NUMERICAL STUDY TO STRUCTURAL INTEGRITY OF MULTI-STOREY BULDING UNDER FIRE

Z. Sokol, F. Wald, M. Pultar, M. Beneš, J. Pašek

Czech Technical University in Prague

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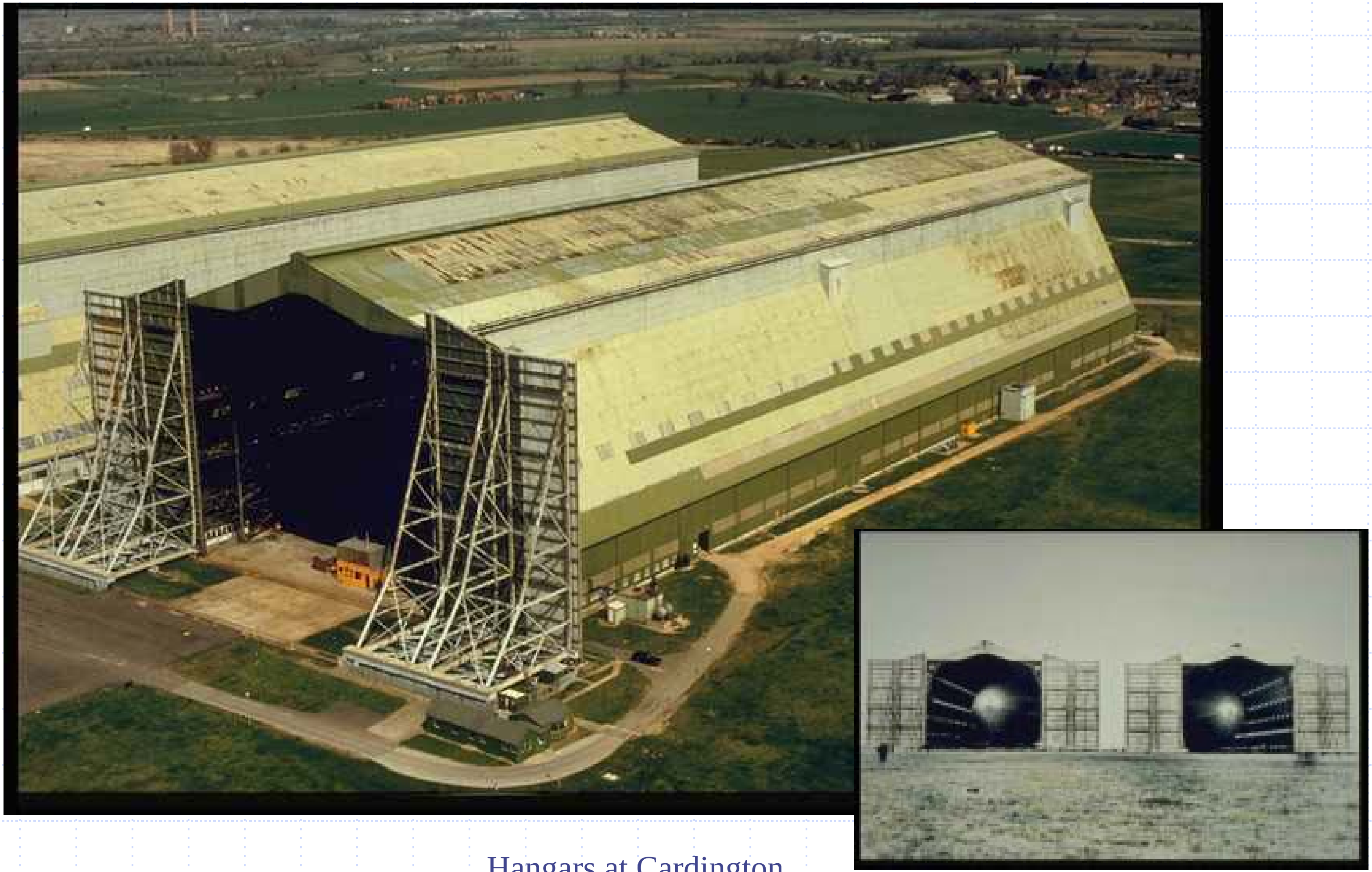
Experiment



Hangars at Cardington

Experiment

Fire load in the compartment
40 kg of wood /m²

Structure during the fire test

Analysis of Response of the Building at Fire

2D Structural analysis using ANSYS 5.7

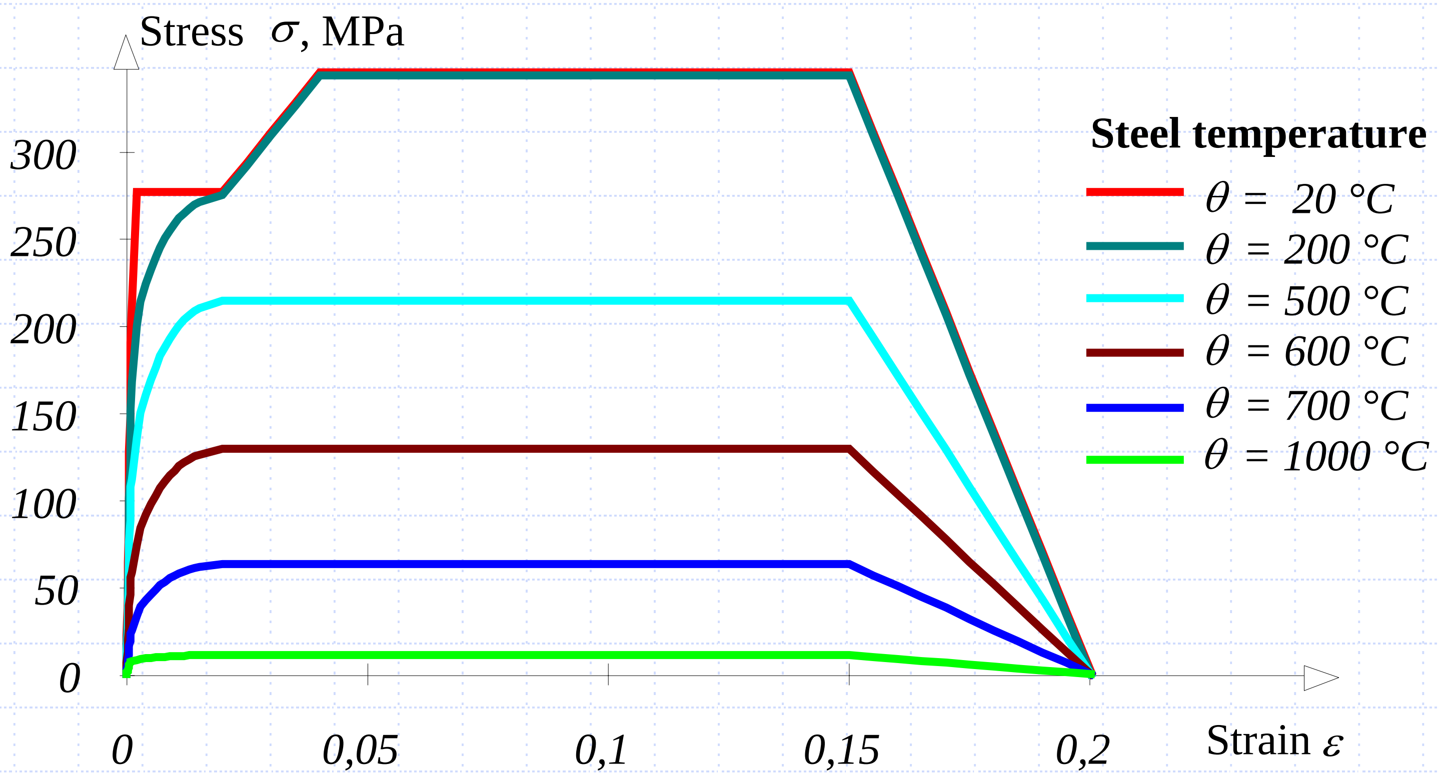
Three steps of the analysis

- Application of dead load
- Heating to 1000°C
- Cooling to 20°C

Non-linear analysis with

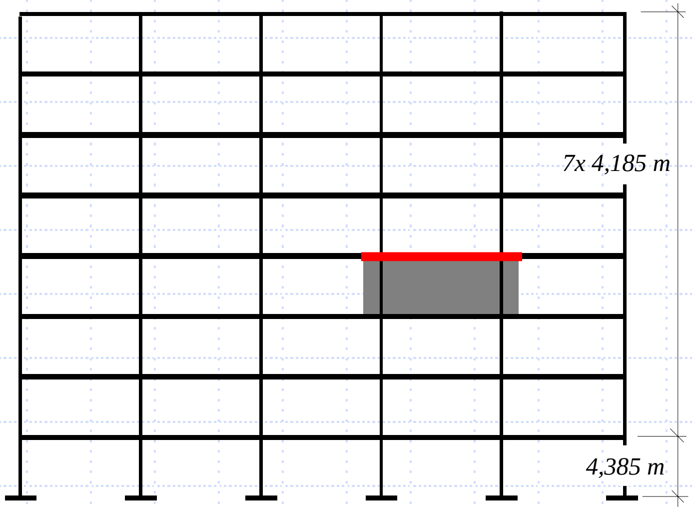
- Large strain
- Large deformations
- Thermal expansion
- Temperature dependent material ……MISO option
- Plasticity…………………………….plastic beam element BEAM23
- Reinforced concrete slab…………......tension-only element LINK10 (reinforcement)
  compression-only el. LINK10 (concrete)
- Shear connectors…………………… non-linear springs COMBIN39
- Modelling of joint characteristics……non-linear springs COMBIN39

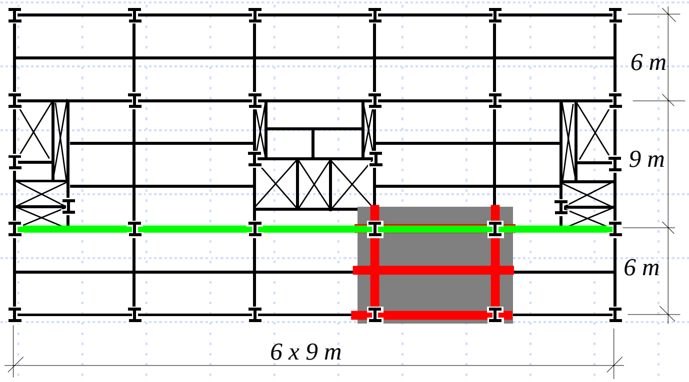
Material Model

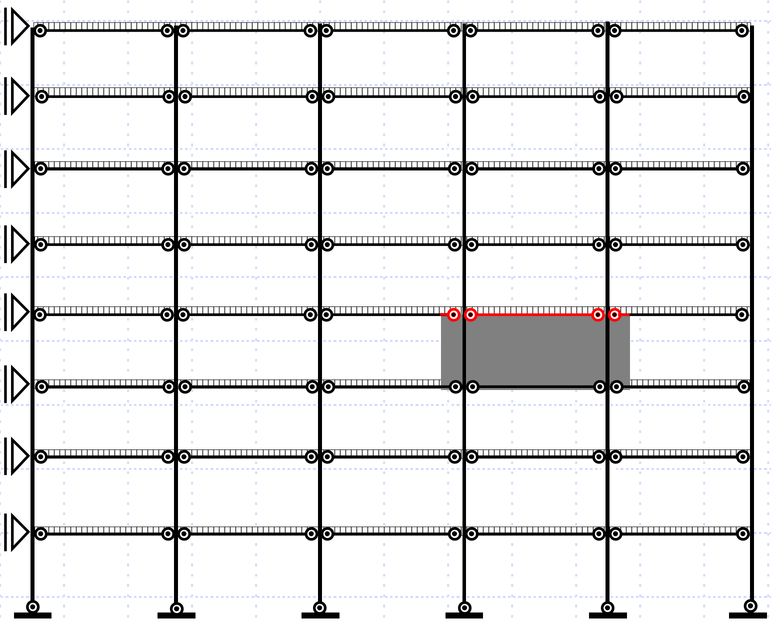


Stress-strain ($\sigma - \varepsilon$) diagram for variable steel temperature

Analysis of Cardington Frame I

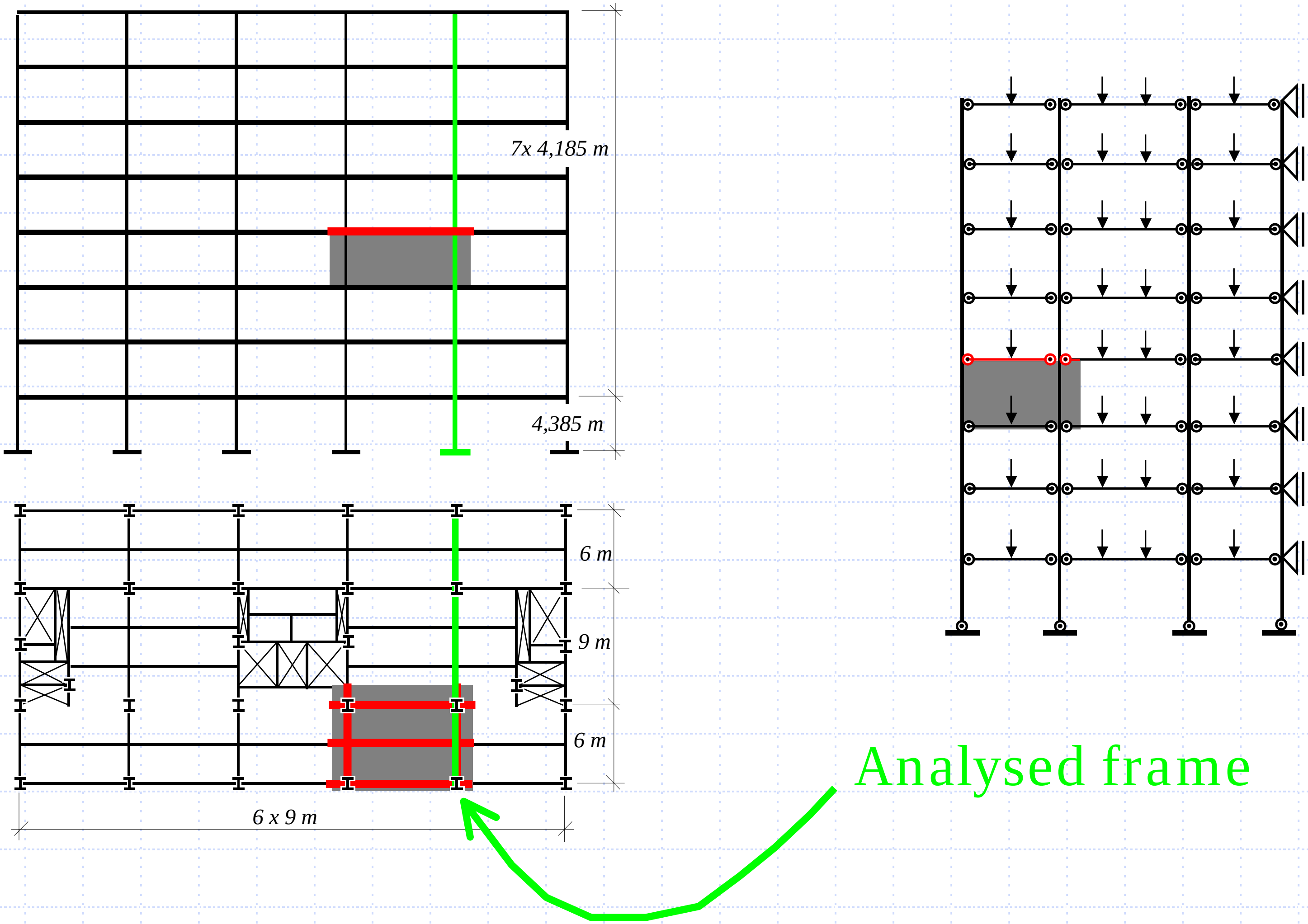




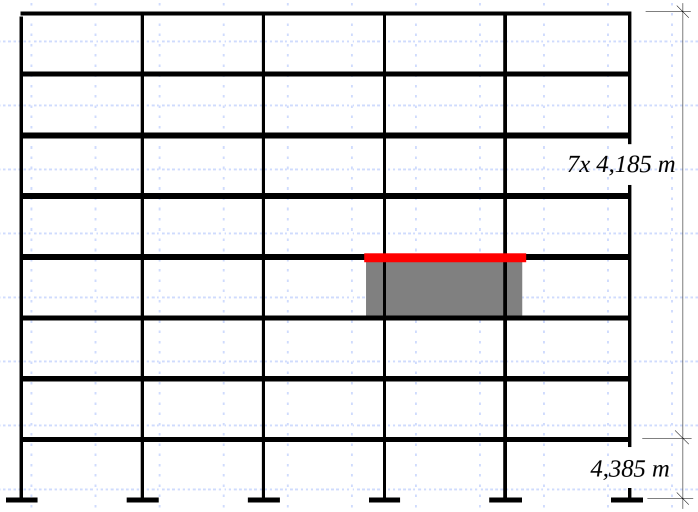


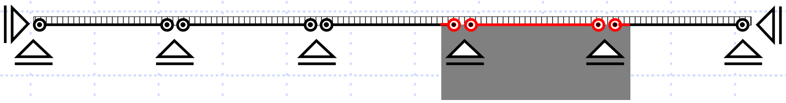
Analysed frame

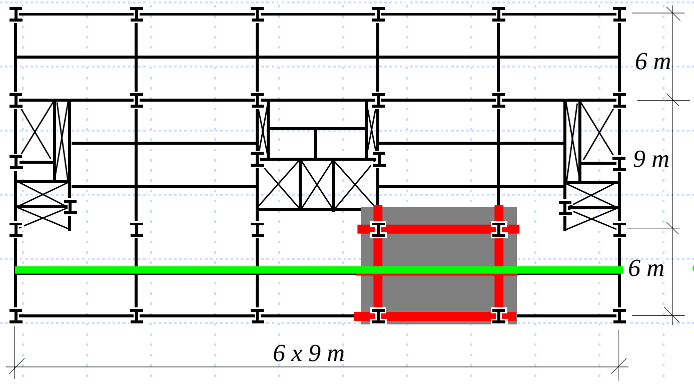
Analysis of Cardington Frame II



Analysis of Cardington Frame III



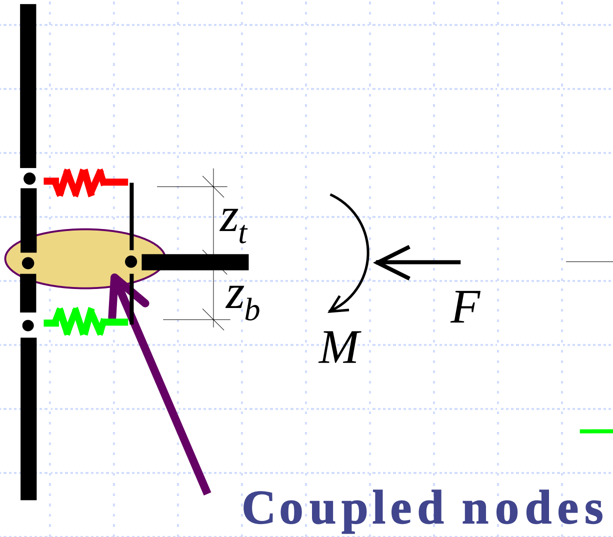


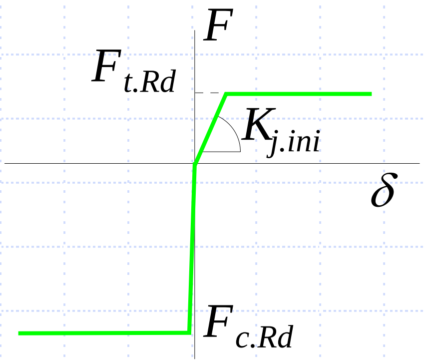


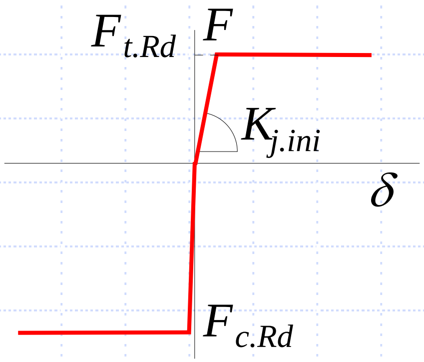
Analysed beam

Modelling of Joints

Model for FEM Analysis

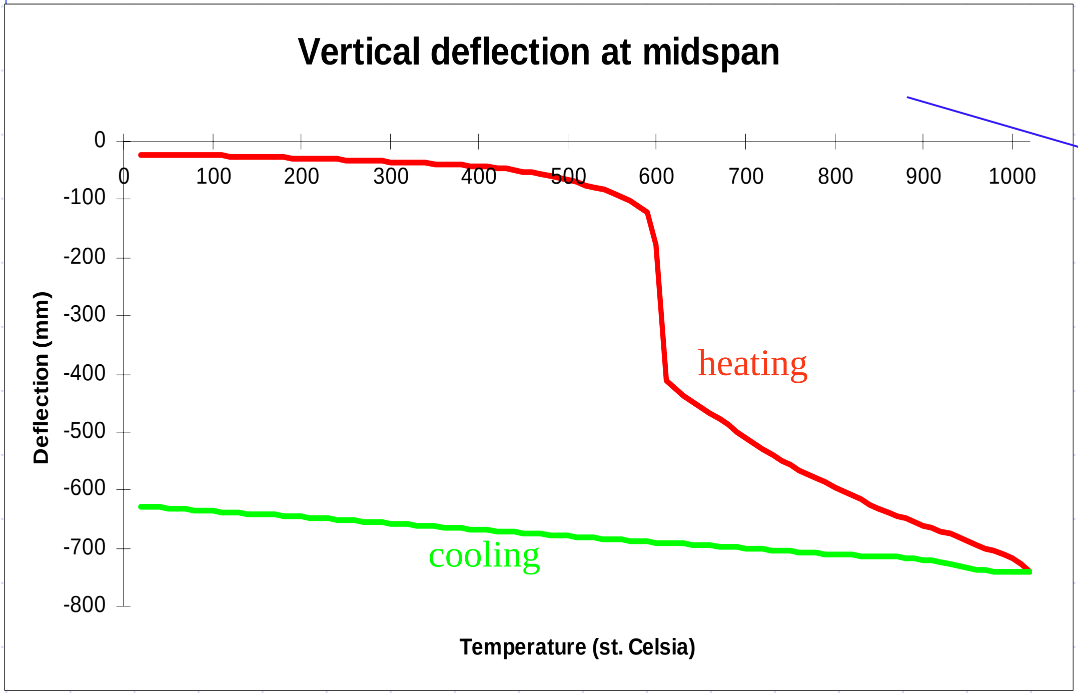


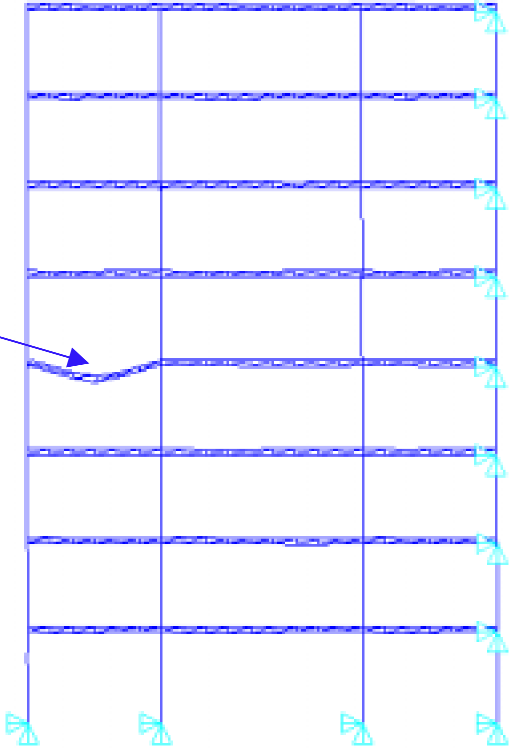




Results
– deformation of primary beam

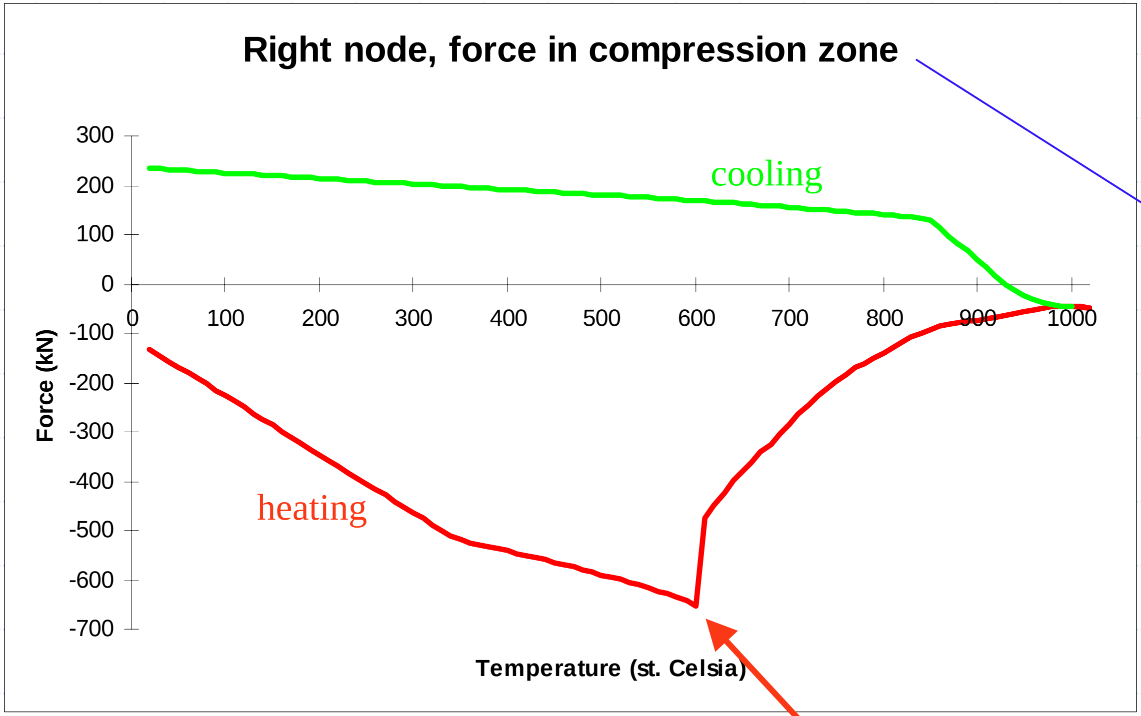
Maximum deflection 750 mm

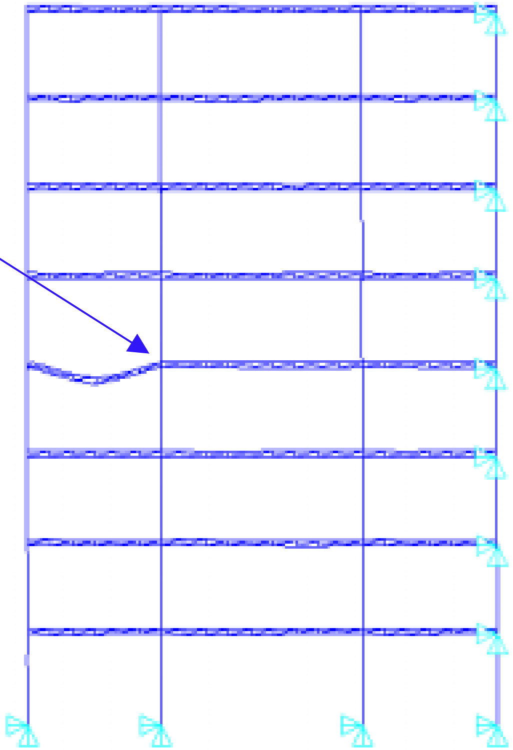




Deflections after Fire

Results – Compression Zone of Joint





Failure of compression zone

Results – Compression Zone of Joint

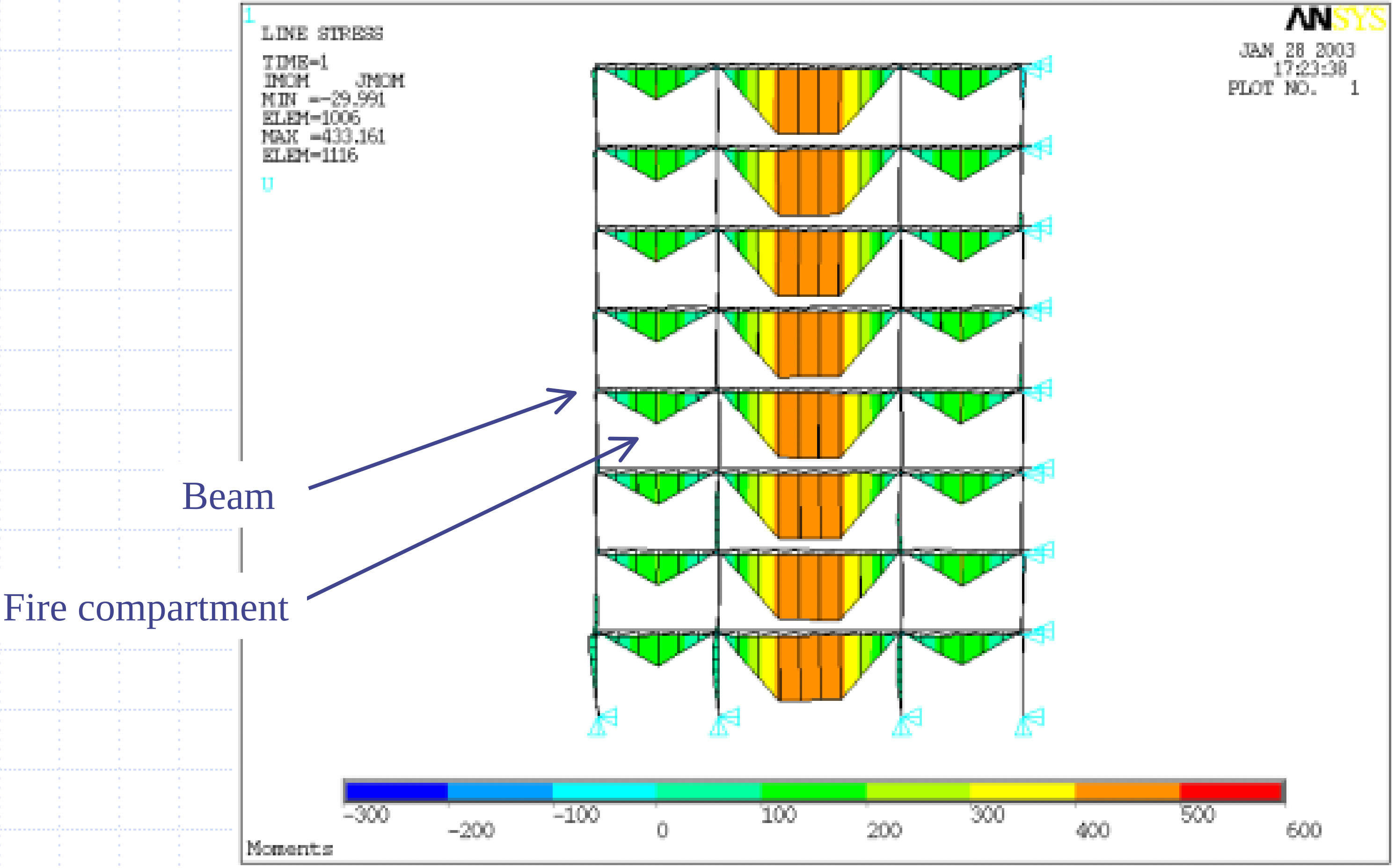
Failure beam flange in compression

Results – compression zone of joint

Failure beam flange in compression

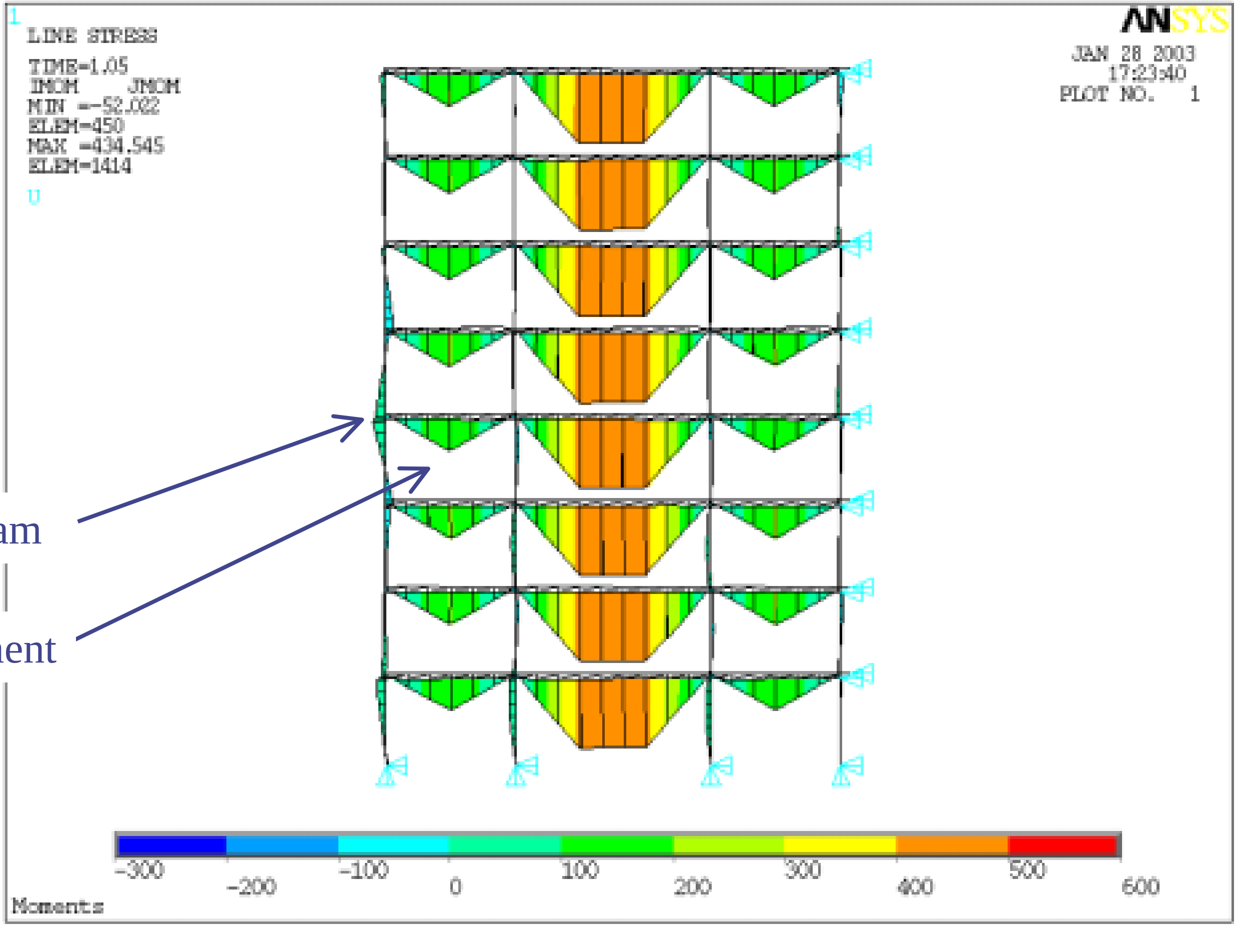
Results – bending of outer column

Temperature 20ºC



Results – bending of outer column

Temperature 50ºC



Beam

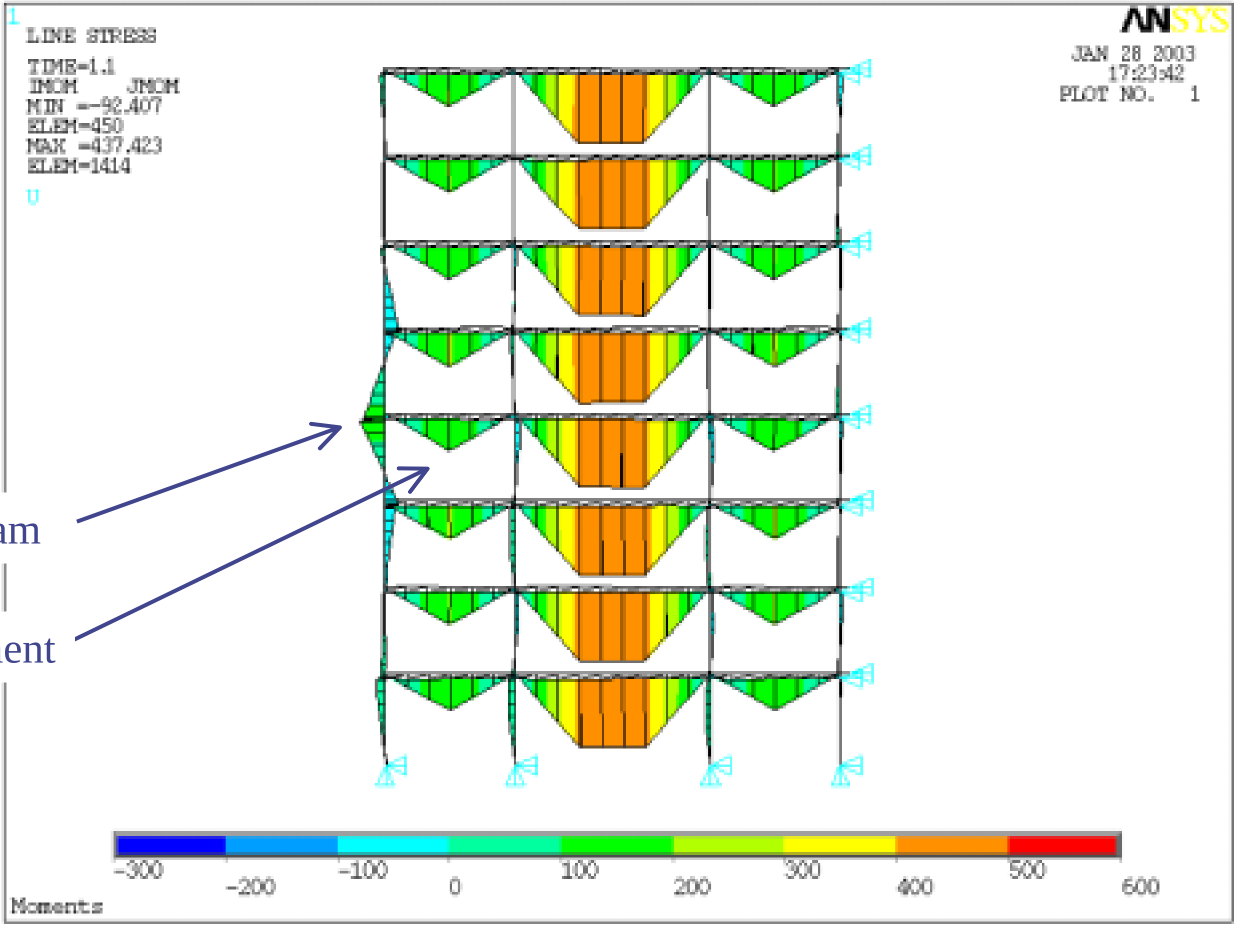
Fire compartment

Results – bending of outer column

Temperature 100ºC

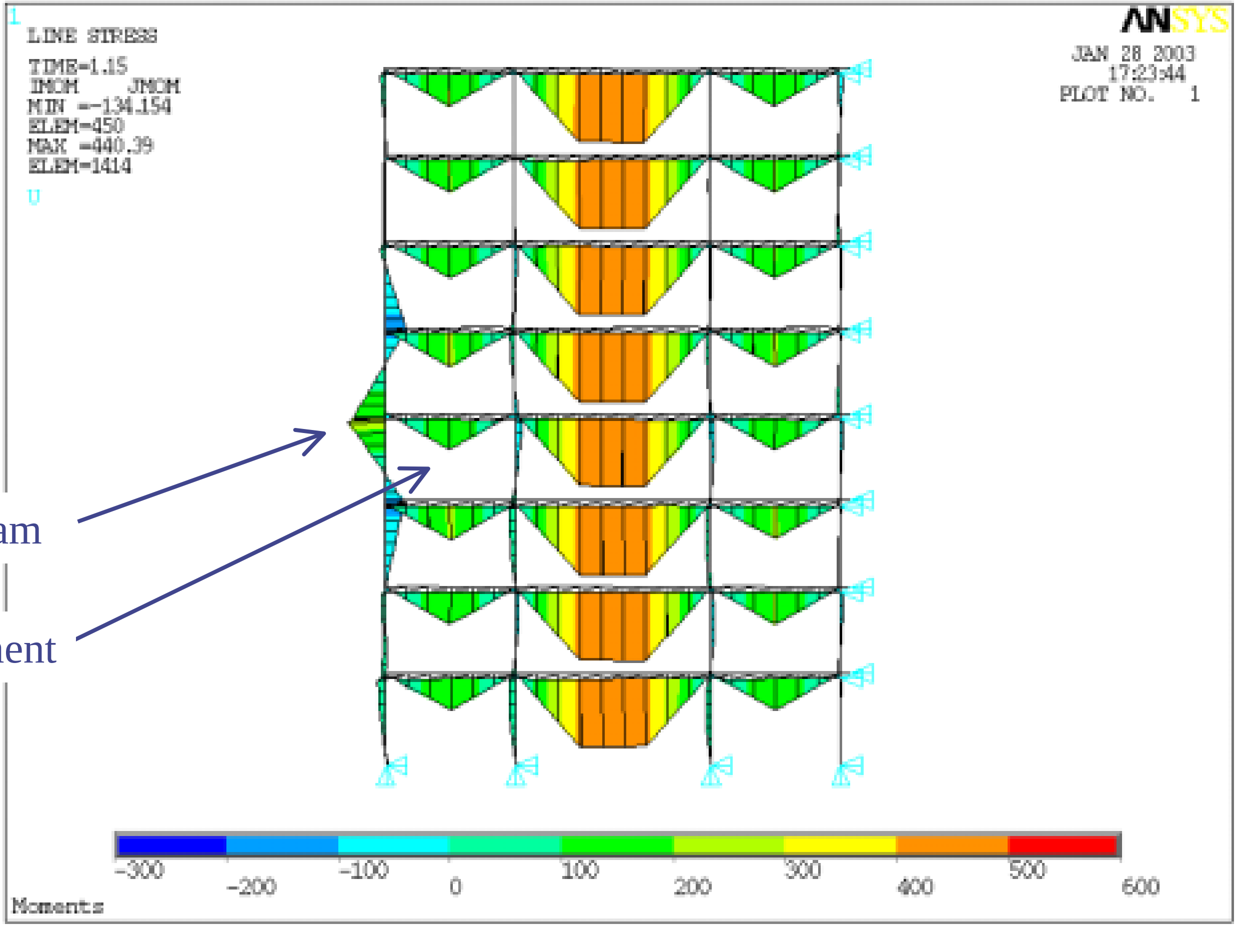
Beam

Fire compartment



Results – bending of outer column

Temperature 150ºC

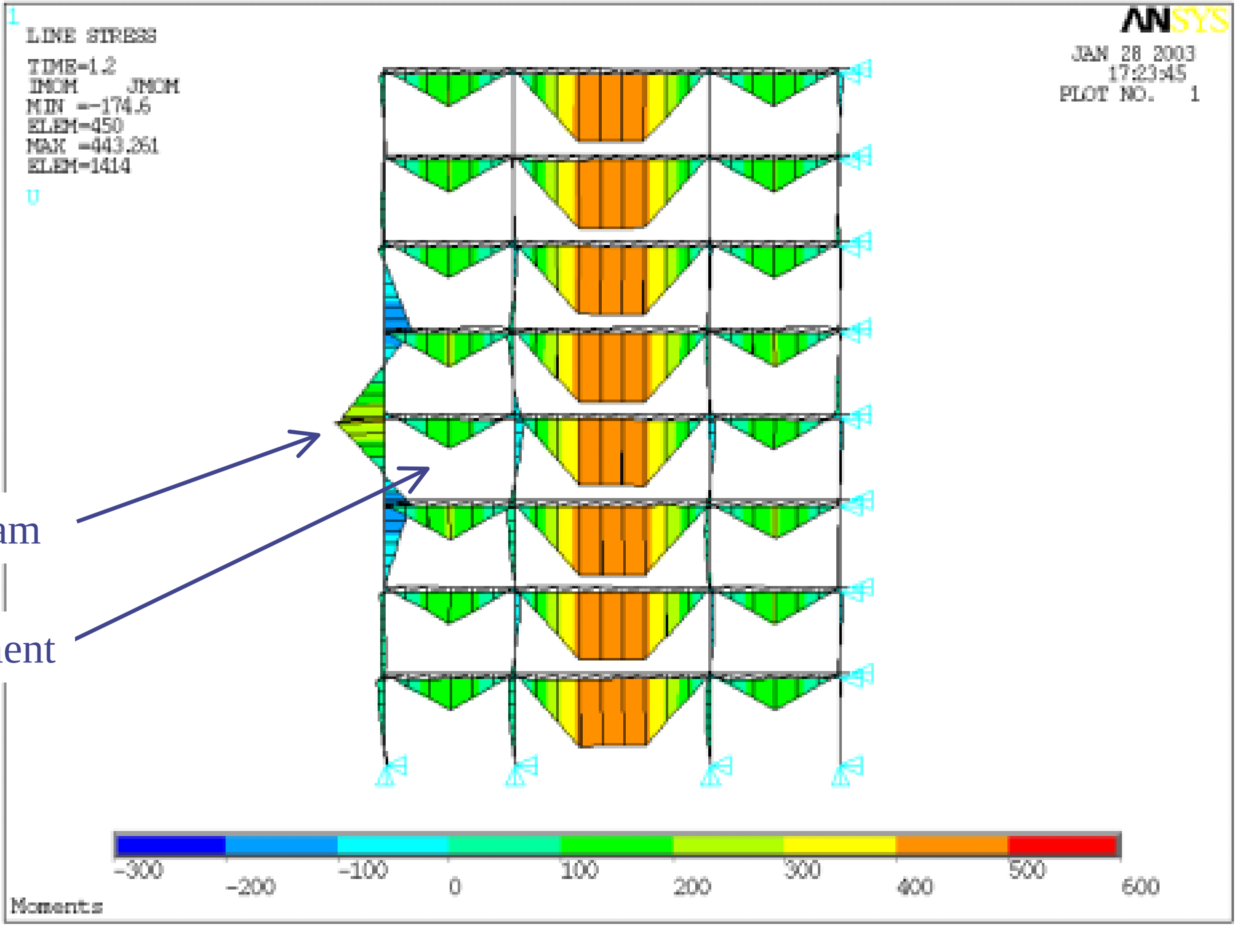


Beam

Fire compartment

Results – bending of outer column

Temperature 200ºC

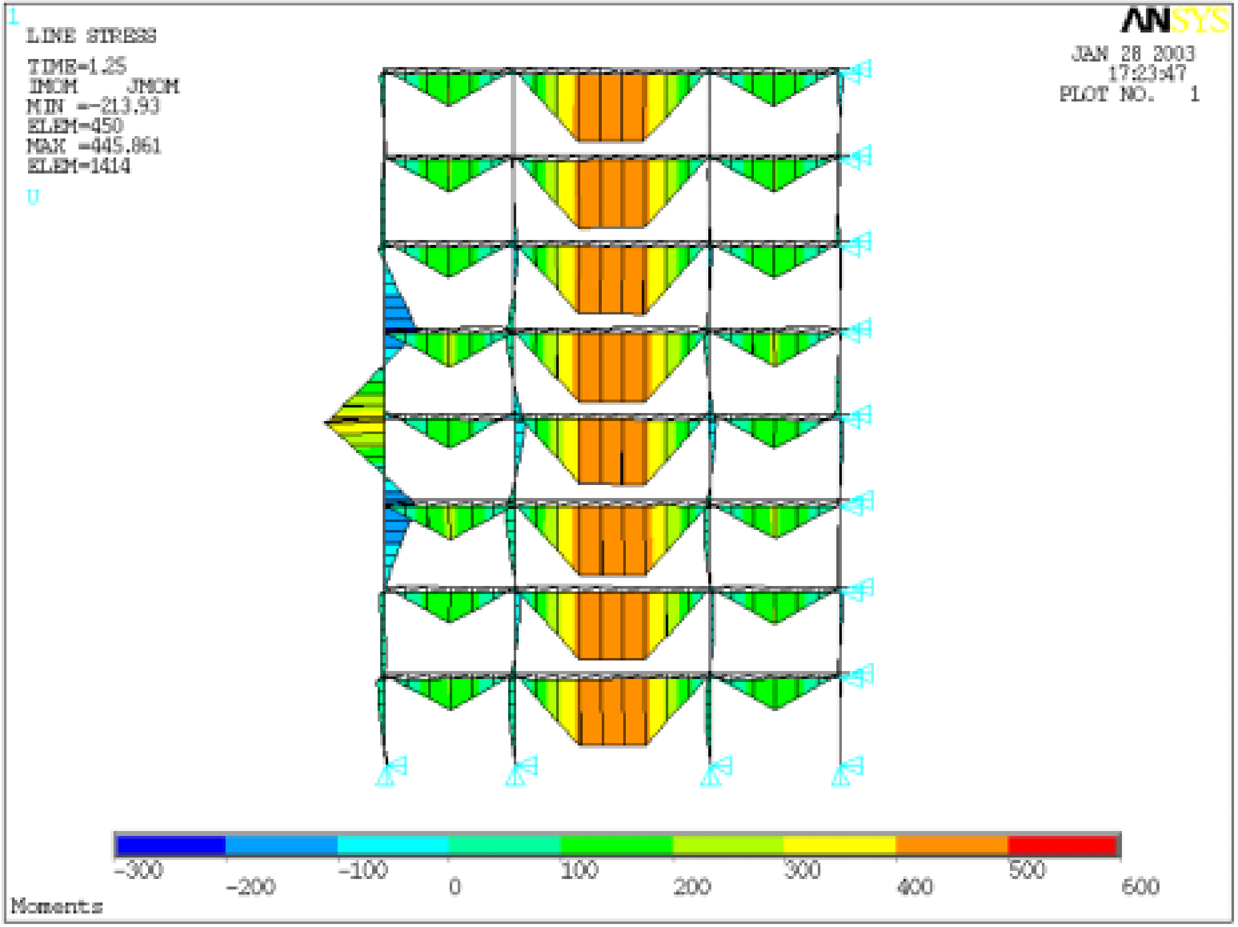


Beam

Fire compartment

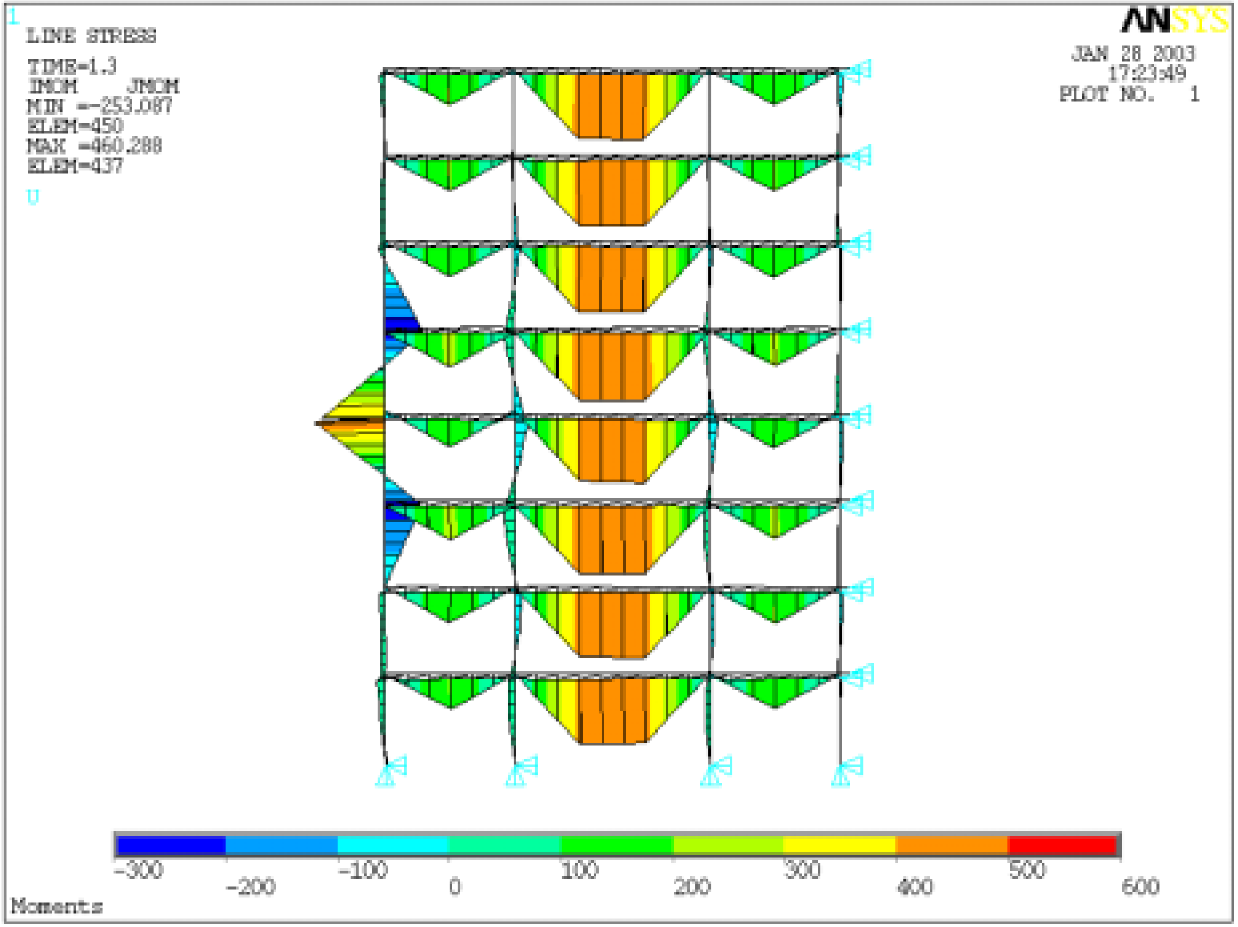
Results – bending of outer column

Temperature 250ºC



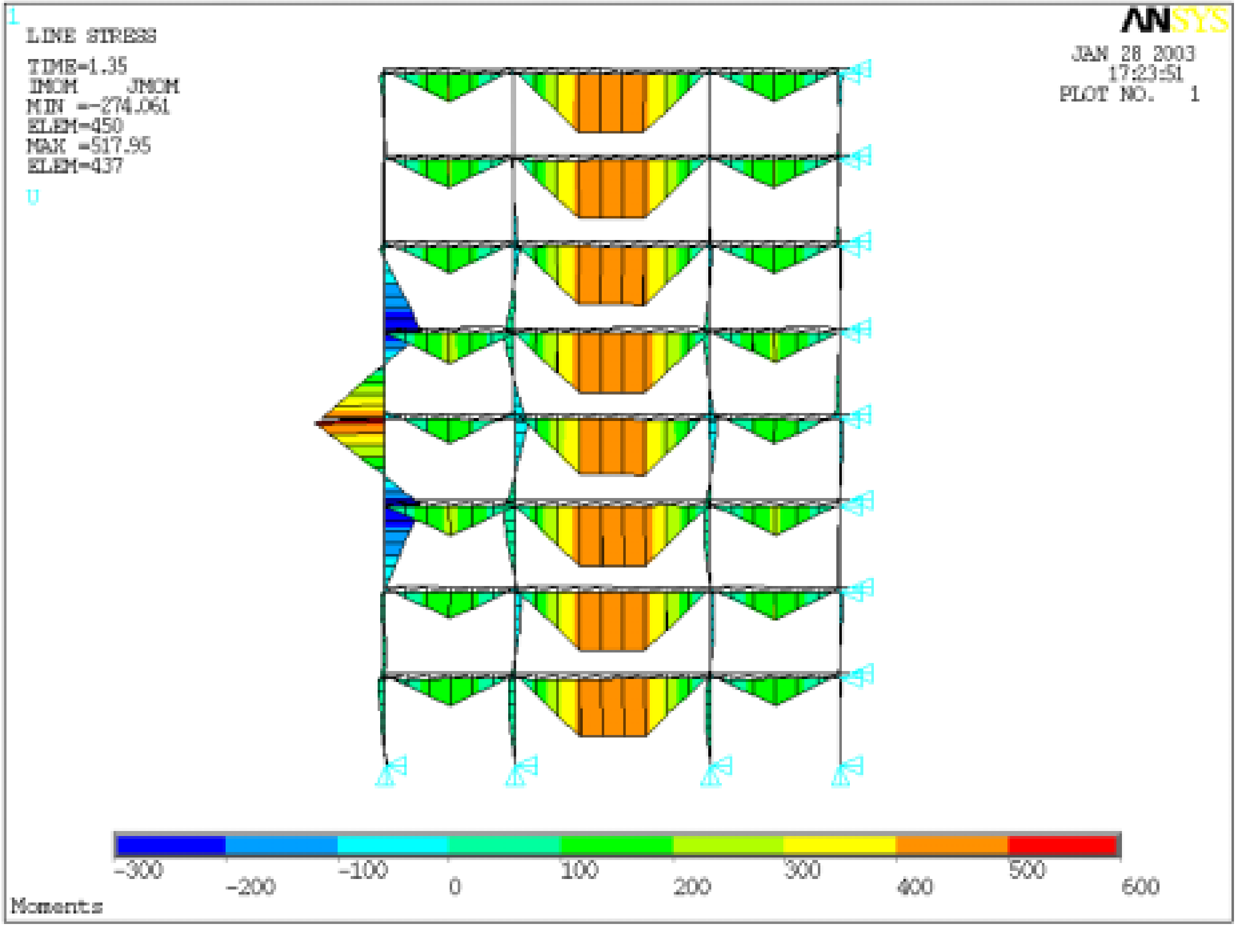
Results – bending of outer column

Temperature 300ºC



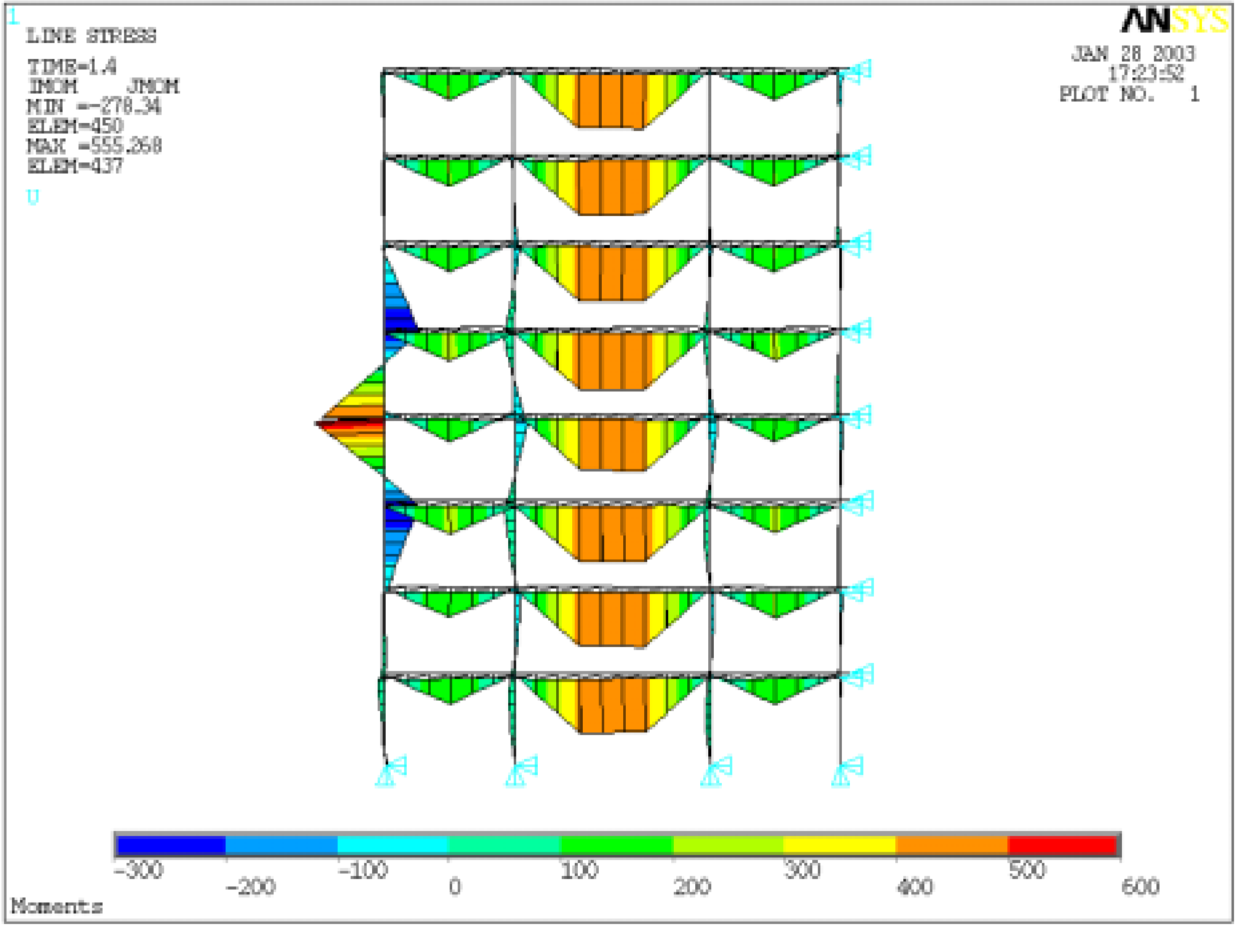
Results – bending of outer column

Temperature 350ºC



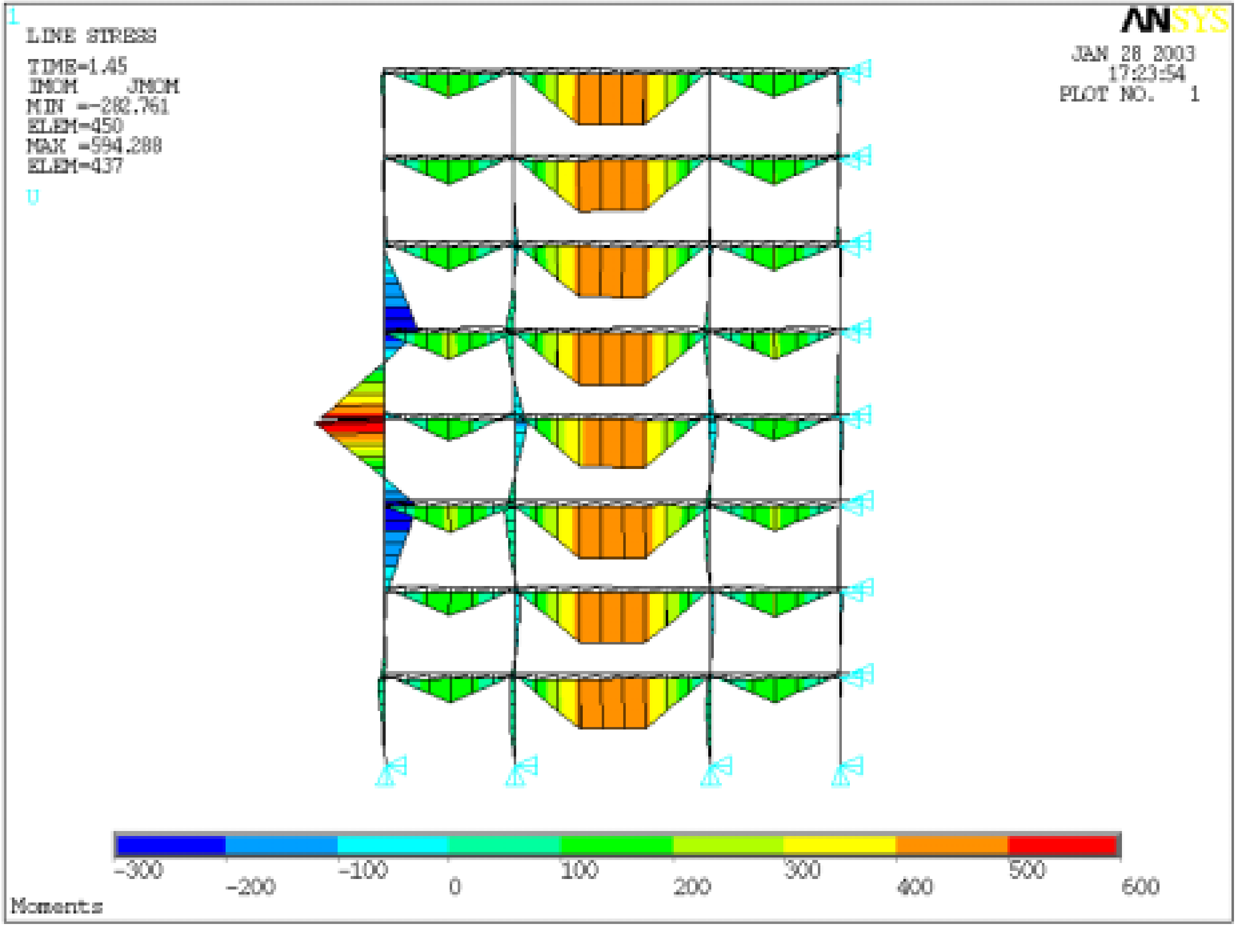
Results – bending of outer column

Temperature 400ºC



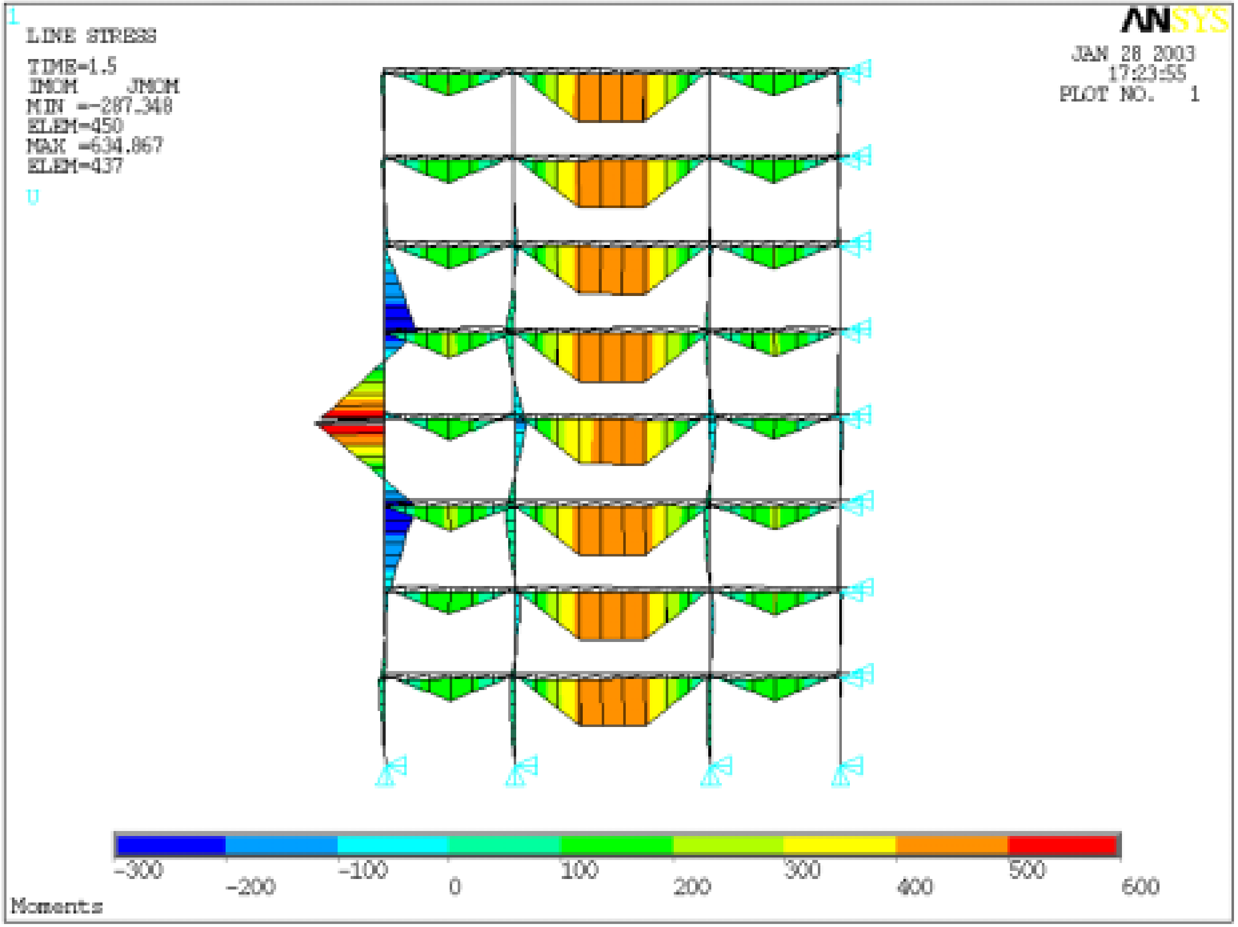
Results – bending of outer column

Temperature 450ºC



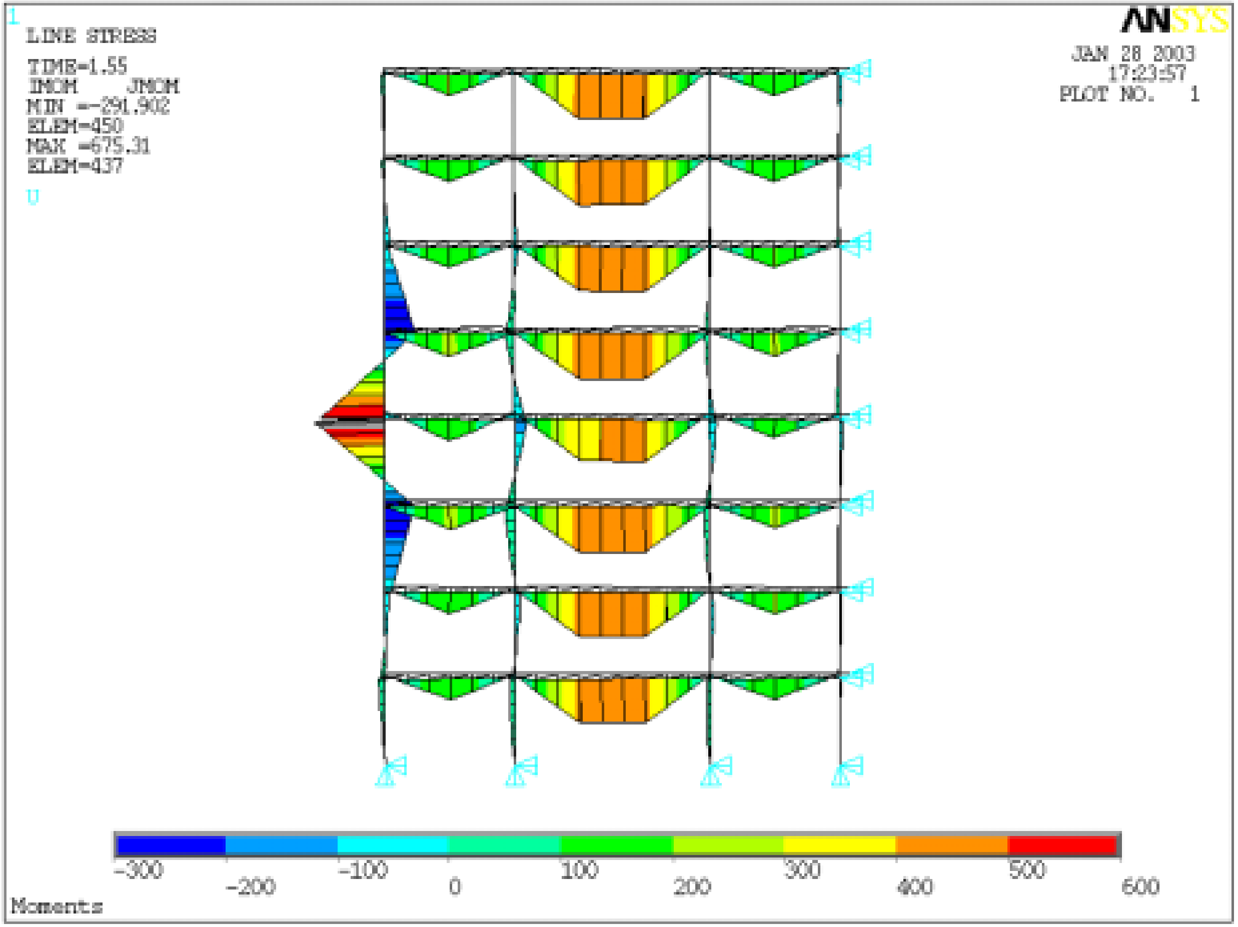
Results – bending of outer column

Temperature 500ºC



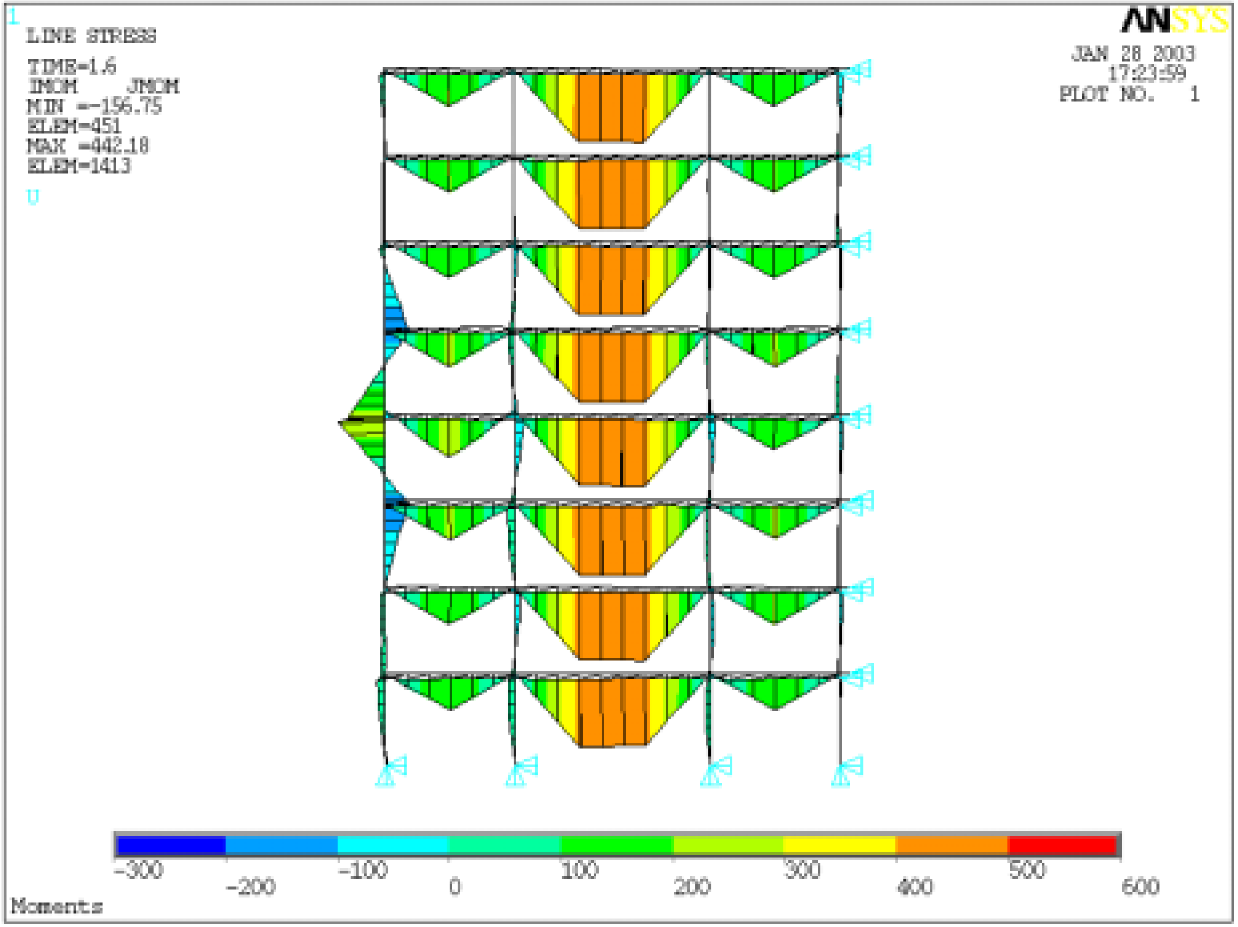
Results – bending of outer column

Temperature 550ºC



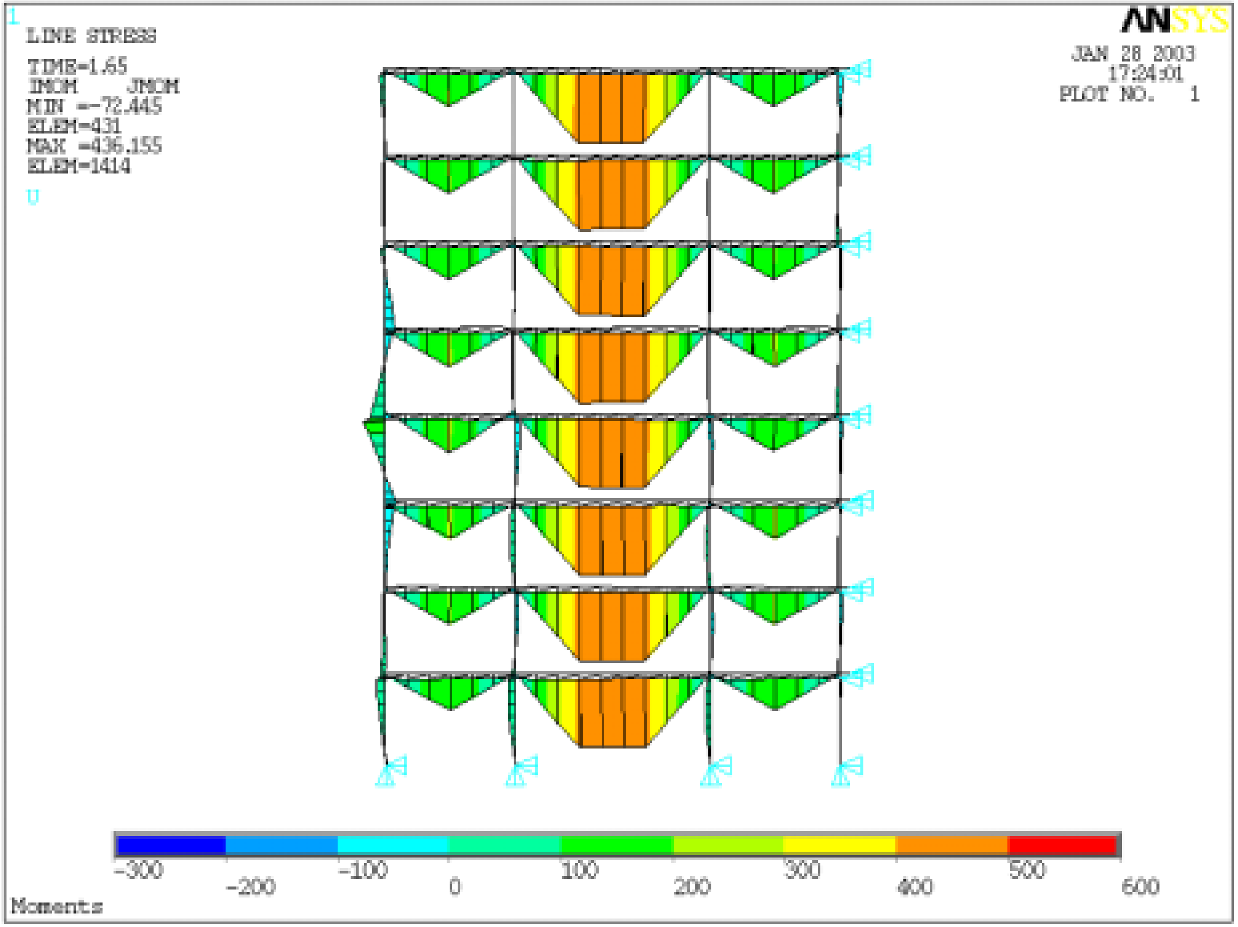
Results – bending of outer column

Temperature 600ºC



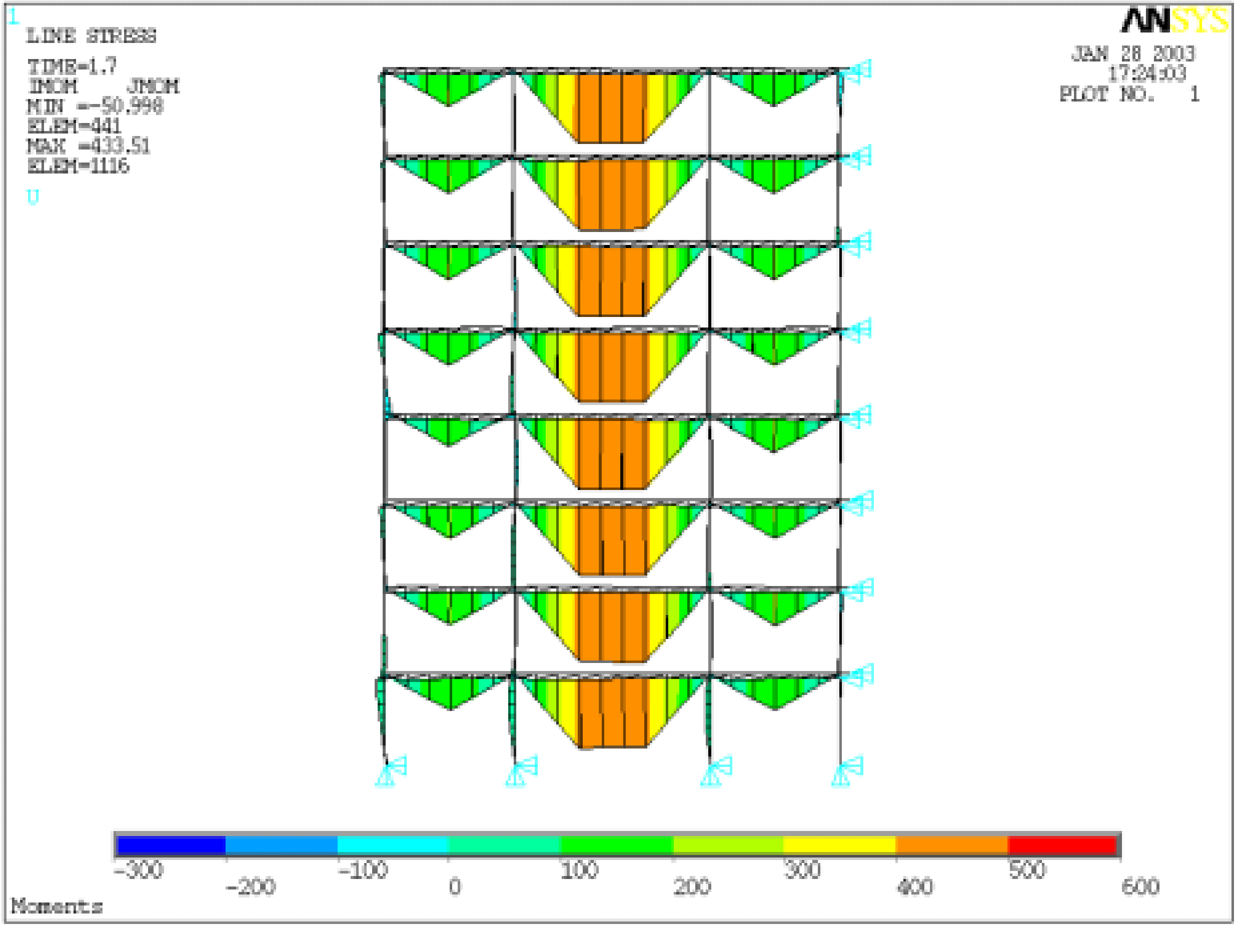
Results – bending of outer column

Temperature 650ºC



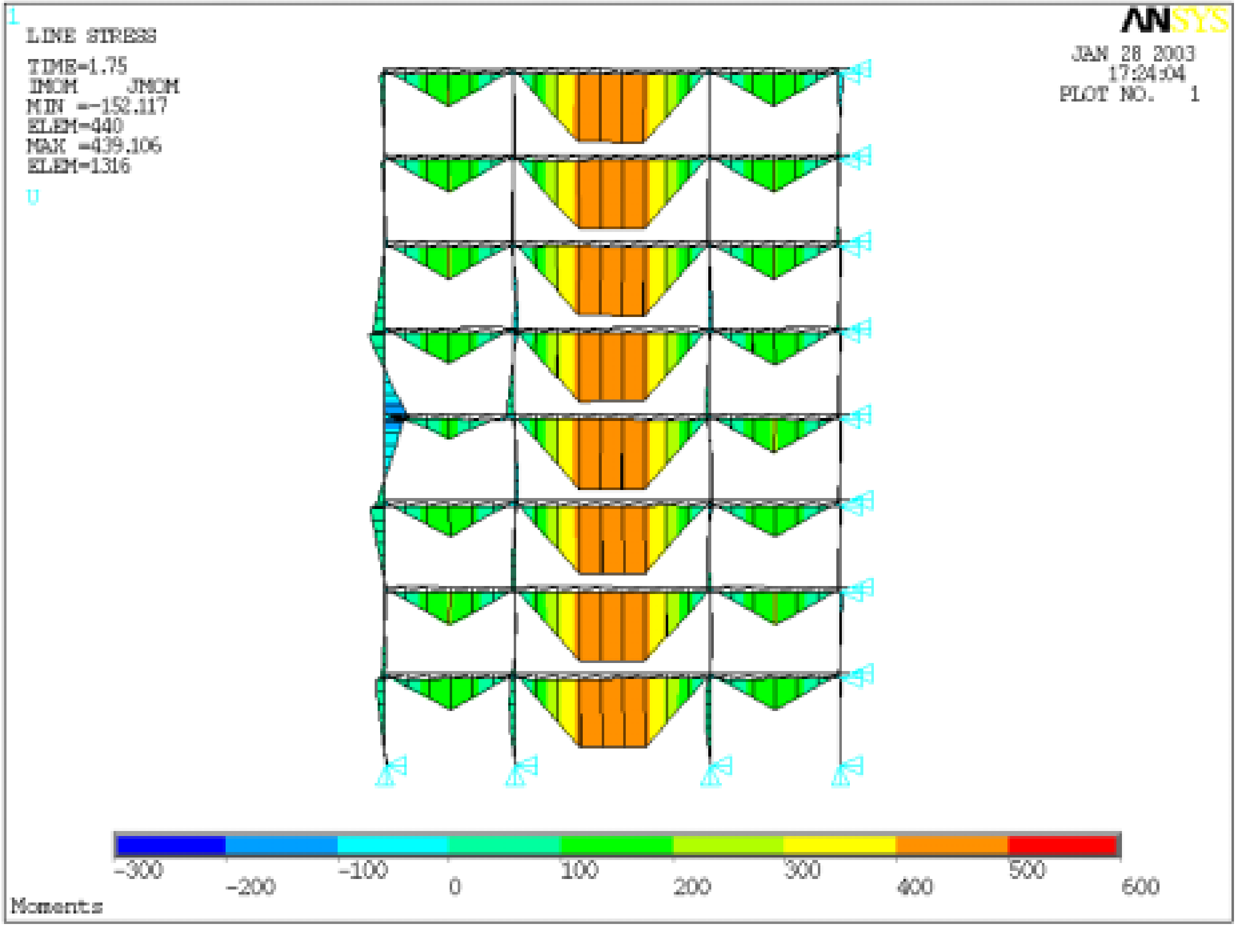
Results – bending of outer column

- Temperature 700ºC



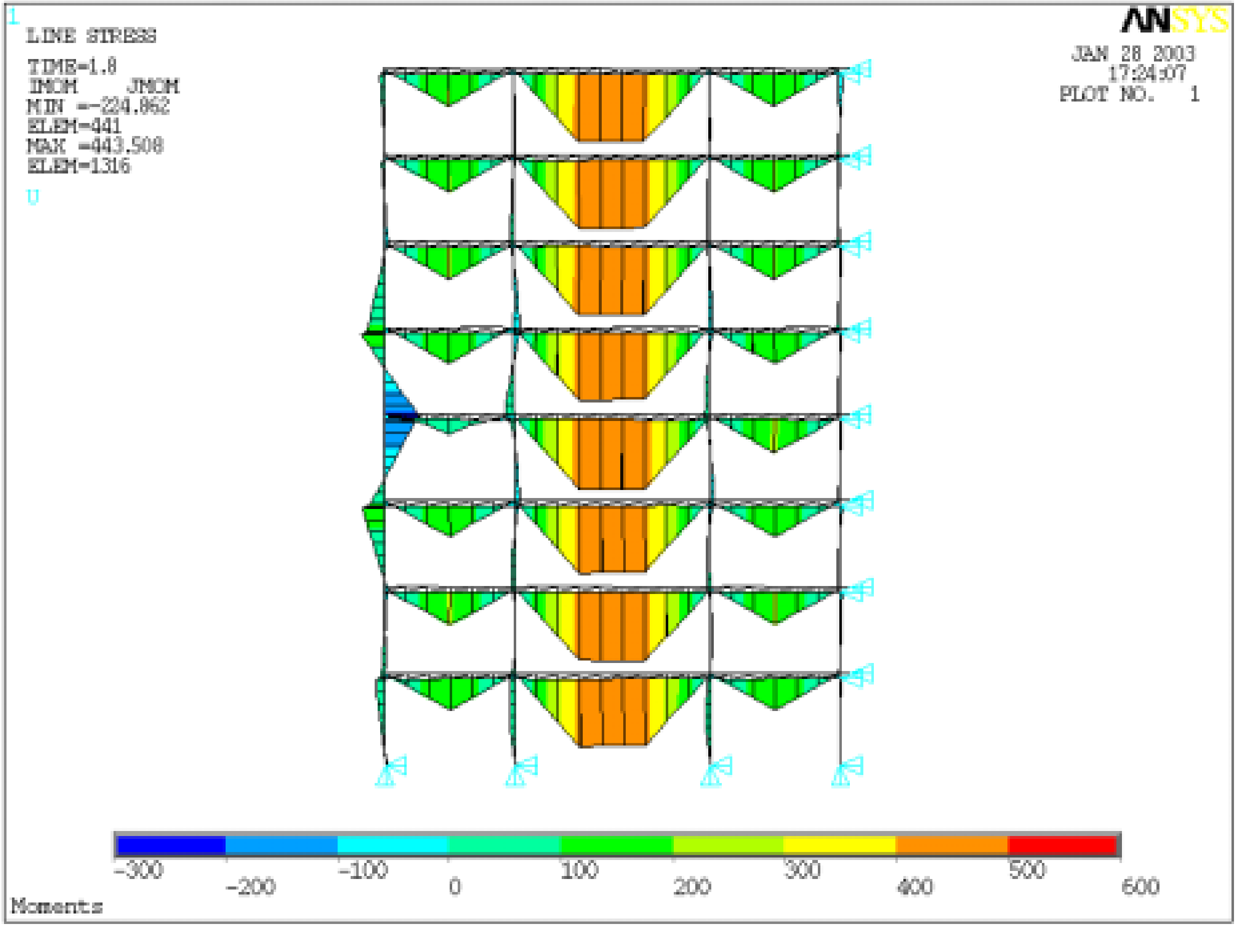
Results – bending of outer column

Temperature 750ºC



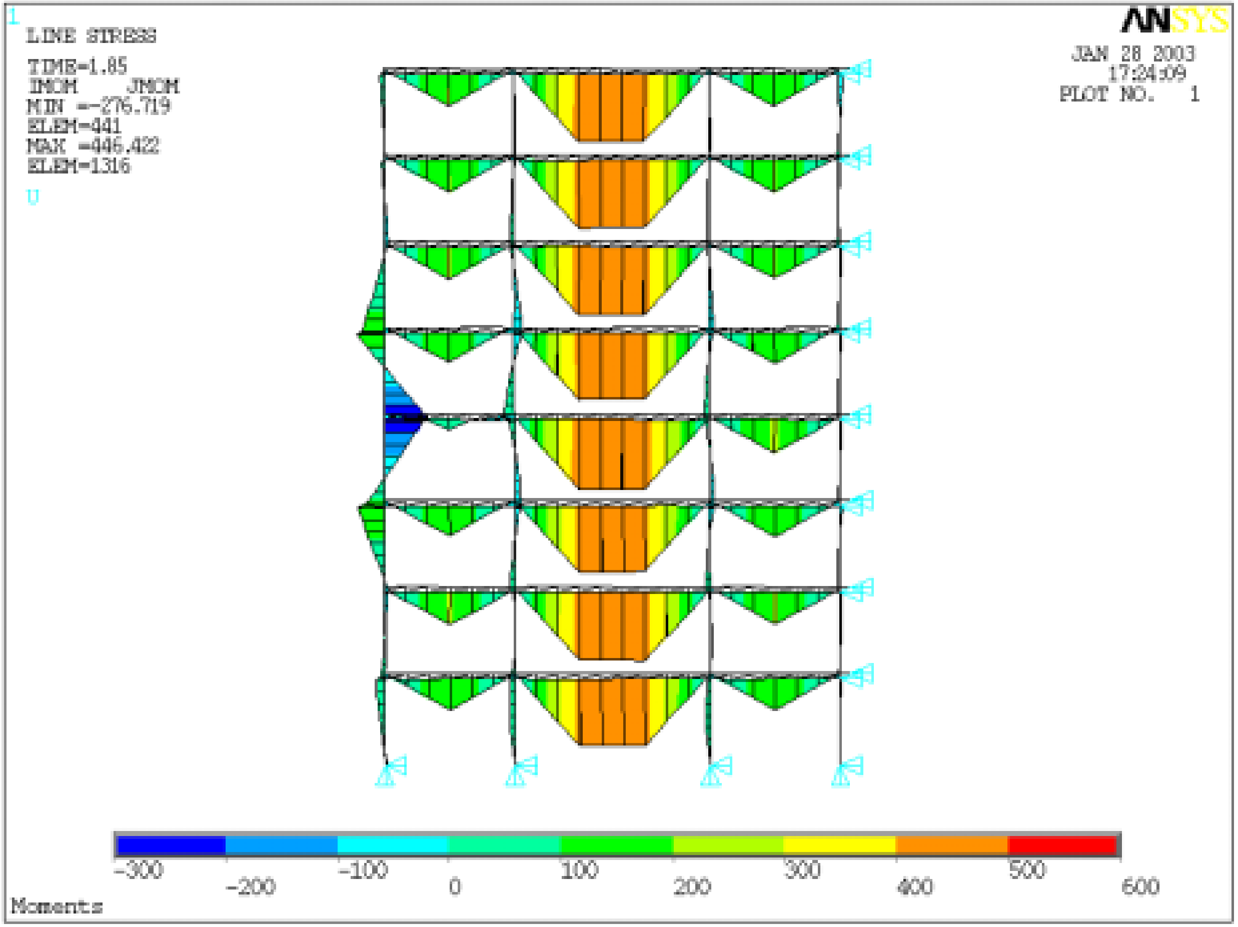
Results – bending of outer column

Temperature 800ºC



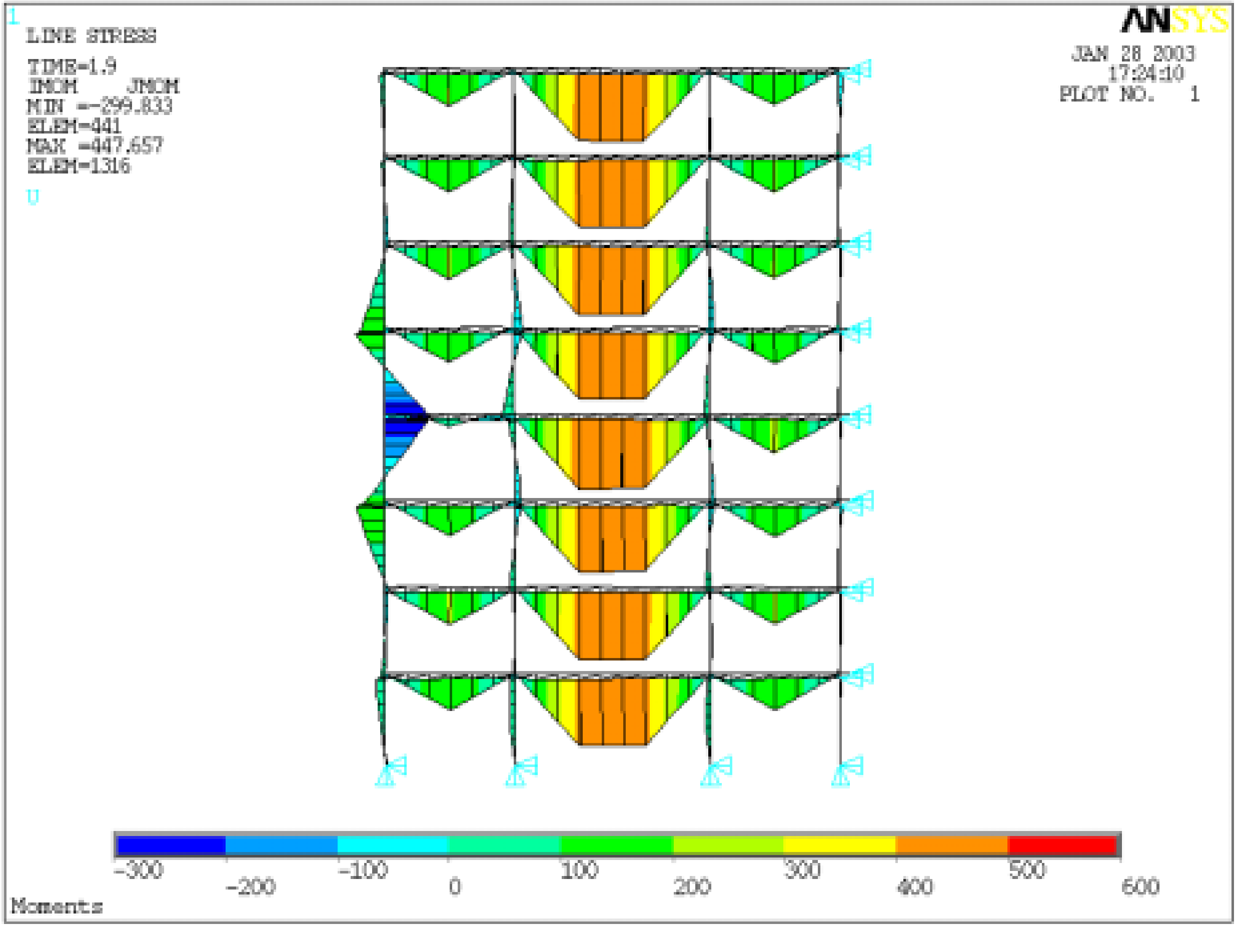
Results – bending of outer column

Temperature 850ºC



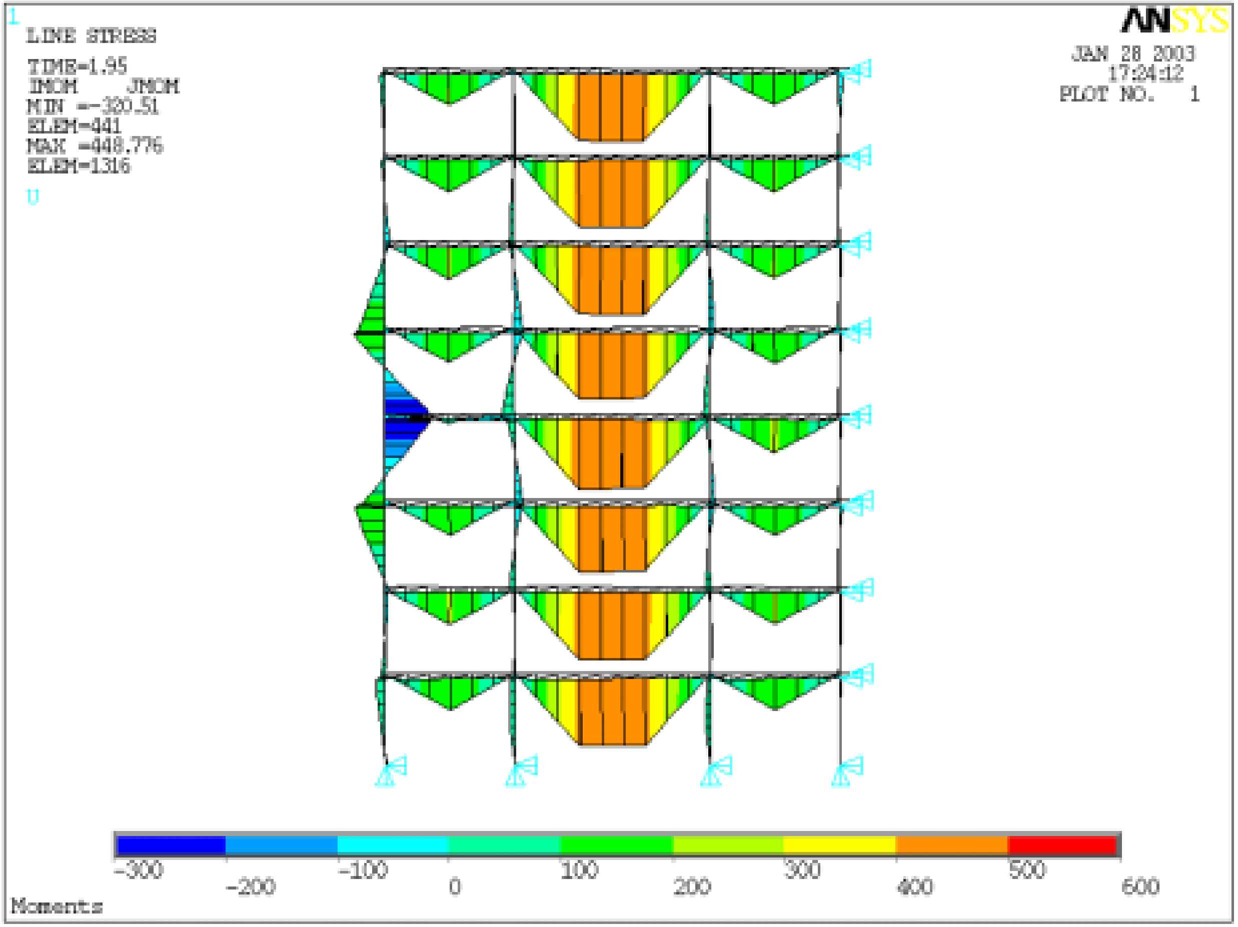
Results – bending of outer column

Temperature 900ºC



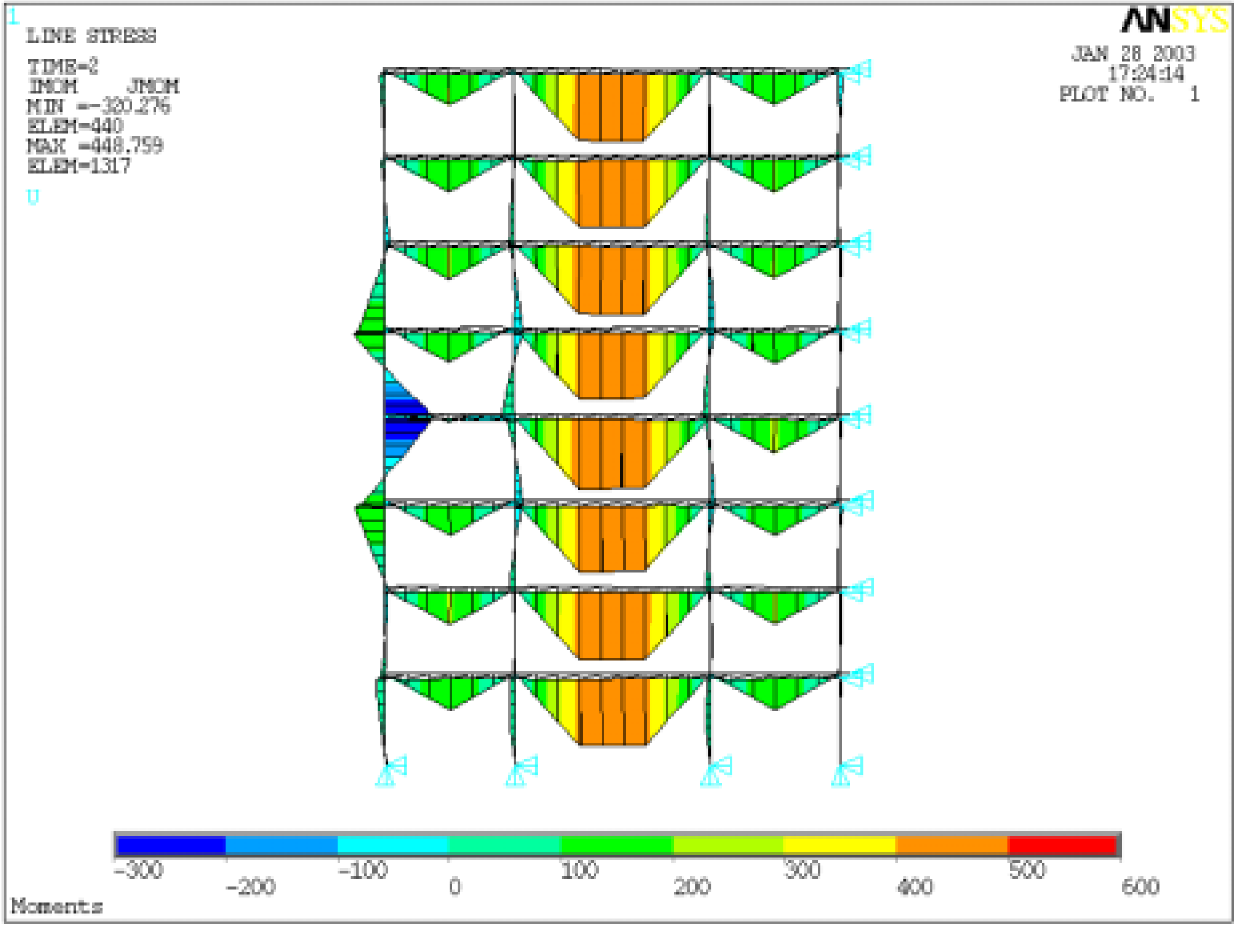
Results – bending of outer column

Temperature 950ºC



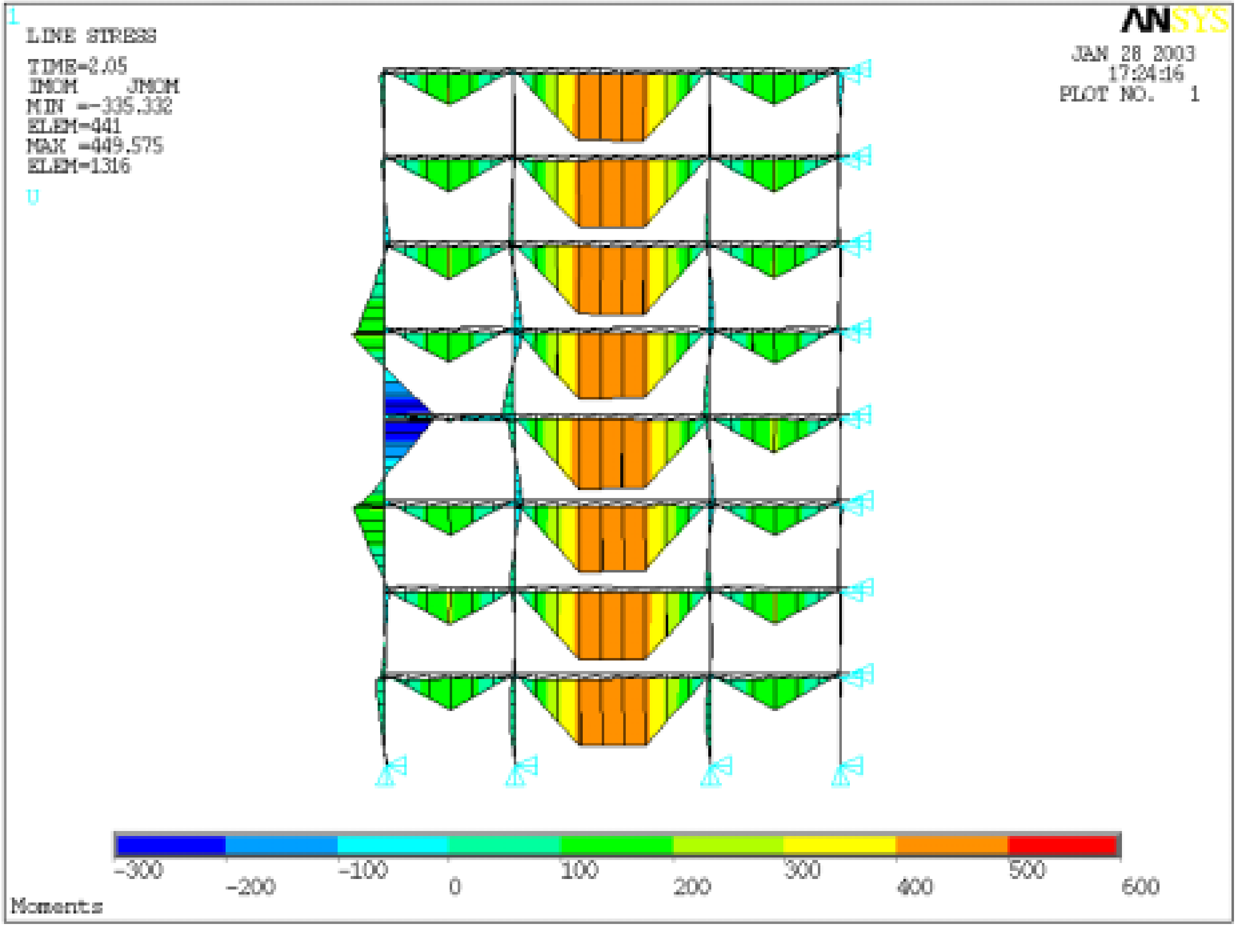
Results – bending of outer column

Temperature 1000ºC



Results – bending of outer column

Temperature 950ºC



Results – bending of outer column

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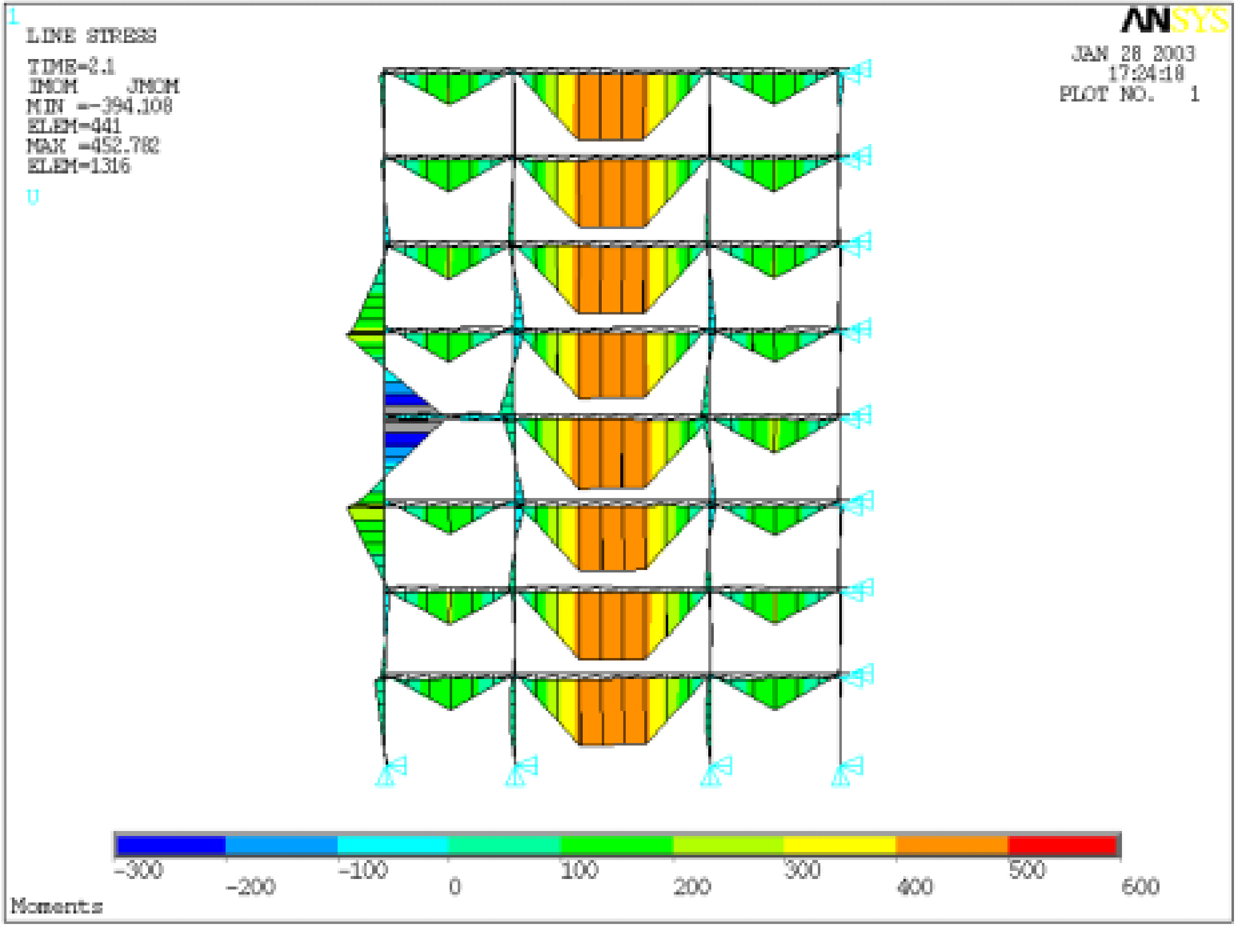

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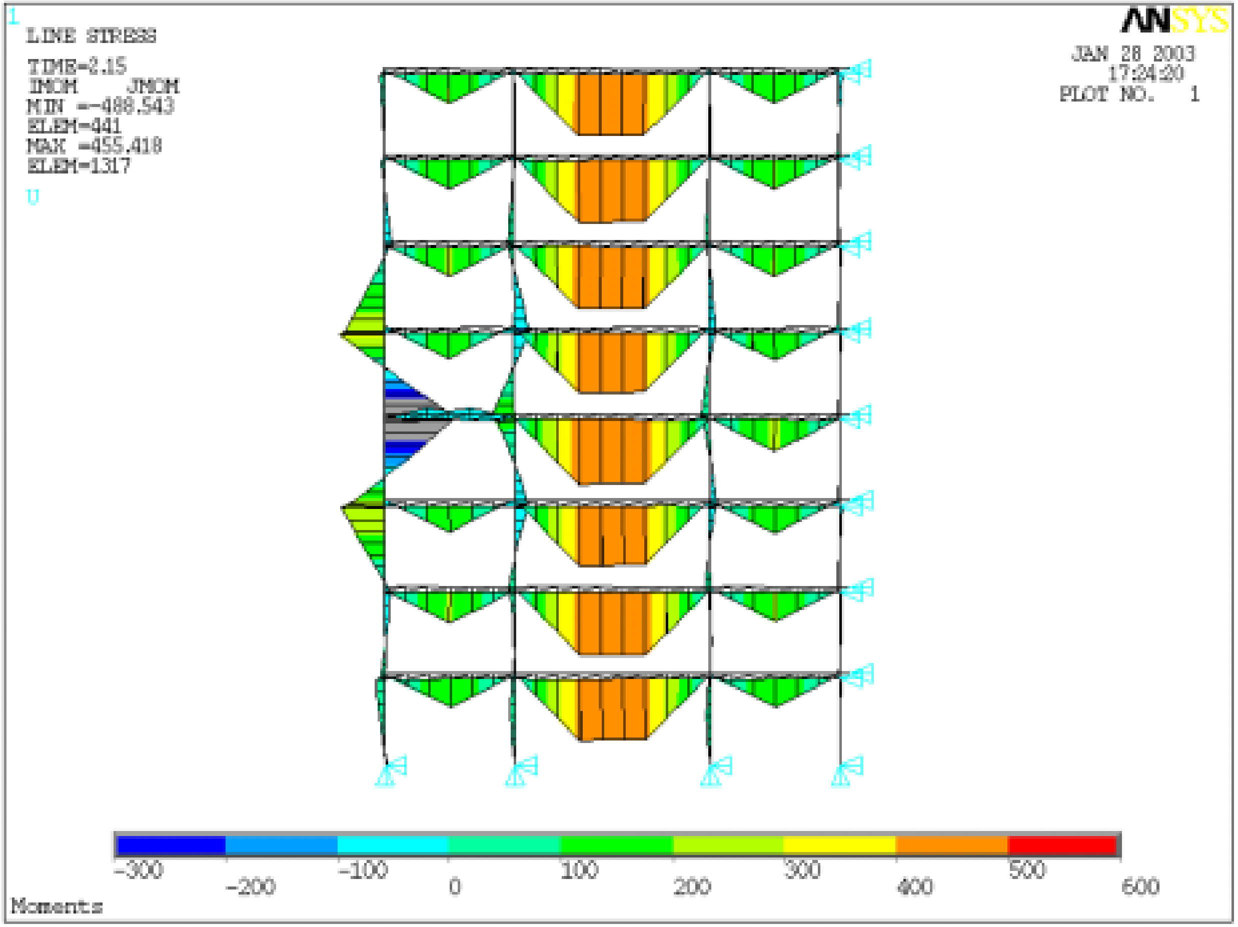
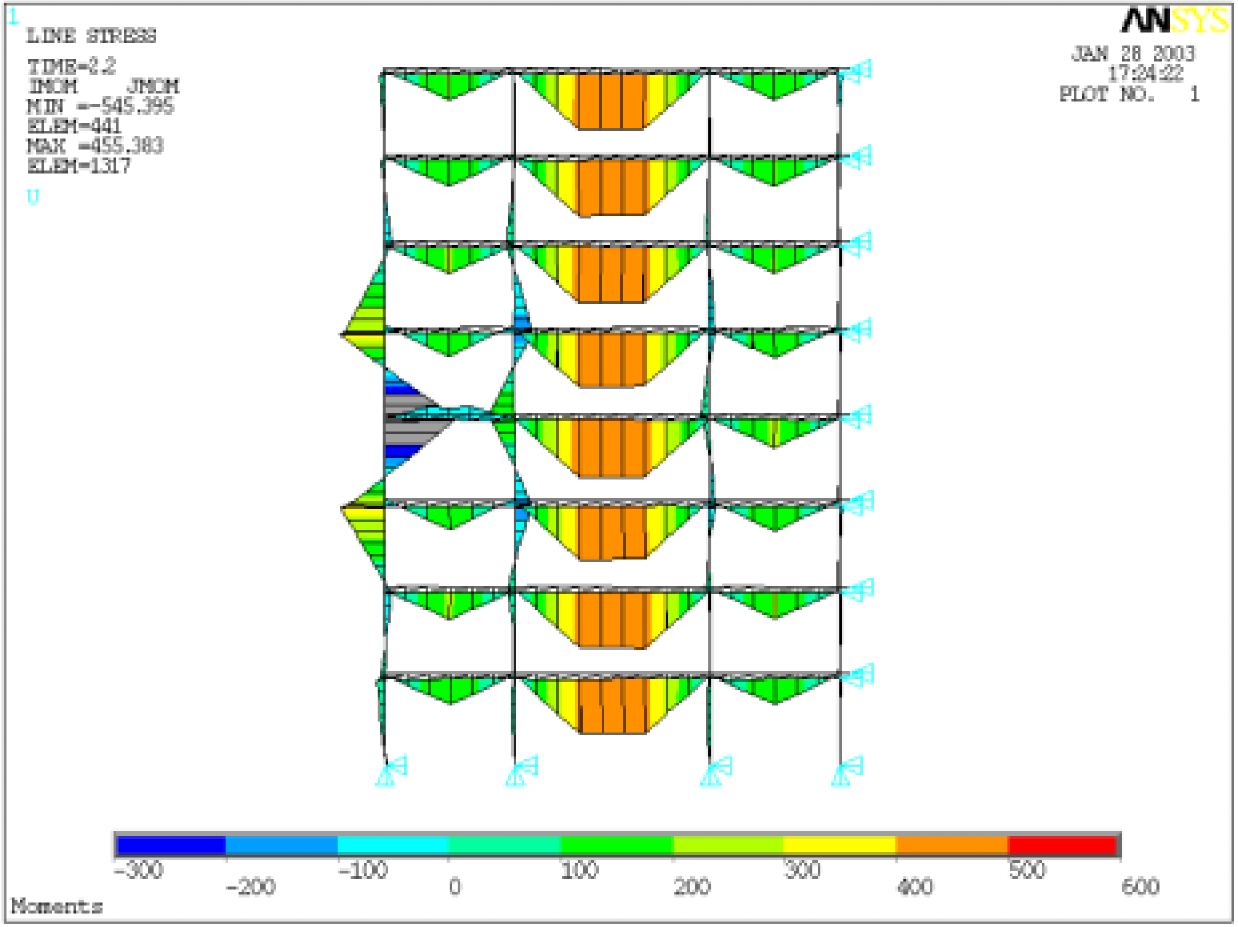


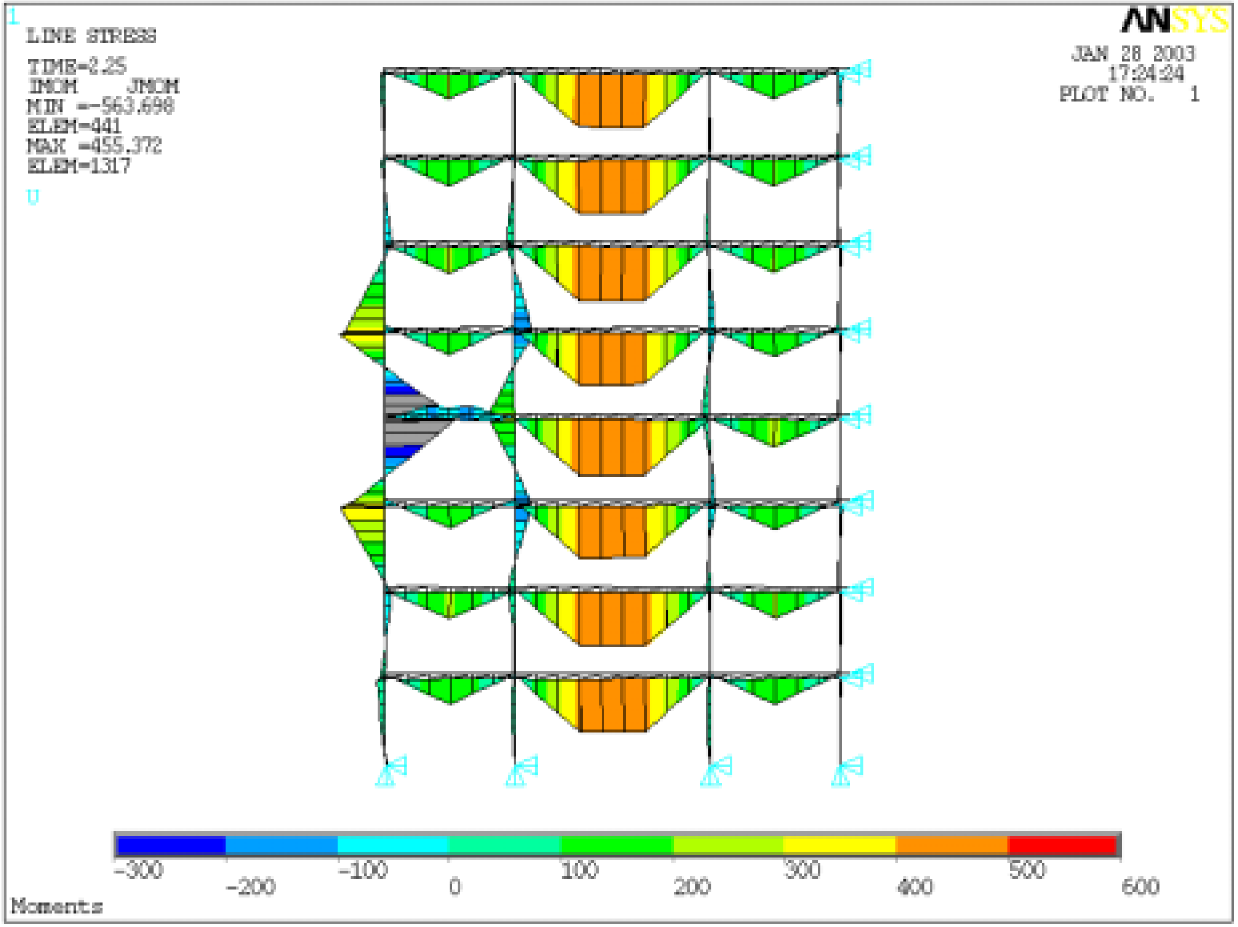
Results – bending of outer column

Temperature 800ºC



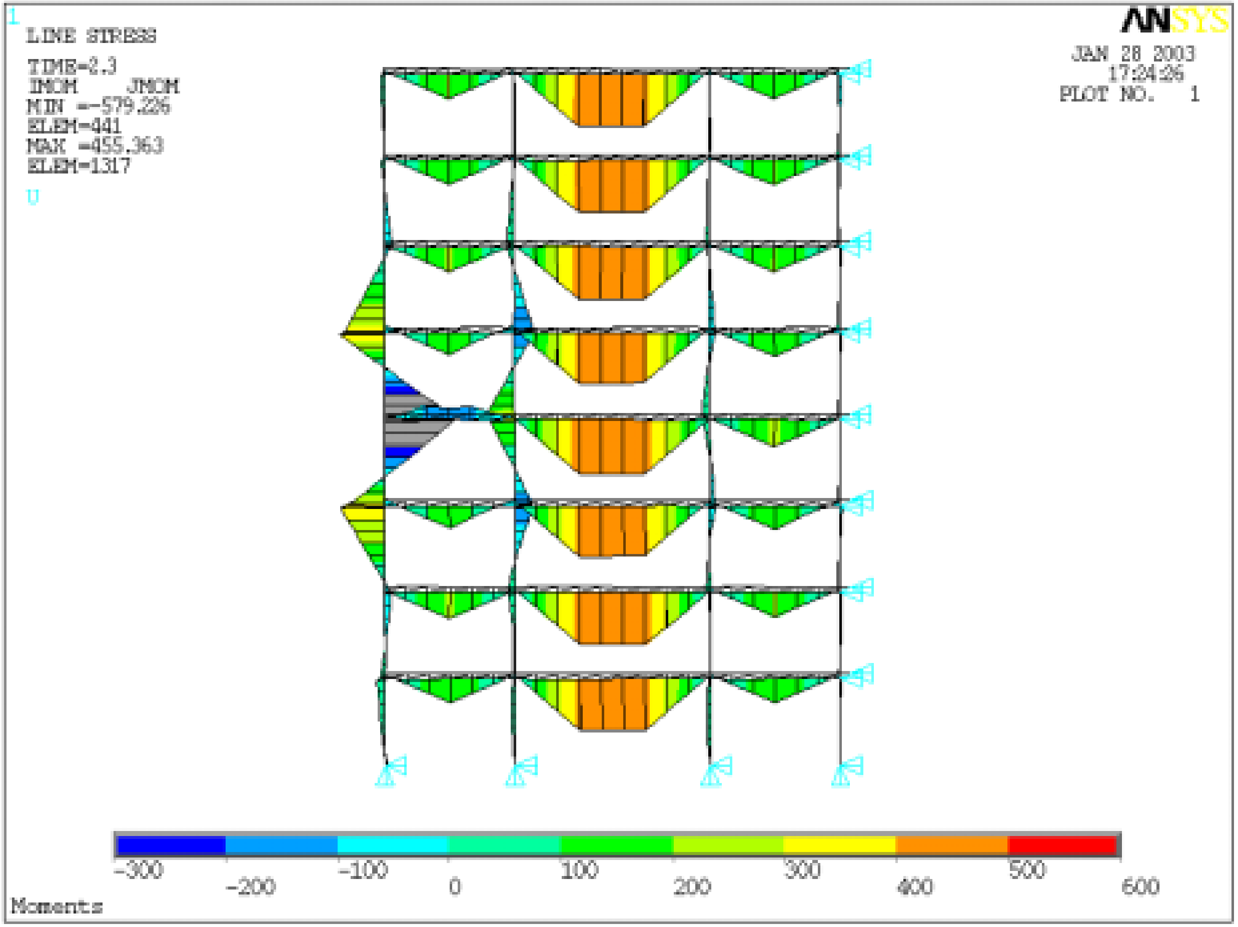
Results – bending of outer column

Temperature 750ºC



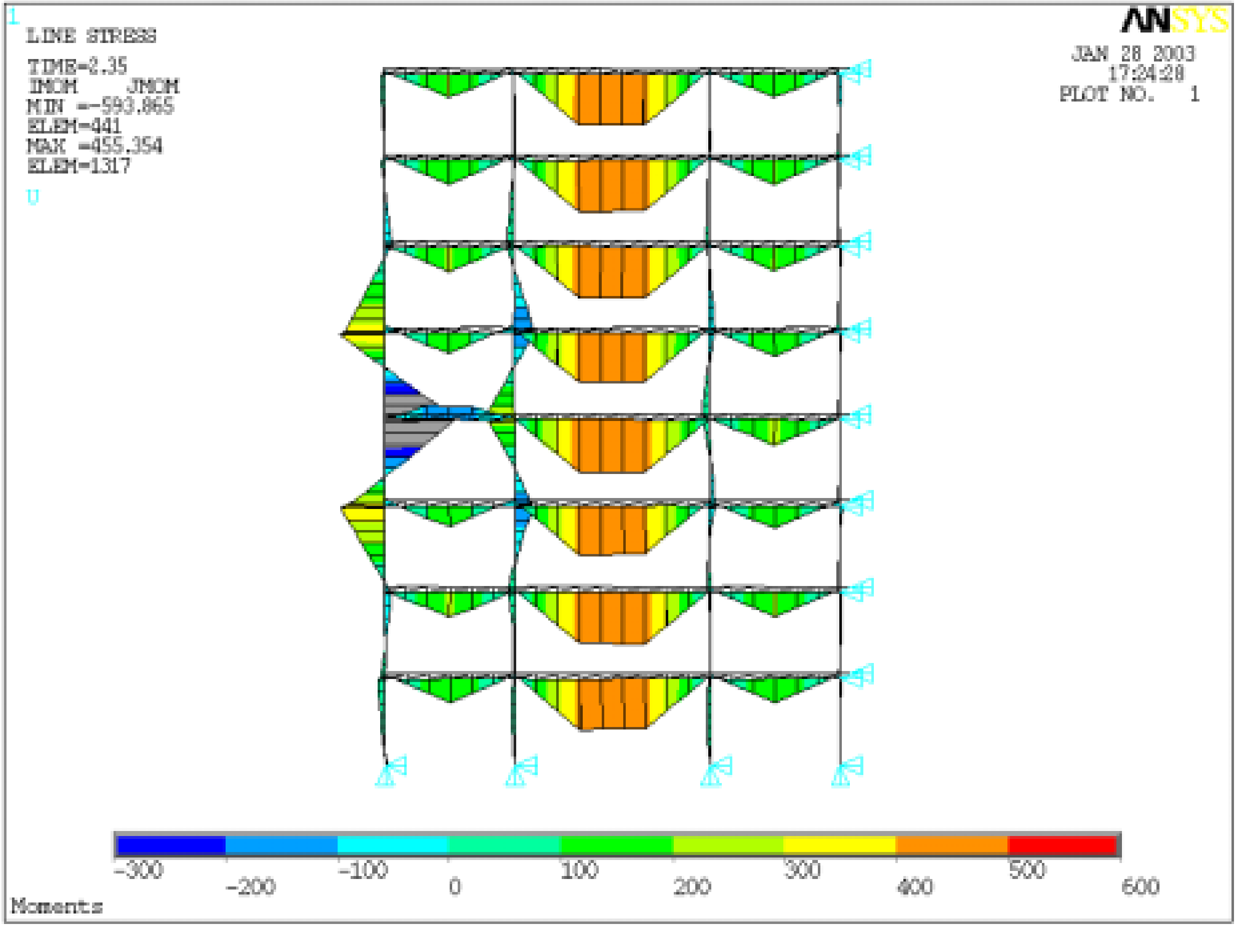
Results – bending of outer column

Temperature 700ºC



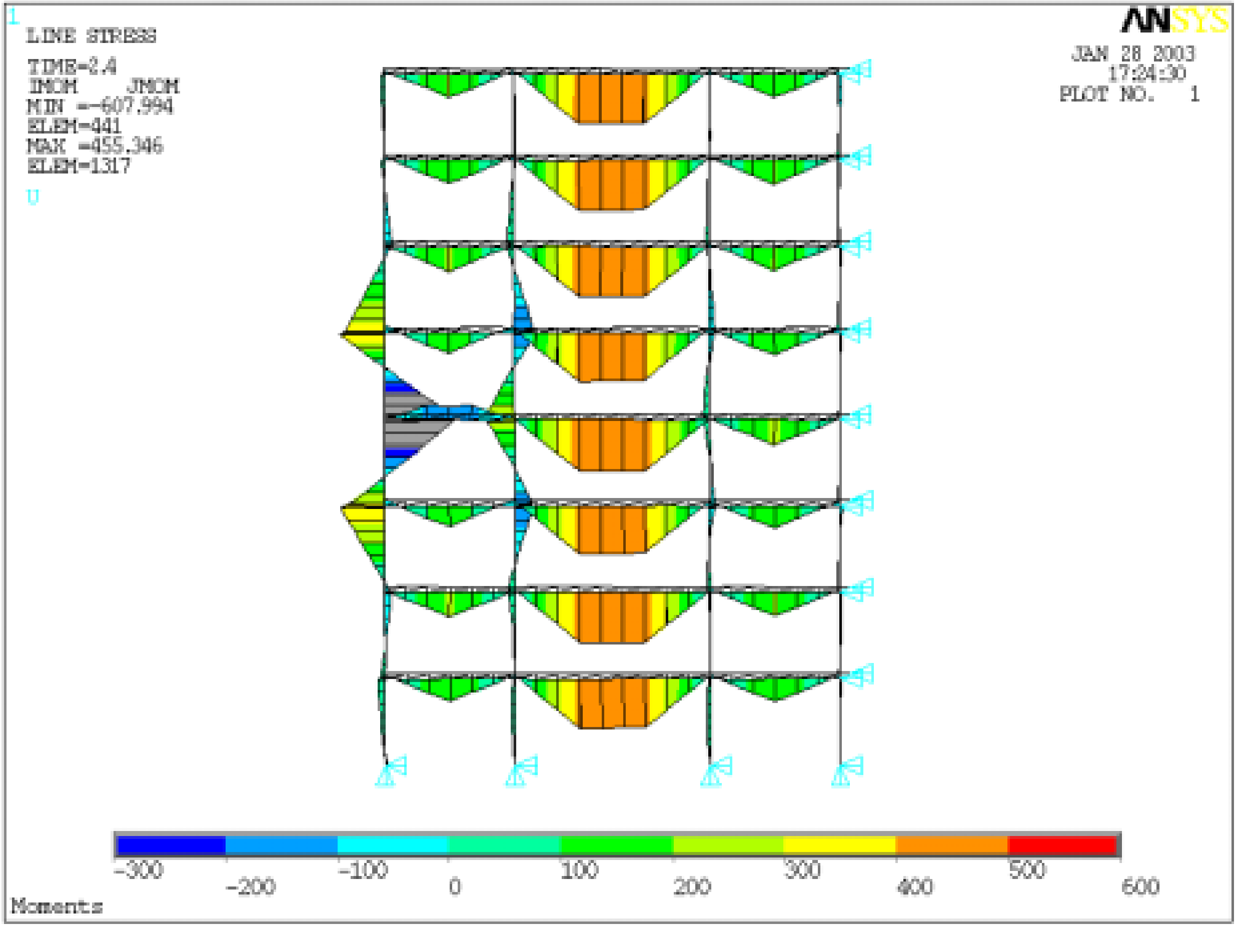
Results – bending of outer column

Temperature 650ºC

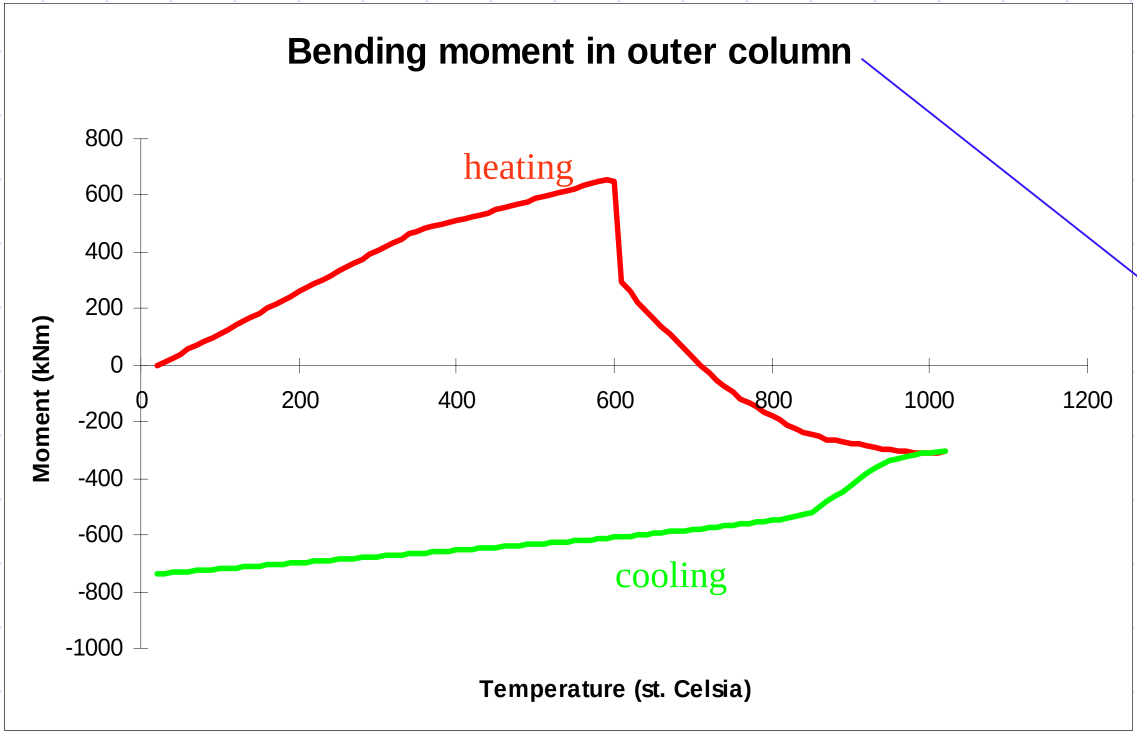


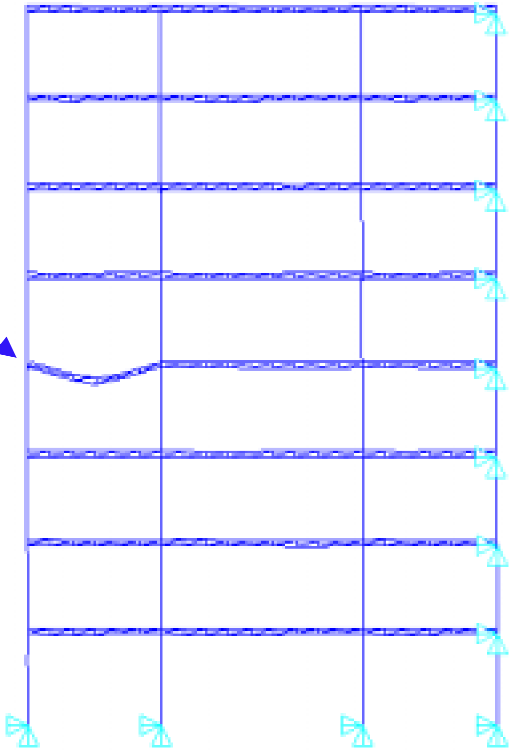
Results – bending of outer column

Temperature 600ºC



Results – bending of outer column





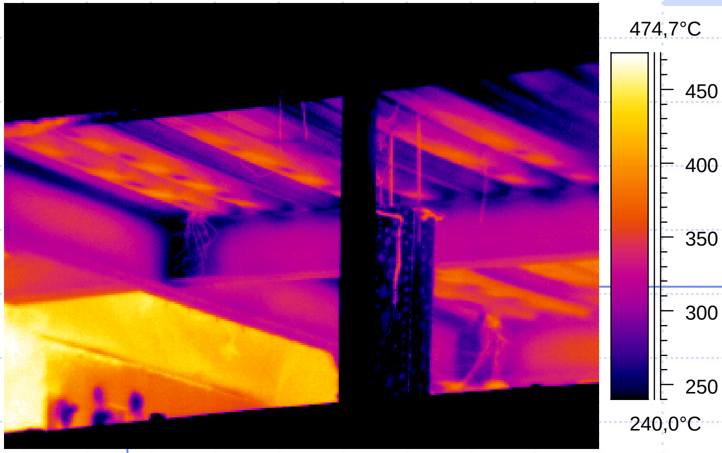
Conclusions

The Cardington test showed

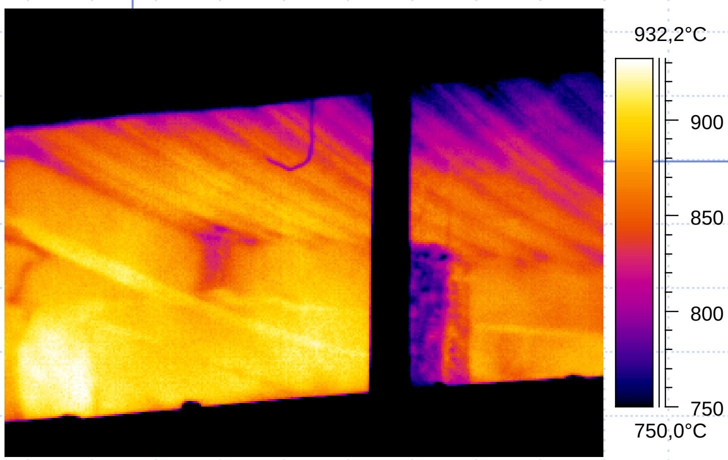
- Thermal distribution in connections
- Internal forces in connections
- Behaviour of composite slab

Temperature distribution on steel

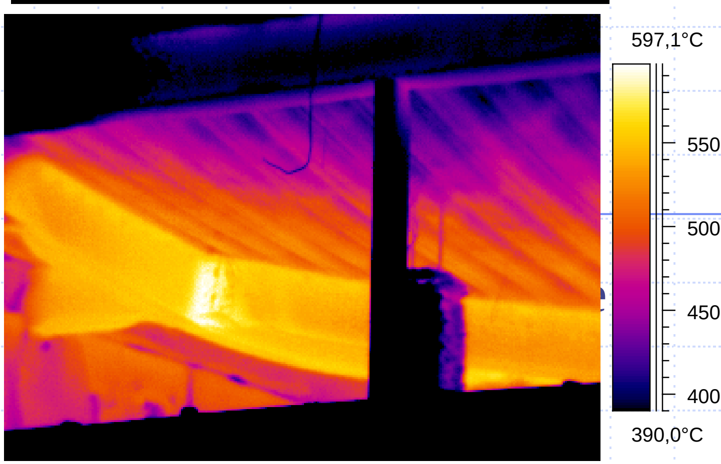
Heading



Maximum temperature



Cooling



THANK YOU

FOR YOUR ATTENTION