timber properties of minor conifer species in Britain and future marketing opportunities

Dan Ridley-Ellis
Centre for Wood Science and Technology

National Forestry Conference
“Minor Conifers in Ireland”
What is wood quality?

• Wood quality depends on the application
• Most important thing is to have knowledge

Before we begin...
1) Focus on density (alone) is misleading
2) Species is not everything
   (to some it does not matter at all)
Density
– not always a good thing

If only we were a bit heavier!
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. (© PB&E.)
Structural engineering design

• About buildings
  – Staying safe
  – Staying fit for use

• Dealing with uncertainty
  – Of material
  – Of the actions on a structure
  – Of analysis and construction

• True irrespective of the material
  (There is always some uncertainty)
Characteristic values

- **Stiffness**
- **Mean**
- **Strength**
- **Density**

Lower 5\(^{th}\) percentile

Frequency of occurrence

Parameter

Probability of a piece being lower = 5%
Current methods in Europe

• Visual grading
  – Visually grade – then assign to strength class

• Machine grading
  – Machine control (large initial testing, fixed settings)
  – Output control (regular testing, settings can change)

• Slightly different basis
• …but same fundamentals
Grading – IP boundaries

“Grade Determining Property”

“Indicating Property”

e.g. $f_m$ (Nmm$^2$) Strength

e.g. $E_{\text{dyn}}$ (Nmm$^{-2}$) Dynamic stiffness

Spruce ‘poor’
Spruce ‘medium’
Spruce ‘good’

“poor”  “medium”  “good”

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Grading – IP boundaries

Grading aims that GDP requirements are met (at least) subject to various adjustments.

Strength

Dynamic stiffness

Depends on

\[ y = mx + c \]

\[ R^2 \]

Mean Variance

“Indicating Property”

“Grade Determining Property”

Spruce 'medium'

5th %ile

"medium"

Grading – IP boundaries

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30/5/2017
Grading – IP boundaries

Grading aims that GDP requirements are met (at least) subject to various adjustments.

Depends on SPECIES & GROWTH AREA variance.

Strength

Dynamic stiffness

GRADE

Grading – IP Boundaries

Grading aims that GDP requirements are met (at least) subject to various adjustments.

Depends on SPECIES & GROWTH AREA variance.

Strength

Dynamic stiffness
Means that...

- Grading not about properties of individual pieces – it is about collective properties
- Often only one of the GDPs is limiting
  - Strength
  - Stiffness
  - Density
- …indeed sometimes none of them are
Based on testing
EN 408
EN 384
EN 14358
What other challenges?

- Perhaps the biggest challenge is overcoming what people think is possible with home-grown wood

- Perhaps the biggest problem is junk and/or unverified knowledge (both negative and positive)
What matters about properties?

• Properties and performance
  – Knowledge / predictability of
  – Variation in
  – Consistency of

  – Generic market categories (e.g. C16)
Some properties that matter

• **Strength** (bending, tension, shear, perp to grain, fracture etc…)

• **Stiffness**

• **Density** (fasteners, charring rate, self-weight, calorific value…)

• **Dimensional stability / distortion**

• **Durability**

• **Colour and colour change**

• **Creep**

• **Finishing, gluing, painting etc**
What might not be the same as same species grown elsewhere

- Density
- Strength
- Stiffness
- Knottiness (and appearance)
- Durability
- Drying distortion
- Reaction wood, splitting
- Log sizes and form
“Sitka”

- “British spruce” WPCS

- Sitka spruce (*Picea sitchensis*) (PCST)
- Norway spruce (*Picea abies*) (PCAB)
- Typically graded C16/reject
  - But does contain potential for higher grades

- Maybe other species can be added?
  (doesn’t need to be spruce, just needs to be similar enough)
“Pine”

• “British pine” WPNN

• Scots pine (*Pinus sylvestris*) (PNSY)
  – Blue stain
  – Dead knots

• Austrian pine (*Pinus nigra*) (PNNN)

• Corsican pine (*Pinus nigra laricio*) (PNNL)?
“Larch”

- “Larch” WLAD
- Hybrid larch (*Larix x eurolepis*) (LAER)
- Japanese larch (*Larix kaempferi*) (LAKM)
- European larch (*Larix decidua*) (LADC)

- Durability
- But heavy
- Reputation for distortion, splitting
Douglas-fir

- Douglas-fir (*Pseudotsuga menziesii*) (PSMN)
- Has visual grading assignments
- Grading settings coming…
- Used as imported construction timber, in combination with Western larch (*Larix occidentalis*) (WPSM)
Up coming…

• Noble fir (*Abies procera*) (ABPR)
• Western hemlock (*Tsuga heterophylla*) (TSHT)
• Western red cedar (*Thuja plicata*) (THPL)

Noble fir and western hemlock are included in the “Hem-fir” combination (WABA)

On the list

- European silver fir (*Abies alba*) (ABAL)
  - in European spruce and fir whitewood (WPCA)

- Pacific silver fir (aka amabilis fir) (*Abies amabilis*) (ABAM)

- Grand fir (*Abies grandis*) (ABGR)
  - Also in “Hem-fir” mix (WABA)
On the list

• Japanese incense cedar (aka sugi / Japanese red cedar) (*Cryptomeria Japonica*) (CYJP)

• Serbian spruce (*Picea omorika*)
Not forgetting hardwoods

• Sycamore (*Acer pseudoplatanus*) (ACPS)
• Birch (*Betula pendula/pubescens*) (BTXX)

EN338 now allows hardwoods to be graded to the C-classes (the “softwood” grades) …particularly useful for the less dense species
Declaration of performance usually via Strength classes (or “grades”) e.g. EN 338:2016

<table>
<thead>
<tr>
<th></th>
<th>Class</th>
<th>C14</th>
<th>C16</th>
<th>C18</th>
<th>C20</th>
<th>C22</th>
<th>C24</th>
<th>C27</th>
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</thead>
<tbody>
<tr>
<td><strong>Strength properties in N/mm²</strong></td>
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<td>Bending</td>
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<tr>
<td>$f_{m,k}$</td>
<td>14</td>
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<td>20</td>
<td>22</td>
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<td>Tension parallel</td>
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<tr>
<td>$f_{20,k}$</td>
<td>7.2</td>
<td>8.5</td>
<td>10</td>
<td>11.5</td>
<td>13</td>
<td>14.5</td>
<td>16.5</td>
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<td>Tension perpendicular</td>
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<td>$f_{90,k}$</td>
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<td>Compression parallel</td>
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<td>$f_{c0,k}$</td>
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<tr>
<td>Compression perpendicular</td>
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<tr>
<td>$f_{c90,k}$</td>
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<td>2.2</td>
<td>2.2</td>
<td>2.3</td>
<td>2.4</td>
<td>2.5</td>
<td>2.5</td>
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<td>Shear</td>
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<td>$f_{v,k}$</td>
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<tr>
<td><strong>Stiffness properties in kN/mm²</strong></td>
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<tr>
<td>Mean modulus of elasticity parallel bending</td>
<td>$E_{m,0,mean}$</td>
<td>7.0</td>
<td>8.0</td>
<td>9.0</td>
<td>9.5</td>
<td>10.0</td>
<td>11.0</td>
<td>11.5</td>
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<tr>
<td>5 percentile modulus of elasticity parallel bending</td>
<td>$E_{m,0,k}$</td>
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<td>5.4</td>
<td>6.0</td>
<td>6.4</td>
<td>6.7</td>
<td>7.4</td>
<td>7.7</td>
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<td>Mean modulus of elasticity perpendicular</td>
<td>$E_{m,90,mean}$</td>
<td>0.23</td>
<td>0.27</td>
<td>0.30</td>
<td>0.32</td>
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<td>Mean shear modulus</td>
<td>$G_{mean}$</td>
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<td>0.56</td>
<td>0.59</td>
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<td>0.69</td>
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<tr>
<td><strong>Density in kg/m³</strong></td>
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<tr>
<td>5 percentile density</td>
<td>$\rho_k$</td>
<td>290</td>
<td>310</td>
<td>320</td>
<td>330</td>
<td>340</td>
<td>350</td>
<td>360</td>
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<tr>
<td>Mean density</td>
<td>$\rho_{mean}$</td>
<td>350</td>
<td>370</td>
<td>380</td>
<td>400</td>
<td>410</td>
<td>420</td>
<td>430</td>
</tr>
</tbody>
</table>
UK-grown timber

- **Actual resource**
  - Spruce (Sitka & Norway)
  - Larch (European, hybrid & Japanese)
  - Scots pine (estimate based on existing settings)

- **Indications from limited datasets**
  - Indications of ~45 year rotation crop
    - Douglas-fir
    - Norway spruce (alone)
    - Western hemlock
    - Noble fir
    - Western red cedar

UK-grown timber

- **Actual resource**: Spruce (Sitka & Norway)
- **Educated guesses**:
  - European silver fir
  - Pacific silver fir
  - Grand fir
  - Serbian spruce
  - Sycamore
  - Birch

- **Strength limited?**
- **Stiffness limited**
Routes for structural timber

• Routes for CE marking
  – Visual grading
    • No minimum requirement, but need some 200-400 pieces

  – Machine grading (machine control)
    • If machine already used, requires 450 pieces (ideally 1000)

  – Machine grading (output control)
    • Requires continuous testing, not suited to small volumes

• Expensive…requires lots of timber
Bypassing CE marking

• One off buildings
• Within a manufacturing process

…but still need to be safe

• And convince an engineer
Commodity strength classes

British spruce (WPCS) “C16+”

UK larch (WLAD)
Example, UK larch with MTG

The Brookhuis MTG is a resonance type machine.
Strength and density

$R^2 = 0.2$
**User defined strength classes for home grown timber (can be graded with Brookhuis MTG960)**

<table>
<thead>
<tr>
<th>Option 1 – approximately ¼ &amp; ¾</th>
<th>Option 2 – approximately ½ &amp; ½</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C24</strong>&lt;br&gt;Strength &gt; C24&lt;br&gt;Stiffness = C24&lt;br&gt;Density &gt; C27</td>
<td><strong>NapierSA</strong>&lt;br&gt;British spruce&lt;br&gt;Sitka spruce (<em>Picea sitchensis</em>)&lt;br&gt;Norway spruce (<em>Picea abies</em>)&lt;br&gt;GB &amp; IE</td>
</tr>
<tr>
<td><strong>C16</strong>&lt;br&gt;Strength = C16&lt;br&gt;Stiffness = C16&lt;br&gt;Density = C18</td>
<td><strong>NapierSB</strong>&lt;br&gt;Strength = C22&lt;br&gt;Stiffness = C22&lt;br&gt;Density = C27&lt;br&gt;C22</td>
</tr>
<tr>
<td><strong>C27</strong>&lt;br&gt;Strength &gt; C14&lt;br&gt;Stiffness = C14&lt;br&gt;Density = C16</td>
<td><strong>NapierSD</strong>&lt;br&gt;Strength &gt; C14&lt;br&gt;Stiffness = C14&lt;br&gt;Density = C16&lt;br&gt;C14</td>
</tr>
<tr>
<td><strong>C30</strong>&lt;br&gt;Strength = C30&lt;br&gt;Stiffness = C35&lt;br&gt;Density &gt; C50</td>
<td><strong>NapierLA</strong>&lt;br&gt;UK larch&lt;br&gt;European larch (<em>Larix decidua</em>)&lt;br&gt;Hybrid larch (<em>Larix × eurolepsis</em>)&lt;br&gt;Japanese larch (<em>Larix kaempferi</em>)&lt;br&gt;GB</td>
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<tr>
<td><strong>C20</strong>&lt;br&gt;Strength &gt; C20&lt;br&gt;Stiffness = C18&lt;br&gt;Density = C40</td>
<td><strong>NapierLB</strong>&lt;br&gt;Strength &gt; C27&lt;br&gt;Stiffness = C30&lt;br&gt;Density &gt; C50&lt;br&gt;C27</td>
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<tr>
<td><strong>C18</strong>&lt;br&gt;Strength = C20&lt;br&gt;Stiffness = C18&lt;br&gt;Density = C40</td>
<td><strong>NapierLC</strong>&lt;br&gt;Strength = C20&lt;br&gt;Stiffness = C16&lt;br&gt;Density = C35&lt;br&gt;C16</td>
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<tr>
<td><strong>NapierLD</strong>&lt;br&gt;</td>
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</tbody>
</table>

For information contact Dan Ridley-Ellis, Centre for Wood Science & Technology d.ridleyellis@napier.ac.uk  
http://blogs.napier.ac.uk/cwst/
What is not going on to help?

- Standardisation demanding more and more test information
- Unfamiliarity of engineers with wood
- Habitual specification of the usual species
- Over specification of grade
WoodProps Ireland

• New joint project (IE with UK)
  – Timber Engineering Research Group at NUI Galway
  – Centre for Wood Science & Technology, Edinburgh Napier University

Funded by the Forestry Division of the Department of Agriculture, Food and the Marine.
WoodProps Ireland

- Characterisation of Irish-grown timber
- Work at National and European level in standardisation for structural timber quality and production
- Exchange of knowledge related to wood quality, products and standards with forestry and processing industries
- Expert advice to regulatory bodies related to construction of modern timber buildings
WoodProps Ireland

• Sitka / Norway spruce
  – Link to UK work
  – Monitoring, prediction of trends
  – Differences public & private estates?
  – Other sources of degrade

• Other species:
  – Norway spruce
  – Douglas-fir
  – Scots pine & lodgepole pine
  – …broadleaves?

Other markets

• Laminated products
• Engineered wood products
• Panel products
• Modified wood
  – Thermal modification
  – Chemical modification
• Bioenergy
Other markets

- Biorefinery
  - Extractives
Finally: it’s what you do with it
Laminated products

- Cross laminated timber (CLT)
- Dowel laminated timber (DLT)
- Nail laminated timber (NLT)
- Nailed cross laminated timber (nCLT)
Dowel laminated timber (DLT)
Nailed cross laminated timber (nCLT)
Cross laminated timber (CLT)

Journal:

Conference: