

A new measurement for box performance

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XQ Innovations

**Box
Performance**

=

**Paper
properties**



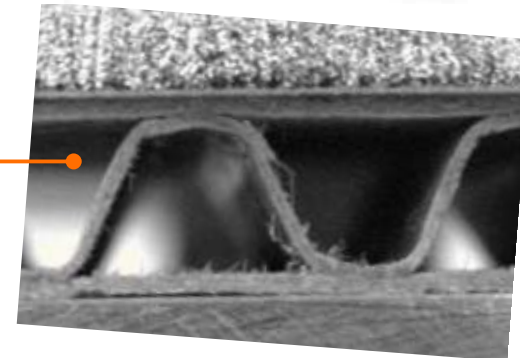
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Box Design

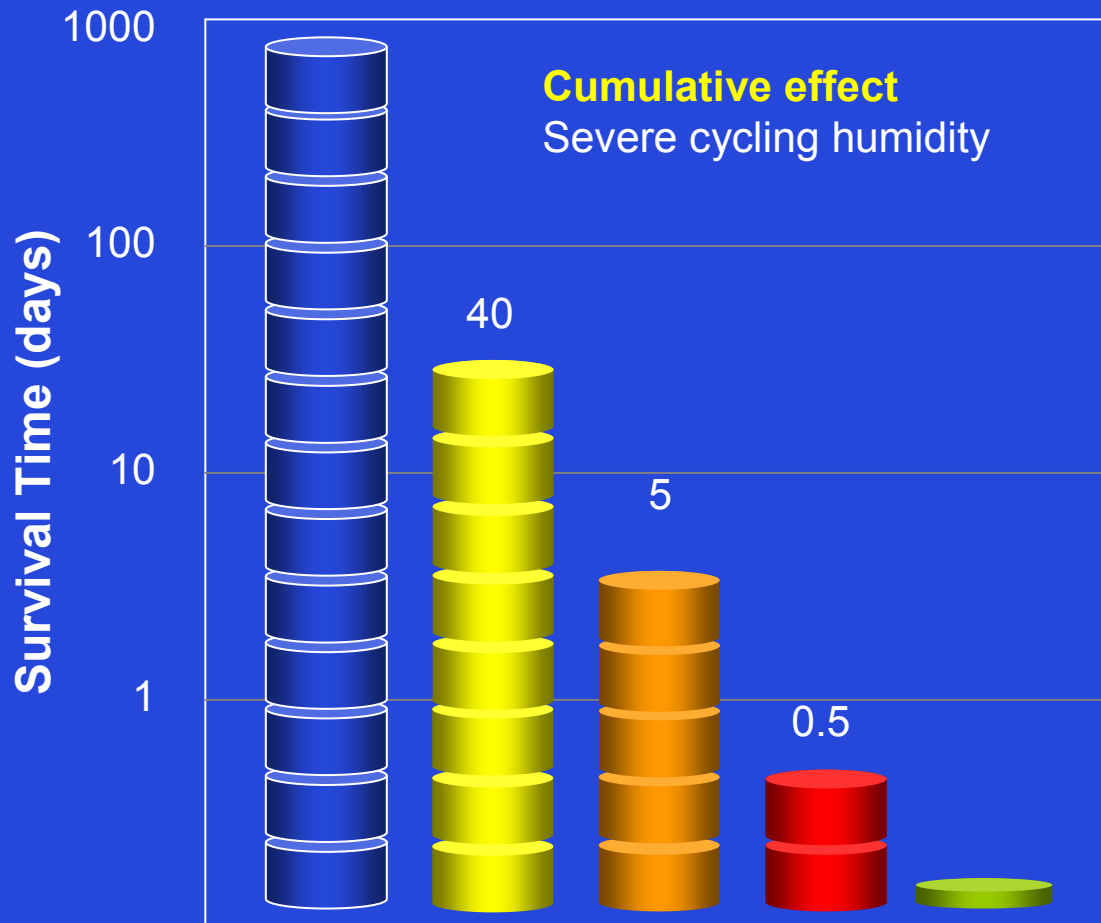
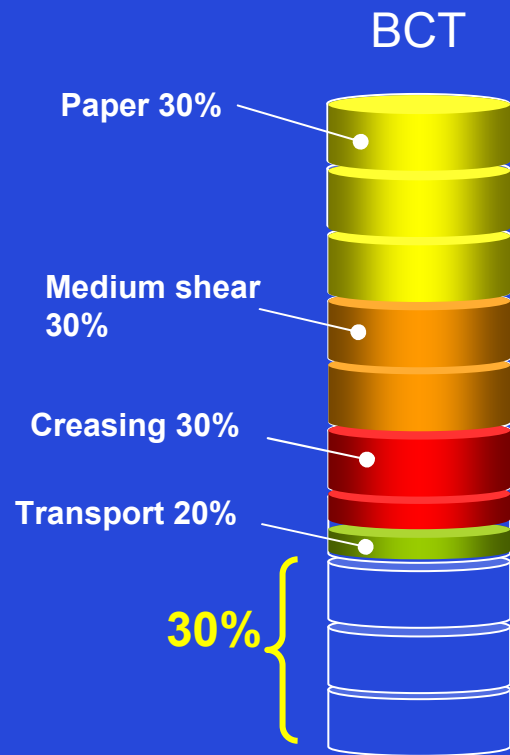


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**Flute size,
flute damage**



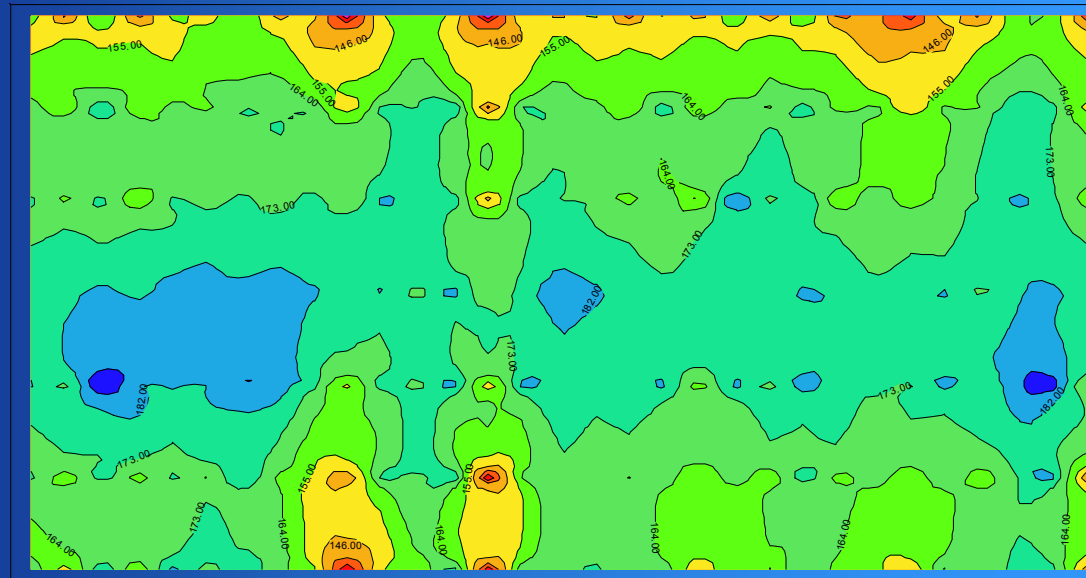
Box performance



Paper Variation



CD
RC(N)

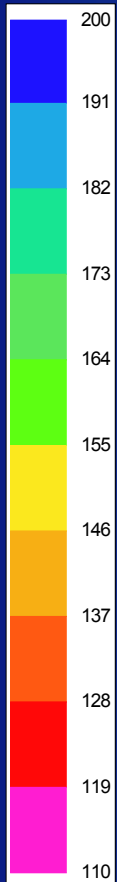


6m

31 meters

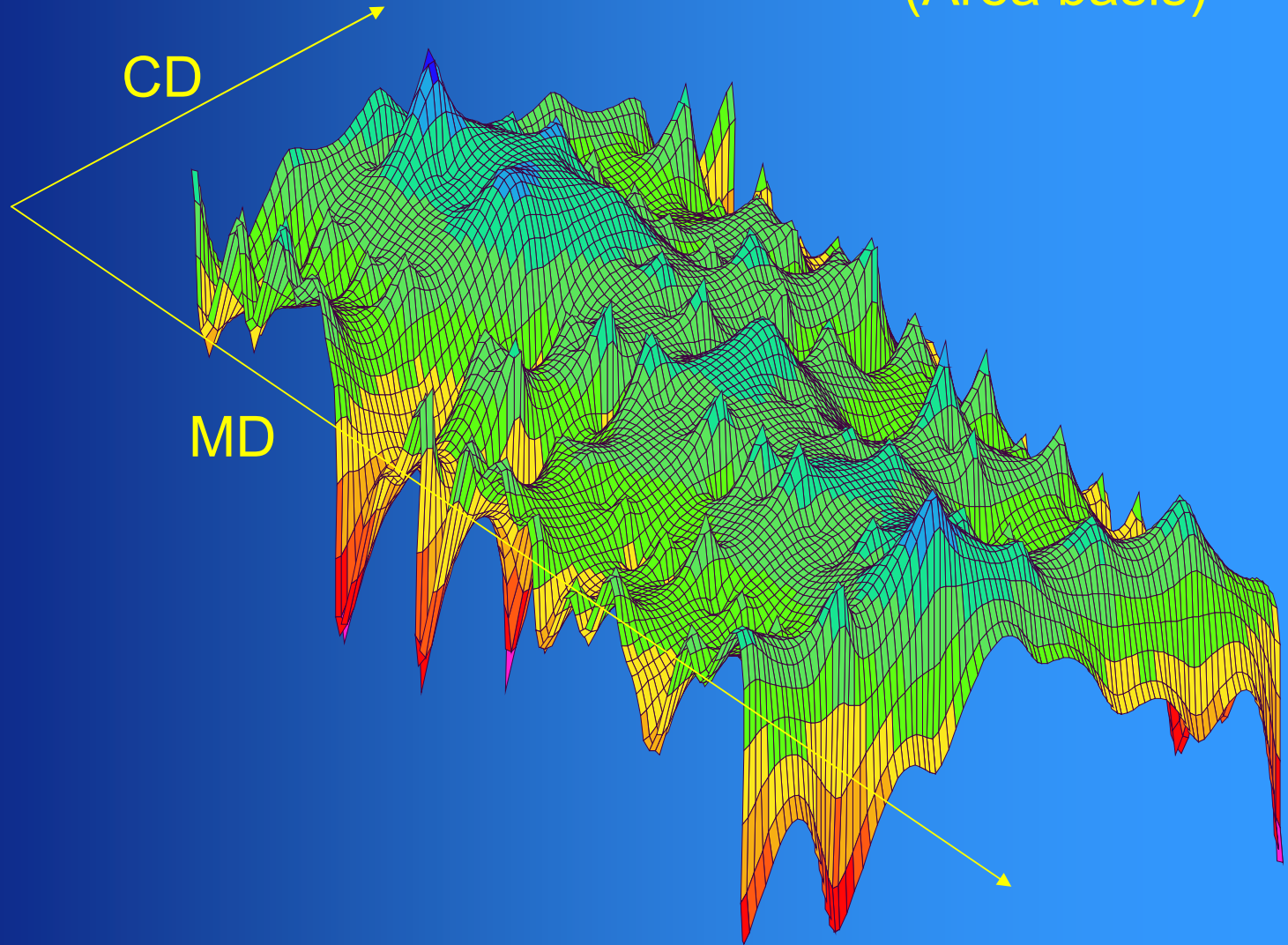
Ring crush variation (Area basis)

CD
RC(N)



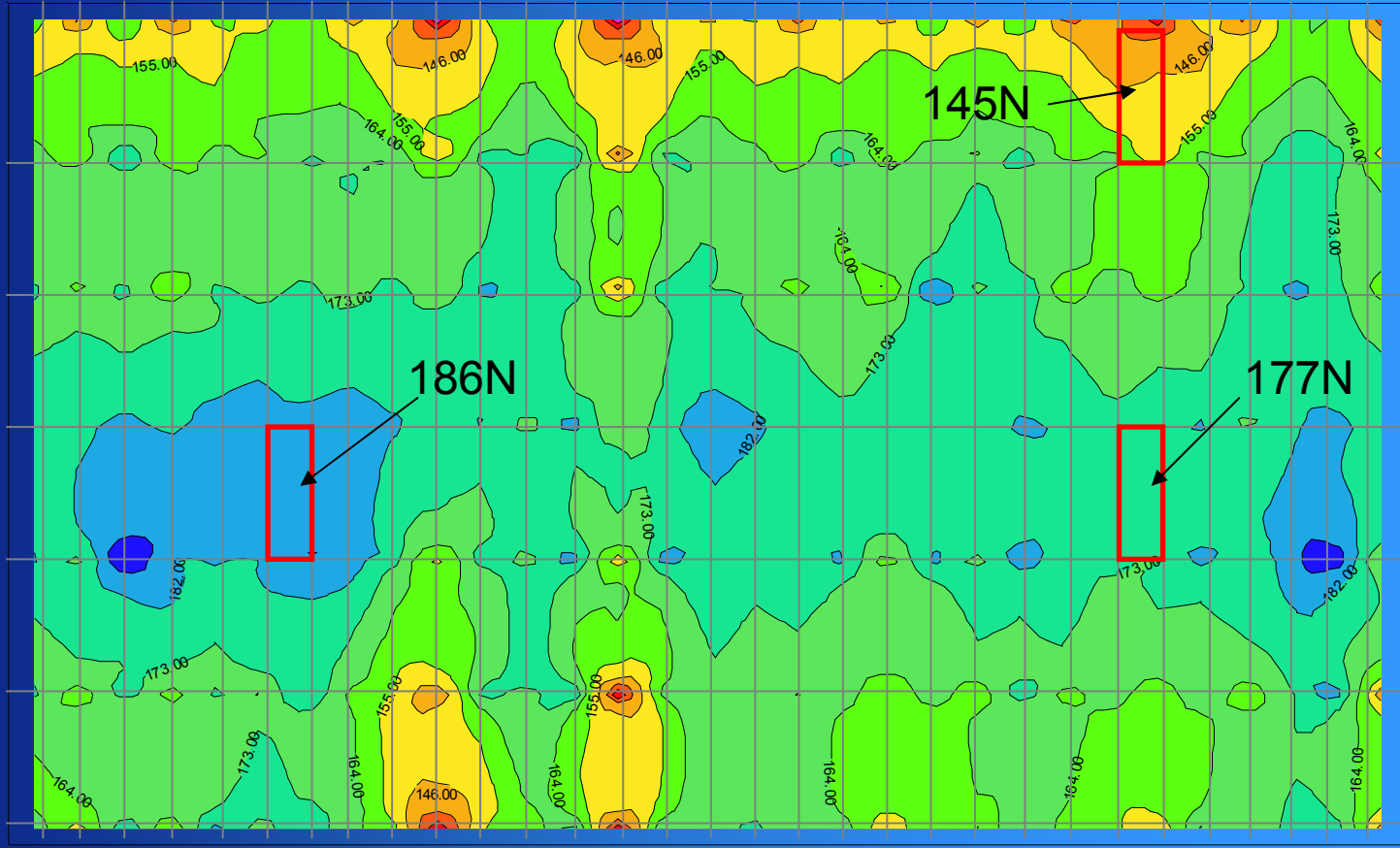
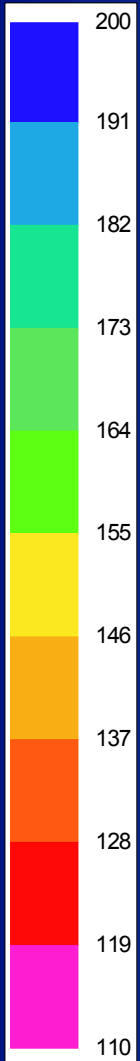
CD


MD



CD Ring Crush variation (Area basis)

CD
RC(N)



 = 1 m²

Requirement to improve

15-25% Variation in CD Ring Crush

- New flow box
 - Drying restraint and active drying systems
 - High efficiency press
-
- Basically, a new paper machine

Conventional Wisdom

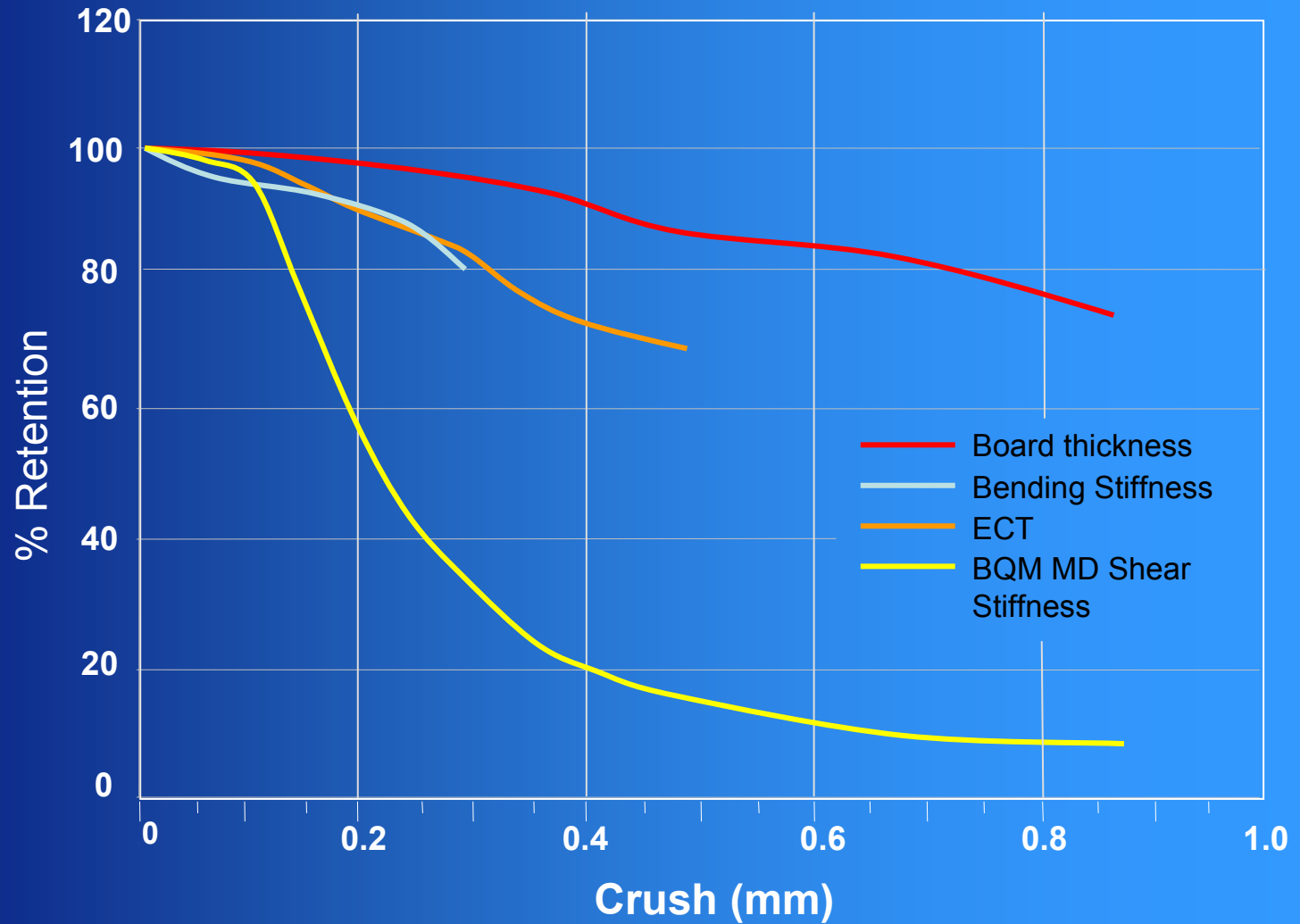
- Keep Liners apart
- Maintain thickness

- The board maker's primary concern should be the edgewise compression strength and caliper of the combined board*.

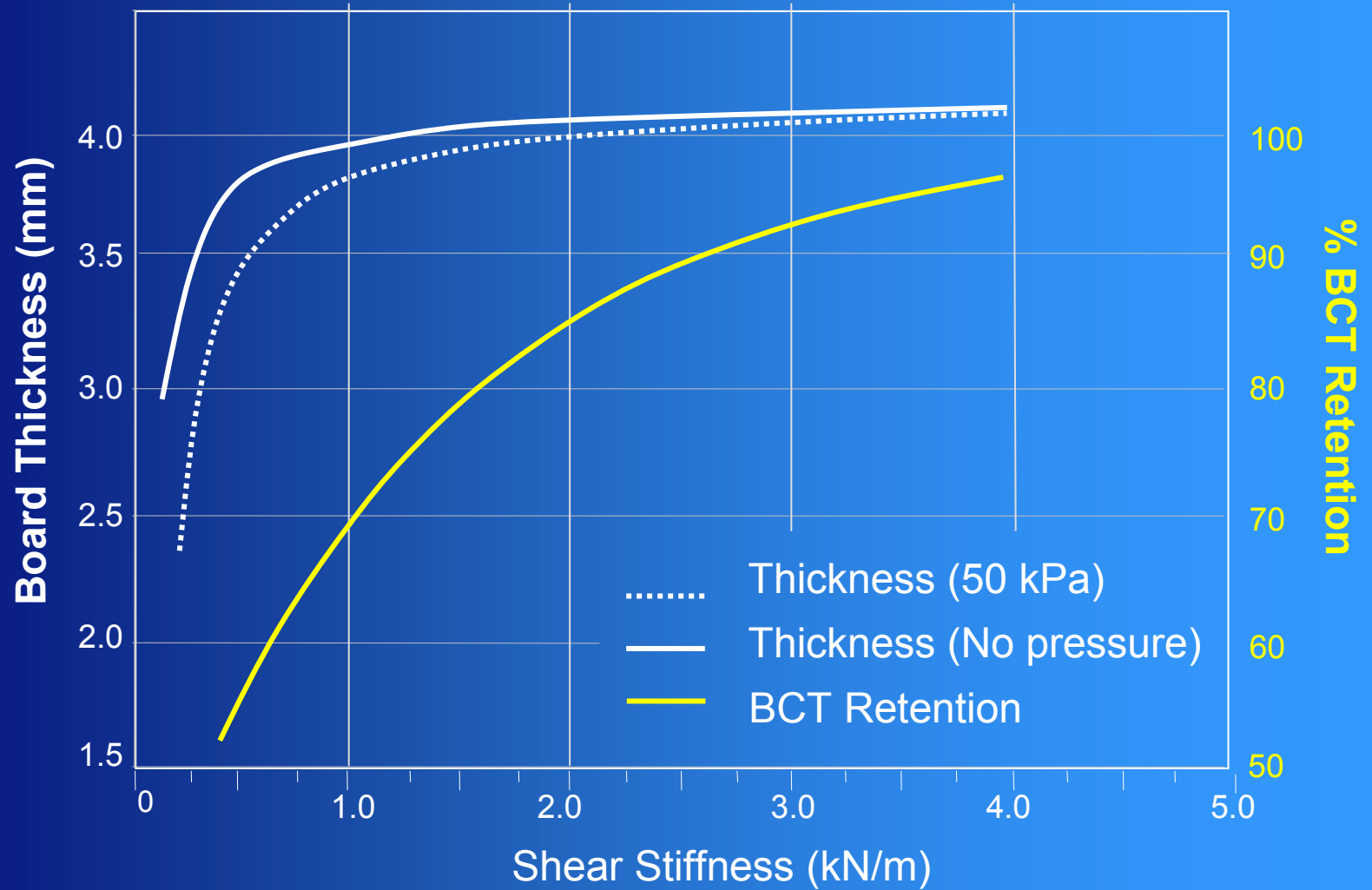
$$BCT = kECT\sqrt{h}\sqrt{z}$$

**Paper Board Packaging 1963*

Thickness is NOT a good measure



Thickness is NOT a good measure



BQM-1

Medium quality measurement



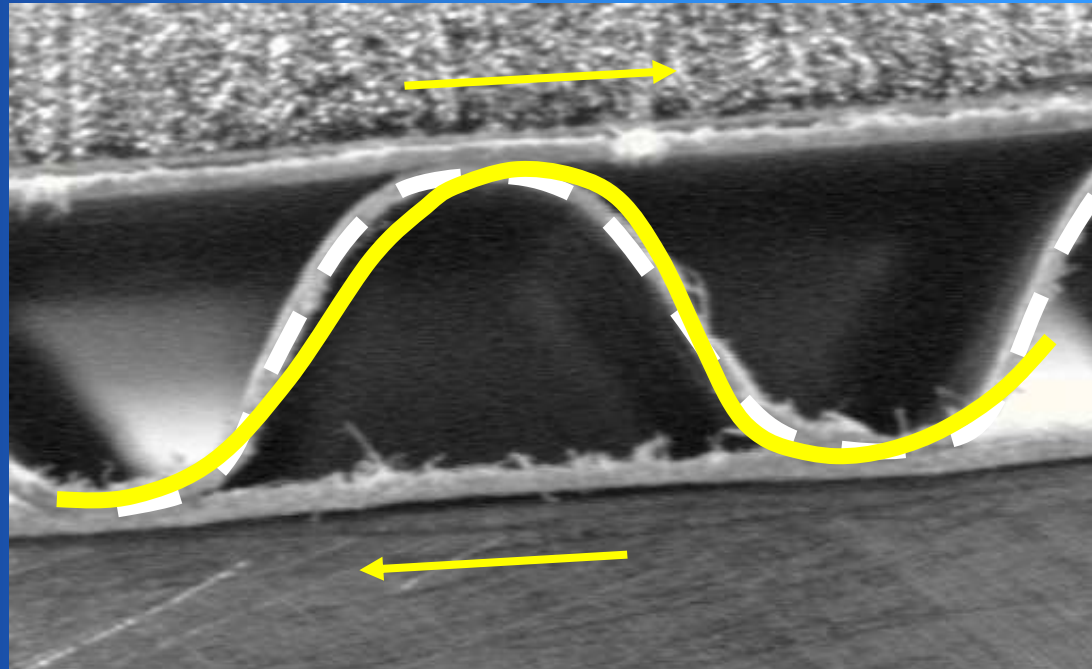
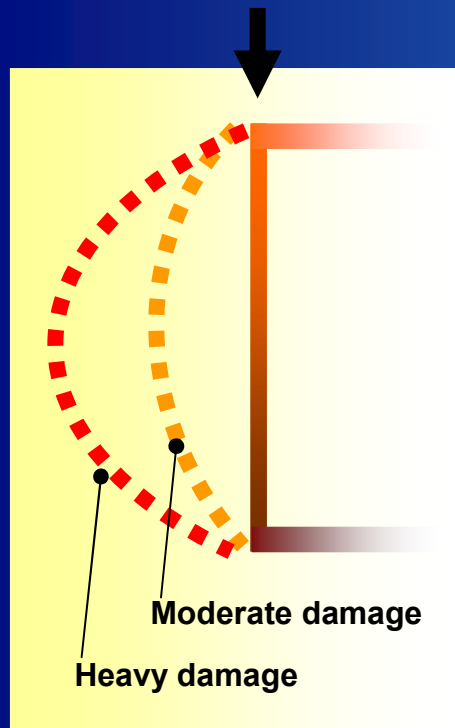
- Hand held
- Portable
- Liner independent
- Optical non-contact sensing
- Doesn't require cutting

Lateral MD Shear Stiffness

Very sensitive to crushing damage

Measure of the resistance of the fluting to resist shear

Important in the retention of panel stability in loaded boxes.



Performance measurement

Stacking

McKee Equation

$$BCT \approx ECT^{0.75} (\sqrt{D_{MD}D_{CD}})^{0.25} Z^{0.5}$$

Where

BCT = Box Compression Test

ECT = Edge Crush Test

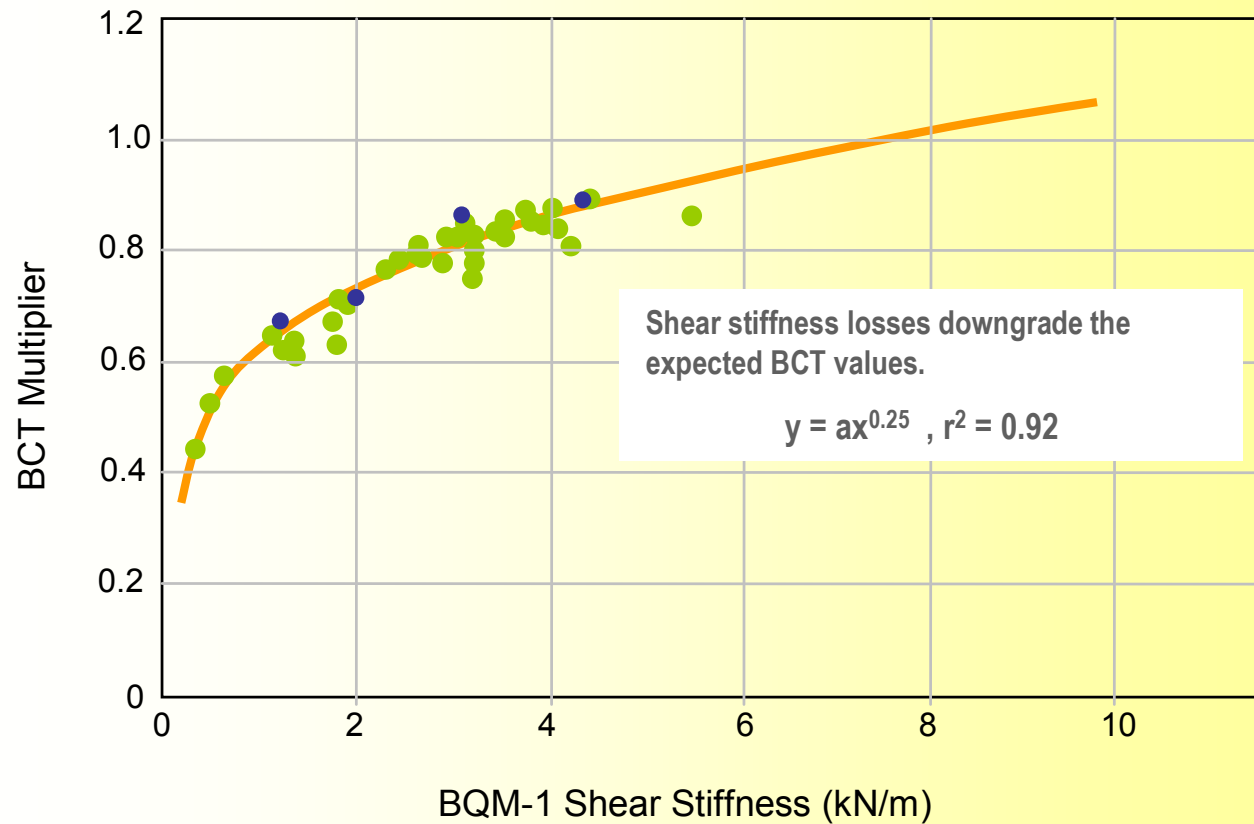
Z = box perimeter

$\sqrt{D_{MD}D_{CD}}$ = flexural rigidity of the board

Flexural rigidity of the board and the box perimeter approximates the buckling load of a panel.

Effect of shear on BCT

BQM shear stiffness acts like a downgrading factor



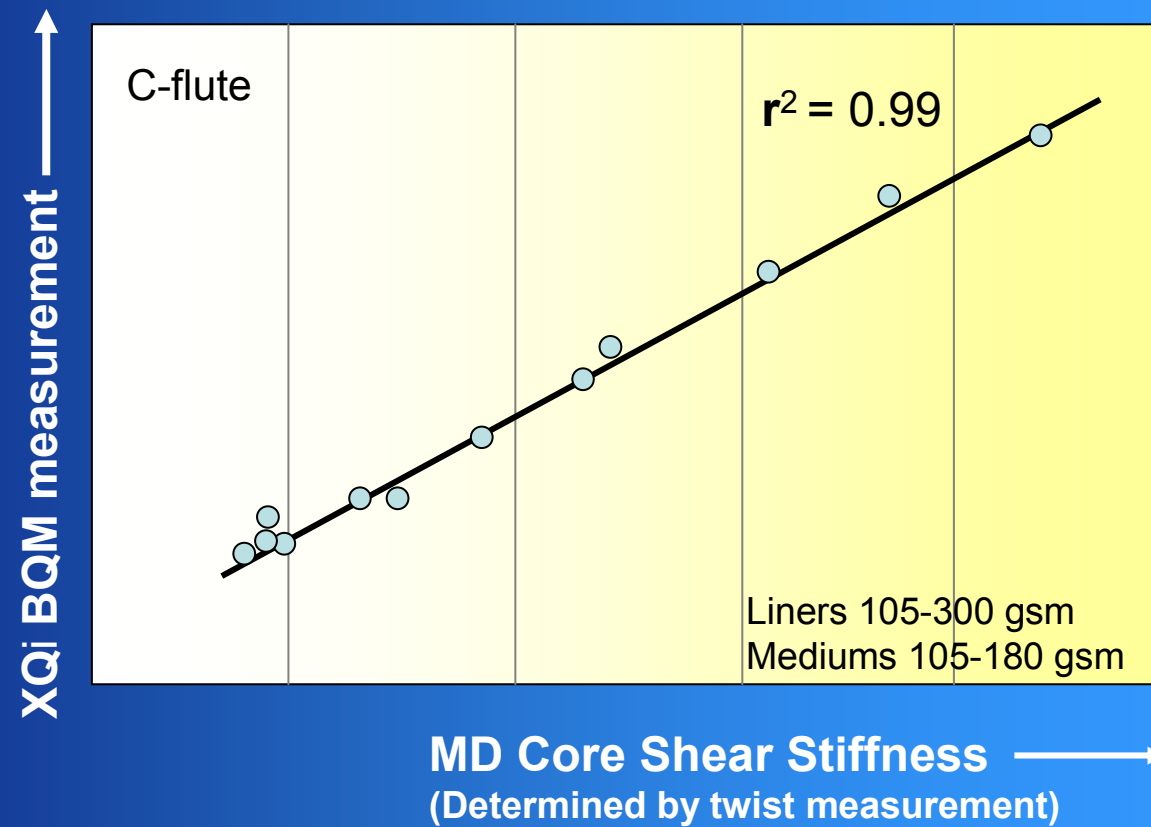
Shear stiffness losses downgrade the expected BCT values.

$$y = ax^{0.25}, r^2 = 0.92$$

• McKinlay, 1992

Technology details

- XQi technology is based on generating a structural resonance in a vibration mode that reflects the shear stiffness of corrugated board medium.



Tacoma Narrows Bridge

Technology

Principle of resonance reflects the natural frequency of the structure.

At resonance the structure moves in sympathy with the excitation applied and large displacements are possible.

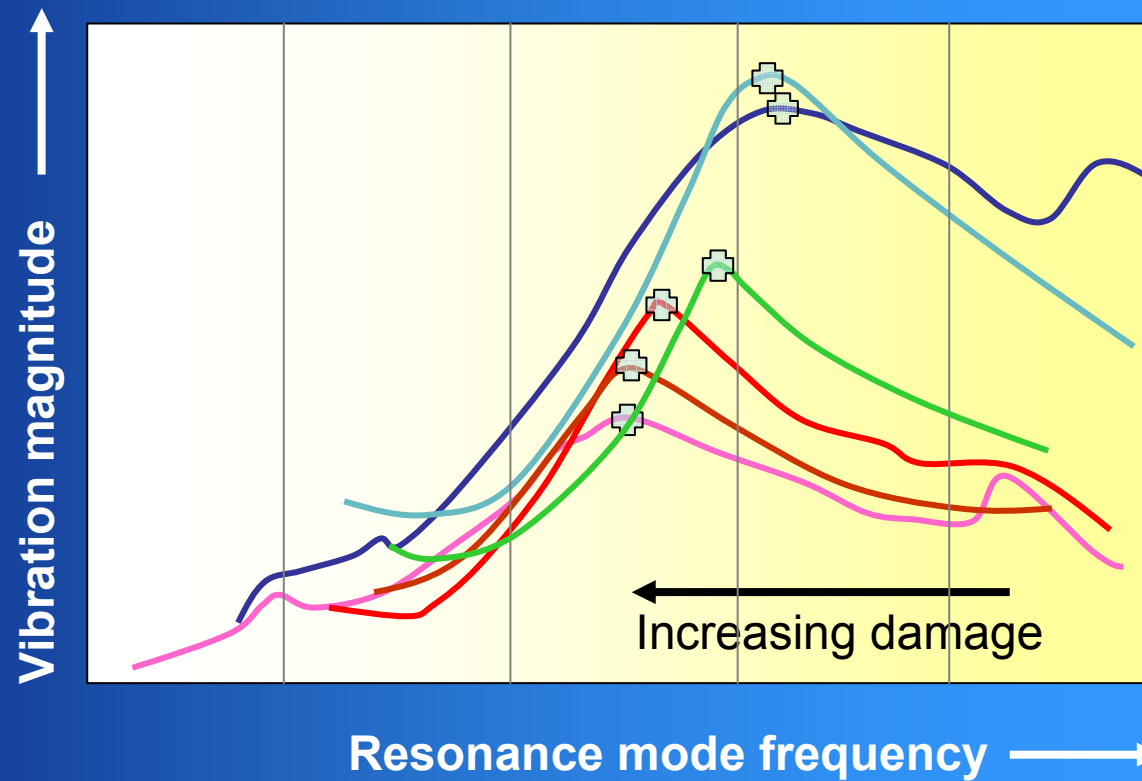
The natural frequency reflects the stiffness and geometry of the structure.



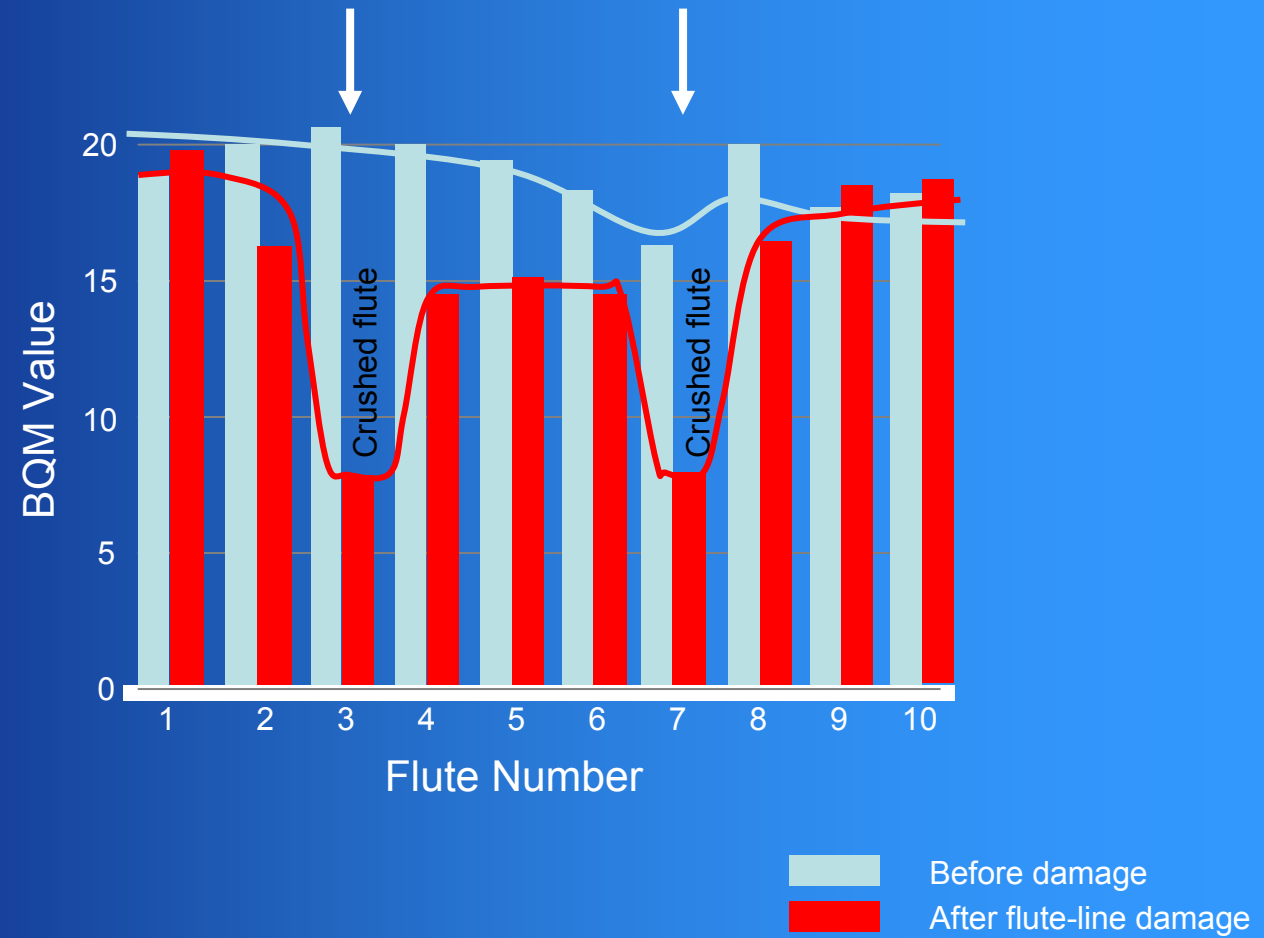
Technology details

- XQi technology is based on generating a structural resonance in a vibration mode that reflects the shear stiffness of corrugated board medium.

$$f_R = A\sqrt{\frac{k}{m}}$$

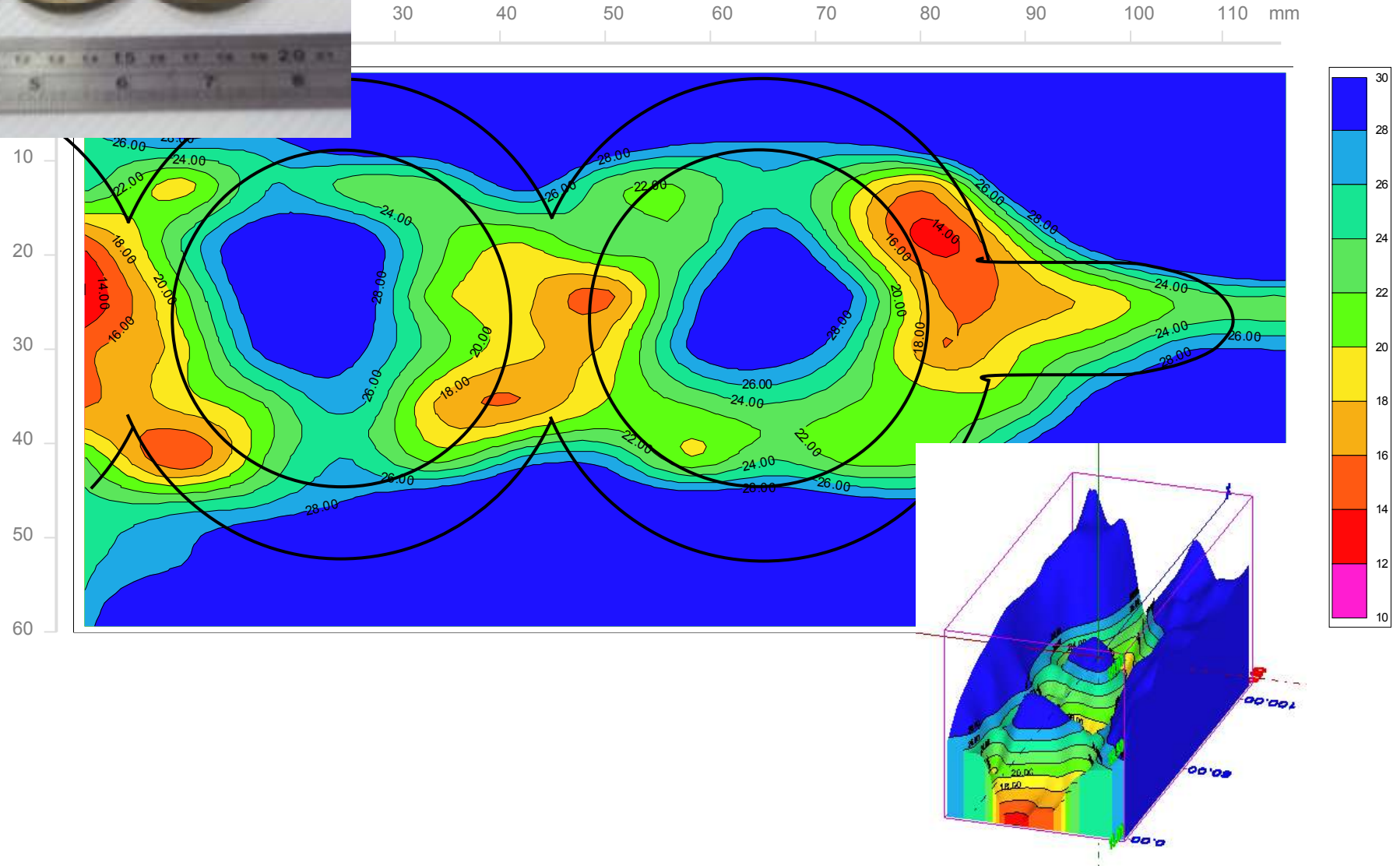


Effect of damage to one flute line



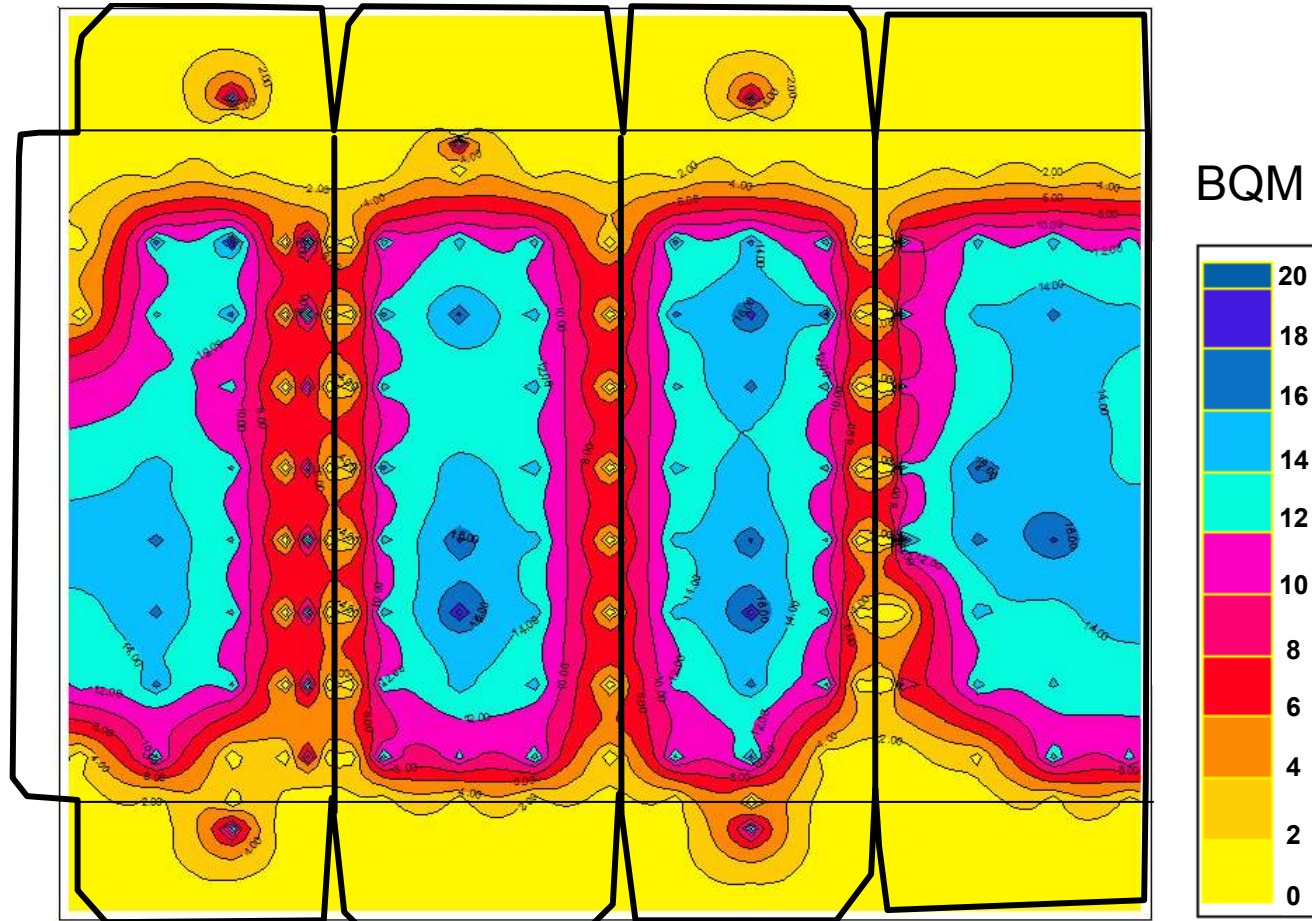


Box Manufacture (Conversion)

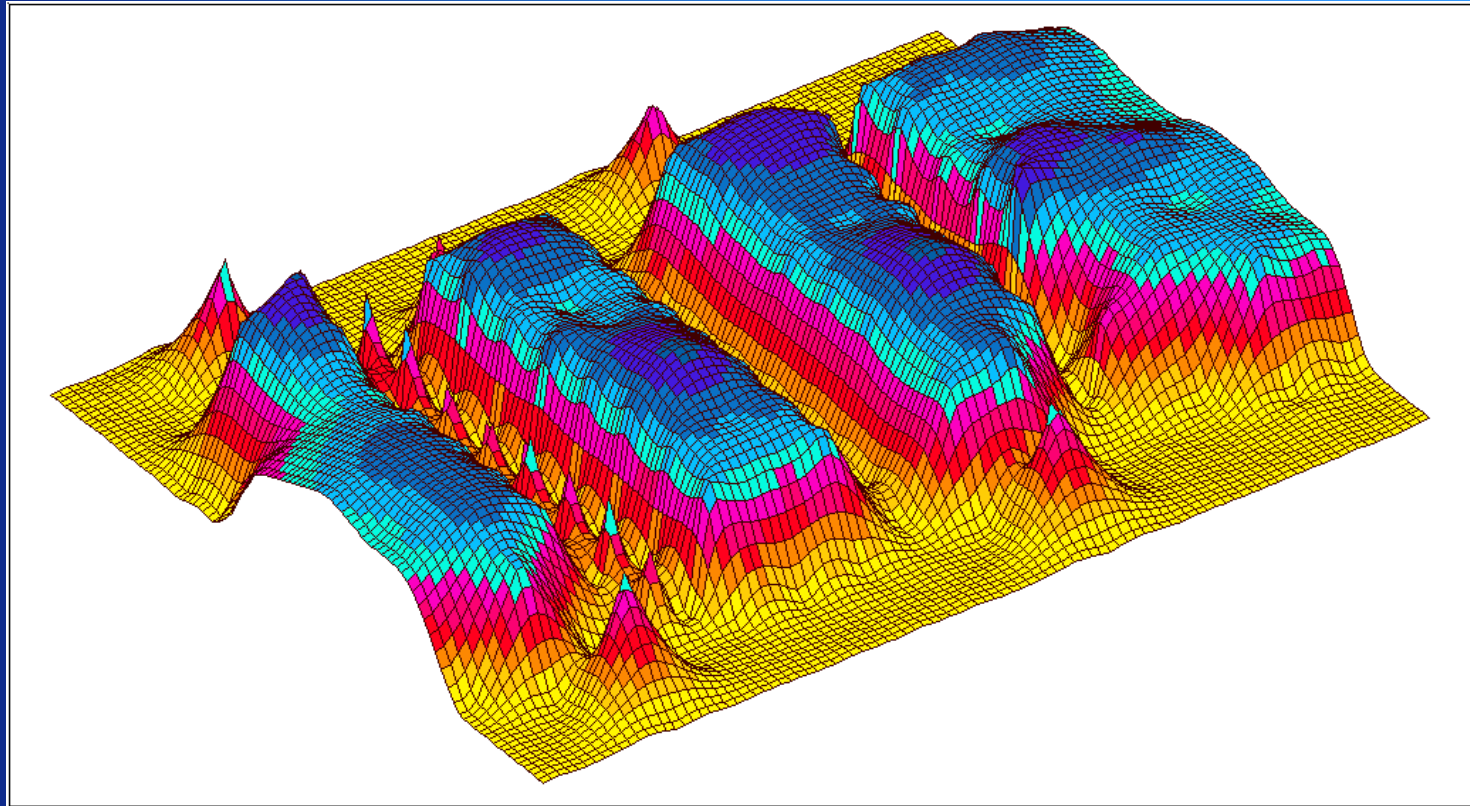


Board Damage Map

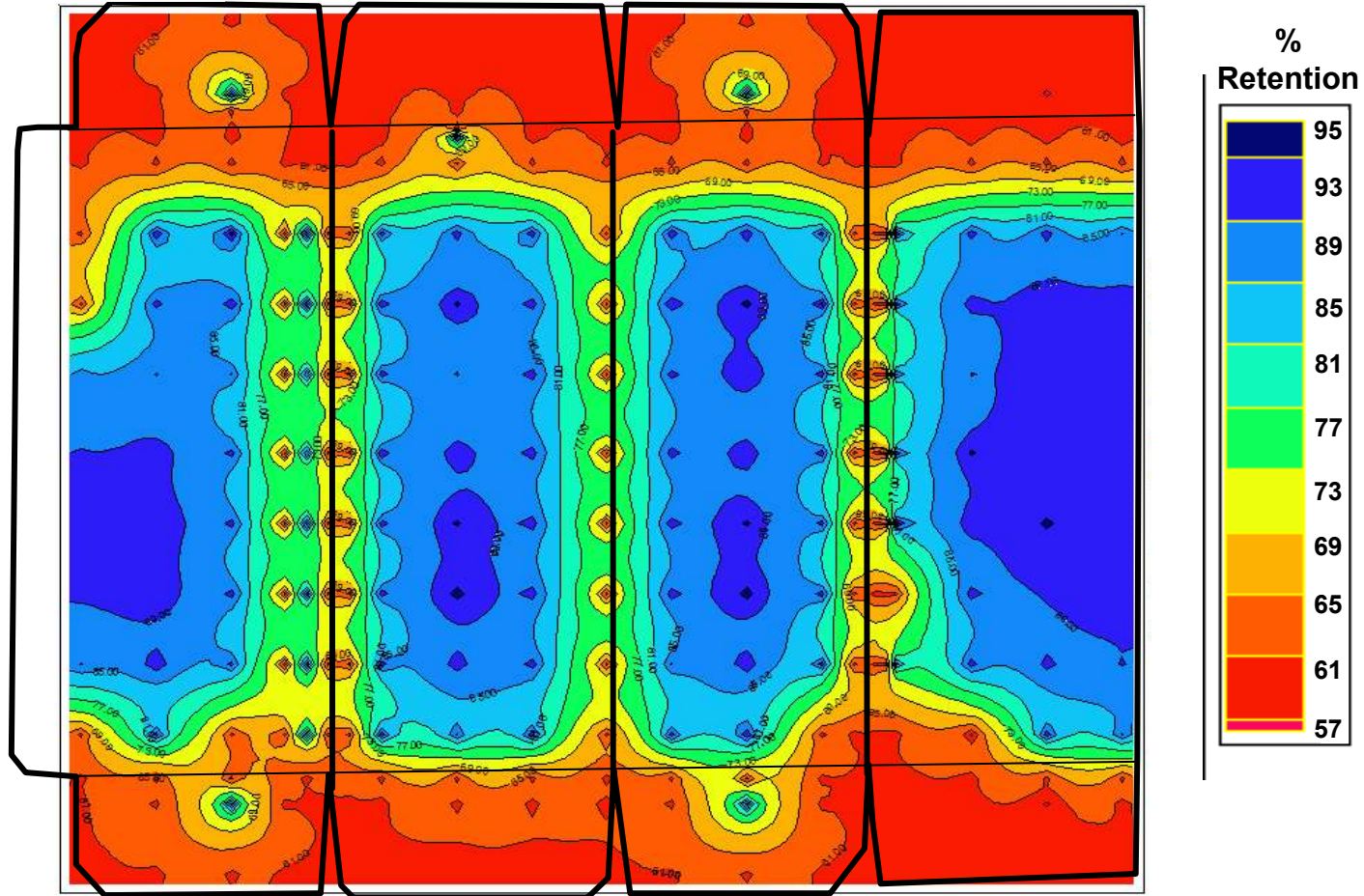
Frozen food

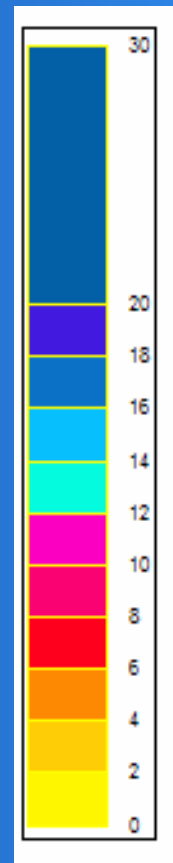
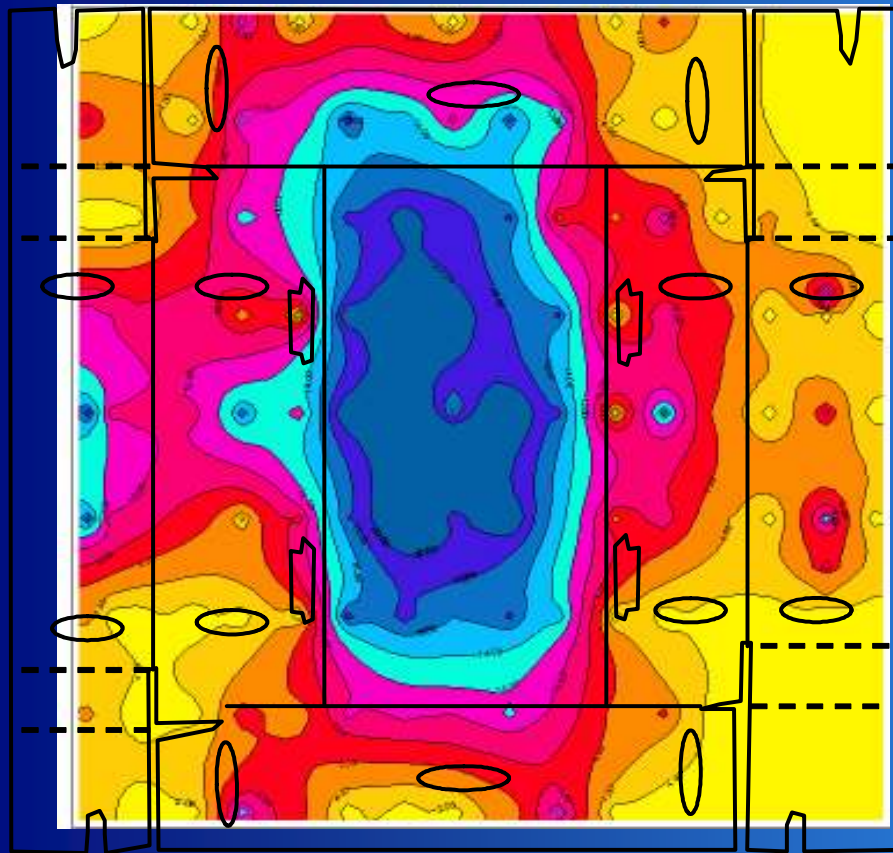


3D - Board Damage Mapping



Board Strength Retention Frozen food



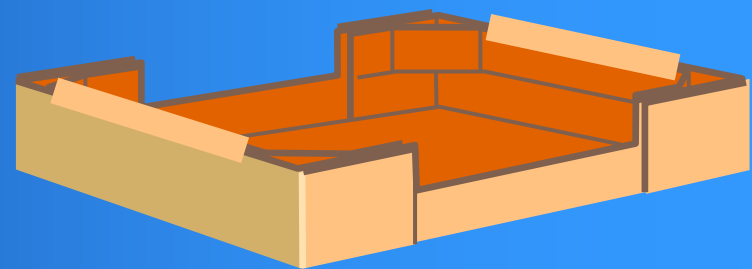


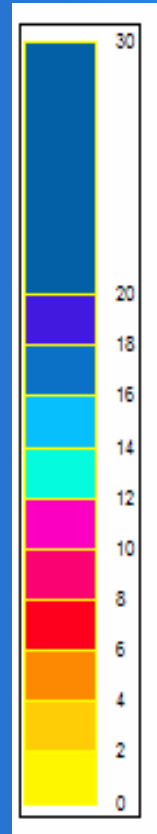
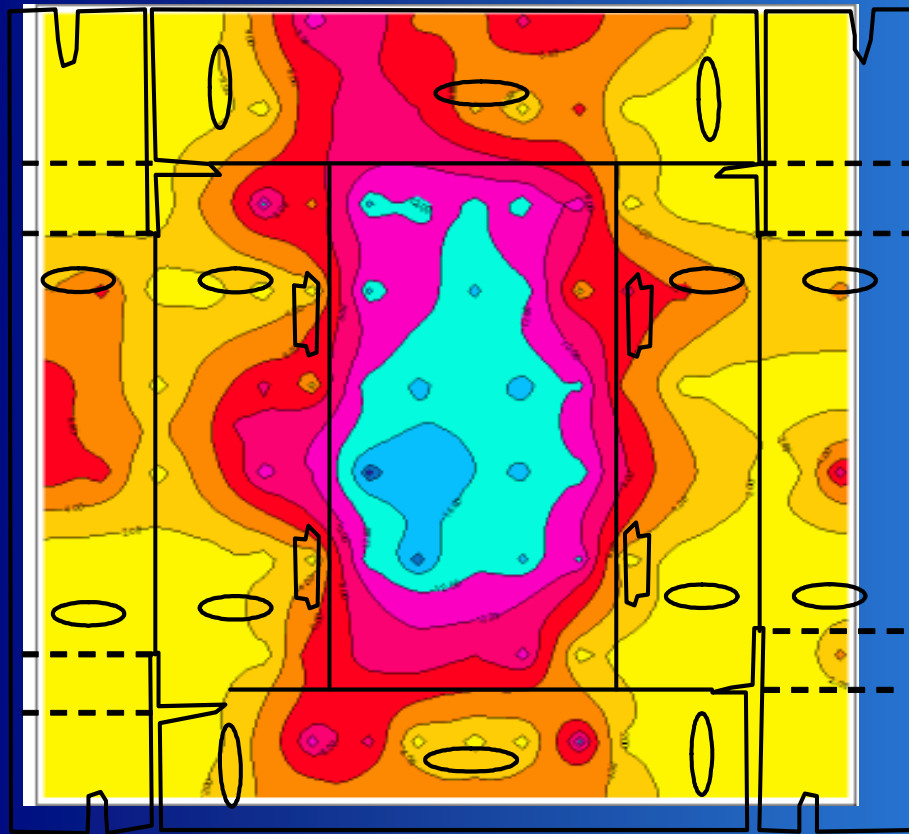
Produce Tray damage mapping

Maximum BQM value is around 30.

Large areas of damage in side walls – both printed and unprinted areas.

Extended crease damage.





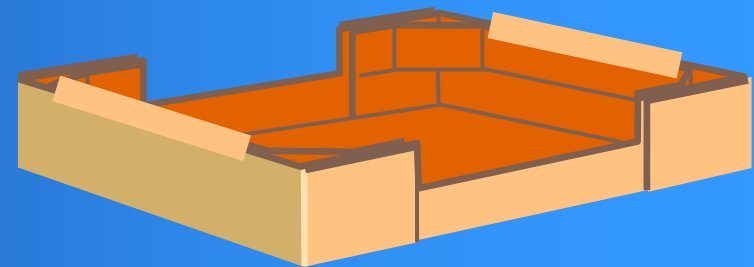
Produce Tray damage mapping (Delivery + 3 months)

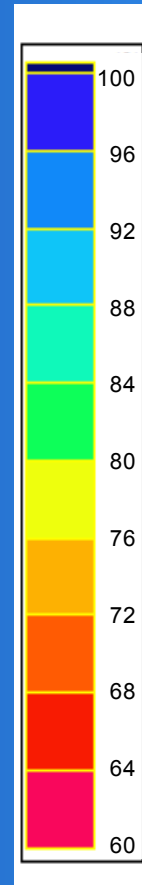
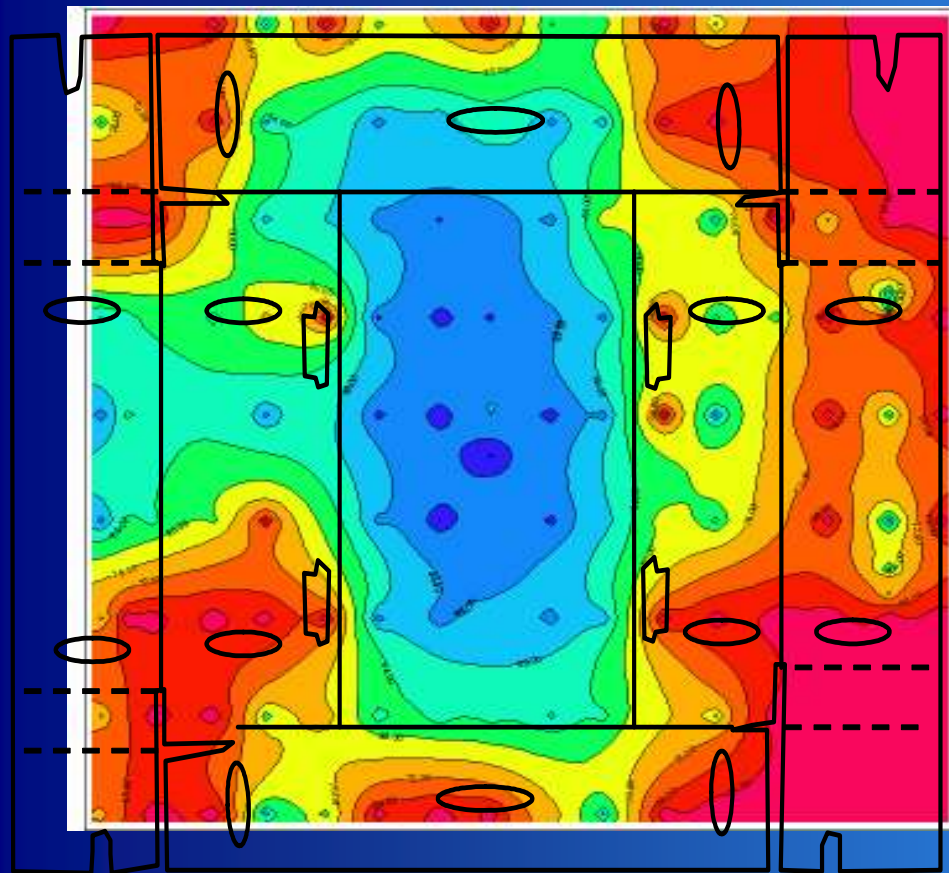
Maximum BQM value is around 18.

Large areas of damage in side walls – both printed and unprinted areas.

Extended crease damage.

Main panel now exhibits lower BQM values that will affect tray “bottom sag”.

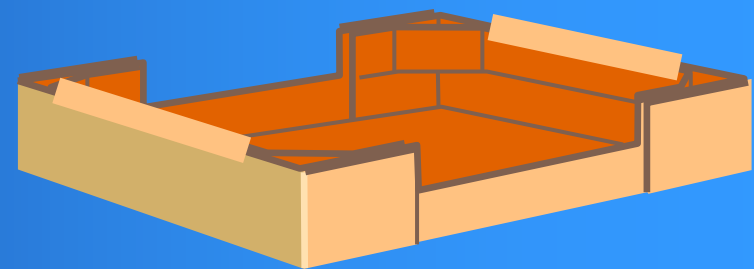




Produce Tray damage mapping (Board Strength Retention)

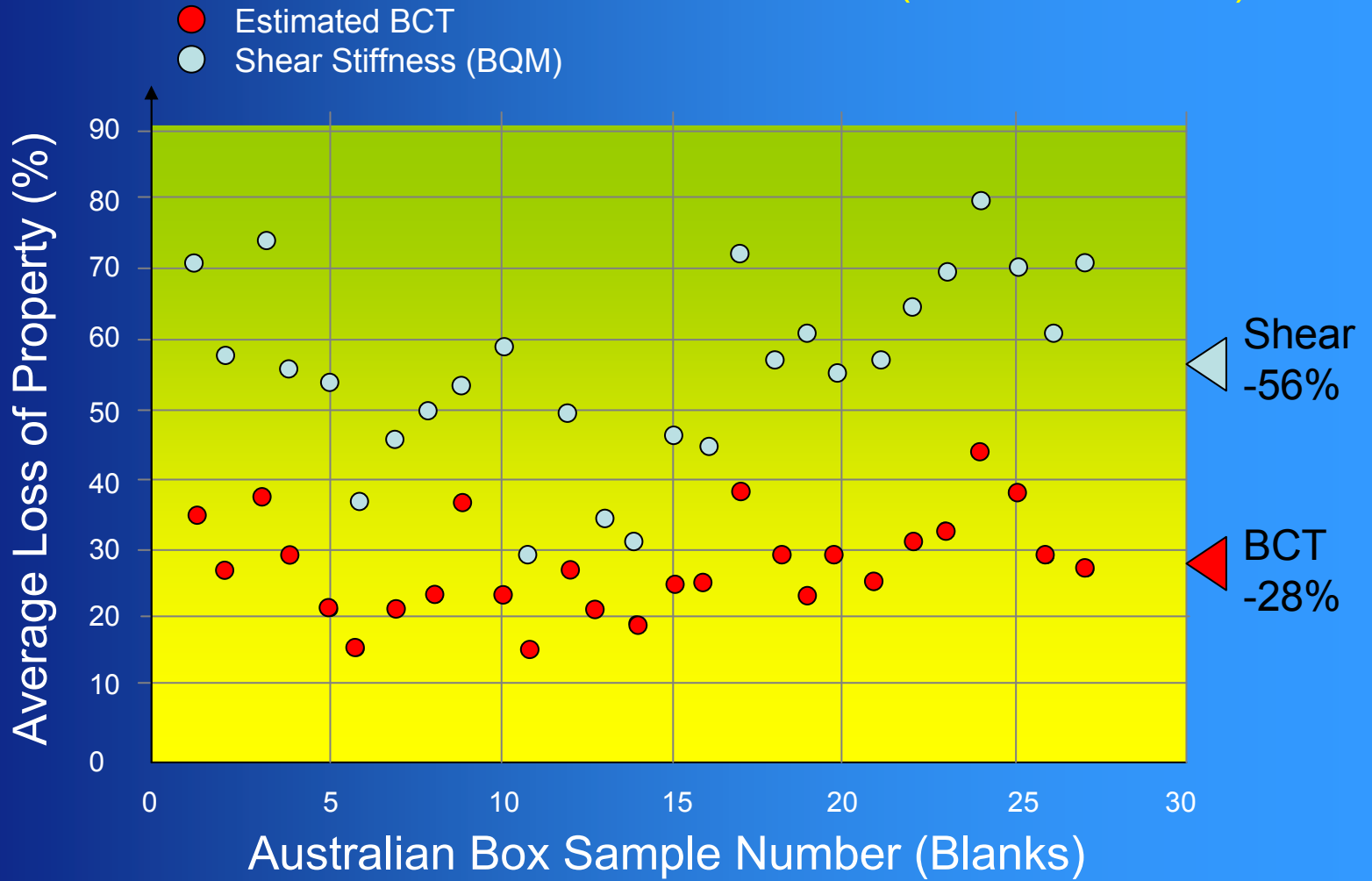
Side walls show 20-25% loss in board strength.

Base shows >10% loss in board strength (particularly in extended areas around creases).



Box Manufacture (Conversion)

(all tests- C flute)



Paper vs Box Saving Comparison

For an integrated box/paper making company:

Paper Machine

• 20% controllable improvement/yr	+ \$ 10 Million	
• High capital cost		- \$ 65 Million
• High installation cost		- \$ 2 Million
• Significant training		- \$0.2 Million
• Continued on-site investment (5 years)		- \$0.5 Million
	<hr/>	
	+ \$ 10 M	- \$ 68 M

Box plant shear measurement

• 20% controllable improvement/yr	+ \$ 10 Million	
• Low capital cost		- \$100k
• Low installation cost (database connection)		< \$250k
• On-site training		< \$25k
• Quality control function (5 years)		- \$750k
	<hr/>	
	+ \$ 10 M	- \$1.13 M

Paper vs Box Saving Comparison

For an integrated box/paper making company:

	Return/yr	Cost	ROFE	Payback Months
Paper Machine	+ \$ 10 M	- \$68 M	0.15	80
Box plant shear measurement	+ \$ 10 M	- \$1.13 M	8.8	1.4

So why wouldn't a company proceed with box quality measurement?