

# Perforations on Boxes

- Technical Aspects

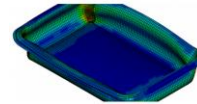
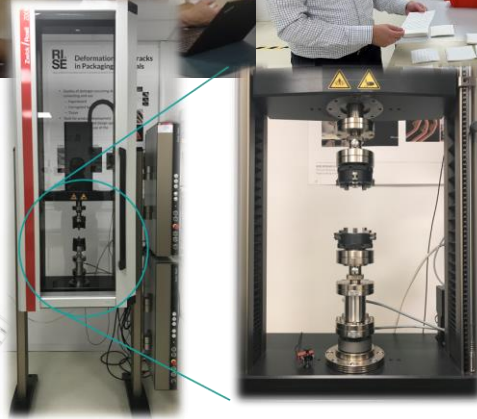
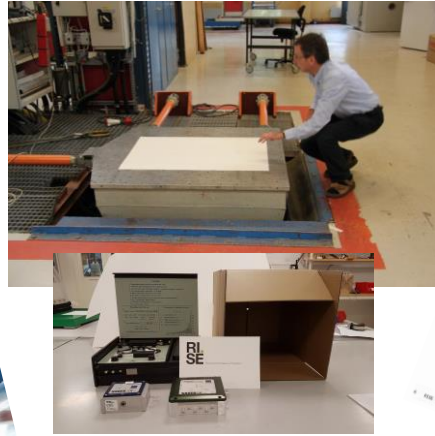
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**Who are we  
anyway?**

# RISE Research Institutes of Sweden

## ~3000 employees, 130+ testbeds



### Numerical Simulations for Fibre based products

Numerical simulation – such as Finite Element Methods (FEM) – is a tool to understand and predict material, product, and process performance.

**Our experts**  
 ANNA JONSSON  
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 MALIN ANDERSSON  
 FRANKLIN JONSSON  
 MALIN ANDERSSON



### Paper mechanics

The mechanical properties of paper materials are of great importance for their function during converting and use of the final products. More effective production, less waste, and optimal material use require good mechanical properties.

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**RISE**

# Perforations on boxes Why?

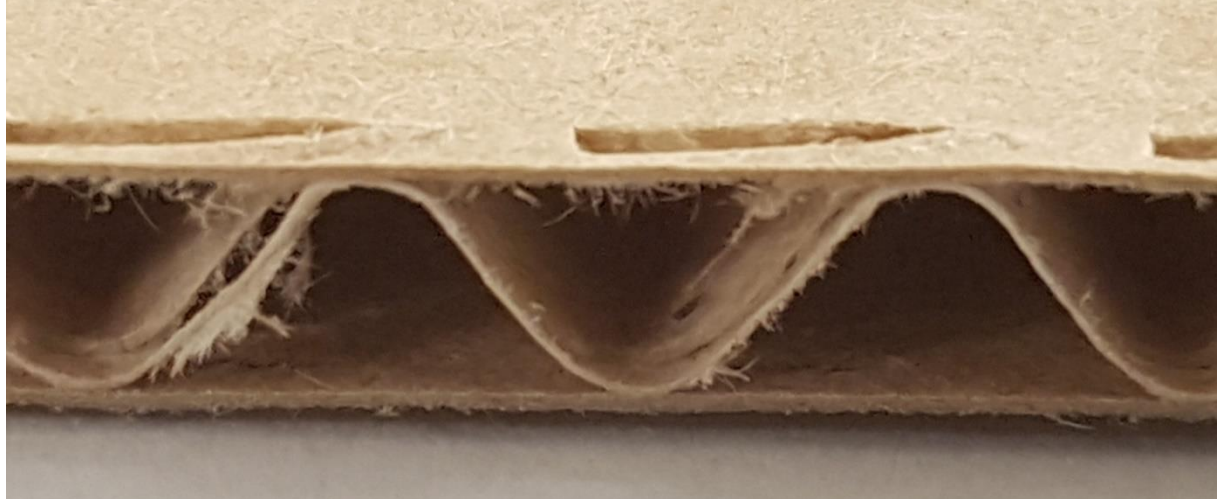
- Shelf ready packaging is growing
- Perforation behaviour is important
- Die cut, rotary cut and cutting table cut perforations does not behave the same, which impacts the box prototyping process
- Our previous work showed: Cutting tables can induce damage due to the tooling that influences the actual cut to uncut ratio.

# **What we did**

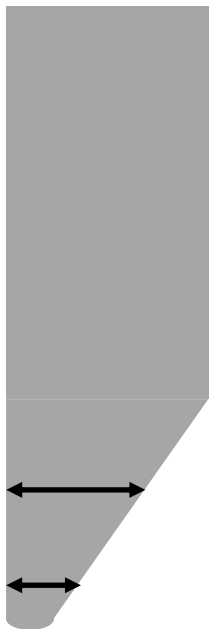
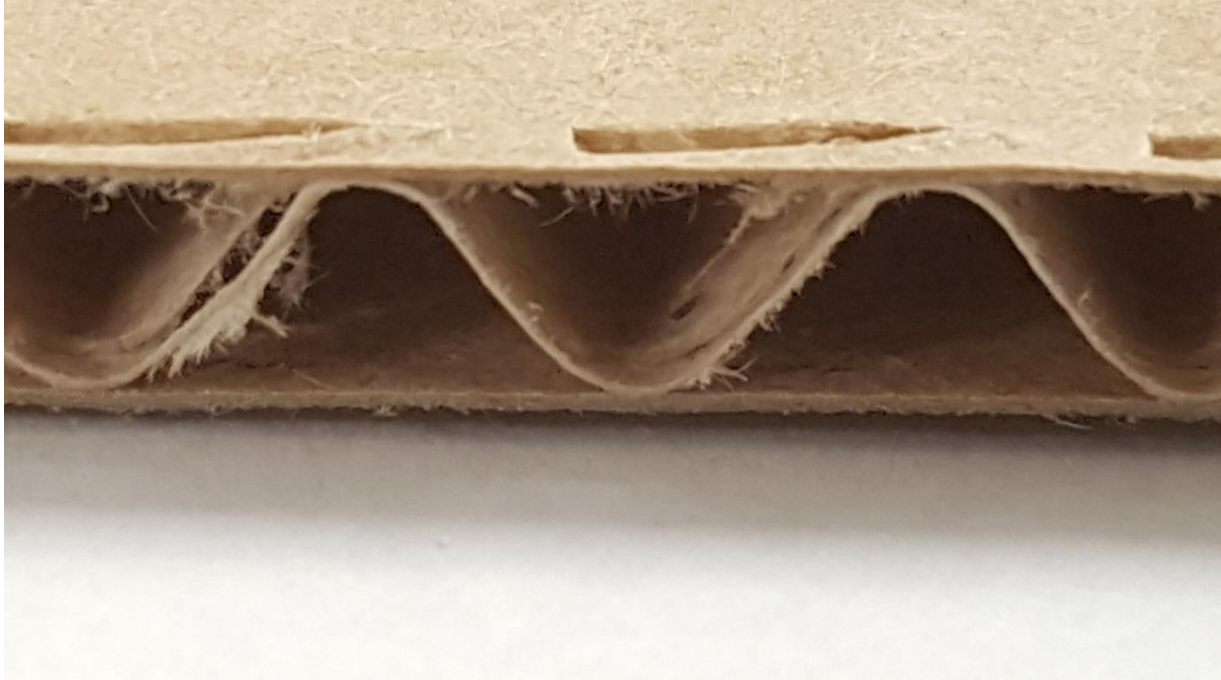
# Cutting

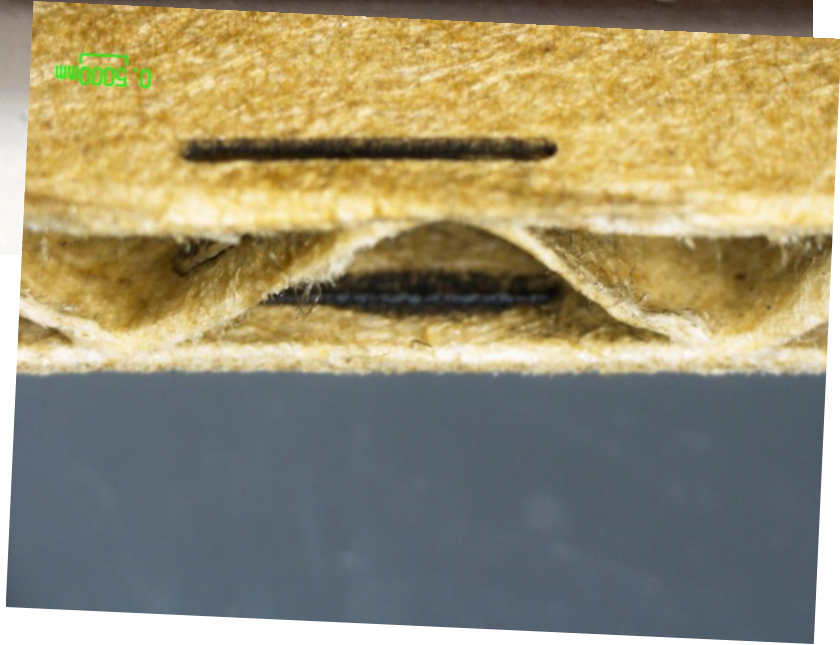
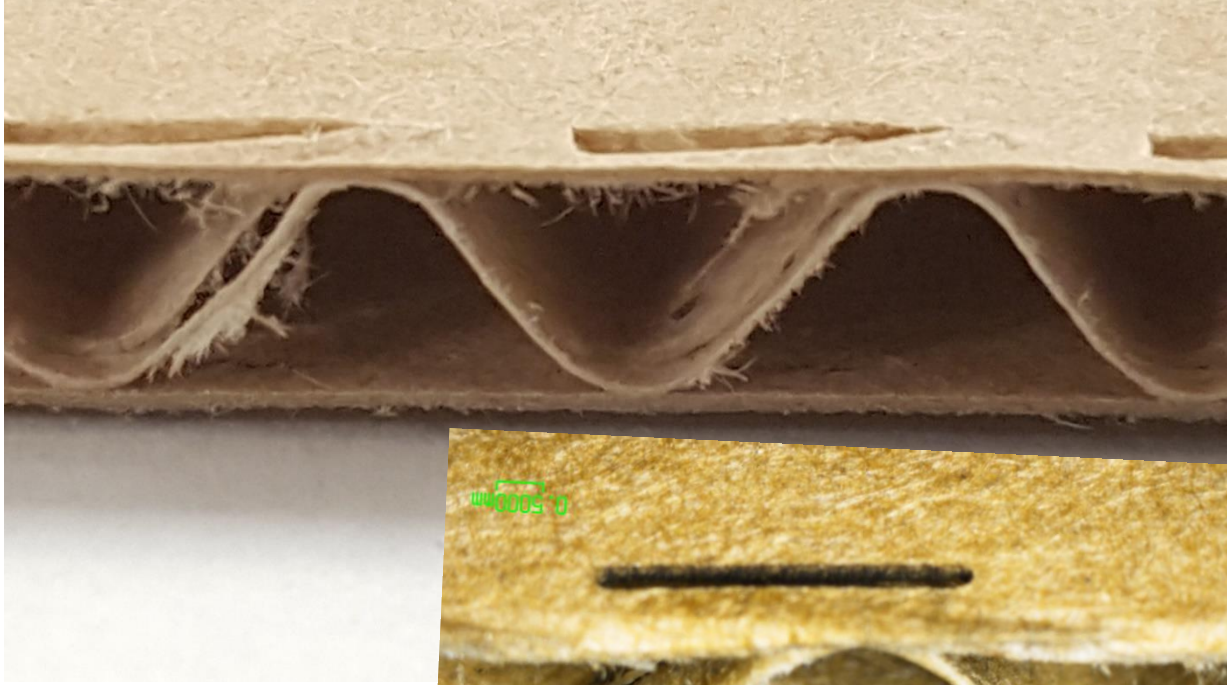
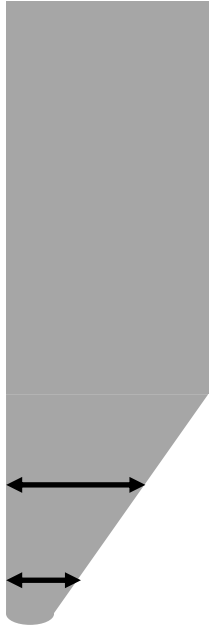


Goal ratio	Actual ratio for the different boards				
Cut/Uncut	BK	BW	CK	CW	Side
2.5/4	4.3/2.3	3.2/2.3	4.5/2.1	4.5/2.0	Top
	3.0/3.5	3.1/3.4	2.9/3.6	3.4/3.0	Bottom
2.5/2.5	4.3/0.6	4.3/0.8	4.3/0.6	4.4/0.6	Top
	3.0/2.1	3.1/1.8	2.9/2.2	3.1/1.8	Bottom
4/4	6.0/2.3	5.9/2.3	5.9/2.2	5.9/2.0	Top
	4.4/3.5	4.5/3.6	4.3/3.6	4.4/3.4	Bottom
4/2	5.8/0.3	5.6/0.2	4.1/1.8	6.1/0	Top
	3.9/2.1	4.4/1.6	4.6/1.4	4.3/1.7	Bottom
8/4	9.8/2.4	9.6/2.3	n.a.	10.0/2.0	Top
	8.6/3.6	8.2/3.9	n.a.	8.4/3.6	Bottom

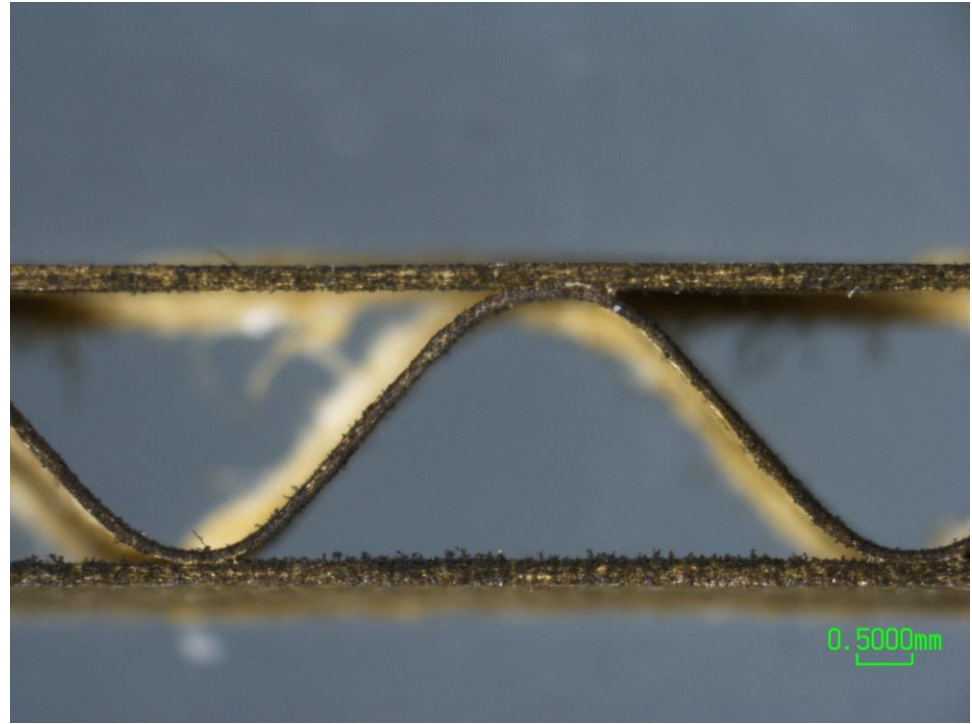
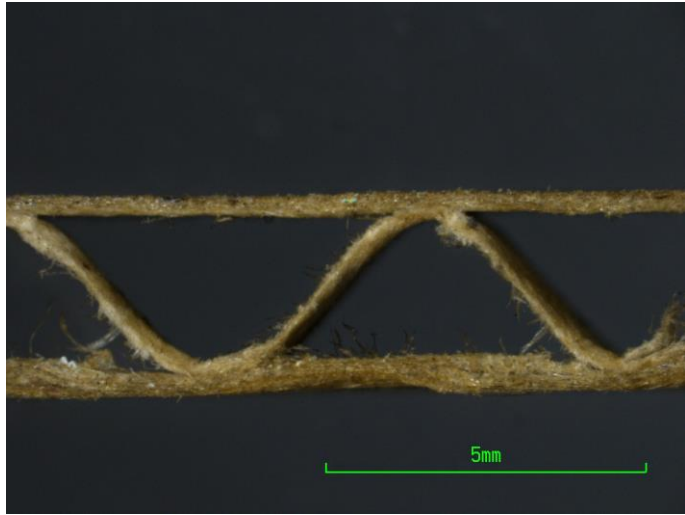


Goal ratio	Actual ratio for the different boards				
Cut/Uncut	BK	BW	CK	CW	Side
2.5/4	4.3/2.3	3.2/2.3	4.5/2.1	4.5/2.0	Top
	3.0/3.5	3.1/3.4	2.9/3.6	3.4/3.0	Bottom
2.5/2.5	4.3/0.6	4.3/0.8	4.3/0.6	4.4/0.6	Top
	3.0/2.1	3.1/1.8	2.9/2.2	3.1/1.8	Bottom
4/4	6.0/2.3	5.9/2.3	5.9/2.2	5.9/2.0	Top
	4.4/3.5	4.5/3.6	4.3/3.6	4.4/3.4	Bottom
4/2	5.8/0.3	5.6/0.2	4.1/1.8	6.1/0	Top
	3.9/2.1	4.4/1.6	4.6/1.4	4.3/1.7	Bottom
8/4	9.8/2.4	9.6/2.3	n.a.	10.0/2.0	Top
	8.6/3.6	8.2/3.9	n.a.	8.4/3.6	Bottom



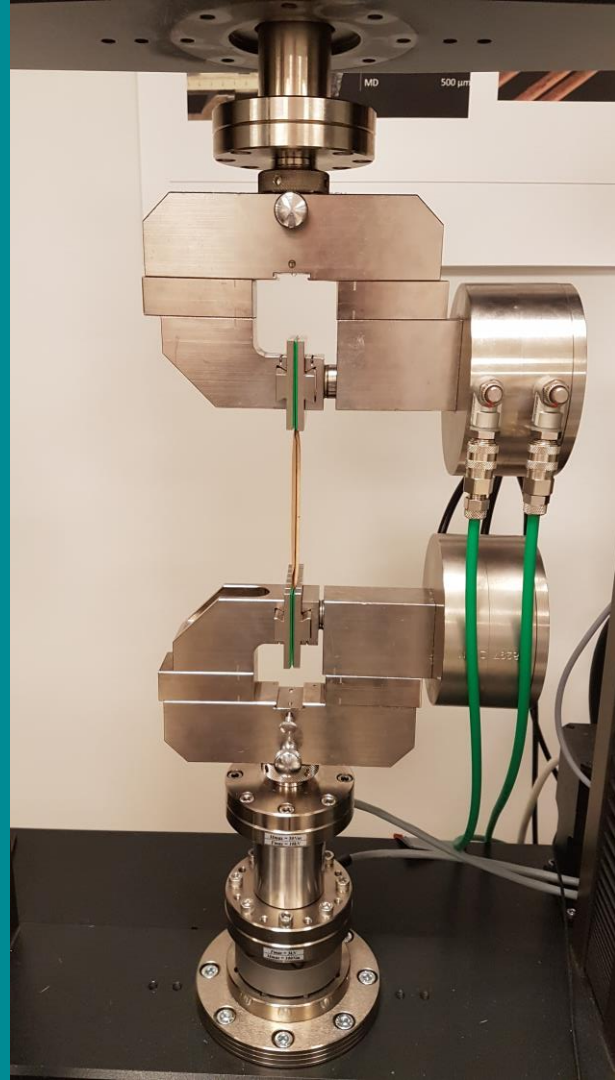


# Conventional cutter vs laser cutting



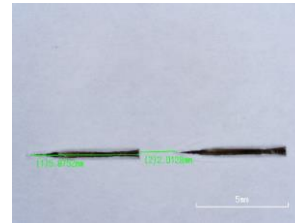
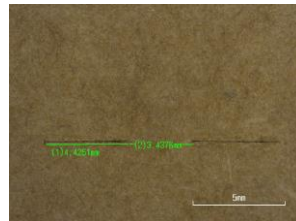
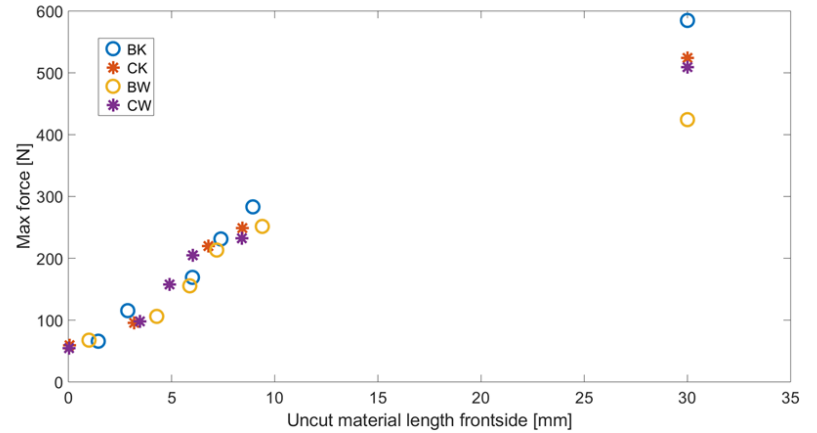
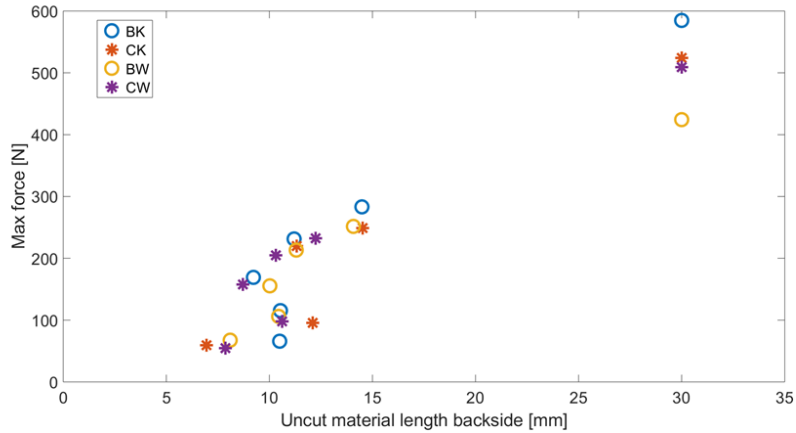
**Lets look at  
some  
parameters**

# Strength

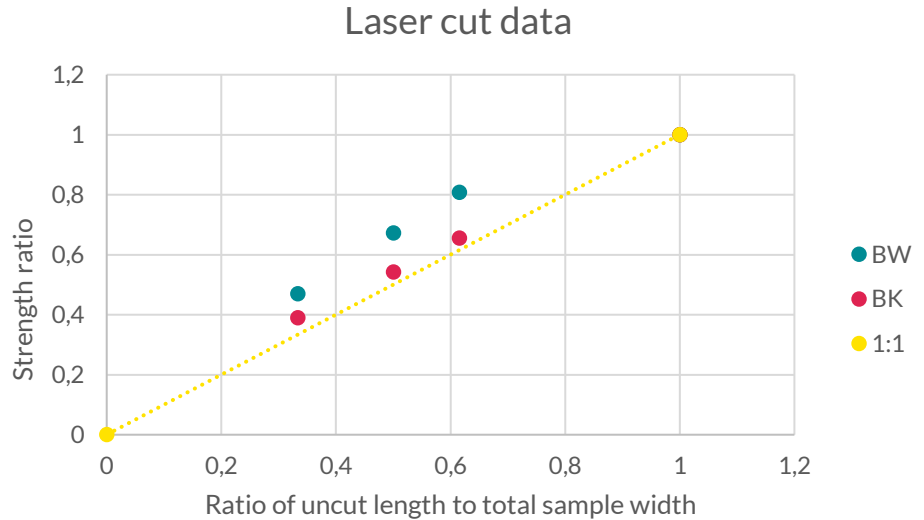
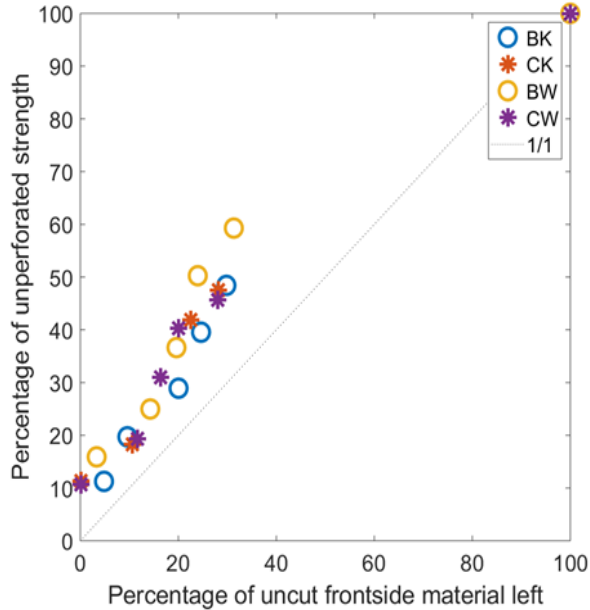


RI  
SE

# Perforations on the cutting table



# In relative terms... and compared to laser cut samples



**The strength of the perforation is governed by the cut/uncut ratio of the most damaged side**

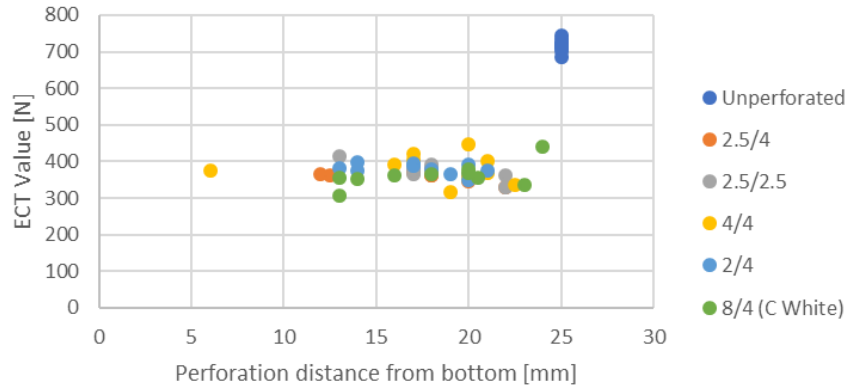
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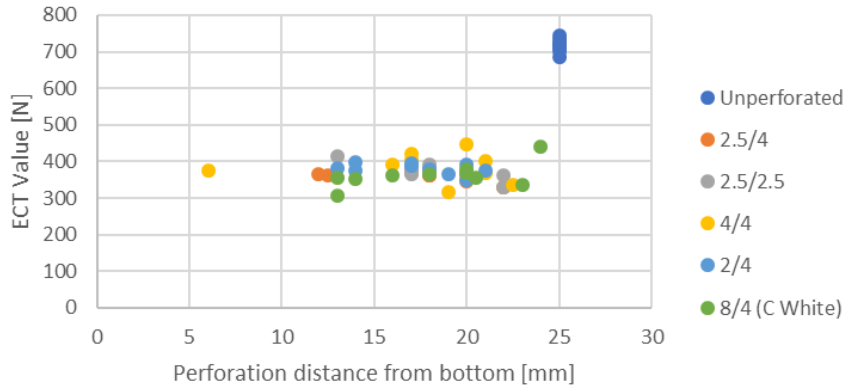
# Edge crush test

Effect of perforation type and placement on ECT test

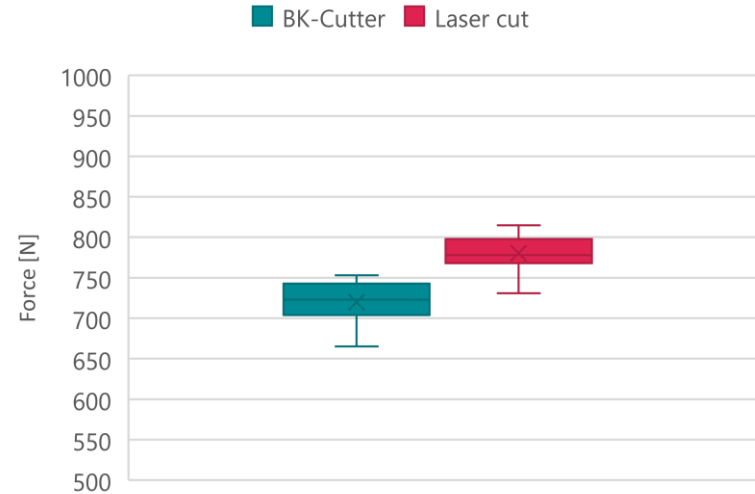


# Edge crush test

Effect of perforation type and placement on ECT test



Edge compression test comparison



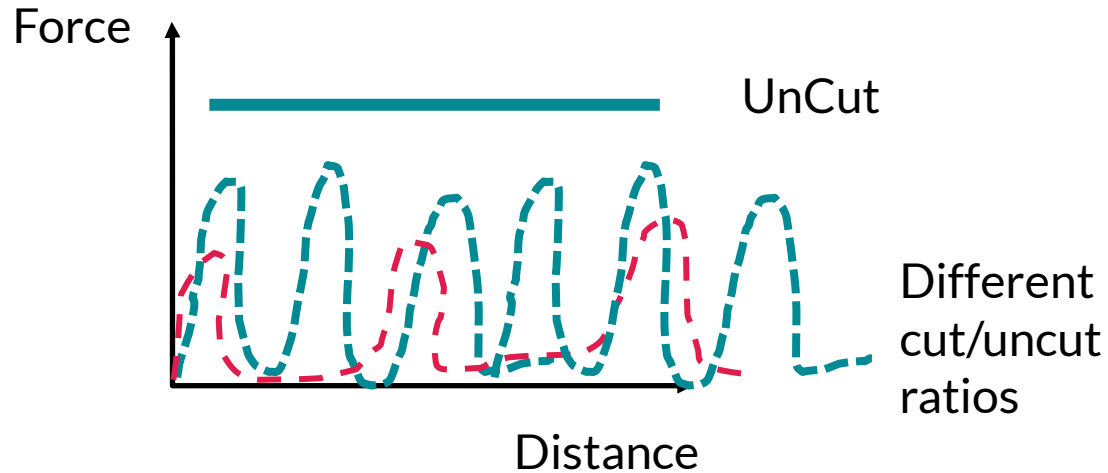
**The ECT is halved  
independent on  
cut/uncut ratio**

**Laser cutting  
increases the ECT  
value slightly**

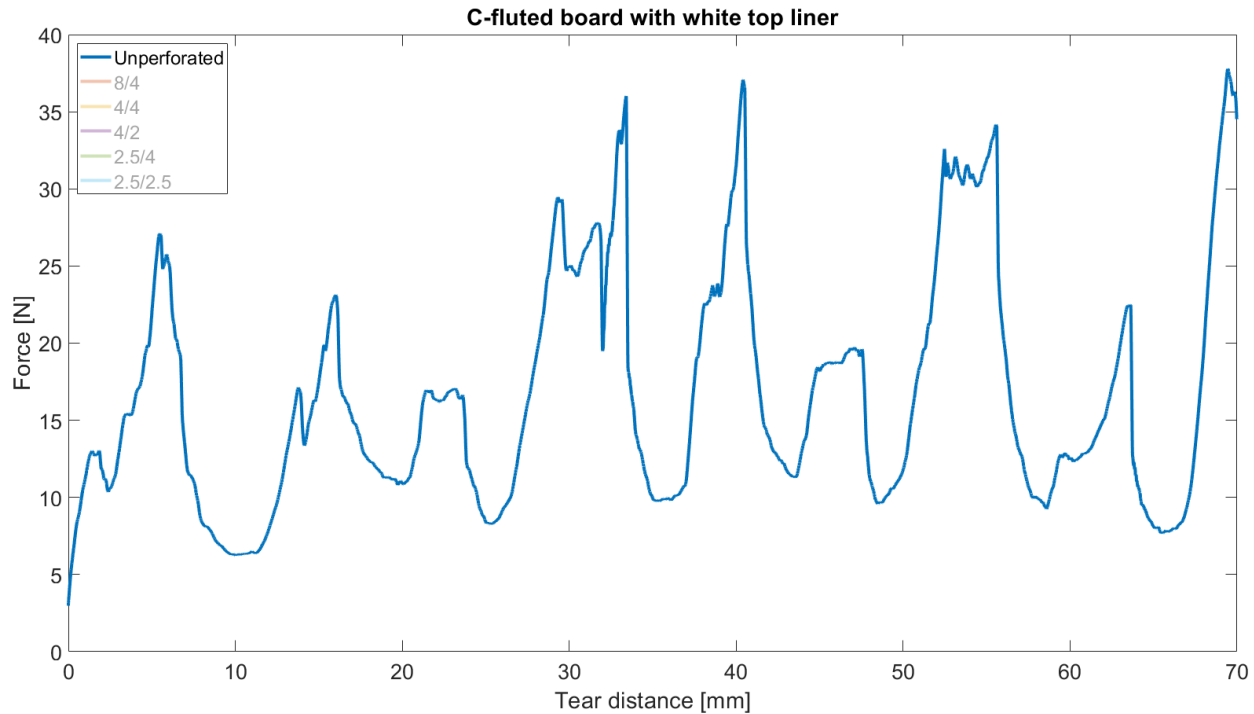
# Tearing the perforation



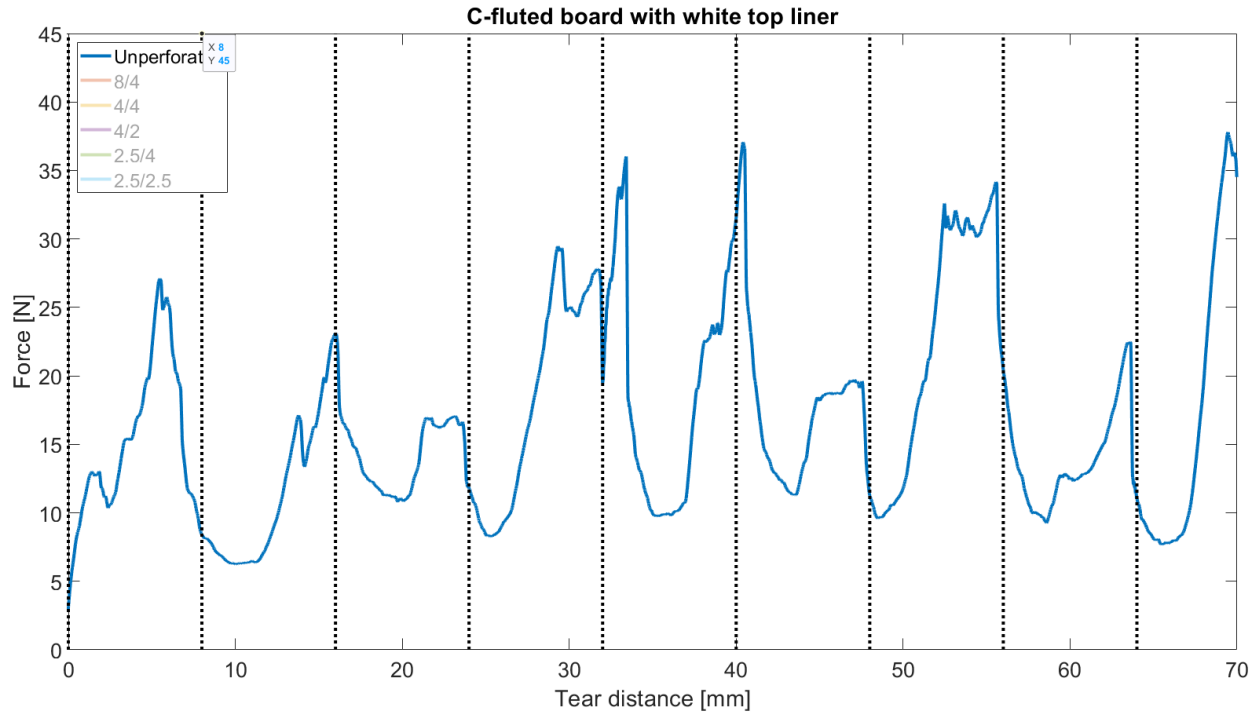
# What we (naively) expected.



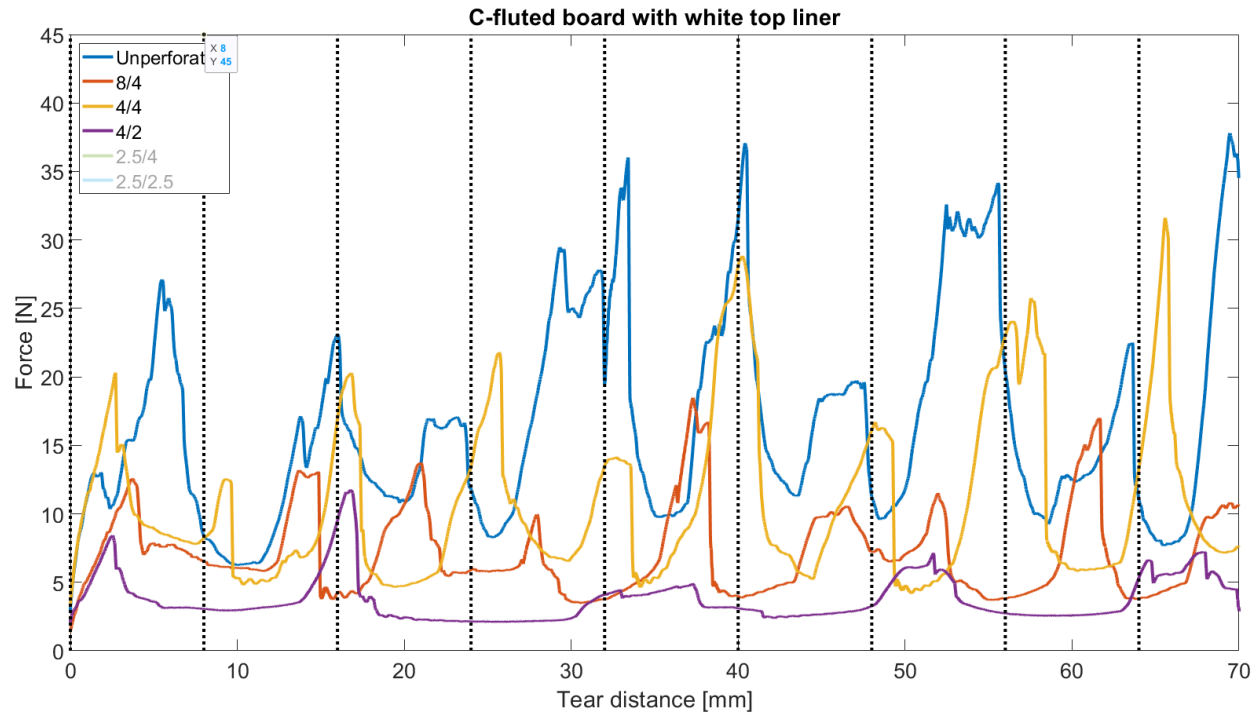
# Reality



# Reality



# Reality



**Is it the  
perforation or the  
fluting that is in  
charge?**

# Conclusions

- Different liner materials and fluting types seem to respond similarly to different kinds of perforations.
- Perforating using a cutting table leads to damages to the top layer which governs the measured behaviour of the perforation, an observation which is well in line with the industry experience.
- The cut/uncut ratio of the perforation should have little influence on the “whole box” mechanics, since the stiffness remains unaffected, and the measured ECT shows an equal strength drop for all ratios.
- The cut/uncut ratio has, as was expected, a large influence on the strength of the perforation.
- Using a laser cutter for sample preparation increases the precision of the samples, simplifying data analysis.

# References:

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- 8. Wang, Di; Ge, Changfeng (2017); Opening of perforated folding cartons: From the field to testing, Packag. Technol. Sci. 2017; 30: 411–425.

**Thank you!**

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