How Homegrown Timber Stands Up to the Job

Transforming Timber

CONTENTS

3 ..... Overview
4 ..... Key Points
14..... Looking Forward

OVERVIEW

Extensive research and testing now conclusively shows that UK-grown softwood timber is ideal for use in mass timber systems. Academic studies and real-world applications demonstrate exciting market potential, especially for the Cross-Laminated Timber (CLT) that is urgently required to address the climate emergency as well as housing needs.

Despite existing misconceptions about homegrown timber, its quality and properties make it ideal for manufacturers to optimise production to meet the growing commercial mass timber demand.

This summary of the report “Material Compatibility and Optimisation for Home-Grown Mass Timber Systems” provides an overview of guidance and emerging best practices for utilising UK-grown softwood for mass timber. It will help manufacturers who want to go into this emerging market to understand the interaction between wood properties and production parameters so that the service performance of the end-product meets expectations, while also being commercially viable. Additionally, it will give architects, designers, and construction professionals awareness of and confidence in the material properties of mass timber products made from homegrown softwood. Opportunities for a manufacturer to optimise are suggested, but since this depends on their individual priorities and target markets, no single solution can be given here. Instead, the potential for manufacturers to optimise to their own situation is presented.

KEY POINTS

1.The UK Timber Resource for Mass Timber Production

Spruce is by far the most commonly produced commercial softwood species available in the UK, with Sitka spruce accounting for approximately 50% of the standing softwood resource and almost 60% within Scotland (Forestry Commission, 2014b). Together with Norway spruce, it is expected to remain the main component of the commercial softwood resource through 2050, though the relative amount is decreasing over time and in the decades to come it will be important to transfer the UK timber industry over to using a more diverse range of species. For now, due to its availability, good strength to weight ratio, and ease of processing, this report focuses on spruce as the primary species considered for mass timber production in the UK.

2. Standardisation frameworks

For UKCA and/or CE marking, it will be necessary to follow the relevant production standards. Meeting or exceeding these is crucial for ensuring both building safety and economic use of the material. In Europe (including the UK), the harmonised European standard EN 14081-1 sets out the grading system for structural timber and sorts rectangular cross-section timber based on bending strength, bending stiffness, and density. No tension grading has yet been established for UK- and Irish-grown timber. Other standards establish parameters and guidelines for fire classification, strength class, customary sizes, and machine grading settings; details on these standards are available in the full report.

Of particular interest to mass timber manufacturers is EN 16351, which sets the standards for CLT. This outlines limitations regarding timber species, grading, layers, and jointing. EN 16351 also gives requirements for fire classification in various CLT applications such as floors, walls, and ceilings. These are summarised in the full report.

In these standardisation frameworks, Sitka and Norway spruces are listed separately, meaning that manufacturers need to carefully attend to compliance across production. Strict reading of the code raises some questions about whether they can be considered the same, but once sawn they are effectively indistinguishable, and have the same wood properties.

3.Properties of UK-grown spruce

The combination of Sitka spruce (Picea sitchensis, PCST) and Norway spruce (P. abies, PCAB) is the main commercial timber species group in UK and Ireland. It is in long-standing use and is recognised in EN 14081-1 where it is given the species code WPCS. Indeed, UK and Irish sawmills do not differentiate between the two species, and they are processed and sold together. For practical purposes, when grown in Ireland or the UK, they can be considered to have the same mechanical properties, and grade in the same way.

Research has been conducted on a number of homegrown species related to wood properties and fire performance.

Figure 1 Simplified grading example for home-grown spruce stiffness

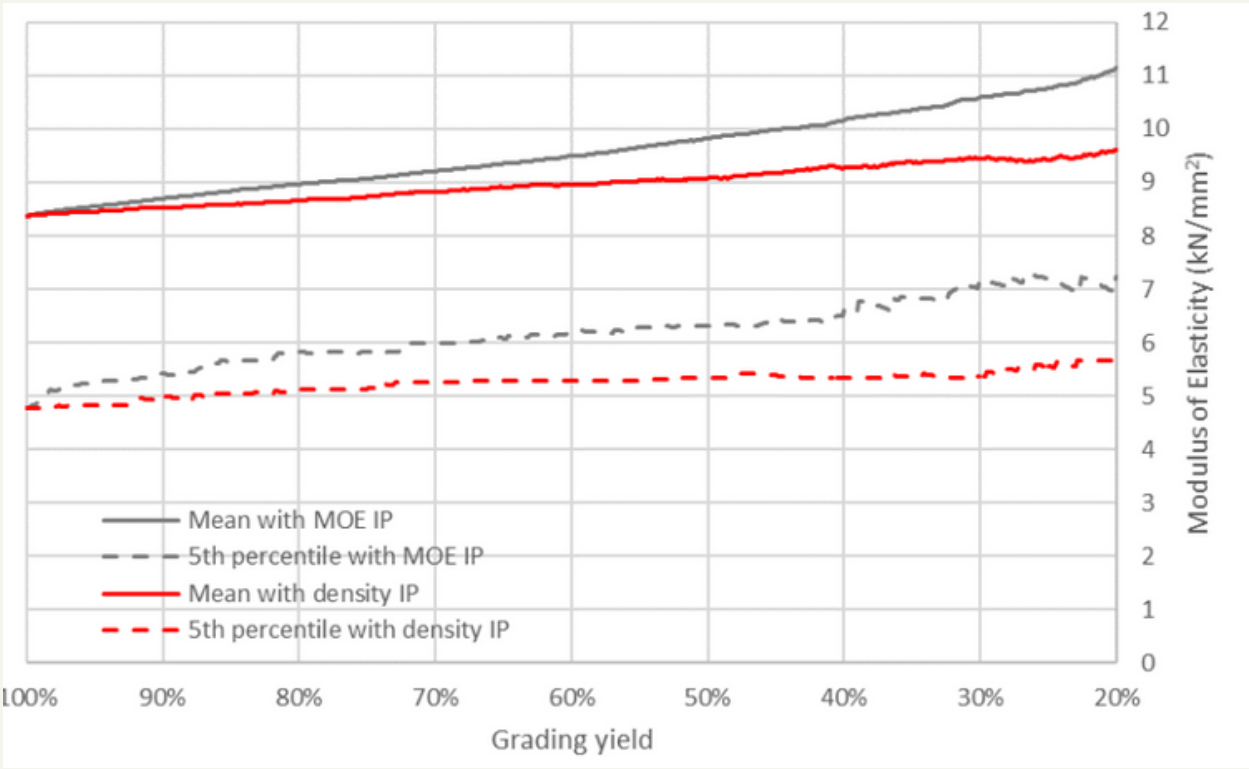


Figure 2 Simplified grading example for home-grown spruce strength

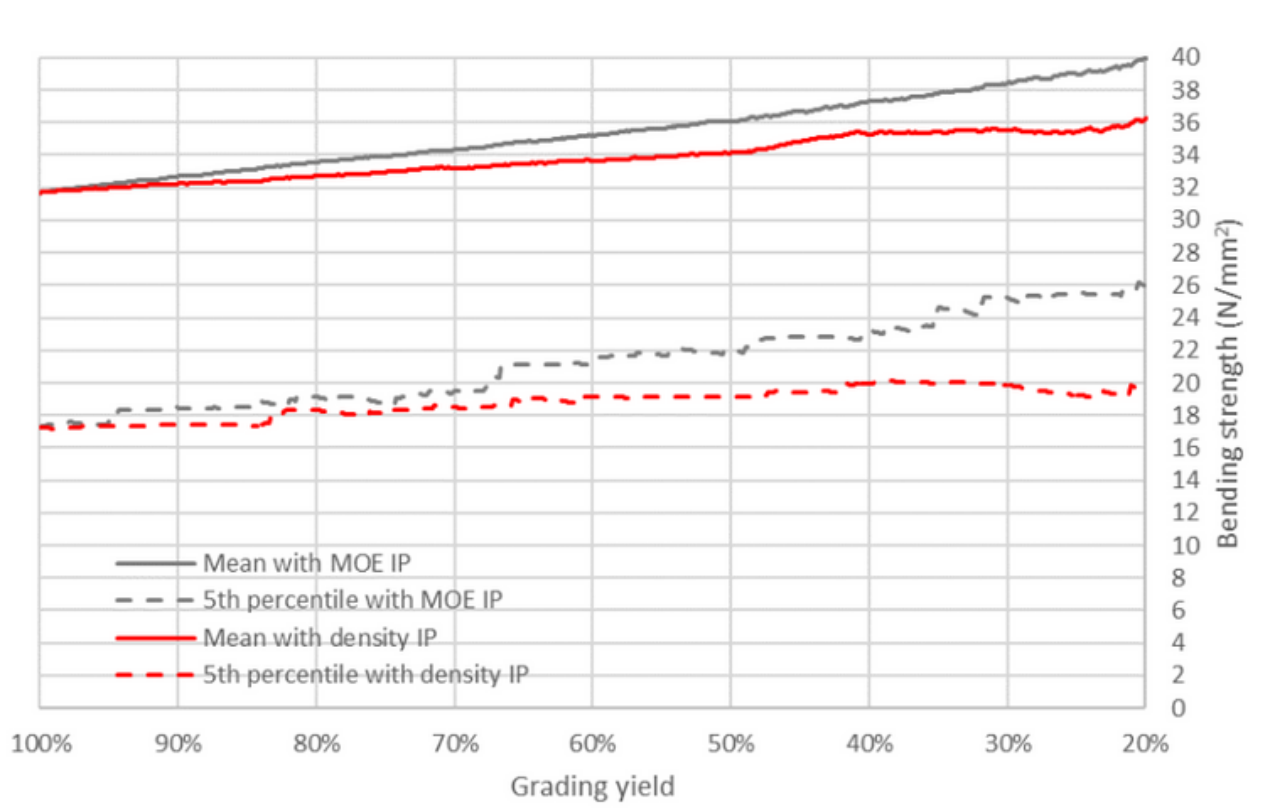
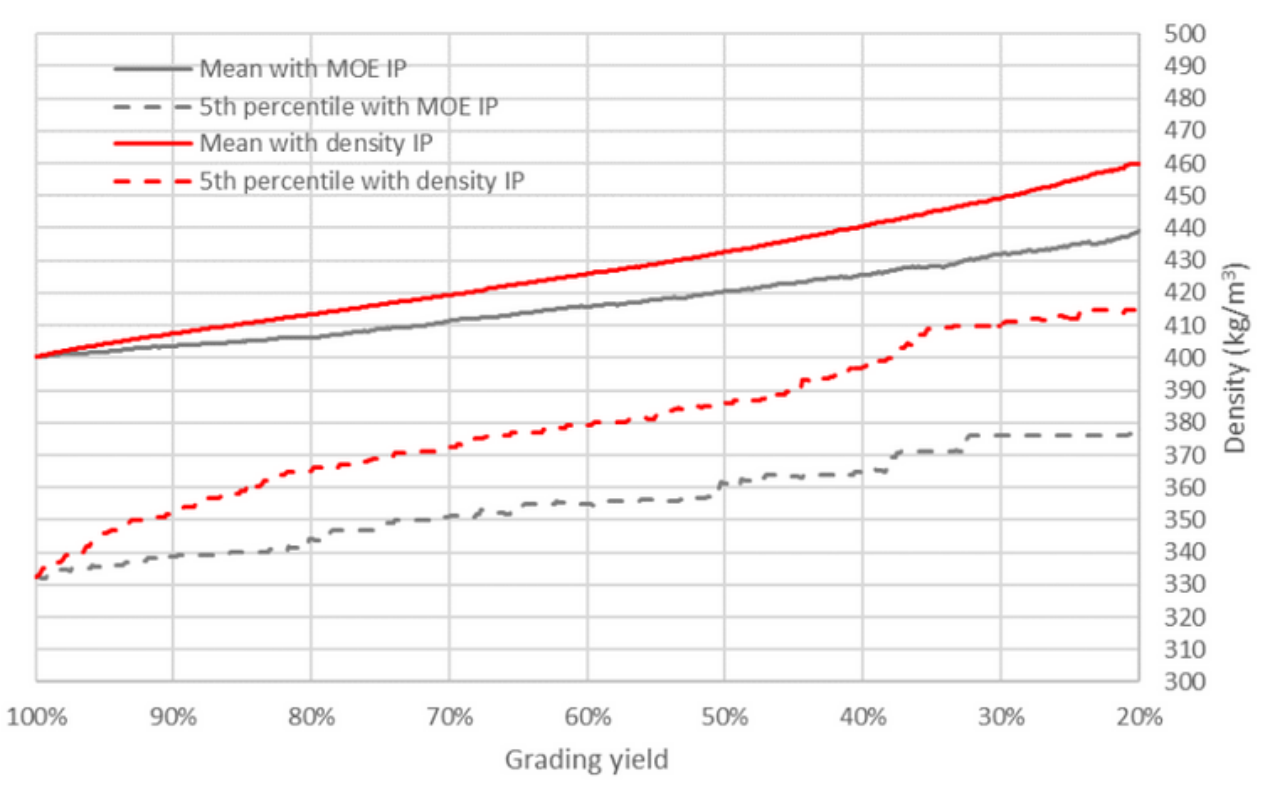


Figure 3 Simplified grading example for home-grown spruce density



In addition to grade-determining properties, secondary design properties can be estimated from these three Indicating Properties using the equations found in EN 384. These include mean density (important for fire requirements), tension strength, compression strength perpendicular to grain, and shear strength and stiffness. The measurement of secondary properties by testing is on the research agenda at Edinburgh Napier University (through the SIRT project) and NUI Galway (through the WoodProps project), but nothing substantial has been published so far. However, if there is a particular cutting pattern and grading process it would make most sense to test the key secondary properties for CLT or glulam with those in mind. In this way, manufacturers can inform an important part of the research cycle and outputs.

Finally, a critical research finding is that variation in wood properties between sites is quite small, so there is high potential for different sawmills in the UK to provide more or less equivalent timber to manufacturers. However, this requires consistency in grading methods and cutting patterns.

4. Grading

There are two parallel systems for grading: visual and machine, both of which follow the same fundamental basis: timber is sorted into grades according to a non-destructive assessment that is predictive of the grade determining properties. The collective characteristic properties of the timber sorted into those grades determines the strength class. A strength class is simply a grade with associated numbers for strength, stiffness and density that can be used in design. Strength class is usually specified with reference to EN 338 (CEN, 2016a), but properties can be declared directly, or by means of a user-defined strength class. Manufacturers may wish to follow the example of European counterparts regarding methods of machine grading. One advantage for home-grown spruce is that the simplest, cheapest and most compact technology (longitudinal resonance) works the best. Approved machine grading settings for home-grown spruce and other guidance is available in the full report.

It is also under EN 14081-1 that visual strength grading can be carried out according to grading rules that are usually (but do not have to be) national standards. Assignment to a strength class is specific to a combination of grading standard and timber source.

Below, the recommended strength and appearance grading methods for spruce are given, along with potential opportunities for bespoke grading. Details may be found in the full report.

Table 1 Current visual grading assignments for home-grown timber

Species	Source	Visual grade	Strength class	Reference
To BS 4978 (BSI, 2017a)				
Spruce *Picea sitchensis* *Picea abies*	UK	GS	C14	EN 1912:2012 (§6)
		SS	C18	EN 1912:2012 (§6)
Pine *Pinus sylvestris* *Pinus nigra*	UK	GS	C14	EN 1912:2012 (§6)
		SS	C22	EN 1912:2012 (§6)
Larch *Larix decidua* *Larix × marschlinsii* *Larix kaempferi*	UK	GS	C16	EN 1912:2012 (§6)
		SS	C24	EN 1912:2012 (§6)
Douglas-fir *Pseudotsuga menziesii*	UK	GS	C14	EN 1912:2012 (§6)
		SS	C18	EN 1912:2012 (§6)
		SS (* large)	C24	PD 6693-1:2019 (§7.2)
To IS 127 (NSAI, 2015)				
Spruce *Picea sitchensis* *Picea abies*	IE	GS	C14	EN 1912:2012 (§6)
		SS	C18	EN 1912:2012 (§6)
To BS 5756 (BSI, 2017b)				
Oak *Quercus petraea* *Quercus robur*	UK	TH2	D24	PD 6693-1:2019 (§7.1)
		TH1	D30	PD 6693-1:2019 (§7.1)
		THB (* large)	D30	PD 6693-1:2019 (§7.1)
		THA (* large)	D40	PD 6693-1:2019 (§7.1)
Sweet chestnut *Castanea sativa*	UK	TH1	D24	PD 6693-1:2019 (§7.1)

* These are for cross-section area > 20,000 mm^2, width and thickness ≥ 100 mm

Note 1: Assignment via BSI Published Document PD 6693-1 is possible when used with the UK National Annex to BS EN 1995-1-1 (BSI, 2014)

Note 2: It is expected the ongoing revision of EN 1912 will extend the assignments of BS 4978 to apply to also to IS 127 and to change the source of spruce for both standards to UK and IE

Below, the recommended strength and appearance grading methods for spruce are given, along with potential opportunities for bespoke grading. Details may be found in the full report.

a. Recommended Strength Grading Method

If the ambition is to use only C16, then the timber properties have little importance to grading machine choice, as there is almost no machine reject.

If the ambition is to use only C16+, then any modern machine is capable, even if it currently does not have settings (they could be calculated from the grading dataset). However, it is easier with the machines that currently have settings. Note, however, that not all mills will have the settings, even if they have the machines that can run them.

If higher grades or grading to multiple grades is desired, the machines that work on dynamic modulus of elasticity (frequency and density) are the most useful. If appearance of the surface layer is very important for the product, grading could instead be on a visual grading basis, assisted by machine. Portable machines based on dynamic MOE would be most useful for this. Enabling this would, however, require new testing and grading development work.

b. Recommendations on Appearance Grading

If different strength grades are used in the outer layers of CLT, the appearance grading rules are ideally incorporated into the strength grading (whatever the required aesthetic considerations are).

Home-grown spruce is quite simple to appearance grade, as it does not have a wide range of defect types, knots are quite consistent, and colour is very uniform. Even though appearance grading does not have the goal to increase the structural performance of a timber population, it does reduce the amount and/or severity of defects. CLT with many defects might be perceived as weaker than a similar product with fewer defects, even when the structural performance of both is declared the same. Appearance grade CLT might therefore be perceived as having superior structural properties compared to non-appearance grade CLT, so that appearance is of importance for sale, even when in the final application it is not.

It should be determined how the market value of CLT is influenced by its appearance grade and whether the additional time needed for an extra grading step can be reflected in the sale price. A study should be conducted to determine which defects in particular influence the customer's valuation of the product, if any at all. Grading to three or more appearance grades instead of only two might prove to be beneficial for marketing.

Ideally, the appearance grading rule can be incorporated into the strength grading rule to take advantage of the increase in quality. If this can be done automatically by the grading machine this would count as normal machine strength grading. If the appearance grading rule is applied manually, the framework instead would be visual strength grading (assisted by machine).

a.Opportunities for Bespoke Grading Approaches

When the desired outcomes of the appearance grading are well defined, bespoke grading rules can be derived for sorting the timber into appearance grades. This could be oriented on existing appearance grading standards but should be adapted to specific customer expectations and required yields. Such rules can cover manufacturing defects as well as timber defects.

There is no point in fully adopting existing appearance grading standards, but they may provide inspiration for in-company bespoke appearance grading rules. Certain issues, such as dead knots, may be possible to avoid earlier in the processing chain via log selection and cutting patterns.

An approach to developing bespoke grading rules is fully outlined in the complete report, and covers how to use existing datasets, new datasets, and multiple grading situations. Additionally, further explanation of existing bespoke and user defined grades such as C16+, of particular value in CLT production, can be found in the full report.

5. Other Production Considerations

When buying feed material for CLT or glulam, it is possible to exclude timber that is likely prone to twist. Contrary to traditional beliefs, the twist behaviour of home-grown spruce does not seem to be related to under-bark slope of grain (Reynolds, 2010), but other predictors can be used. Manufacturers can set requirements from timber sellers aimed at preventing distortions such as twisting. Research and best practice is available as guidance in terms of moisture content, cutting patterns, and drying schedules.

The current cutting patterns used in Irish and UK sawmills tend to take the structural product (carcassing dimensions) from the centre of the log, aiming for maximum volume recovery for the sawn timber overall. The centre is sometimes considered to be the better-quality timber, but in truth this is the juvenile core, which tends to have inferior stiffness and strength, compared to the wood on the outer part of the log. This is a potential topic of research to optimise cutting patterns, resource and grading potential for CLT manufacture, but not one that can really be answered by the testing done so far. There are indications that a cutting pattern aimed at CLT lamellas from the outer part of a log of typical rotation length could raise the general grade from C16 to C18 or even C20 thanks to the trend for increasing stiffness with radial position (Moore, et al., 2012). This would require new grading settings work aimed specifically at this process (current grading settings are for the most general cases and reflect current industrial practice and products).

In terms of drying, what is best in a production process will depend very much on the kiln size and technology, as well as the cutting pattern used to make the timber, and any sorting of the kiln load. There has been little academic research on this topic in the UK, but the drying parameters are so specific to the sawmiller's production process that the parameter optimisation is best done in the company anyway. The starting point is documented best practice (Riddiough, 2000).

The spruce planes well, but drying distortion can cause significant practical problems and/or wastage for the CLT layup. Twist is usually considered to be the most problematic type of distortion. It can be minimised by good kilning, stacking and storage practice, but usually gets worse once the timber dries past 20% so the problem of distortion usually manifests after the timber has left the sawmill, especially if it is not properly stacked and stored. Avoiding unnecessary reject from distortion due to poor kilning, stacking and storage practice will be paramount, since it cannot really be avoided by resource segregation at the green stage, although cutting pattern producing CLT lamellas from the outer part of the log probably would help.

6.Suggested Production Parameters

Table [insert table 20] summarises the recommended production parameters for a UK-based mass timber (CLT) production facility. The data, such as, recommended volume output, timber species, timber and panel dimensions is based on the previous research undertaken by Edinburgh Napier University.

LOOKING FORWARD

It is important to note that there are also other related developments on the horizon:

- Studies are ongoing to support the future planting of additional species to suit the UK timber industry. Japanese, North American, and European species have had their material properties tested with varying results. Key conclusions include the potential for additional conifer species to be included into the C16 mix through mixed processing and subject to adequate grading practices.

- Timber recovered from existing buildings, during deconstruction or renovation, is a potential additional resource in the UK. With interest in circularity increasing, research has begun to test the material properties of secondary CLT (made from timber collected from construction and demolition sites). Several compression and bending properties were tested. Research around Europe has confirmed these findings using other wood sources.

- Revision of standards and standardisation frameworks is an ongoing piece of work, and it should take into account the latest research and testing results. It is hoped that these revisions will provide even further clarity and guidance for new production opportunities.

- The mass timber manufacturing sector is transforming in the UK. Significant opportunities exist to create new possibilities for use of homegrown timber, especially in the production of CLT. With this available information about species, wood properties, strength grades and grading, and production recommendations, we hope the industry can be maximised for scaled up volume.

Transforming Timber

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