Implications for Forecasting Stiffness

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Acoustic Tools

Acoustic tools have been used worldwide for a number of years for assessing wood properties. New developments have produced robust, ruggedized systems with increased accuracy, which can predict the stiffness of timber, either in standing trees or in logs. Examples of acoustic instruments are illustrated in Figure 1 and Figure 2. The instruments are manufactured by Fibre-gen, New Zealand and Fakopp Instruments, Hungary respectively but a number of other manufacturers exist.

The machines work by measuring the acoustic velocity in the wood and this is related to the stiffness of the wood through the relationship:

$$E = \rho V^2$$

where E is the dynamic modulus of elasticity (N m^{-2}), ρ is the mass density of the wood (kg m^{-3}) and V is the speed of sound (m s^{-1}).

Figure 1: Fibre-Gen acoustic tools for measuring timber stiffness in standing trees (left) and logs (right)

Figure 2: Fakopp Instruments acoustic tools for measuring timber stiffness in standing trees (left) and logs (right)

Variability in Stiffness

Due to the inherent variability in wood properties between forests, between trees, and within a log, approximately 20% of processed spruce sawn timber fails to meet the minimum requirements for the C16 grade. This is generally due to the timber failing during stress grading because it is too flexible (has too low a value of stiffness). There are substantial financial and environmental costs associated with downgrading such material; downgraded timber is sold at a lower price for alternative non-structural uses, such as biofuel, pulp, fencing, box making or pallets. Such inefficiency increases operating costs since trees are normally processed and the timber kiln-dried before it is strength graded. In addition knowledge of the quality of the forest resource is crucial for making informed sawmill investment.

The new generation of acoustic tools available on the market for measuring the stiffness of standing trees, logs and sawn timber allow lower stiffness material and stands of lower average stiffness to be identified. The technology is widely used in Australia, New Zealand and the US but has only recently been taken up by the UK forest industry. However, the initial results have shown that they have real value as a means of providing information on the within and between site variation in timber stiffness (Figure 3). In addition the measurement of stiffness in standing trees and logs has been found to be well correlated to sawn timber performance in the sawmill when the timber is graded.

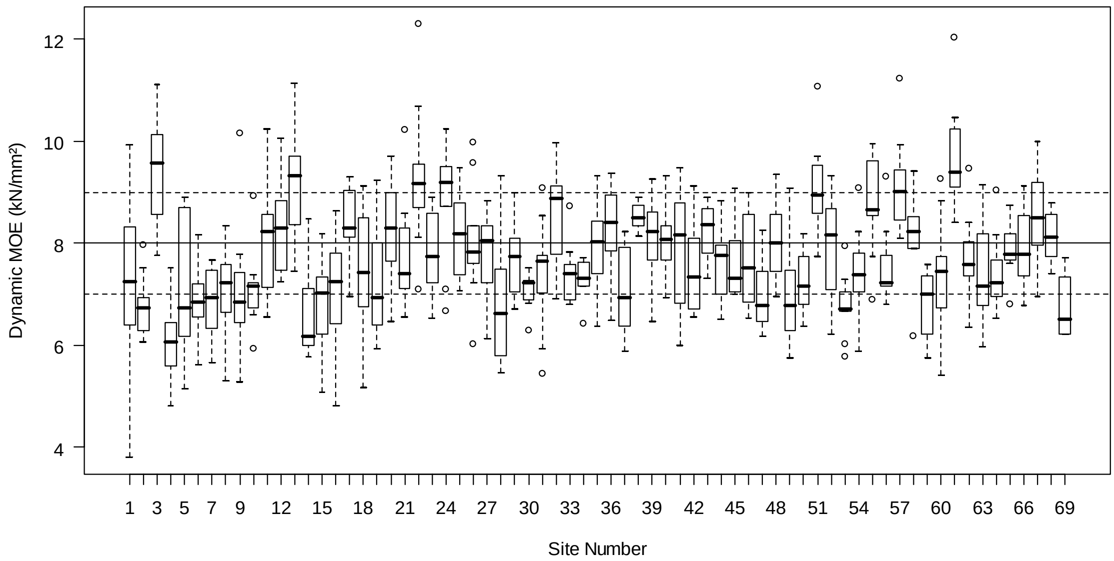

Figure 3: Variation in stiffness of standing Sitka spruce from 69 sites across Scotland and Northern England.

Forecasting Stiffness

The variation in stiffness shown in Figure 3 is for a relatively limited number of stands within Scotland and Northern England. It indicates that even though there is always a large variation of timber stiffness from tree to tree in a stand there is still significant variation from stand to stand. This stand to stand variation has been related to a number of factors, principally elevation, yield class and initial spacing. However, further measurements need to be made to confirm and validate these findings. In particular a wider range of site latitude is required and additional measurements will be carried out in the next 2 years from Borgie in Sutherland to Devon. The field measurements will be complemented by laboratory tests of the strength and stiffness of sawn timber from trees extracted from a number of sites in order to correlate measurements of stem stiffness with sawn timber performance.

The models described above would be able to forecast the distribution of stiffness in Sitka spruce across the UK in a similar way to the planned forecast of stem straightness in the next Production Forecast. This would enable a forecast of timber stiffness in addition to volumes, product breakout, and stem straightness. The work validating the stiffness models will be completed within 2 years.

Adding Stiffness Measurements to the National Inventory

The next National Inventory will provide measurements of conifer volumes and stem straightness. While this will provides valuable information on the volume and breakout of timber that can be recovered, it will not provide any indication of the mechanical properties of the resource. Adding a measurement of acoustic velocity and therefore timber stiffness would be extremely helpful for informing the sawmilling industry of the likely variation in sawn timber performance. It would also add to the sampling being carried out in the previous section, improve the validity of the forecast models and extend the measurement of stiffness to other conifer species (e.g. pine, Douglas fir and larch).

The cost of the portable acoustic tools required for such measurements is from £2000-£5000 and the approximate time for measuring each tree is 2 minutes.