



WoodWisdom-Net

Comparison of four basic approaches in machine strength grading

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Topic of presentation

Comparison of four methods of determination of settings in machine strength grading:

1. Yield and strength (5 percentile, and 0.5 percentile) are compared
2. Methods are applied to GE 706 grading data at a sawmill with added simulated strength values



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Sawmill strength grading data

MiCROTEC GoldenEye 706 results at a Finnish sawmill
Oct 2008 - March 2009

Average properties of boards with different widths, $n = 150\ 000$ specimens. Numbers in parenthesis are mean values of numbers shown for all widths.

width in mm	n	$E_{dyn,mean}$ in N/mm ²	COV in %	ρ_{mean} in kg/m ³	COV in %	$f_{m,mod,mean}$ in N/mm ²	COV in %
75	17 334	12 800	17	461	11	43.4	22
100	53 473	12 800	16	460	10	42.6	22
125	13 829	12 700	16	449	10	41.7	22
150	42 609	12 500	17	447	11	42.3	22
175	7 867	13 000	15	461	9	43.8	20
200	22 900	11 600	17	423	10	39.2	24
225	16 065	10 600	18	401	10	35.6	27
all	156 743	(12 300)	(17)	(443)	(10)	(41.2)	(22)



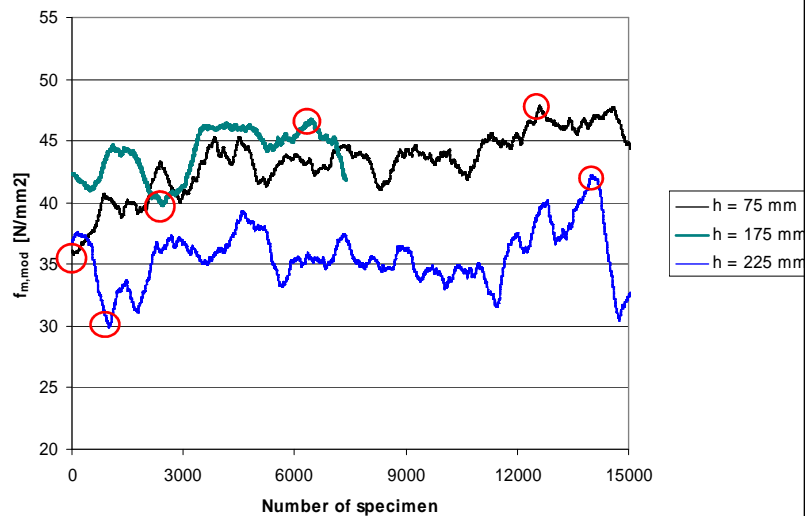
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Moving average of predicted bending strength of 500 consecutive specimens

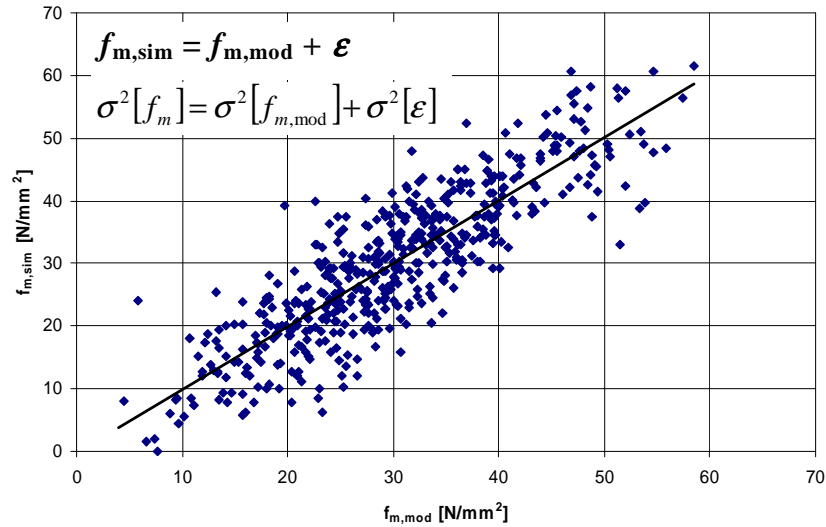


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Simulation of strength values of sawmill data



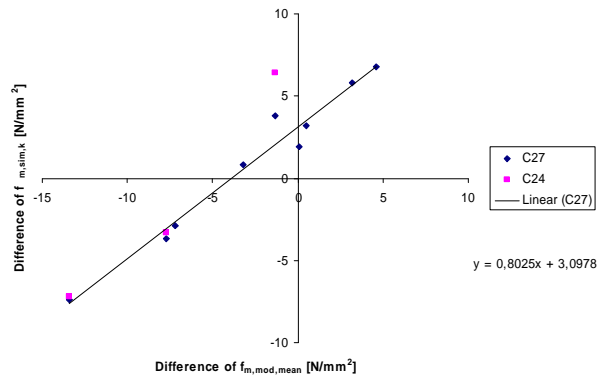
Methods to be compared

1. European machine control method (EN 14081-2 and -4)
2. "Input control method", settings of EN 14081-4 adjusted to IP of 100 previous boards on order to achieve required 5 percentile of strength
3. "Absolute method" based on confidence/prediction intervals, a zero-bandwidth method
4. Absolute method adjusted to 10 N/mm² bandwidth

Methods to be compared: Input controlled method

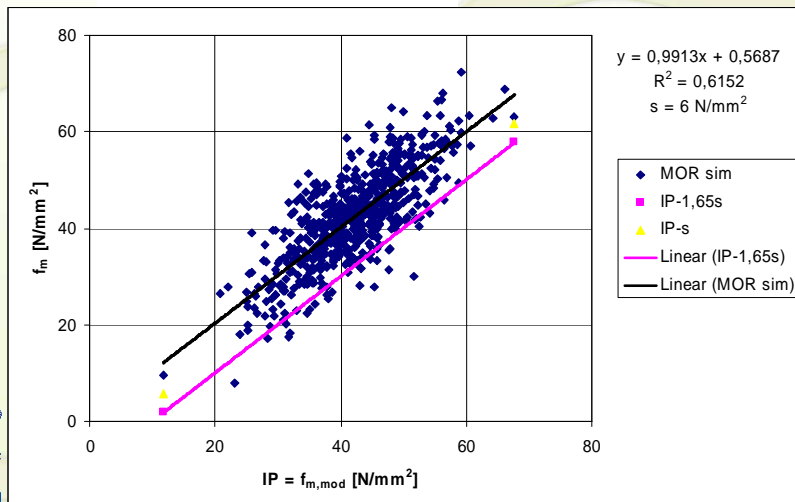
EN-settings are used with modified IP

$$f_{\text{mod,adj}} = f_{\text{mod}} - 0,8(f_{\text{mod,mean,ref}} - f_{\text{mod,mean100}})$$



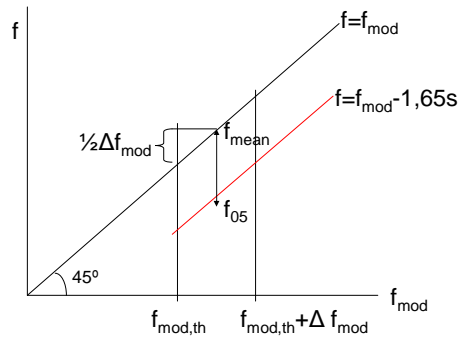
Methods to be compared: Absolute method: $f_{\text{mod,th}} = f_{05} + 1,65 s$

$$f_{m,sim} = f_{m,mod} + \varepsilon ; \varepsilon = N(0;s)$$



Methods to be compared: Adjusted absolute method

$$f_{\text{mod,th}} = f_{05} + S \text{ for } 10 \text{ N/mm}^2 \text{ bandwidth}$$



Settings used in examples for

IP-MOR ($f_{\text{m,mod}}$)

Grade	Settings		
	EN	$f_{05}+10$	$f_{05}+6$
C27	20.3	37	33
C40	48.9	50	46
C24	16.0	34	30

Dataset	Grade	$f_{m,05}$ [N/mm ²]				$f_{m,005}$ [N/mm ²]				Yield [%]			
		EN	EN adj	f_{05+10}	f_{05+6}	EN	EN adj	f_{05+10}	f_{05+6}	EN	EN adj	f_{05+10}	f_{05+6}
225 all low density	C27	20.4	24.0	31.7	28.6	12.6	16.4	25.7	21.5	90	87	45	60
	C40	41.2	44.3	50.3	39.3	35.5	39.1	36.6	34.7	8	3	6	12
	C24	18.1	21.5	28.9	19.6	10.3	13.9	22.0	12.0	89	86	51	81
175 all normal density	C27	27.3	27.4	33.1	30.9	18.3	18.6	26.8	25.3	99	99	79	90
	C40	42.8	41.2	43.9	40.1	36.8	36.1	37.5	33.6	27	31	23	40
	C24	25.7	25.5	30.1	27.6	17.0	17.0	25.1	22.6	73	69	65	55

1. EN 14081-4 settings gave acceptable 5 percentiles of strength for normal quality material sample, as expected, but too low values when low quality material was graded: 20.4 N/mm² for C27 and 18.1 N/mm² for C24. 0,5 percentiles were only half of the requirement for 5 percentiles of these grades.
2. When using **adjusted indicating property** based on previous 100 boards, 5 percentile values were improved to nearly acceptable level: 24.0 N/mm² for C27 and 21.4 N/mm² for C24 and 0,5 percentiles improved by 15 to 30 percent. For normal quality sample the adjusted EN-settings give practically same strength values and yields as EN-settings, except that for yield to C40 raises from 27 to 31 percent when using adjusted values.



CONCLUSIONS

3. **Absolute grading method** gives conservative strength values also when low quality material is graded and 0,5 percentiles are less than 10 % lower than nominal strength value given in C-class title.

4. When absolute method is **adjusted to 10 MPa** bandwidth, strength values are conservative for normal quality sample, but not in all cases for low density material, and yield to C40 raises from 23 to 40% for normal material, which is higher yield than given by adjusted EN-method (31%). The same time, yield to C24 is so much lower that we obtain 5% rejects, whereas EN-methods give 0% rejects.



SUMMARY TABLE OF CONCLUSIONS

Material quality	Settings	Yield [%] to C40&24	5-percentile	0,5-percentile C27,C24
Normal	EN 14081-4	100	OK	0.70
	EN adjust	100	OK	0.70
	Absolute	88	High	1.02
	Abs adjust	95	OK+	0.94
Low	EN 14081-4	97	Low	0.45
	EN adjust	89	OK	0.58
	Absolute	57	High	0.93
	Abs adjust	93	OK-	0.5...0.8

