Influence of local strength determining defects on grading machine settings based on dynamic measurements

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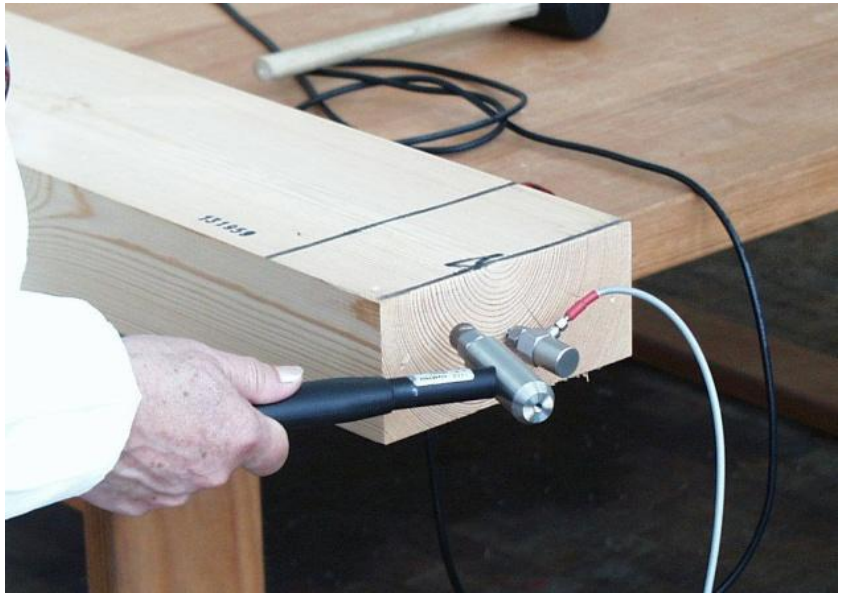
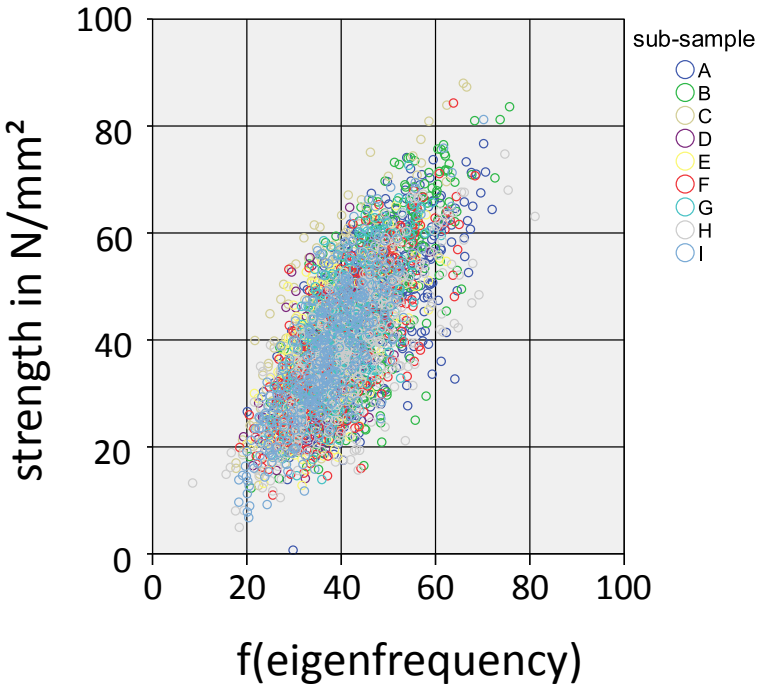
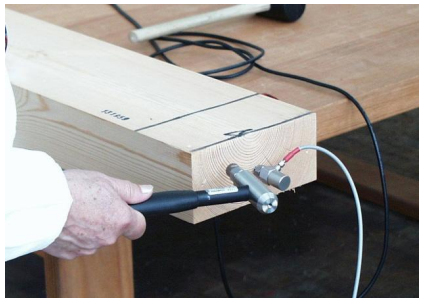
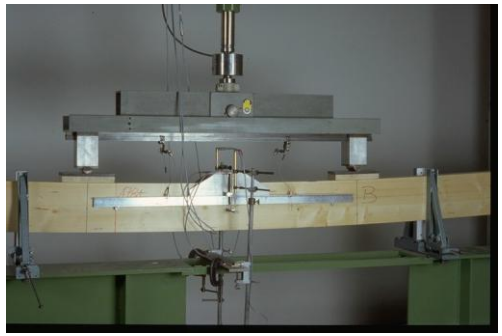
Sopron, Hungary, September 15th 2011




strength in N/mm²
f(eigenfrequency)
sub-sample
A
B
C
D
E
F
G
H
I
0
20
40
60
80
100

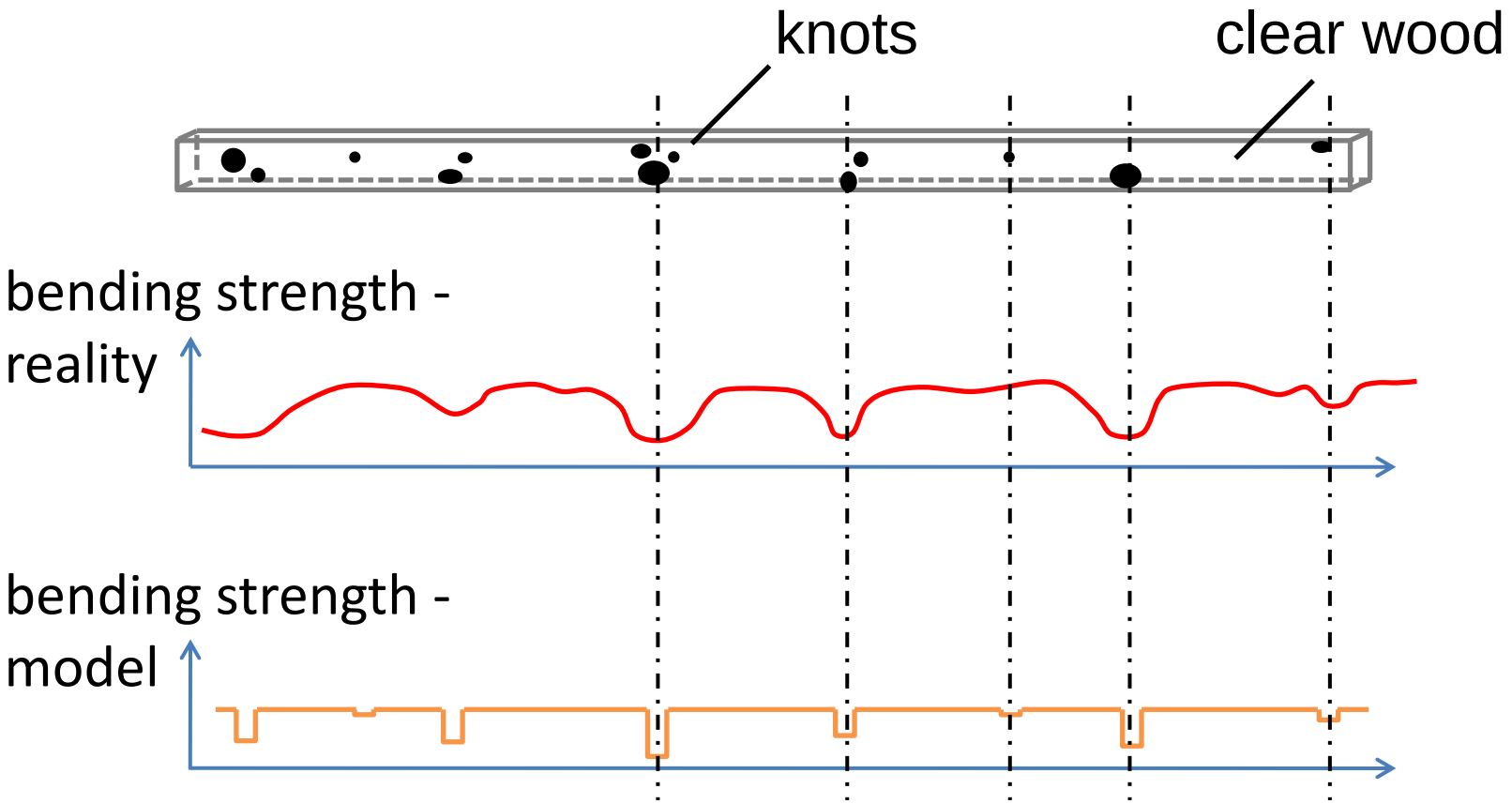




IP ⟷ **GDP**

is combined with

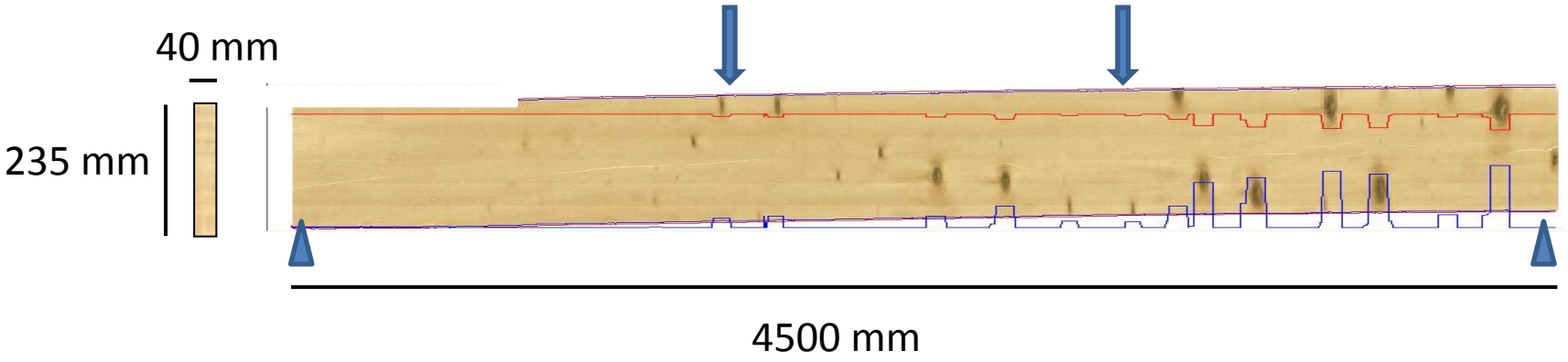
ID	IP_f	bending strength	static MOE	density
...	...	...	...	...
...	...	...	...	...
3200	25.7	23.0	7100	332
3403	35.9	50.3	10600	449
3533	45.4	42.0	11000	459
5142	56.8	38.1	13500	517
6238	56.7	69.0	15900	512



Riberholt, Madsen 1979

EN 384

"…a **critical section** shall be selected in each piece of timber. This section is the position at which failure is expected to occur, based on a **visual examination** and **any other information** such as measurements from a strength grading machine ..."

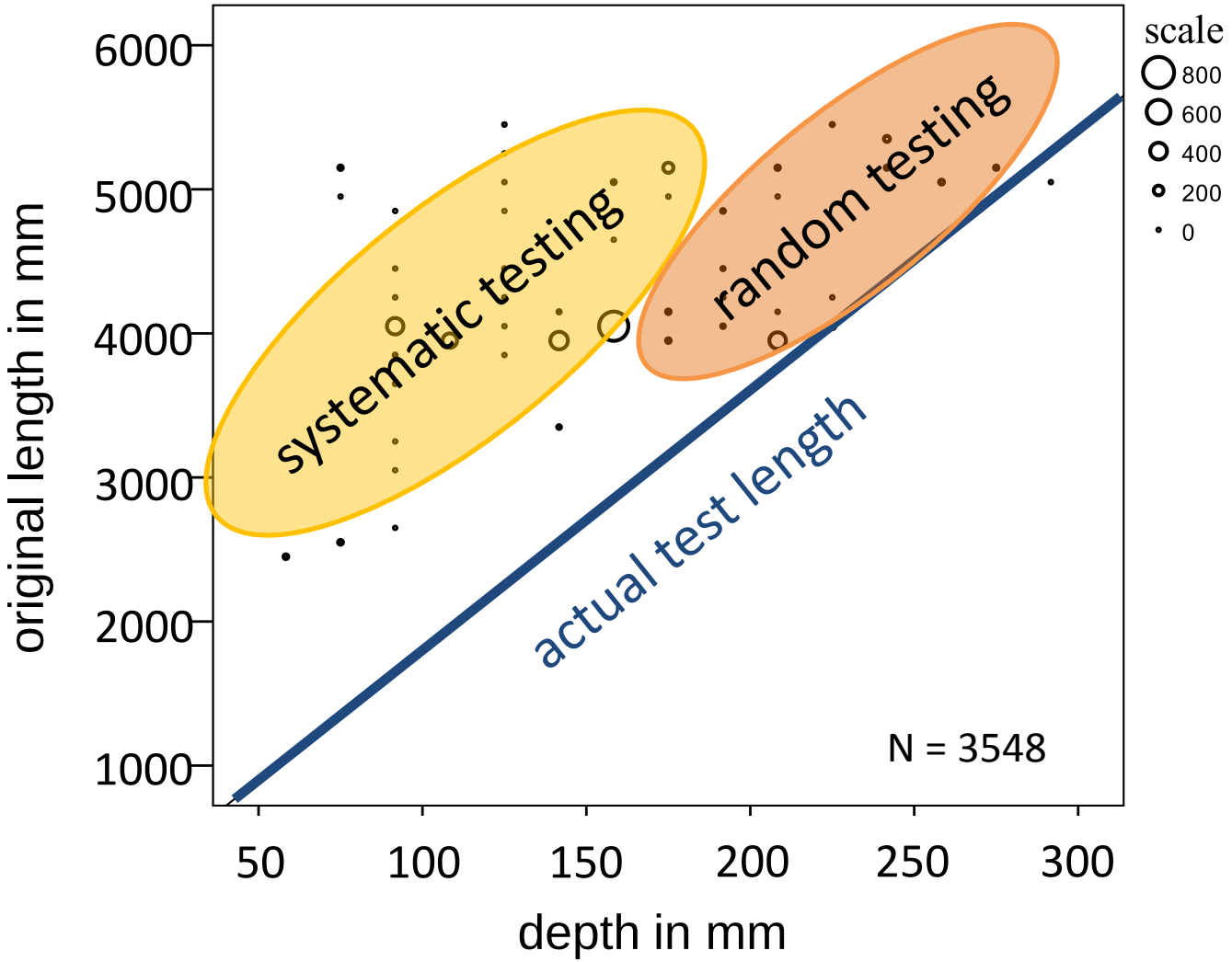


IP **GDP**

bending strength
...
53.1
...

ID	IP_MOEdyn
...	...
667	44.1
...	...

bending strength
...
47.6
...


original length in mm
6000
5000
4000
3000
2000
1000
50
100
150
200
250
300
depth in mm
systematic testing
random testing
actual test length
N = 3548
scale
800
600
400
200
0

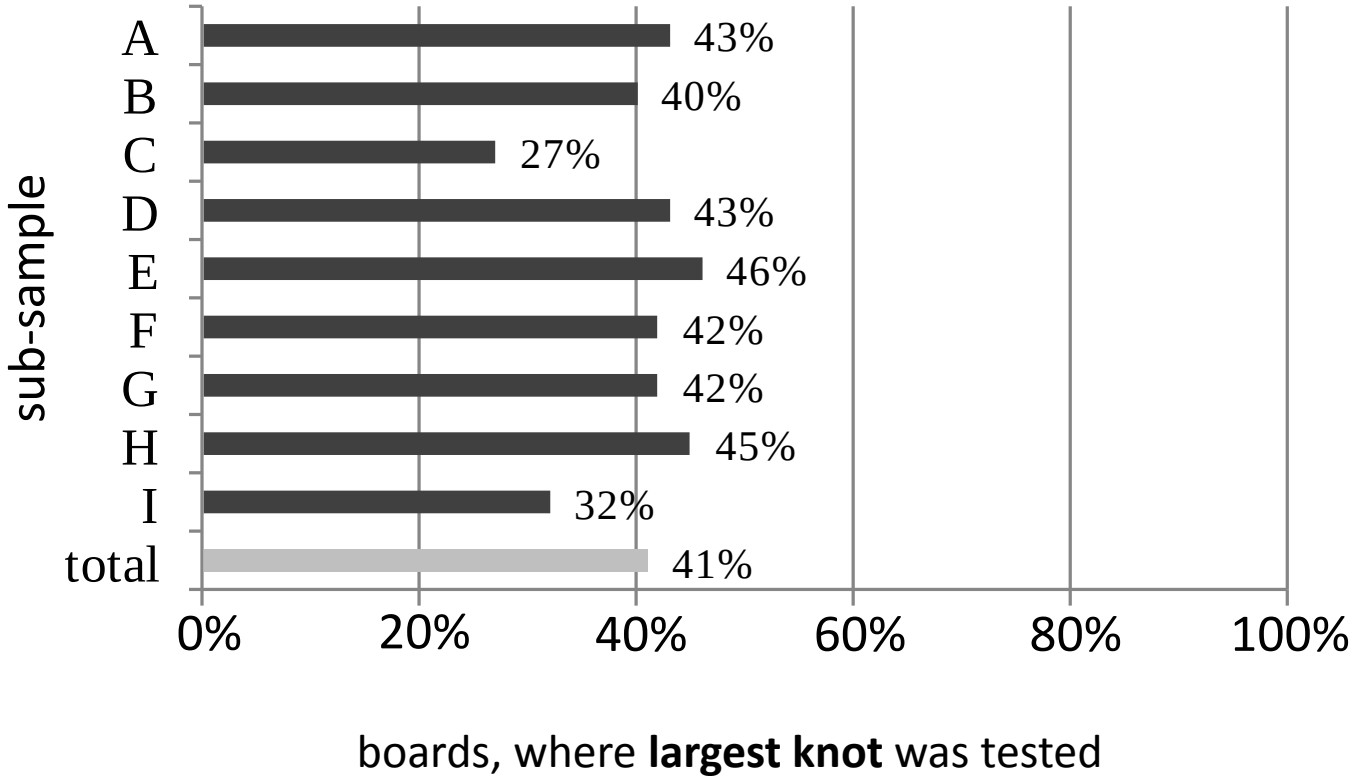
Objectives

1. How often is the section with the largest, local defect tested in a bending test?

2. How does a grading machine based on dynamic measurements benefit, if the weakest section is not tested?

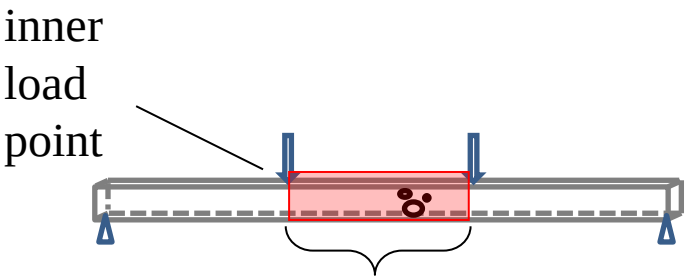
sub-sample	region	n	Simulated MoR middle		Simulated MoR entire		MoE		ρ	
			mean in N/mm²	cov in %	mean in N/mm²	cov in %	mean in kN/mm²	cov in %	mean in kg/m³	cov in %
A	Slovenia	637	42.7	29.5	41.3	30.7	11.2	19.8	444	9.8
B	Slovenia	489	43.3	31.1	41.7	32.0	11.2	21.3	448	10.0
C	Sweden	210	40.1	31.6	38.3	34.1	10.8	21.5	435	11.9
D	Romania	203	37.7	27.7	36.3	28.9	9.7	16.8	391	8.2
E	Slovakia Ukraine	304	36.1	35.1	34.8	36.4	10.0	19.1	396	10.1
F	Poland	433	39.0	31.0	37.6	32.5	10.8	20.4	440	10.8
G	Luxembourg Belgium	471	40.0	28.9	38.5	29.9	10.9	15.5	436	9.2
H	Austria Czech Republic	416	38.0	37.0	36.7	38.0	10.8	24.1	438	12.4
I	Germany	385	39.1	32.3	37.2	34.9	10.8	21.5	440	12.2
	Total sample	3548	40.0	32.0	38.5	33.3	10.8	20.7	434	11.3

Weakest section/largest knot

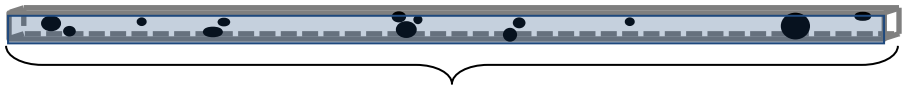


=> More than half of the boards was not tested at the weakest section!

Settings



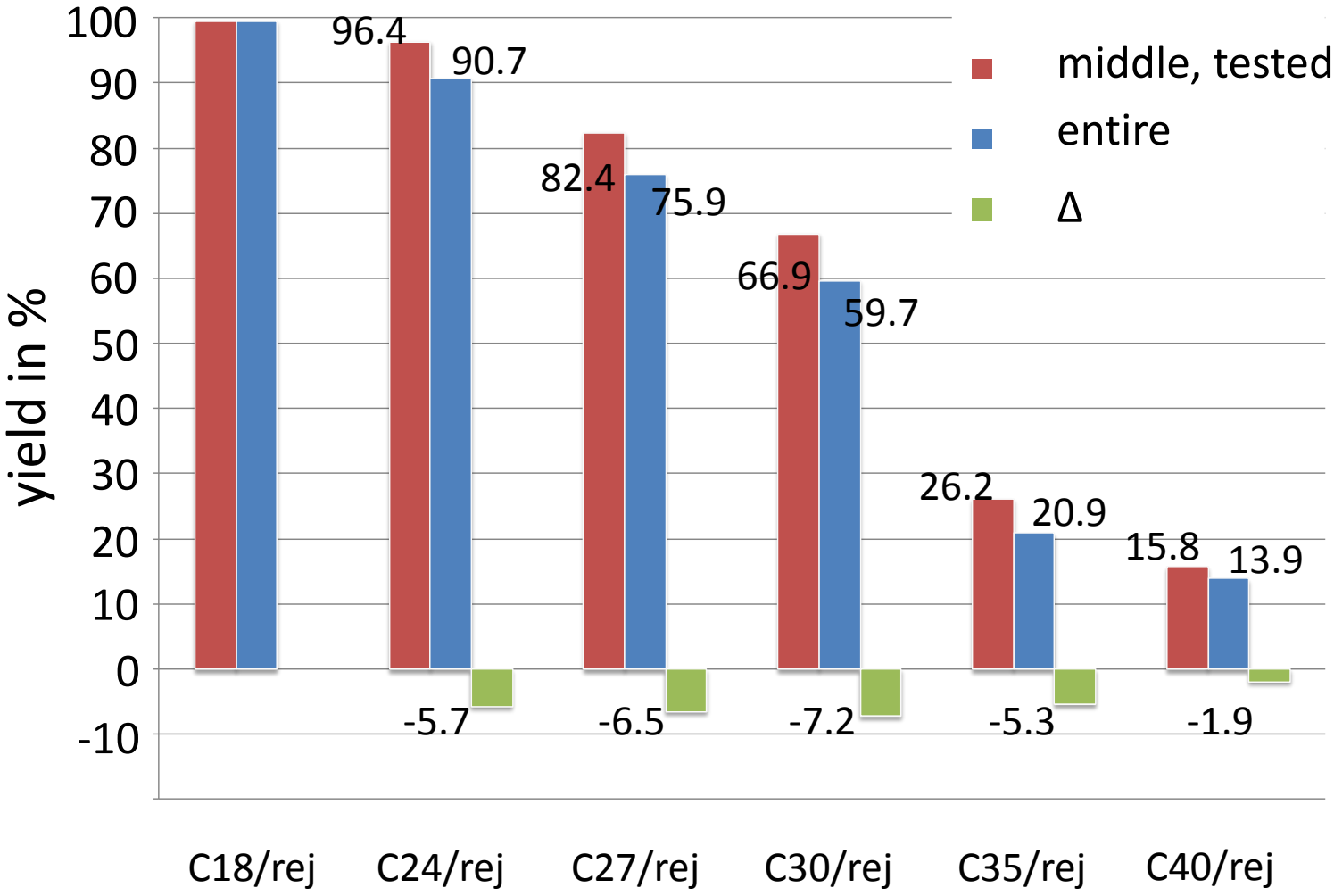
middle, tested section



entire board

	middle section [N/mm²]	entire board [N/mm²]	ratio [-]
C18 / rej	19.8	19.8	1.00
C24 / rej	25.2	28.7	1.14
C27 / rej	31.7	33.8	1.07
C30 / rej	35.9	37.4	1.04
C35 / rej	45.6	47.4	1.04
C40 / rej	49.5	50.4	1.02

Yield


yield in %
100
90
80
70
60
50
40
30
20
10
0
-10
96.4
90.7
82.4
75.9
66.9
59.7
26.2
20.9
15.8
13.9
-5.7
-6.5
-7.2
-5.3
-1.9
middle, tested
entire
Δ
C18/rej
C24/rej
C27/rej
C30/rej
C35/rej
C40/rej

Conclusion

- Derivation of settings is a very sensitive point.

- Eigenfrequency or dynamic modulus of elasticity are not able to detect local defects (only a average property).

- It is not always possible to locate the weakest section between the inner load points in a bending test. The lowest strength is not measured.

- Consequently, settings are too low, yields are too high.