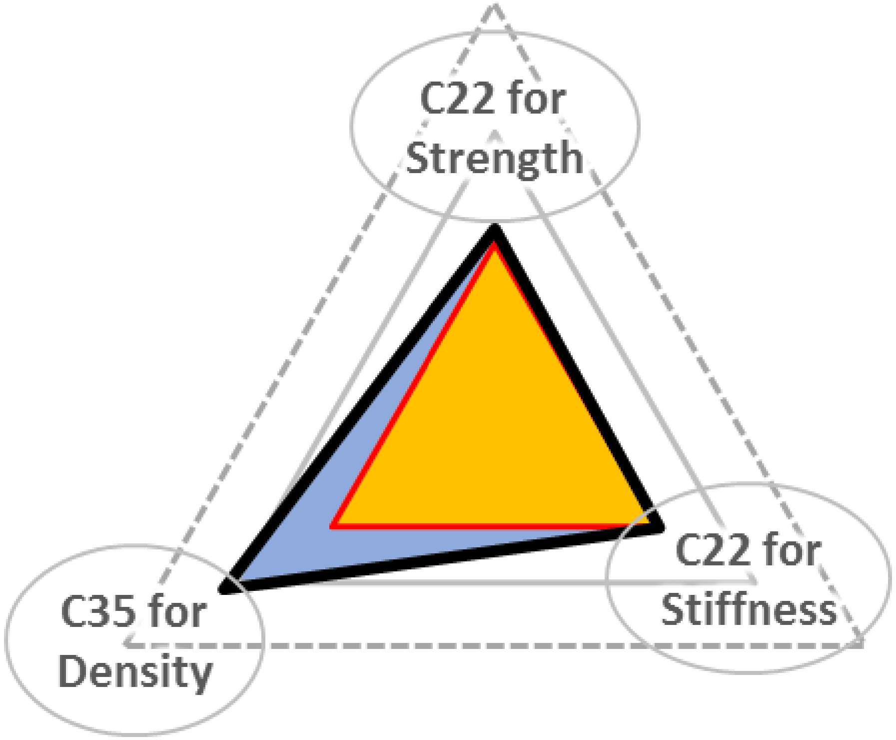


British spruce (WPCS)



UK larch (WLAD)

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UK-grown timber

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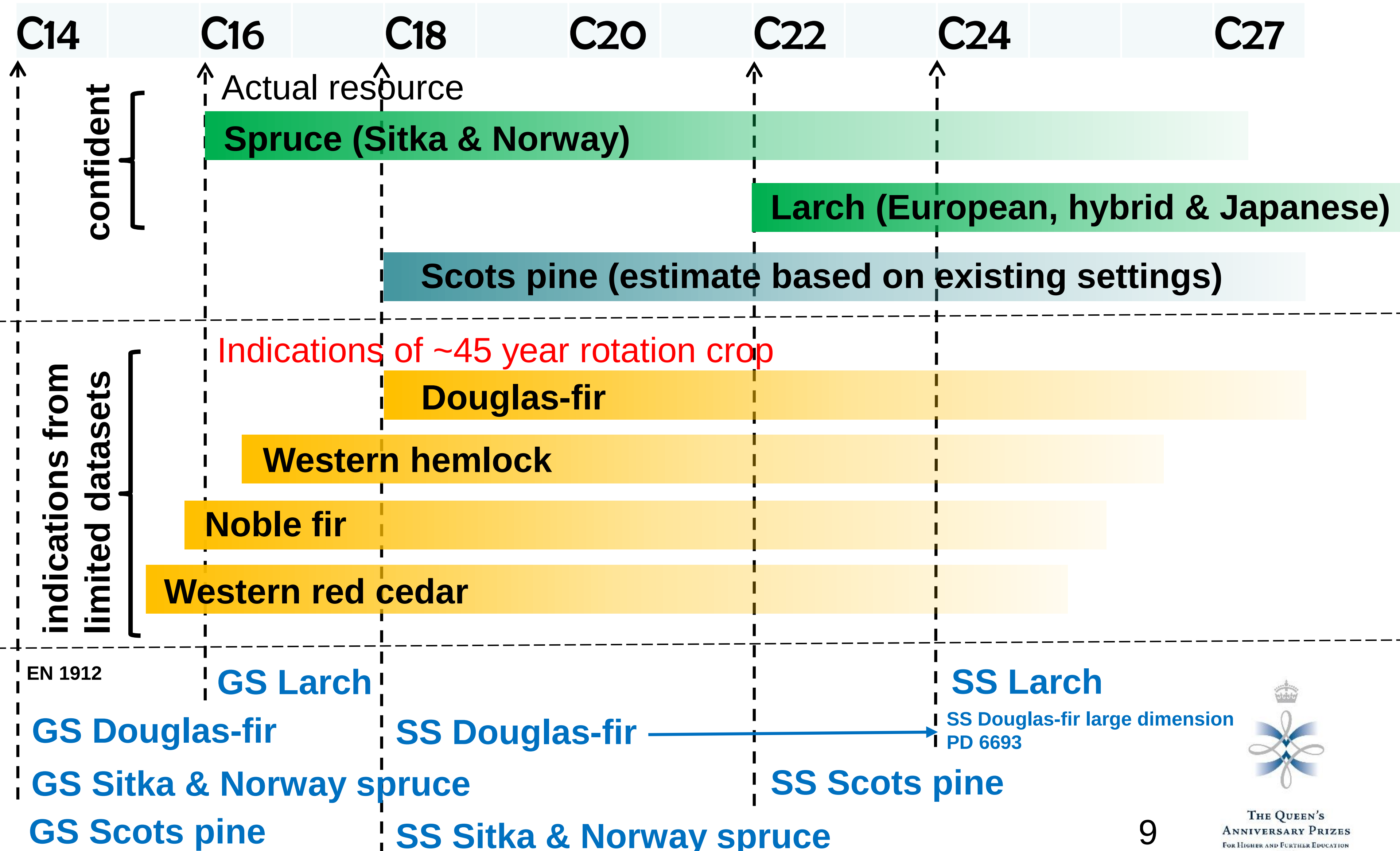

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UK-grown timber

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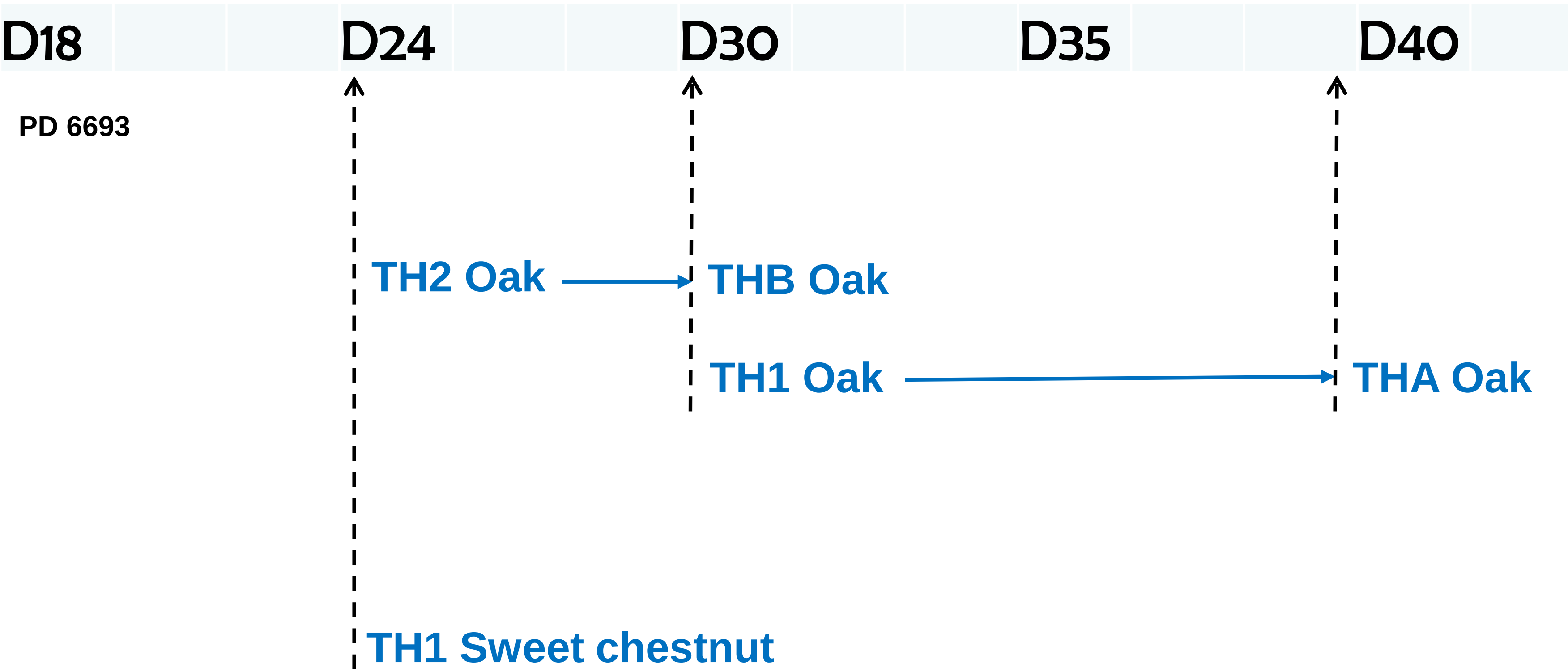

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Institute for Sustainable Construction

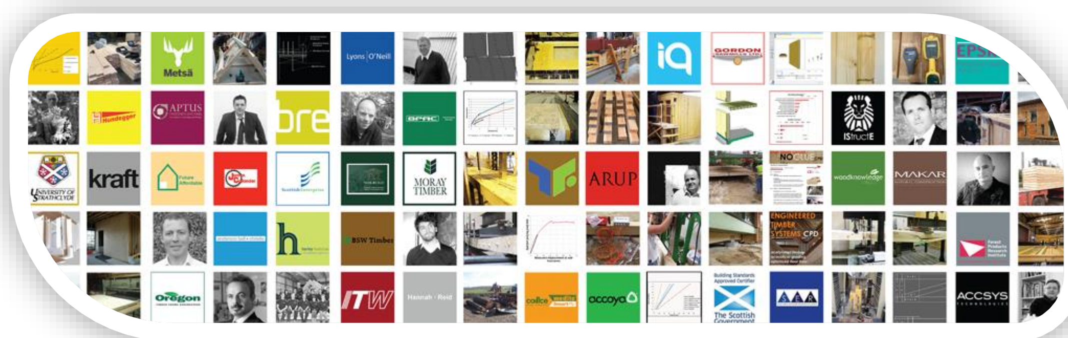
Centre for Offsite Construction + Innovative Structures

Research,

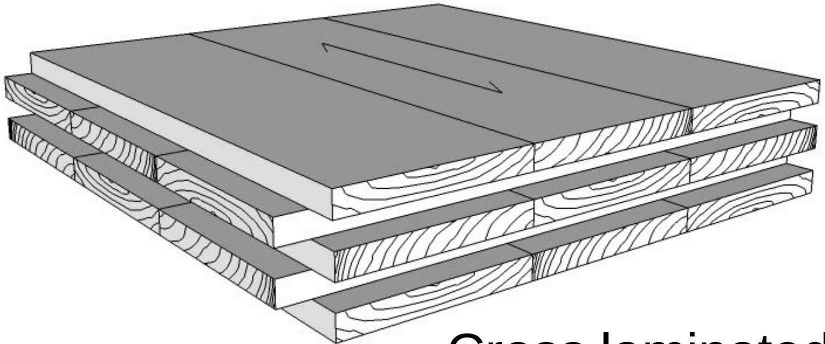
Innovation,

Commercialisation.

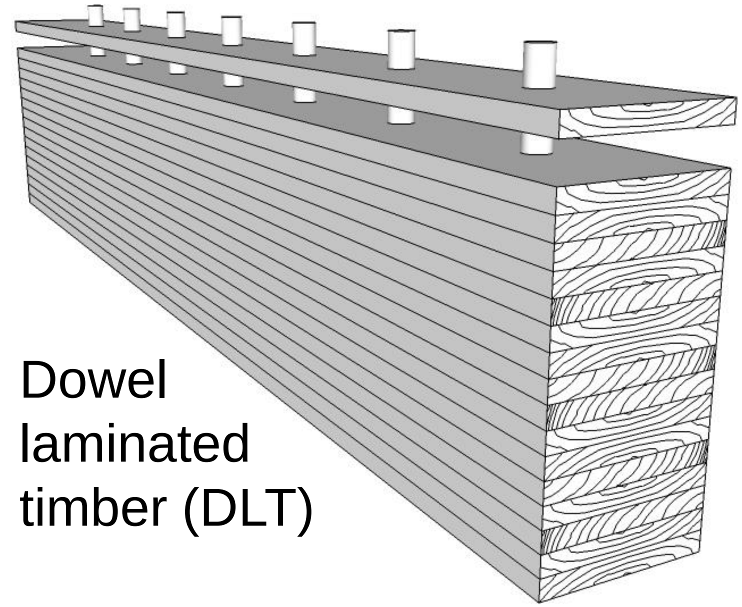
COCIS Vision Statement: “To engage with partners creating the built environment in order to add value to their activities through research, innovation and knowledge integration.”



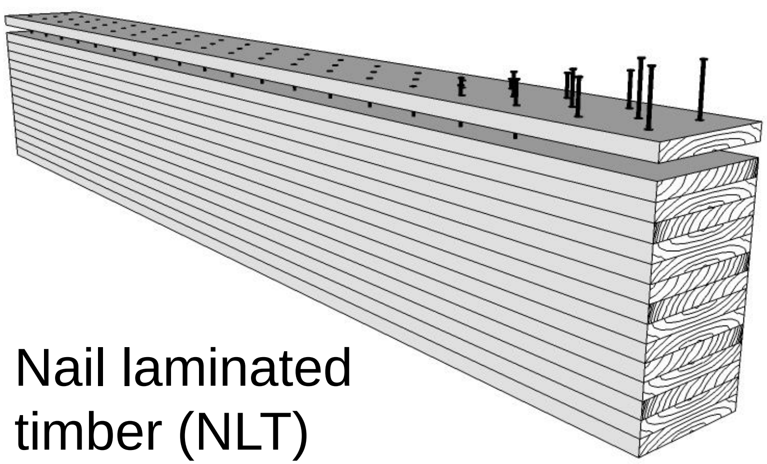
Laminated products



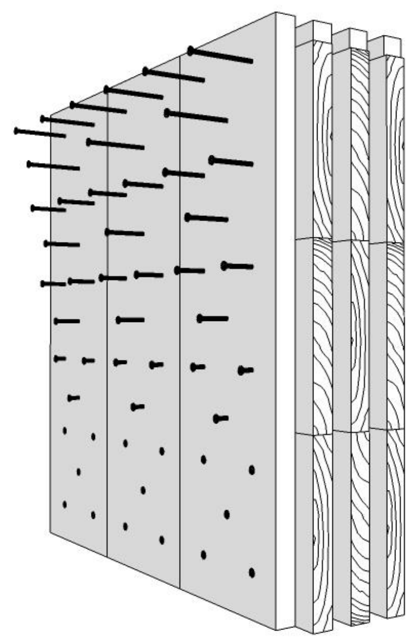
Cross laminated timber (CLT)



Dowel laminated timber (DLT)



Nail laminated timber (NLT)



Nailed cross laminated timber (nCLT)

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MAKAR
NATURAL CONSTRUCTION

Dowel laminated timber (DLT)

CarbonDynamic

Nailed cross laminated timber (nCLT)

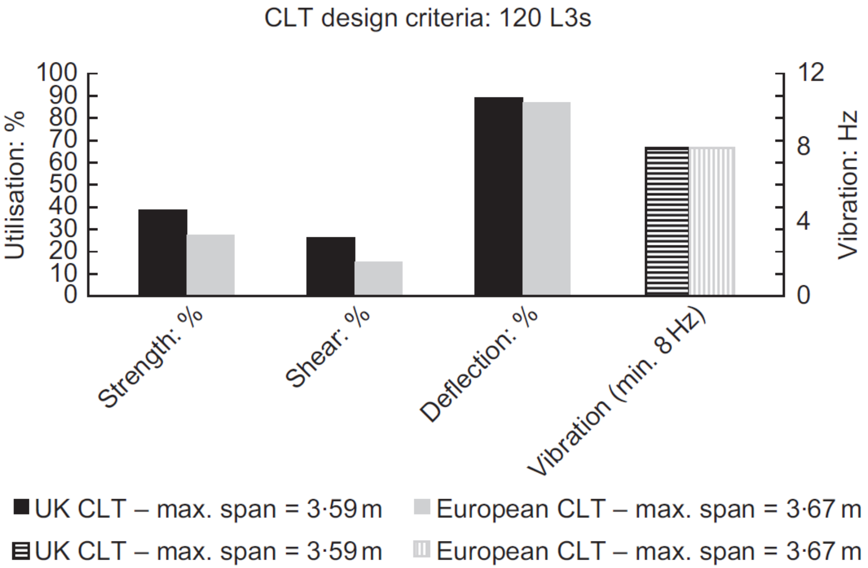
Cross laminated timber (CLT)

Journal:

- Crawford, D., Hairstans, R., Smith, S. & Papastavrou, P. (2015) "UK Cross-Laminated Timber (CLT): Market Assessment, Resource Compatibility and Structural Performance" ICE Construction Materials Volume 168, Issue 3.

Conference:

- Crawford, D., Hairstans, R. & Smith, R. (2013) "Feasibility of Cross-Laminated Timber Production from UK Sitka Spruce" COST Action FP1004 Focus Solid Timber Solutions – European Conference on Cross Laminated Timber, 23rd – 24th May, Graz University of Technology



Company has ambition on Titanic scale

Titan at Eurocentral covers 122,000 sq ft

Thursday 28 May 2015 / Business Extra & Commercial Property

CCG's purchase of £4.15m plant aims to lead the way in production of 'green' timber, says, Bob Serafini

Summary

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- British spruce achieves C16, almost 100% yield
  - Stiffness is the limiting property (not density)
  - Has higher strength and density than C16 requires
  - There is good timber within the resource
- UK larch almost as good as that grown in the Alps
  - But *Phytophthora ramorum* ☹
- We need to gather more information about other species – appears stiffness is commonly limiting
  - Can’t rely on small amounts of test data, small clear tests, or data from timber grown elsewhere

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