Variation in yield of strength graded timber due to board origin

Audun Øvrum

Norsk Treteknisk Institutt (NTI), P.O. Box 113 Blindern, NO-0314 Oslo, Norway, audun.ovrum@treteknisk.no

Keywords: forest variation, grade yield, strength grading

ABSTRACT

Normally strength grading is done on batches of timber without any information about the origin of the boards. The yield from the strength grading machines is hence accepted, and there is rarely any active pre grading of batches or logs to increase the yield of high grades. Different batches of timber will evidently vary in yield of different grades, but no active investigation is normally done on this matter due to the large area saw logs are purchased from. Also it is very difficult to track boards backwards towards origin in an industrial saw mill today. In this investigation a batch of timber where all data from the stand, the trees position in the stand and the boards position in the tree where collected, and linked to the strength grade of the boards given by a Dynagrade machine. The stands were sampled after fertility and general forest quality, with site indices ranging from G11 to G23. The results show that there is a great variation in yield of strength grades from timber from different stands even in stands in very close proximity to each other. An assessment of the forest quality before logging showed very good correlation with the yield in high strength classes and indicates a possibility of pre-sorting in the forest.

INTRODUCTION

The later years work has been done on making models for the strength properties in boards based on log parameters (Brännström, Oja *et al.* 2007; Jäppinen 2000; Oja, Grundberg *et al.* 2001). Jäppinen (2000) found that through a pre-sorting of logs based on variables from a 3D scanner the yield of glulam lamellas could be improved significantly. Oja et.al. (2001) found that data from an X-ray logscanner could give good indications about the stiffness in the centre boards graded by a Cook-Bolinder machine. Brännström et.al. (2007) found that an X-ray logscanner predicted the strength in centre boards with the same accuracy as a standard strength grading machine (Goldeneye 702). In Norway strength grading is done on saw falling batches of timber and no pre-sorting based on 3D scanners or X-ray scanners are done. In this way there exists no information about the origin of the boards and the yield from the strength grading machines is hence accepted. Different batches of timber will evidently vary in yield of different grades, but no active investigation is normally done on this matter due to the large area saw logs are purchased from in big saw mills. Theories about reasons for the variation exists of course but it is very difficult to track boards back towards origin in an industrial saw mill today, and no formal investigations on this matter has been performed. (Chrestin 2000) found that Norway spruce timber from the mountainous regions in northern Sweden had lower values for mechanical properties, while timber from central Sweden and some parts of southern Sweden had higher values for mechanical properties. The mechanical properties was the modulus of elasticity measured by a Cook-Bolinder machine, the modulus of elasticity tested after EN 408 and the bending strength tested after EN 408. In this study the aim is to discover the variation in strength grade, i.e. the modulus of elasticity measured by a Dynagrade-machine, within a specific region, based on a sampling that covers normal forest stands from the worst to the best case scenario for a typical Norwegian saw mill.

MATERIALS AND METHODS

This study comprises 586 boards which are originating from 108 trees extracted from six different forest stands. The stands were sampled after fertility and general forest quality, with site indices ranging from G11 to G23 in the H40 system used in Norway (Tveite 1971). All stands were situated within the same geographic region within a maximum distance of 16 km between two stands. In each stand all trees within a specific area were cross measured at breast height and ranked by diameter. The trees were then grouped in three groups defined as dominant, co-dominant and suppressed. Within each group 6 trees were randomly selected resulting in 18 sample trees from each stand. The trees were cross-cut in fixed lengths of 4 m or 6 m. The logs were divided according to Nordic practice with a splitting of the log in the middle with a saw cut –heart splitting. The dimensions ranged from 38 x 100 mm^2 to 50 x 225 mm^2, and dimensions were given by the sawing pattern giving the maximum sawing yield from each log. The boards were then dried by yard seasoning for two years giving a moisture content of about 18 % at the time of grading. Finally they were machine strength graded by a Dynagrade, which is the most common machine for strength grading in Norway. The Dynagrade measures the resonance frequencies originating from a strike by a metal hammer in the end of the board. Together with the length measured by a laser the machine calculates the dynamic modulus of elasticity (E_{dyn}). This E_{dyn} is correlated to the strength of the boards resulting in an allocation of boards in to strength classes. The borders for the different strength classes are set after the requirements in EN 519 or EN 14081, but in this study the E_{dyn} is used directly as an expression for board strength.

RESULTS

Table 1 shows the data from the different stands with the yield from the strength grading included.

Table 1. Sample size and strength properties in the different stands

Stand	No. of boards [n]	Site index	Forest quality	Altitude [m]	E_{dyn} (st.dev)	Grade yield [%]			
						C30	C24	C18	Reject
1	122	G17	Medium	450	5 710 000 (1 070 436)	20	48	30	2
2	104	G20	Good	470	6 496 935 (867 464)	53	43	3	1
3	76	G17	Medium	620	5 948 421 (927 472)	17	70	9	4
4	64	G11	Poor	630	5 250 781 (780 893)	3	48	33	16
5	146	G23	Good	350	6 627 671 (603 437)	59	38	3	0
6	64	G11	Poor	770	5 096 563 (1 636 775)	32	48	16	4
Total	576				5 996 910 (1 121 127)	32	48	16	4

A stepwise regression was performed, and the following variables were tested:

- Status of tree in stand (SUPPRESSED, CO-DOMINANT and DOMINANT)
- Log type (BUTT log or not)
- Type of board (INNER, which is the centre boards closest to the pith and OUTER which is all other boards)
- Forest quality (divided in GOOD , MEDIUM and POOR by a general assessment before logging)
- Altitude (meters above sea level)

The variables forest quality, status of the tree in a stand and log type were significant contributors to the fitted model with a significance level of 5 %. The model gave R^2= 25,5 % and RMSE=970 333 and gave a residual plot with no specific trends indicating that the model describes the variance quite well. The parameter estimates are shown in Table 2.

Table 2. Parameter estimate for the regression model for E_{dyn}

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	5 893 971	47 097	125,15	0,0000
Tree status[Co-dominant]	106 545	61 753	1,73	0,0850
Tree status[Dominant]	-150 279	56 291	-2,67	0,0078
Forest quality[Good]	704 934	56 227	12,54	<,0001
Forest quality[Medium]	-43 402	58 184	-0,75	0,4560
Butt log	-33 556	42 365	-0,79	0,4287

DISCUSSION

A general assessment of quality in a stand before logging showed very high correlation with the yield of strength graded timber. The stand giving most C30 with 59 % of the total of boards graded (stand 5) was assessed as the stand with the highest quality before logging, while the stand giving least C30 with 3 % of the total of boards graded was assessed to have a poor quality. The assessment of the "goodness" before logging consisted of several parameters, the most important being frequency of top ruptures from snow and other influences, and taper. All logs from the trees were used as long as they satisfied the demand for minimum dimension, which in this case was 13 cm outside bark and did not have rot or excessive sweep which made them impossible to saw in a standard sawing machine. This implies that many of the logs from the poor sites will not be classified as saw logs since the log quality will be poorer than the grading rules for saw logs allows. Large knots and knot groups are possibly much of the reason for the great differences between stands.

The effect of the status of a tree in a stand was significant, but not very important but showed that at least dominating trees had a lower E_{dyn} than the co-dominant and suppressed trees. This is probably due to the larger knots in dominant trees, and the larger annual ring widths which will give lower density.

A significant lower grade in butt logs is somewhat surprising, and contradicts results from other studies (Blomqvist and Nylinder 1988a; Blomqvist and Nylinder 1988b; Høibø 1991) who found better quality in butt logs than in the rest of the stem. The effect was however quite small, and may be caused by coincidences, but the fact that this study comprises all logs and not only classified saw logs might be a factor in this case. This study is only a first screening of this data, and further studies will hopefully give more consistent and significant results.

CONCLUSIONS

Great differences between stands in strength properties were found in this study. This indicates that one can expect large differences in yield from strength grading in one saw mill even if the raw material are collected from a close proximity. Pre-sorting of logs by choosing stands which will give higher yields of high strength classes should therefore be of interest.

REFERENCES

Blomqvist H, Nylinder M (1988a) 'Samband mellan granstockars geometri, utbyte och kvalitet: resultat från provsågningar vid Rockhammars sågverk.' Sveriges lantbruksuniversitet, Institutionen för virkeslära, 202, Uppsala.

Blomqvist H, Nylinder M (1988b) 'Samband mellan tallstockars geometri, utbyte och kvalitet: Resultat från provsågningar vid Rockhammars sågverk.' Sveriges lantbruksuniversitet, Institutionen för virkeslära, 91-576-3573-0, Uppsala.

Brännström M, Oja J, Grönlund A (2007) Predicting board strength by X-ray scanning of logs: The impact of different measurement concepts. *Scandinavian Journal of Forest Research* 22:60 - 70.

Chrestin H (2000) Mechanical properties and strength grading of Norway spruce timber of different origins. In 'Proceedings from the World Conference on Timber Engineering'. Whistler Resort, British Columbia, Canada

Høibø OA (1991) Virkeskvaliteten til gran (Picea abies (L.) Karst) plantet med forskjellig avstand. Doctoral thesis, Agricultural University of Norway.

Jäppinen A (2000) Automatic sorting of saw logs by grade. Doctoral thesis, Swedish University of Agricultural Sciences.

Oja J, Grundberg S, Grönlund A (2001) Predicting the Stiffness of Sawn Products by X-ray Scanning of Norway Spruce Saw Logs. *Scandinavian Journal of Forest Research* 16:88 - 96.

Tveite B (1971) 'Site-index curves for Norway Spruce (*Picea abies* (L.) Karst.).' Meddelelser Norsk institutt for skogforskning, 33(1), Ås.