

# Simulation of the roll-forming process of an open thin-walled upright section

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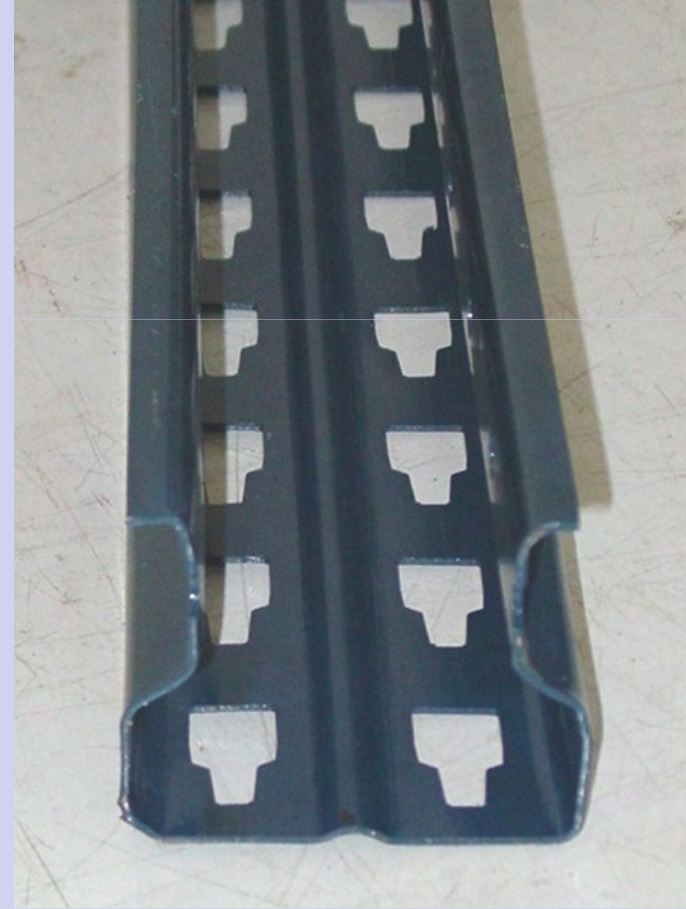
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ECCS TC7 WG 7.5  
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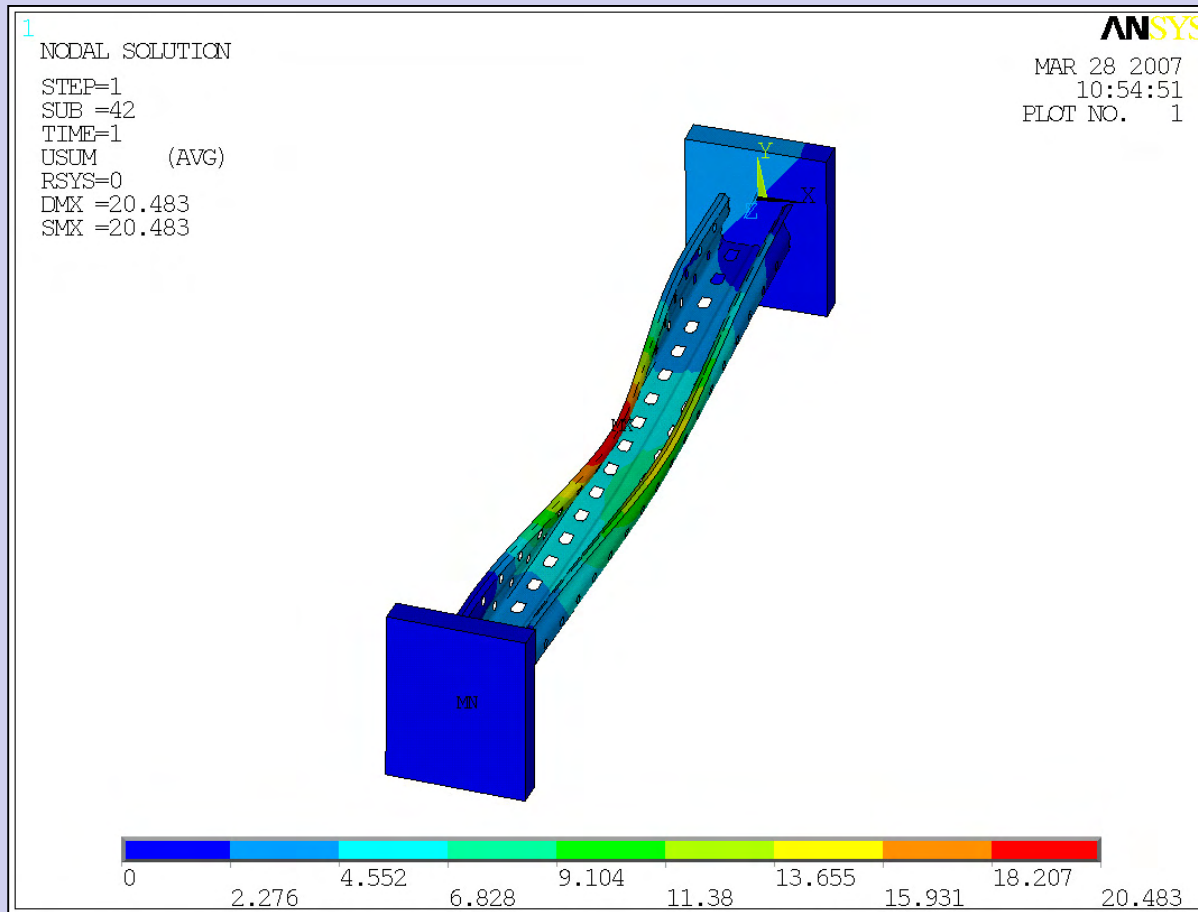
In pallet racking systems it is habitual to use for the uprights open cold-formed thin-walled steel sections, obtained by roll-forming



Their behaviour under compression can be analysed experimentally,



analytically or by finite element simulation.



- In the finite element simulation usually material non linearity, large displacements and initial geometric imperfections are considered.
- But until now, the effect of the residual stresses due to the forming process, is usually non considered.
- With the aim of introducing these stresses in the finite element simulation, our group has started to simulate the roll-forming process of open steel sections, using the COPRA RF an COPRA FEA software.
- In this paper we present our first experiences and results.



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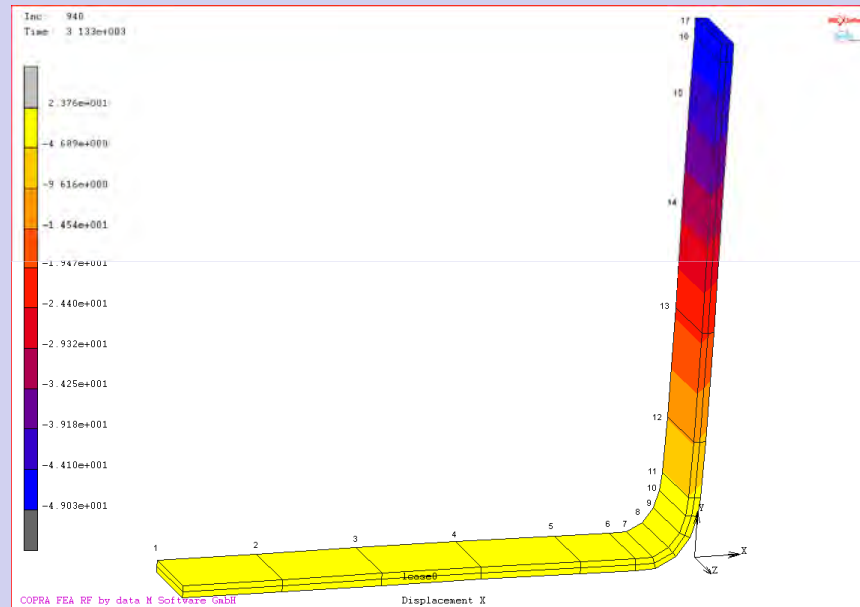
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U-section (102,7 x 51,4, t = 1,22 mm)

Steel:  $f_y = 329$  MPa,  $f_u = 420$  MPa

6 forming stands + 2 rectification stands

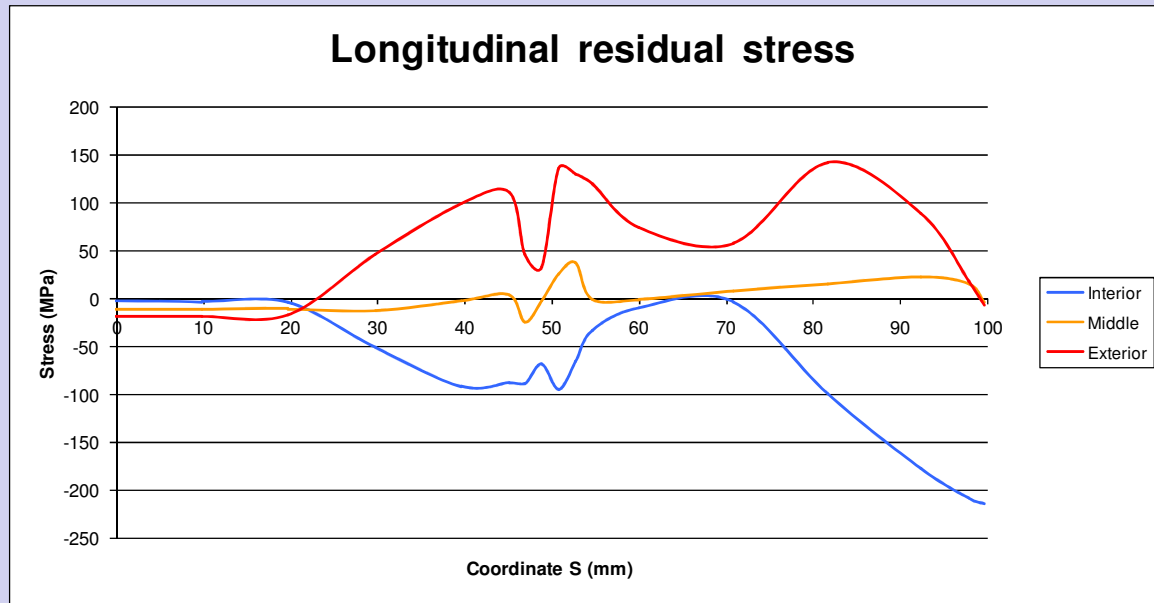
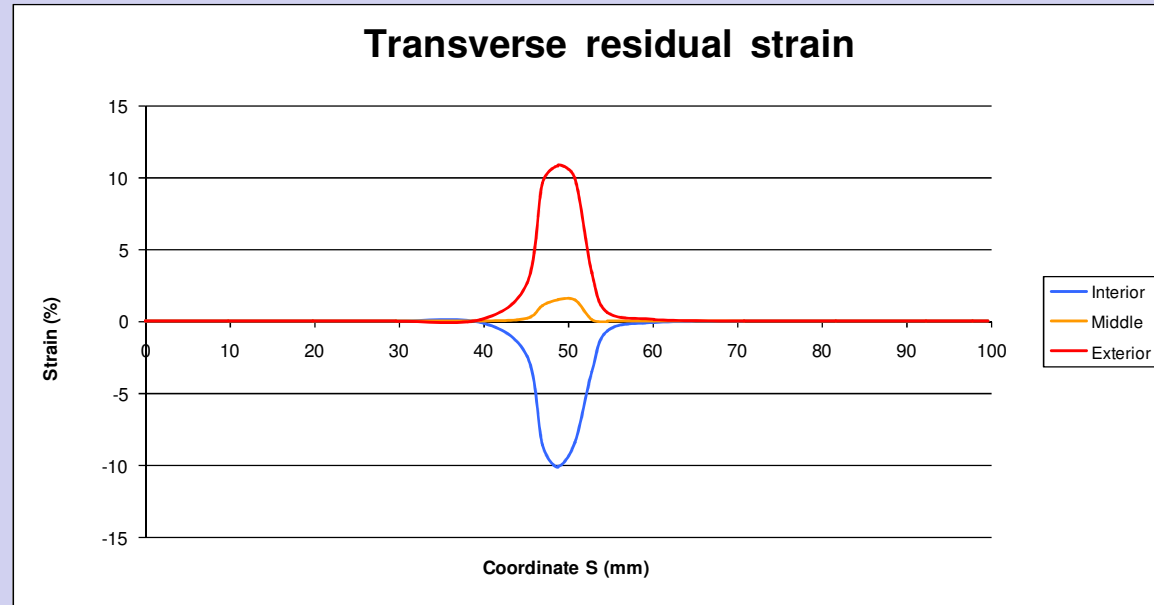
Distance between stands: 350 : 400 mm



Mesh MU1

16 div. x 2 lay. x 61 lin. = 1952 elem.





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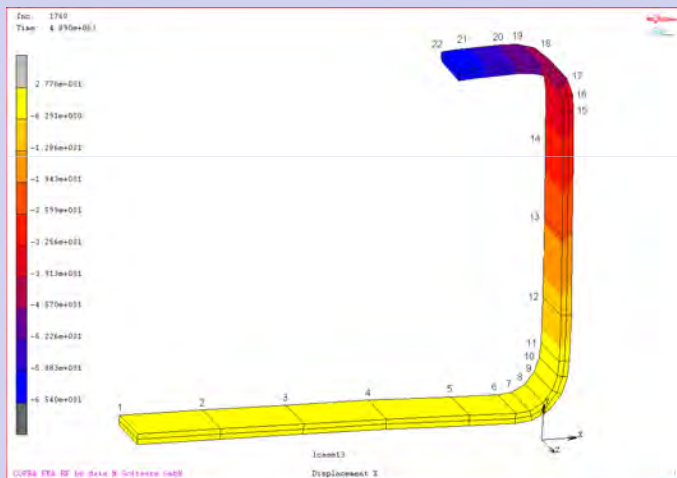
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C-section (102,7 x 40,0 x 11,4, t = 1,22 mm)

Steel:  $f_y = 329$  MPa,  $f_u = 420$  MPa

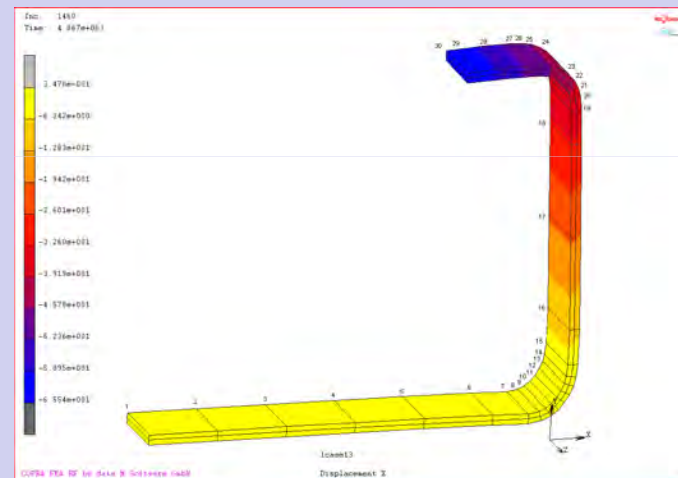
11 forming stands + 2 rectification stands

Distance between stands: 350 : 400 mm



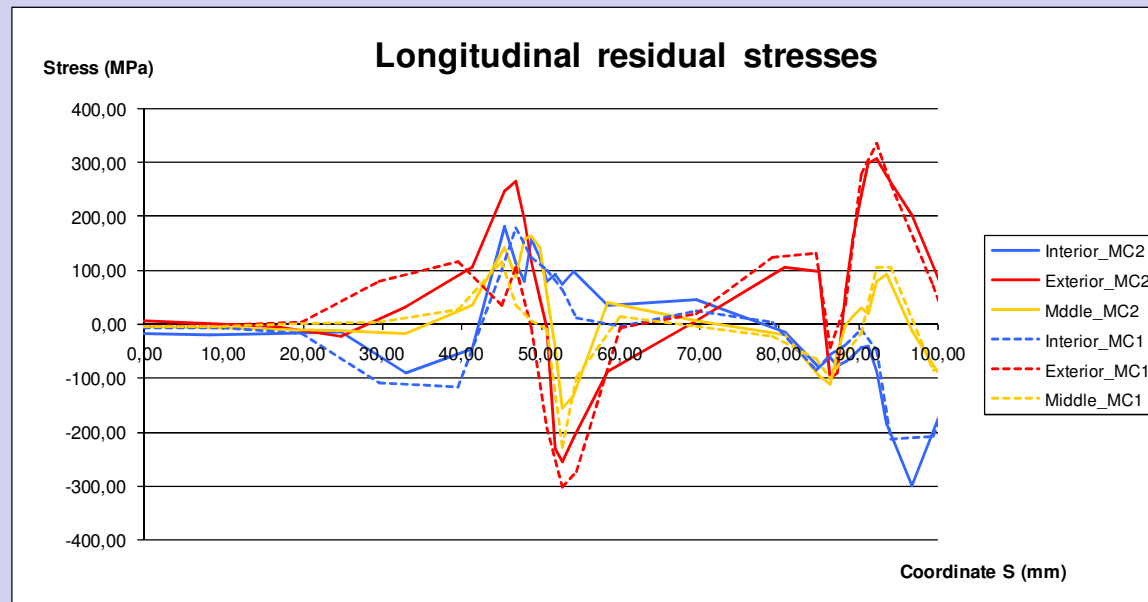
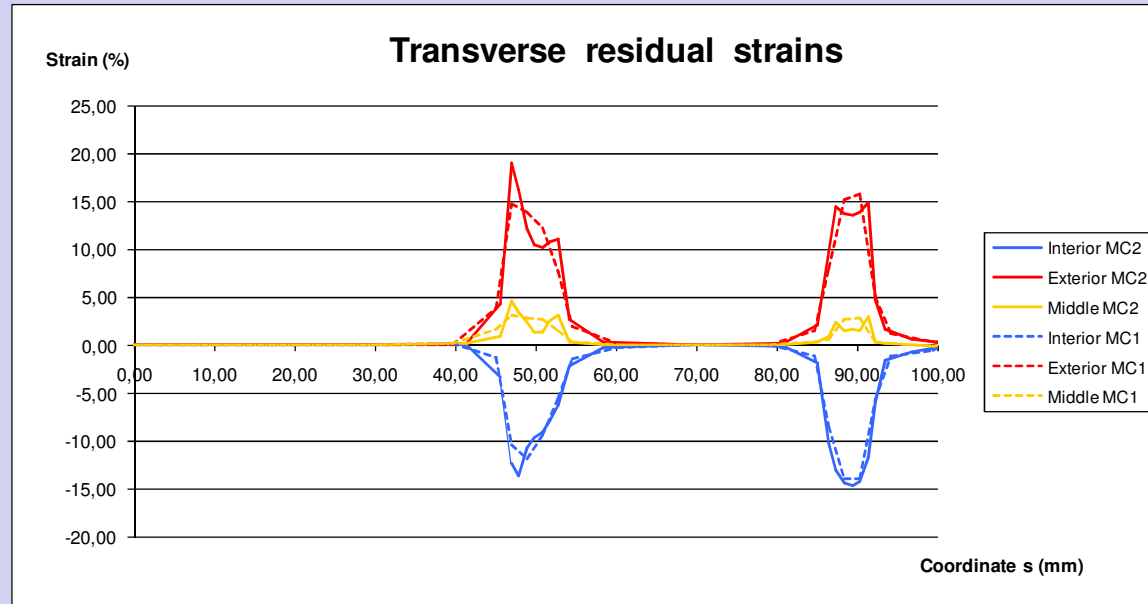
Mesh MC1

21 div. x 2 lay. x 61 lin. = 2562 elem.



Mesh MC2

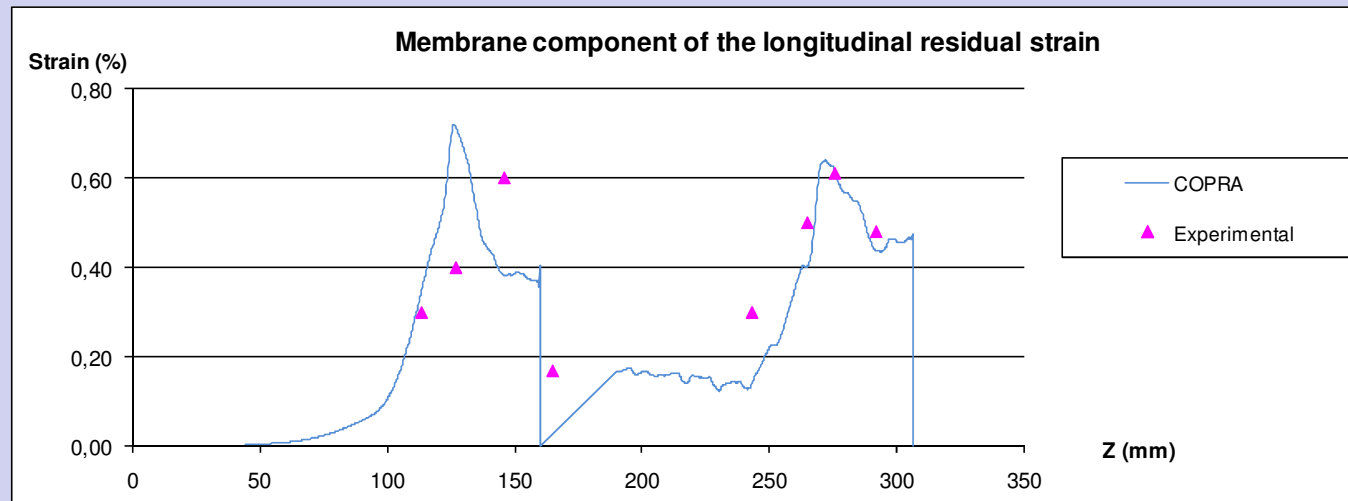
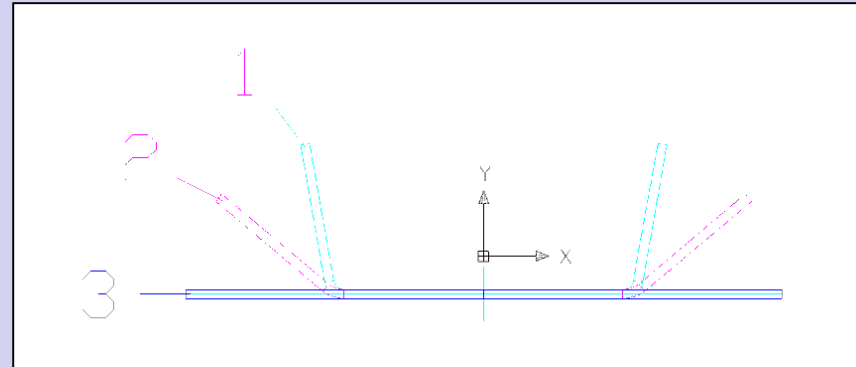
29 div. x 2 lay. x 61 lin. = 3538 elem.



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Trapezoidal-section  
(20 x 10 80°, t = 0,6 mm)  
3 forming stands

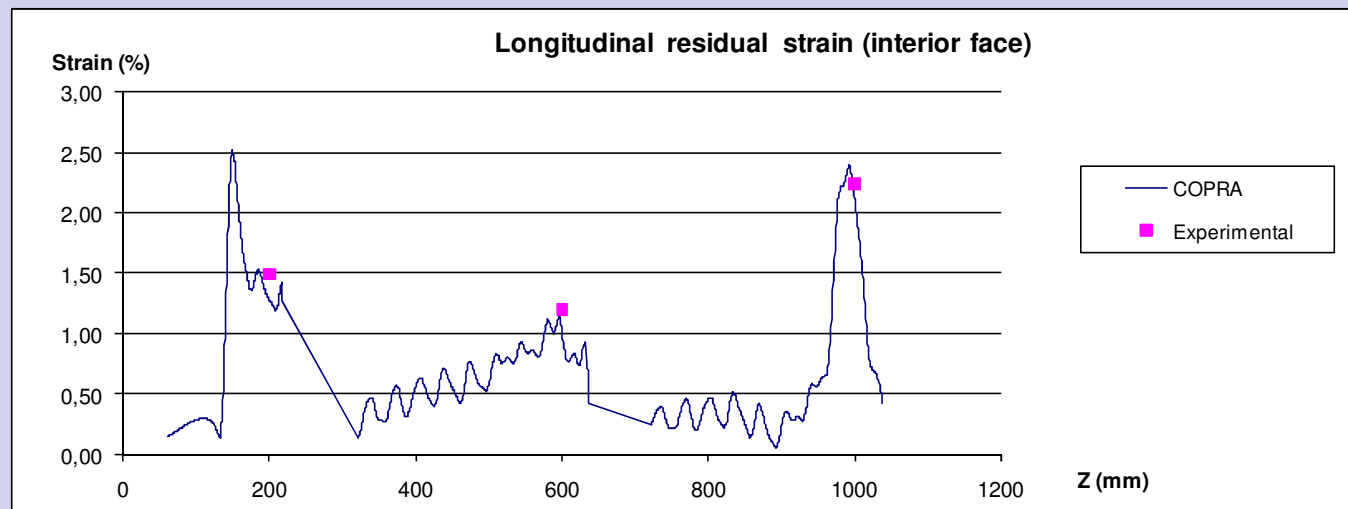
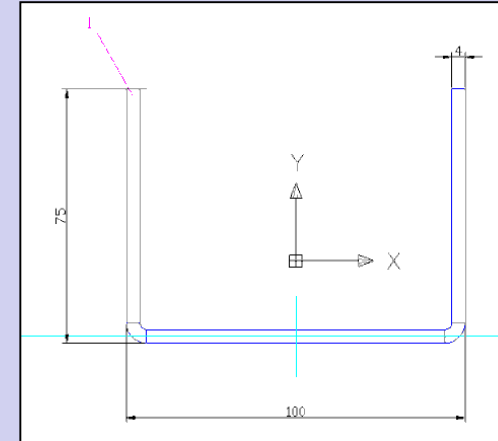


Comparison with experimental results (Bhattacharyya, D. , Smith, P.D.)

## U-section

(100 x 75,  $t = 4$  mm)

4 forming stands



Comparison with experimental results (Heislitz, F. & others, Damm, K.)



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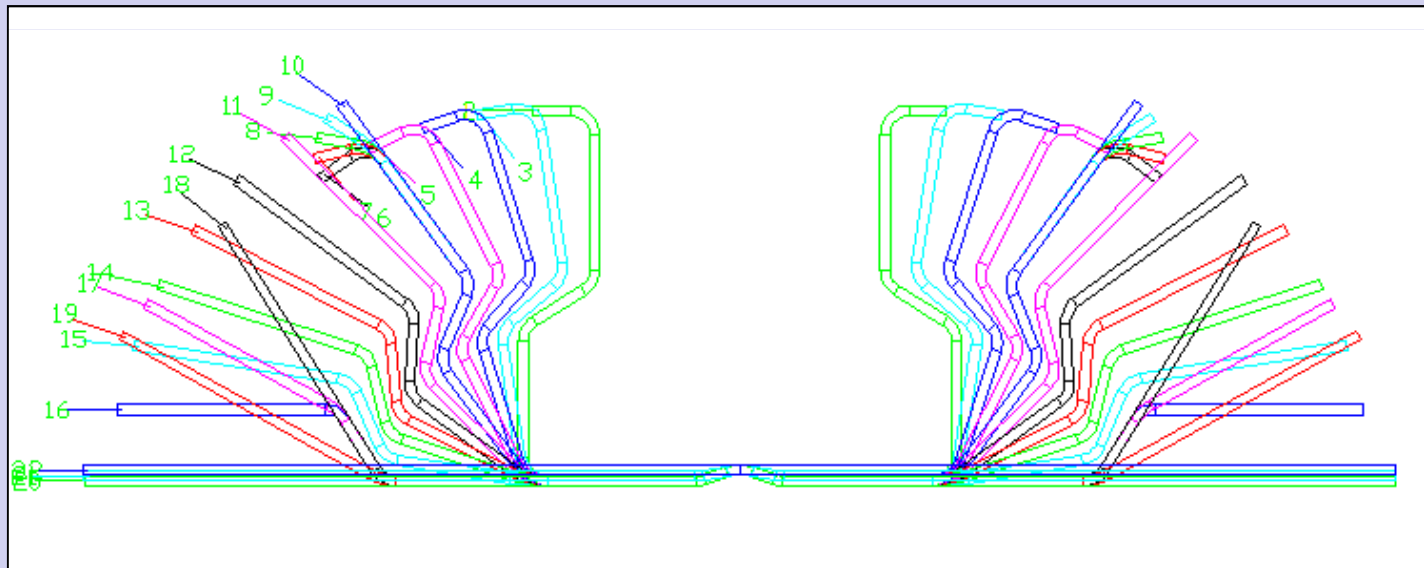
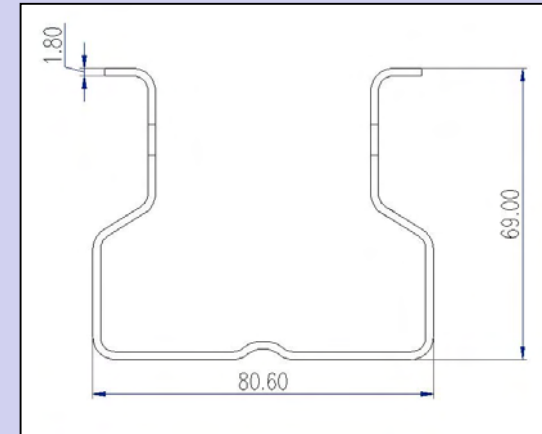
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Upright-section (80 x 69, t = 1,8 mm)

Steel:  $f_y = 402$  MPa,  $f_u = 500$  MPa

20 forming stands + 1 rectification stand

Distance between stands: 350 : 400 mm



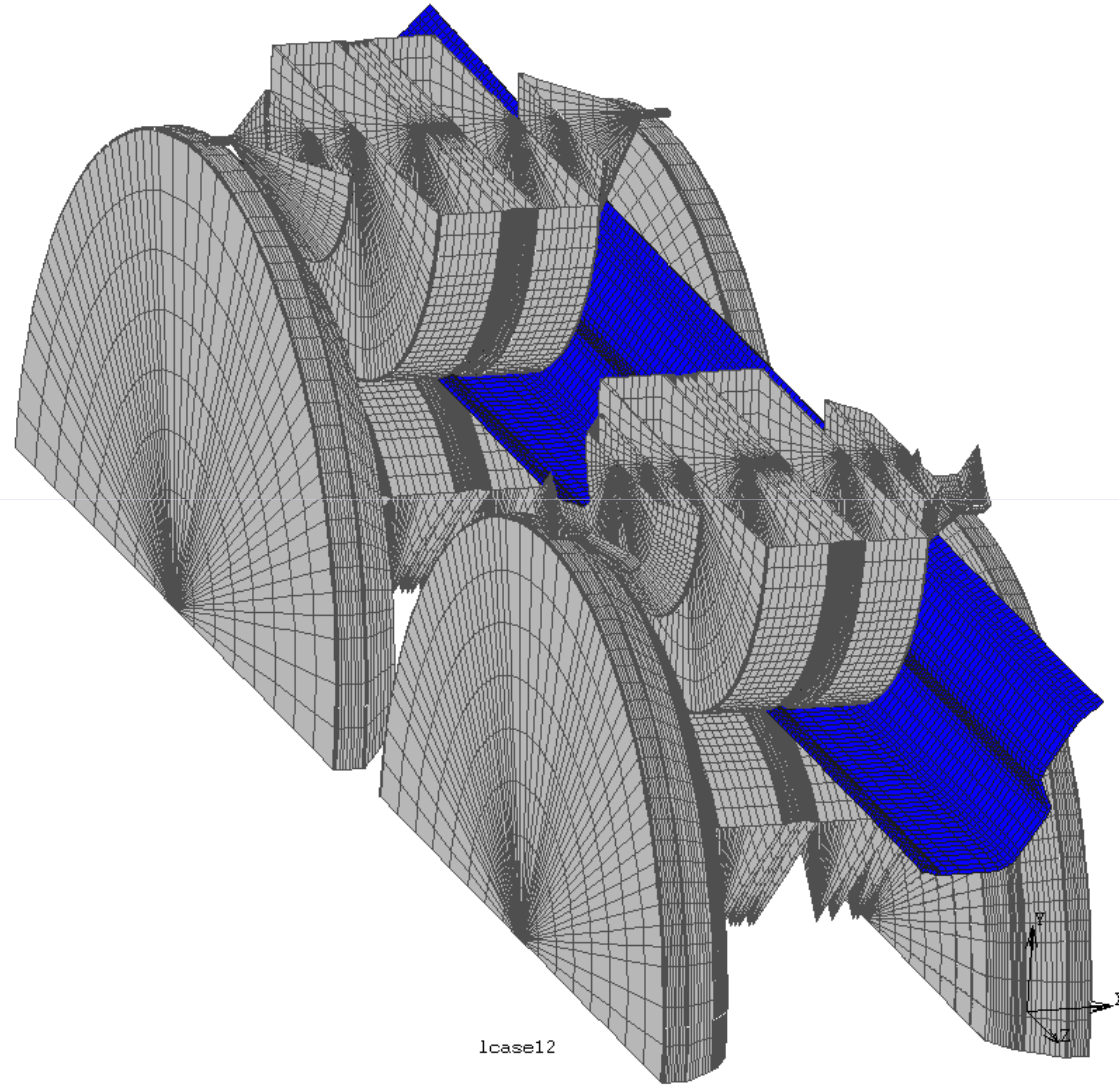
20 step flower for defining the roll-forming of the Upright section

## Roll – forming line

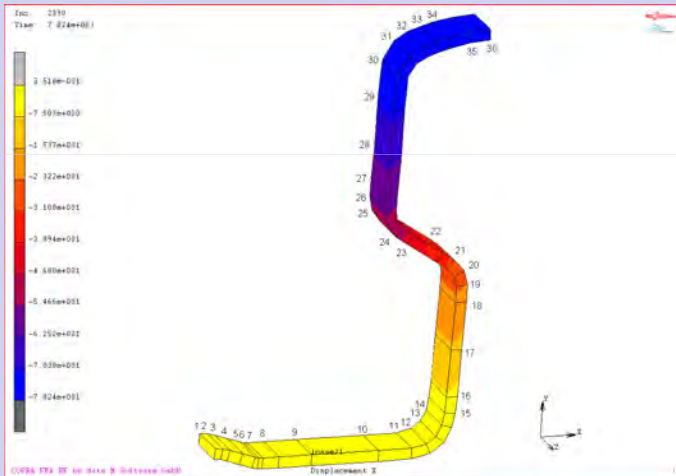


## Mesh details

Inc: 1815  
Time: 4.232e+003

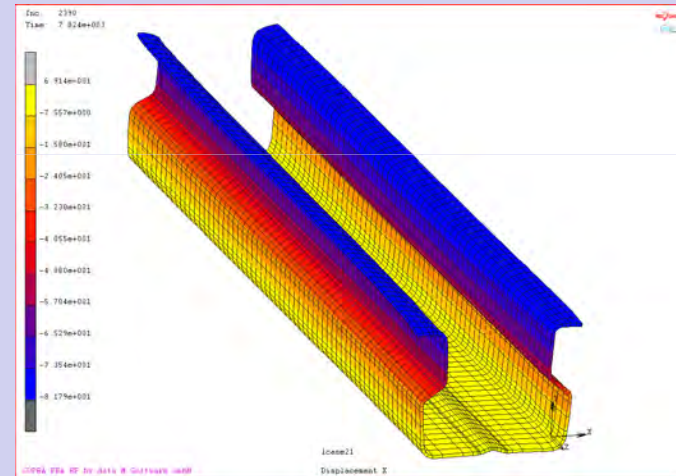


## Upright-section (80 x 69, t = 1,8 mm)



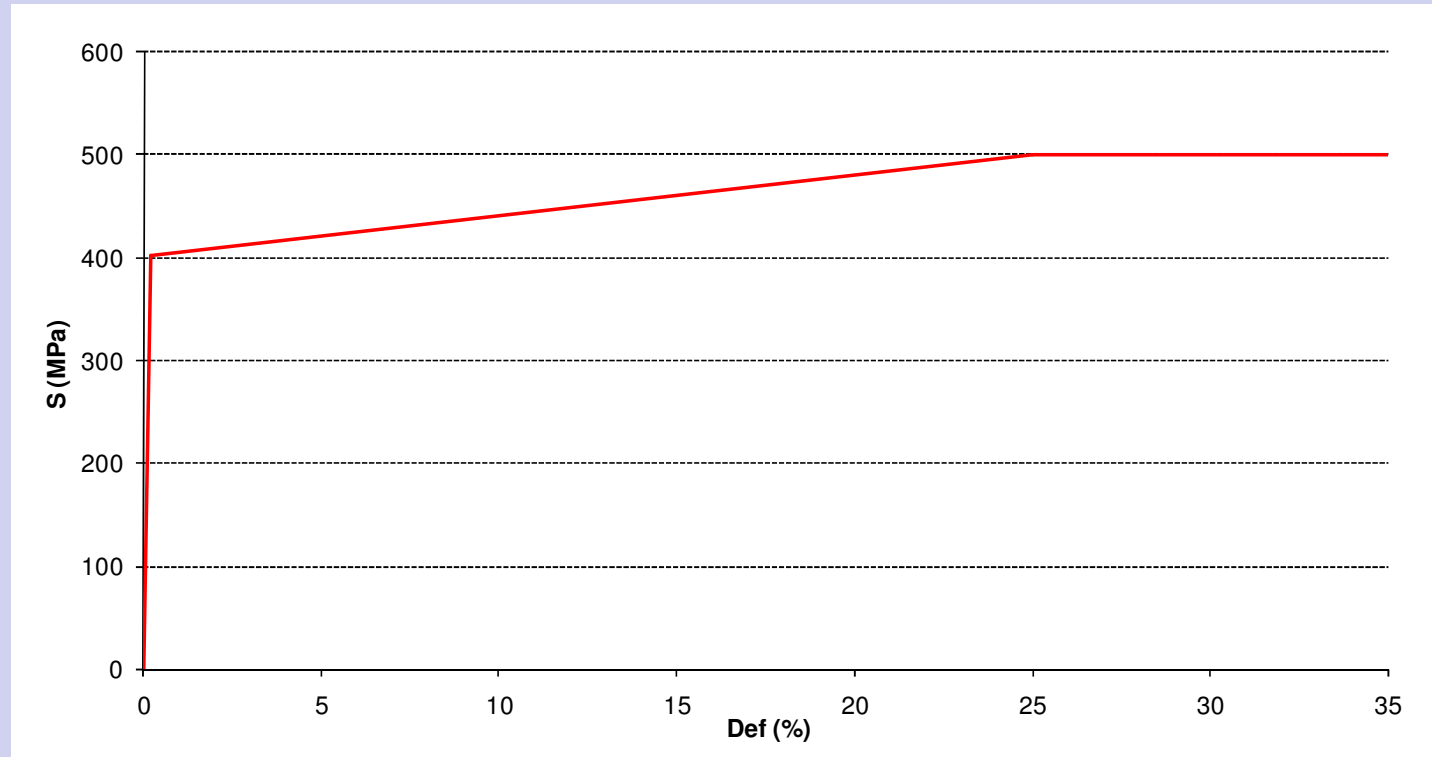
Mesh MP1

35 div. x 1 lay. x 62 lin. = 2170 elem.



Simulated roll-formed Upright P1

Material curve used in the simulation :



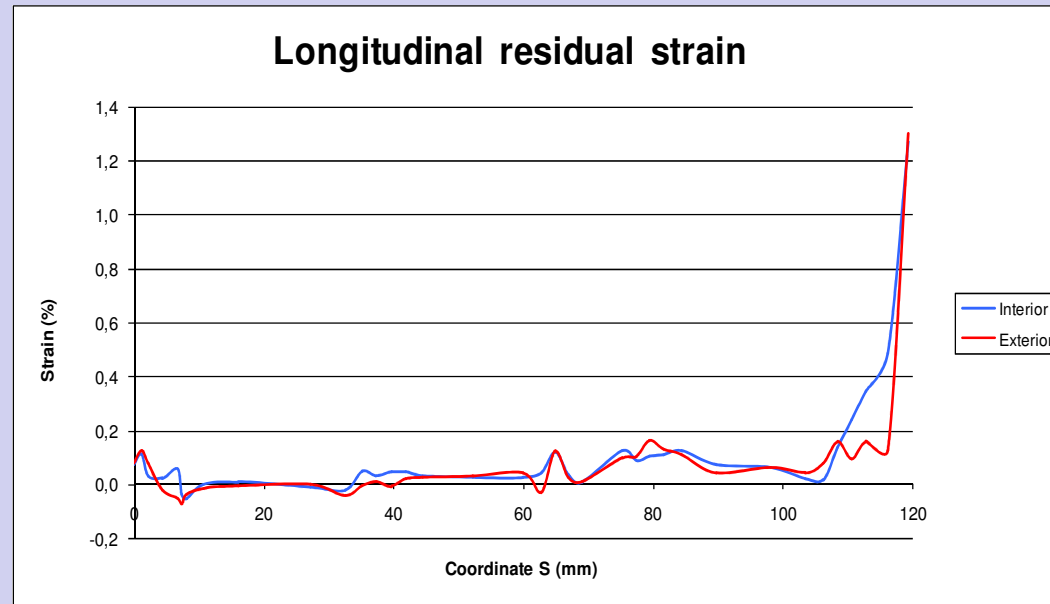
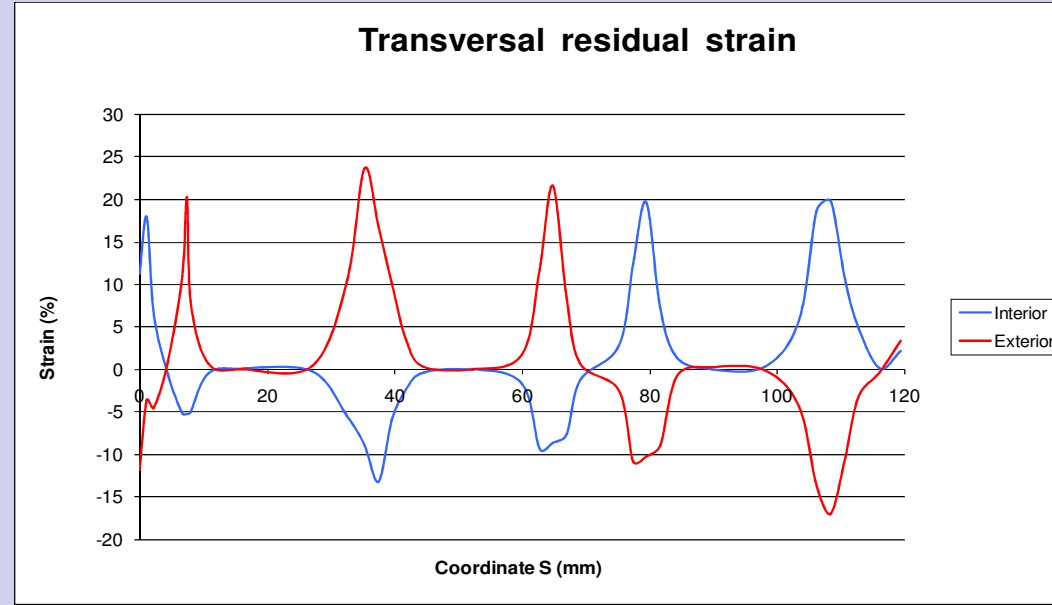
## Equivalent Von Mises Residual Stress

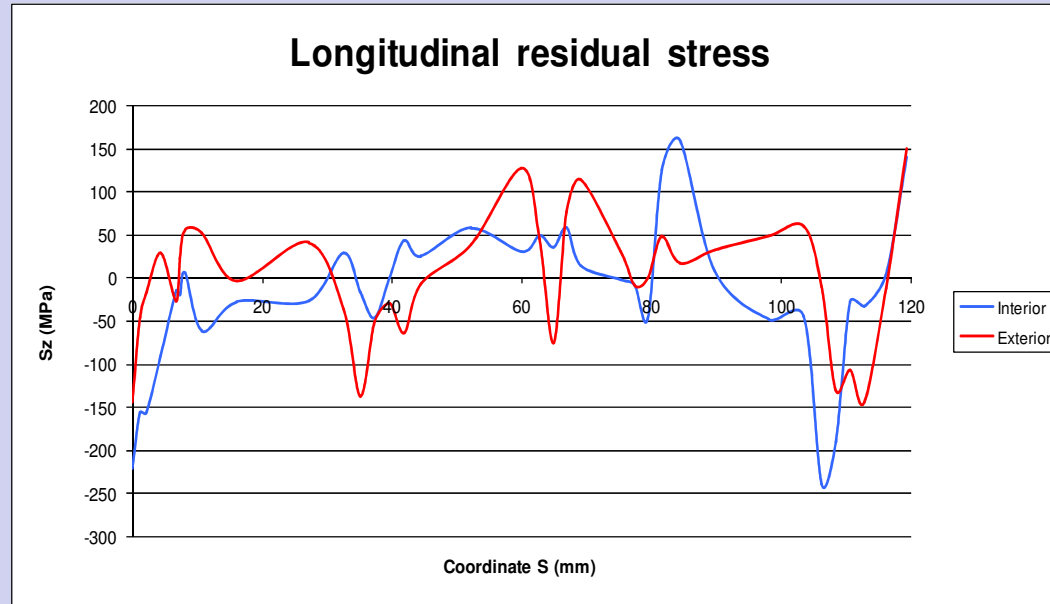




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Coordinate	0	35	60	85	105	120
Exterior	- 144	- 137	+ 126	+ 16	- 11	+ 150
Interior	- 221	- 17	+ 30	+160	- 240	+ 140

Peak values of longitudinal residual stress (MPa)

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- With the use of COPRA RF and COPRA FEA software it has been possible to simulate the roll-forming of:
  - U-section and C-section, obtaining consistent results.
  - Channel-trapezoidal-section and U-section, and compare with experimental results in the literature, with good agreement.
  - Upright-section, obtaining residual strains and stresses.
  - The values of the residual longitudinal stresses are high, and they probably will be significant when doing the stability analysis of the upright.

- The results obtained are very consistent and promising. The next steps will be:
  - Refine the model and process of the upright-section.
  - Obtain the distribution of residual strains and stresses.
  - Include these values in the stability analysis of the upright.
  - The possibility of doing some experimental measures of the residual stresses is considered.

## Acknowledgements

- This research project has the support of XARTAP (Reference Network in Advanced Production Techniques) University and Industry Department of the Generalitat de Catalunya.
- The authors wish to thank DATA M, for the advice and support in the use of the COPRA software.



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