# Variation in Timber Strength of Fast Grown Unthinned Sitka Spruce in Northern Ireland

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## Summary

Timber from six unthinned stands of Sitka spruce (*Picea sitchensis* (Bong.) Carr.), of general yield classes ranging from 20 to 24 m³/ha/year, and established at spacings of 1·5-2·0 metres, was machine stress graded to determine the amount of timber sawn to structural sizes that attained BS 5268 Strength Classes (SC) 3 and 4. The stands were derived from seed from at least two North American sources. Although there were some differences between stands related to provenance, none was statistically significant. Within the range of conditions tested, yields of SC4 structural timber obtained varied between 24% and 57% of battens tested, the differences being primarily related to local yield class. Yields obtained of SC3 timber ranged from 36% to 69% of battens tested, and between 3% and 9% of battens did not meet the machine grading requirements of SC3 or SC4.


## Introduction

This study was initiated in order to supplement results obtained from tests on timber from a Sitka spruce spacing experiment at Loughermore, Co. Londonderry, conducted during 1984 by the Building Research Establishment and the Forestry Commission (Hands, pers. comm). The tests showed that timber from all spacings sampled was weak in comparsion with that tested from spacing experiments in Britain. Previous tests on timber grown in Northern Ireland had shown that it was of comparable strength to that specified in BS 5268 for British grown Sitka spruce (Taylor, 1982).

The stand at Loughermore, planted in 1956, was of higher than average growth rate (GYC 22), whereas timber previously tested had come from older, slower growing stands that had been thinned. Records indicate that the stand at Loughermore originated from seed purchased in 1953 from a merchant based on Vancouver Island.

The aims of this study were to determine whether the results obtained from Loughermore are atypical, and relate to peculiarities of site and provenance, or whether they are representative of all Sitka spruce timber derived from high yield class unthinned plantations. It should be acknowledged that

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**Table 1:** Sample Plot Measurments

| Site | Top Height (m) | General Yield Class ($m^3$/ha/yr) | Basal Area ($m^2$ha) | Standing Volume to tdob ($m^3$/ha) 7cm | Standing Volume to tdob ($m^3$/ha) 14cm | Stocking (Stems/ha) Initial | Stocking (Stems/ha) Current | Top Height Form Factor | Mean Volume ($m^3$) Plot | Mean Volume ($m^3$) TST | Local Yield Class ($m^3$/ha/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ballintempo | 18·6 | 20 | 58·6 | 502 | 301 | 4565 | 2775 | 0·46 | 0·18 | 0·29 | 24 |
| Springwell | 18·8 | 22 | 51·2 | 425 | 262 | 3019 | 2475 | 0·44 | 0·17 | 0·31 | 22 |
| Tully (A) | 21·0 | 24 | 57·1 | 487 | 331 | 3019 | 2225 | 0·41 | 0·22 | 0·37 | 24 |
| Washington/ Oregon Mean | 19·5 | 22 | 55·6 | 477 | 320 | 3534 | 2492 | 0·44 | 0·19 | 0·32 | 23 |
| Tully (B) | 17·3 | 20 | 56·2 | 369 | 237 | 3673 | 2525 | 0·38 | 0·15 | 0·24 | 18 |
| Conagher | 21·3 | 24 | 75·7 | 618 | 438 | 3858 | 2925 | 0·38 | 0·21 | 0·35 | 26 |
| Loughermore | 19·1 | 22 | 79·1 | 657 | 556 | 2403 | 2041 | 0·43 | 0·32 | 0·37 | 28 |
| Vancover Island Mean | 19·2 | 22 | 70·3 | 540 | 398 | 3311 | 2497 | 0·40 | 0·22 | 0·32 | 24 |
| Overall Mean | 19·3 | 22 | 63·0 | 511 | 346 | 3423 | 2494 | 0·42 | 0·20 | 0·32 | 24 |

the majority of Sitka spruce plantations in Northern Ireland are not thinned owing to risk of windthrow (Phillips, 1980).

This paper presents results obtained from testing of timber from Loughermore forest and five other stands, two of which, at Conagher and Tully forests, were grown from the same seed lot as at Loughermore, the remaining three, at Ballintempo, Springwell and Tully forests, being grown from seed obtained from an Oregon based merchant. The implications of the results for silviculture and management of Sitka spruce on fertile sites susceptible to windthrow are discussed briefly.

The work was carried out by the Department of Building, University of Ulster. The timber was processed and tested at Ballycassidy Sawmills, Enniskillen, Co. Fermanagh (Gawn, 1986).

**Selection of Stands**

Stands were identified for possible testing on the basis of seed lot number, planting year and top height. Visual inspection showed that some stands, including that at Loughermore, were characterised by generally poor stem form and heavy branching. In the others, stem form was better and branching finer. It was not possible to ascribe seed lot numbers to all the stands falling into the latter category because records had been lost. However they fulfilled the main criteria for testing, being of high growth rate and of a different seed origin to that at Loughermore, and were most probably of Washington or Oregon provenance.

**Selection of Sample Trees for Testing**

In each selected stand, plots of 0·04 ha were marked out, avoiding edges and patches of windthrow, and the diameter at breast height (dbh) of all trees within was measured. Fifteen timber sample trees (tst's) and five volume sample trees (vst's) were systematically selected from across the dbh range, constraints being that tst's would represent stems of dbh greater than 18cm and vst's greater than 18cm and less than 7cm. Forked stems were to be rejected, but this did not prove necessary. Timber sample trees and vst's were felled and measured; measurements were used to derive standing volume to 7cm and 14cm top diameter overbark (tdob), form factor and local yield class. Top height was taken as the mean height of the four largest dbh stems per plot.

**Conversion and Machine Stress Grading**

Timber sample trees were cross cut in order to yield the maximum number of sawlogs of 14cm or greater top diameter underbark (tdub); these were graded according to Forestry Commission/Home Timber Merchants Association rules, and additionally to the Biological Grading System proposed by the Forestry Commission and Building Research Establishment (FC/HTMA, 1983). This applies the same criteria except that restrictions

**Table 2:** Sawlog Characteristics and Batten Properties

| Site | %Structural Timber/ Volume 14cm tdob/ha | % Select Grade Logs | Mean Knot Size (mm) | % Juvenile Core | No. of Battens | % SC3 Battens | % SC4 Battens | Mean Ring Width (mm) | Oven Dry Density (kg/m³) |
|---|---|---|---|---|---|---|---|---|---|
| Ballintempo | 19·5 | 73·3 | 19·6 | 58·1 | 44 | 36·4 | 56·8 | 7·16 | 386 |
| Springwell | 24·5 | 46·5 | 19·5 | 52·6 | 56 | 48·2 | 42·9 | 7·66 | 399 |
| Tully (A) | 23·6 | 46·9 | 23·2 | 53·7 | 78 | 46·1 | 51·3 | 7·99 | 387 |
| Washington/ Oregon Mean | 22·5 | 55·6 | 20·8 | 54·8 | 178 | 43·6 | 50·3 | 7·60 | 391 |
| Tully (B) | 23·1 | 7·7 | 27·9 | 57·1 | 47 | 38·3 | 57·4 | 7·10 | 414 |
| Conagher | 21·1 | 33·3 | 19·5 | 52·6 | 55 | 58·2 | 36·4 | 7·99 | 411 |
| Loughermore | 32·9 | 45·7 | 18·9 | 63·3 | 80 | 69·0 | 24·0 | * | 399 |
| Vancover Island Mean | 25·7 | 28·9 | 22·1 | 57·7 | 182 | 55·2 | 39·3 | 7·54 | 408 |
| Overall Mean | 24·1 | 42·2 | 21·4 | 56·2 | 60 | 49·4 | 44·8 | 7·58 | 399 |

* Missing value

on top diameter are removed. Mean knot size was determined from whorls falling on either side of the mid length point of each sawlog. Sample discs were taken from the base of all sawlogs prior to measurement for determination of oven dry density; percentage juvenile core was assessed from the diameter to the 12th ring of second log discs. On conversion the yield of structural timber for strength testing was maximised by varying the depth of battens, with an optimum width of 44mm, between 75, 100, 125 and 150mm; processing to standard 100 × 50mm battens would have resulted in lower yields and excessive waste. Battens were then kiln dried down to an equilibrium moisture content of 16-18%, and planed down to size prior to stress grading. A Cook Bolinder stress grader was used, with separate runs for each strength class (Home Grown Timber Research Committee, 1984; Building Research Establishment, 1973 & 1984). Mean ring width of each batten over four ring widths was measured when stress grading had been carried out. A total of 360 battens suitable for stress grading was obtained following drying. The number obtained for each site varied from 44 to 80. Battens were stress graded without regard to visual grading.

**Results**

Plot measurement and results from timber testing for all five sites sampled are shown in Tables 1 and 2, together with plot measurements and timber testing results for the closest spacing at Loughermore (by courtsey of the Forestry Commission and Princes Risborough Laboratories). A partial correlation matrix of results is given in Table 3.

**Table 3:** Partial Correlation Matrix of Results

| | | **% Structural Timber 1** | **% SC4 Battens 2** |
|---|---|---|---|
| % Structural timber | 1 | – | |
| % SC4 battens | 2 | -0·75 | – |
| Local yield class | 3 | 0·43 | -0·76 |
| Mean tst volume | 4 | 0·45 | -0·69 |
| Initial stocking | 5 | -0·88* | 0·65 |
| % Juvenile core | 6 | 0·65 | -0·34 |
| % Select grade logs | 7 | -0·10 | -0·03 |
| Oven dry density | 8 | 0·06 | -0·19 |
| Mean ring width† | 9 | -0·29 | -0·76 |
| Mean knot size | 10 | -0·20 | 0·62 |

† Excluding Loughermore

* Significant at p = 0·05

Differences related to seed origin are not significant, although the wide variation in local yield classes observed between stands of the same provenance was not anticipated when they were selected. Results from log grading under the biological grading system are also shown; since top diameter restrictions are removed, straightness is the most significant reason for downgrading.

On average, 44.8% of battens attained SC4, compared to 24% from the closest spacing at the Loughermore site. Six percent (range 3% – 9%) of battens failed to meet the machine grading requirements of SC3 or SC4, the remainder being of SC3. There was no discernible trend between provenances or sites in the percentage of battens rejected, although a considerable proportion of the SC4 and SC3 battens obtained would be rejected on visual grading, owing to the presence of wane.

**Discussion**

The results from the tests described demonstrate that the low yield of SC4 timber from Loughermore is not likely to be representative of all unthinned Sitka spruce of equivalent age (28 yr) and GYC 22, planted at spacings equivalent to 1·5-2·0m. They also demonstrate the variation in timber strength occurring between apparently similar stands.

The average yield of SC4 timber obtained is low compared to published results from tests performed in timber from unthinned stands in Britain, which were considerably older and of lower yield classes (Brazier and Hands, 1985; Hands, 1985). However it is important to note that only a small pecentage of battens failed to meet the requirements of SC4 or SC3; the major limitation of the stands tested is the low yield of structural timber obtained on conversion. The results show that the yield of structural timber is related to factors influencing or affected by average tree size. However the absence of any strong correlation (except for the negative correlation with initial stocking) suggests that relationships are obscured by the small size of the majority of sawlogs obtained.

While there are broad differences between sites in terms of the yield of SC4 battens the results obtained indicate that, in order to effectively evaluate the significance of factors influencing timber strength, it would be necessary to sample a wider range of site conditions and to ensure that more battens (80-120) are obtained for machine stress grading from each location. The absence of any significant correlation between timber strength and mean knot size, the percentage juvenile core or oven dry density also may be an effect of comparatively close spacing in all stands. Multiple regression shows that within the range of conditions tested, timber strength is predominately related to initial stocking and local yield class; the relation is described by the equation:

$$\% \text{ SC4 timber} = 73{\cdot}6 - 2{\cdot}37 \times \text{local yield class} + 0{\cdot}00797 \times \text{Initial stocking}$$

($r = 0{\cdot}88$, significant at $p = 0{\cdot}05$).

This implies that, at an inital spacing of 2·0 metres and typical yield classes, no more than 60% of structural timber from unthinned Sitka spruce stands of equivalent height is likely to be SC4. The yield of SC4 timber is most probably limited by the high percentage of juvenile wood in all the samples, a consequence of the relative immaturity of the stands from which timber was tested.

Currently 56% of the underbark cross sectional area of sawlogs in the stands sampled is assessed as juvenile core, at an average top height of 19·3m and average tree size of 0·21m$^3$. Using published yield models (Edwards and Christie, 1981) and calculated factors to account for differences in standing volume and stocking to predict changes in crop structure, the indications are that at a top height of 24·3m, juvenile core material is reduced to 32% of mean cross sectional area, equivalent to 4-5% for every metre gained in top height. Consequently, if the high proportion of juvenile material in stands tested is a significant factor contributing to low yields of SC4 material, silvicultural practices promoting stability, and thereby allowing longer rotations, are of great importance (Brazier, 1986; Senft, 1986).

Since the yield of structural material is related to average tree size it can be influenced by thinning. Moreover, any selective thinning operation which seeks to remove crooked or deformed stems will patently have an effect in terms of improving timber quality throughout the stand (Hands, 1985). Thinning will also lead to the formation of more wood with mature characteristics relative to juvenile wood in sawlogs, albeit with wider ring widths compared to mature wood in sawlogs from unthinned stands. It would therefore be inappropriate to consider the effects of thinning on timber strength in isolation from factors already discussed.

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