Timber Tool Kit for Structural Engineers
Sawn and Roundwood Timber

November 2021

The following notes relate to using structural timber in a relatively unprocessed state in Scotland - either as roundwood or sawn timber. Structural timber is discussed within the context of what is available and what is likely to be available in the near future, with the issue of what we should be growing and how we grow it left for a discussion elsewhere. It is assumed that any structural design will be in compliance with the relevant Eurocodes or British Standards and this document should be seen as supplementary information to these standards and their accompanying guidance documents.

Information regarding typical dimensions available are noted based on experience but it may be that individual sawmills and suppliers can supply a greater or lesser range than indicated. As a general rule, if looking for small quantities of timber it is surprising how much variety there is available. Talk to your local sawmill. A good source of information on independent sawmills is the Association of Scottish Hardwoods (ASHS) website.

Figure 1. Sitka Spruce (Picea sitchensis) trial plantation from the early 20th century at Corrour Village. (Photo: Tom Hay)

Generally Available Sawn Timber

Treated, kiln dried, machine graded C16/C24 sawn/machined structural softwood is extensively available and used in the Scottish building industry, primarily for small scale structures and building elements. A significant quantity of this is Scottish grown [1]. Scottish structural timber (typically spruce) is usually machine graded as C16, with grading constrained by the tested stiffness values. However, in theory a new grade, with the stiffness of C16 but higher strength properties, could be defined which more closely corresponds to the properties of spruce grown in Scotland. This has not happened as yet as far as the author is aware.

Timber is typically supplied in sawn dimensions of up to 75mm x 250mm but sizes of up to 50mm x 200mm are more readily available. Lengths of 4.8m are typical but 6.0m can be sourced or even 7.2m.

FSC (Forest Stewardship Council) certified Scottish timber is available.

[1]. https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/

Species Availability and Quality

The most readily available softwood species for structural applications are Sitka Spruce (*Picea sitchensis*), Norwegian Spruce (*Picea abies*) and Douglas Fir (*Psendorsuga menziesii*). Scots Pine (*Pinus sylvestris*) and various Larch (*Larix*) species and subspecies are available in significant quantities. Other softwood species are also available. The only Scottish grown hardwood which can be conventionally strength graded for structural purposes is European Oak (*Quercus petraea and Quercus robur*). A useful guide to the properties of the key species is the Wood Information Sheet WIS 2/3-67 'Specifying British Grown Timber' 2017.

The quality of Scottish timber, both in terms of durability and strength, can vary quiet markedly between different areas. Some pockets of Scotland produce phenomenal timber, for example Morayshire, where the Föhn Effect results in dry, cool conditions that make for strong, durable, straight stock – similar to some of the timber that comes from alpine regions, Scandinavia and the Baltic. It is also worth noting that structural properties of the timber that becomes available of the coming decades may alter due to climate change.

Drying Timber and Using Green Timber

Kiln drying timber is an energy intensive process which, depending on the energy source, can have a substantial impact on the embodied carbon of construction timber. Alternative drying processes include air drying and 'solar kilns'. Both processes result in significantly reduced embodied carbon but are not currently widely used for commercially available timber. This may change in the near future. Green timber is available directly from sawmills in sizes of up to around 400mm x 450mm in 6m+ lengths. Eurocode 5 allows for the design of green timber, assuming service class 3 (moisture content >20%). However, care should be taken to consider the qualitative behaviour of specific species (i.e. how they will shrink and creep during the drying process and any subsequent wetting cycles), in addition to undertaking the relevant structural calculations.

Structural Grading

Machine grading is used widely in the commercial, high volume sawn/machined structural timber market. Visual grading of softwood can be done in the UK to BS4978, with two grading assignments GS (General Structural) and SS (Special Structural). For oak (BS 5756) the gradings are TH1, TH2, THA and THB. Visual grading comes into its own for large sections which machines aren't designed or calibrated for, and for small batches of timber. You don't need to be a structural engineer to visually grade timber but you do need to be trained and certified by a licensed body such as BM TRADA. The company that supplies the timber must also be certified. For a detailed discussion of the fundamental differences between machine and visual grading refer to Dan Ridley Ellis's presentation on "Strength Grading of Scottish Timber in 2019" at the Centre for Wood Science and Technology, Edinburgh Napier University.

As noted above, the only hardwood grown in Scotland that has a grading standard is oak. However, in principle the strength and stiffness of other hardwoods (and indeed unusual softwoods) can be calculated and designs justified using testing data. A good source of data for timber grown in the UK is 'The Strength Properties of Timber' by Gwendoline M Lavers, BRE. Another document that can be used as guidance when assessing the strength and stiffness properties of hardwoods is the superseded standard CP112 "The structural use of timber Part 2" which covers a greater range of domestic timbers than the current standards.

Durability

The risk of fungal and insect attack to timber in Scotland is highly dependent on the moisture content, which should remain below 20% to minimise the risk. Where such a risk exists the necessity for timber preservatives (or other form of bioremediation) needs to be considered in relation to the natural durability of the timber and the exposure of the timber to moisture. A simple model of the risks due to the presence of moisture is outlined in BS EN 335. Five 'use' categories (1-5), taking into account construction detailing, are used in conjunction with the species specific 'natural durability' of the timber heartwood (1-5) to define a design life without any bioremediation. More sophisticated models can be used and are being developed. (Refer to 'Design life for wood and wood based products' by TRADA). Interestingly for the Scottish context, research in Scandinavia provides evidence that lower air temperature can quantifiably reduce the risk of fungal attack. Whether or not the BS EN 335 calculations are undertaken, there should be separate structural calculations as outlined in Eurocode 5, taking into account the moisture content of the timber.

It is commonly accepted that all softwood timber in construction must have some preservative treatment (bioremediation) and in practice it can be difficult to source untreated structural timber of standard sizes in Scotland - certainly in comparison to other parts of Europe. However, that does not mean that from a technical standpoint timber preservative are necessary in many instances provided that the construction details are well considered. Prior to 1940, there was virtually no timber treatment, and anecdotally we can see that many old softwood timber buildings have survived.

The timber preservatives used in Scotland's sawmills are varied and it can be difficult to find out what chemicals are in fact used. It would appear that in practice suppliers are not obliged to provide information on the preservative treatments that are used at point of sale. Information is often limited to 'yellow', 'green' and 'brown' indicative of the degree of protection provided. Information on the permitted treatments are provided by the Wood Protection Association.

The designing out of wood preservatives should be considered as a design objective. Most permitted wood preservatives are not entirely benign to people or the environment. Further information on the less toxic alternatives, if necessary, can be found at greenspec.co.uk.

It should be noted that timber grading includes assessment for the presence of rot and insect attack.

The risk of the moisture content of timber increasing to a level above 20% is highly dependent on how a building is detailed. Timber within building fabric which is to a greater or lesser extent 'breathable' or 'sweatable' is more likely to remain with a low moisture content. As a result, the risk of timber decay in a building must be assessed with reference to the performance of the building fabric as a whole.

Round-pole Timber

It is a good discipline to consider the appropriateness of using timber in its natural unprocessed state in the first instance. A 'pole' retains structural properties lost when sawn up and is inherently less subject to warp and wane. Having said that the research, (certainly in the UK) into the structural behaviour of round-pole members and structures is limited. There is a knowledge gap, as confirmed by TRADA, who receive regular queries regarding the use of round-pole timber. From a calculation and grading perspective, it is common practice to fall back on our understanding of sawn timber sections by imagining a rectangular beam placed within the circular cross section. This conservative approach clearly does not quantify the benefits of the uncut circumferential fibres. There are US ASTM standards for round pole construction but these should be used for guidance only given the different species and growing conditions in North America.

It should be borne in mind that there can be good technical (as well as cultural reasons) why round-pole timber members are not appropriate. Generally, when a sealed building element is to be formed or there are complex material interfaces, the approximately curved surface of a round-pole in combination with moisture movement can cause practical problems, which can be avoided with more conventional construction.

Oak Structures

The following documents are recommended for a good overview of specific structural engineering challenges and opportunities of both traditional and contemporary oak structures.

- "Green Oak in Construction" by Ross, Metten and Holloway. TRADA 2007.
- "What Designers need to know about Timber Framing" by Holloway. The Green Oak Carpentry Company Ltd.

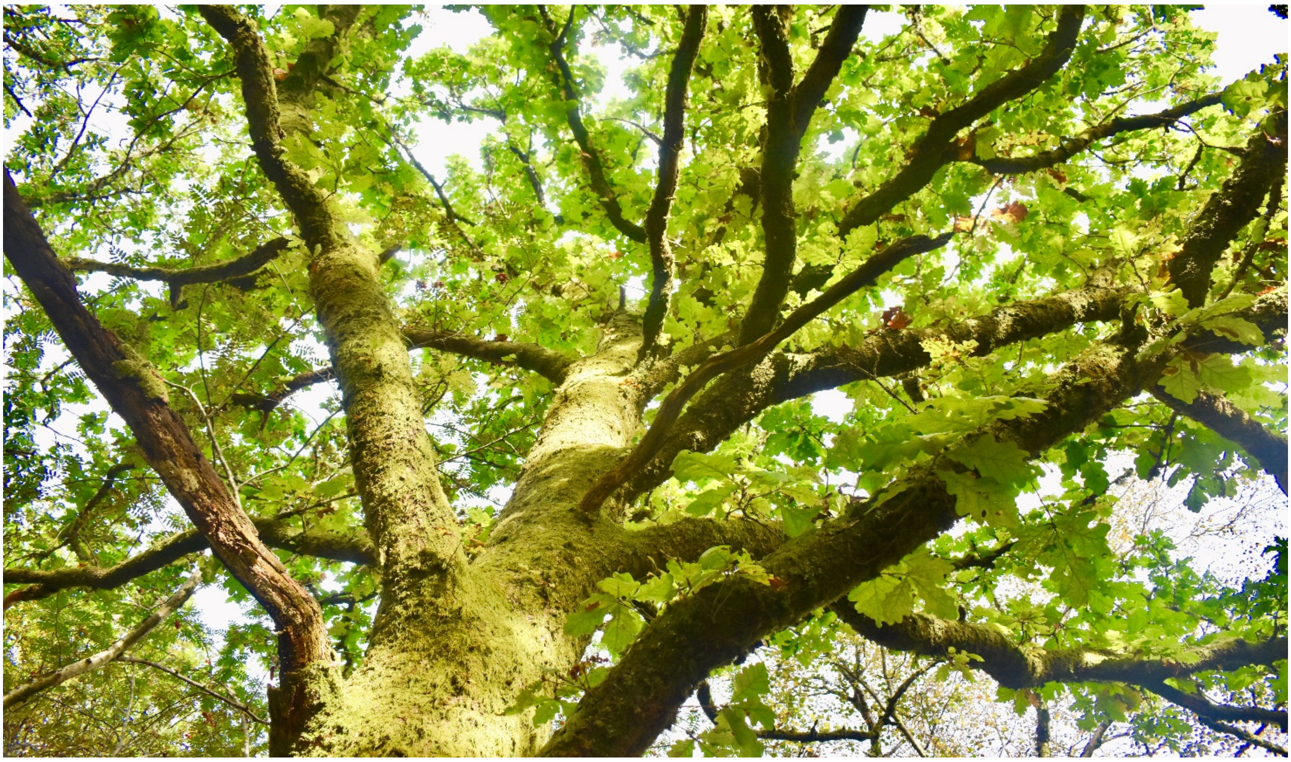

Figure 2. Sessile Oak (quercus petraea) in ancient woodland on the Kelly Burn, North Ayrshire. (Photo: Tom Hay)

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