

SEFPRO

BRIGHTER SOLUTIONS TOGETHER



GMIC

GLASS MANUFACTURING
INDUSTRY COUNCIL

Supporting the evolution of glass furnaces
through advanced thermo-mechanical
simulation of electro-fused crowns

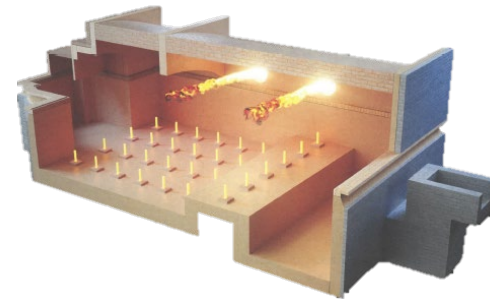
SIMON M., GAUBIL M.

September 15th 2026



Evolution of glass melting technology to face the CO2 challenge

Decarbonization is a key priority for glass industry, requiring a transformation of the production tools to reach carbon neutrality targets.



Optimizing proved solutions

- ❖ Oxy-gas/ higher boosting
- ❖ Higher levels of cullet
- ❖ Improved thermal insulation
- ❖ Modeling, monitoring

Development of hybrid system

- ❖ High Boosting + Oxy-gas
- ❖ H₂ – NG Mixes
- ❖ Bio-Fuels

Impact on the superstructure ?

- ❖ Thermal cycling
- ❖ Insulation increased
- ❖ New operation methods

THE CROWN A CRITICAL AREA



Overheating of fused cast AZS crown

OPTIMIZATION OF THE THERMAL PERFORMANCES

RISKS OF OVERLOADING THE CROWN,
INCREASING THE TEMPERATURE OF THE
CROWN = HIGH CREEPING



Wrong choice of refractory material

NEW OPERATING CONDITIONS

= NEW CROWN BEHAVIOR



CROWN FACES NEW CHALLENGES :

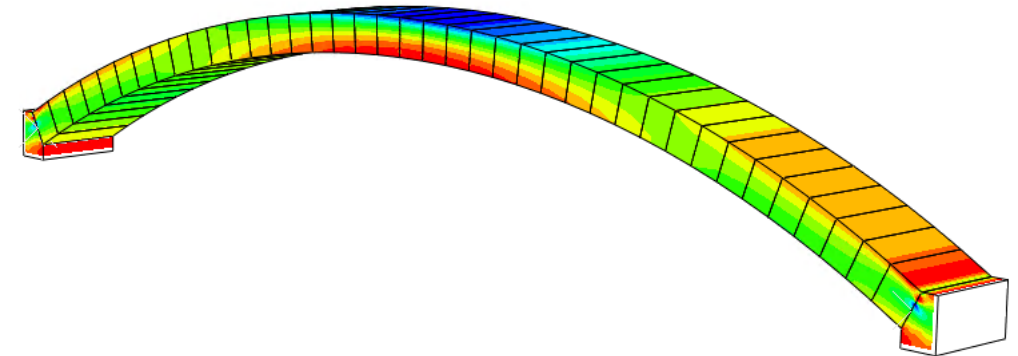
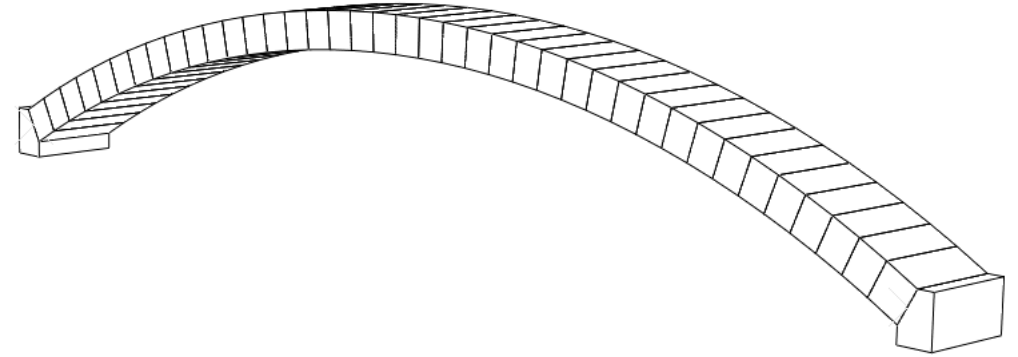
- HYBRIDATION RATE MODIFICATION
= THERMAL CYCLING
- LARGER FURNACES = HIGHER
MECHANICAL RISKS
- WHAT ARE THE
THERMOMECHANICAL EFFECT OF
SUCH CHANGES ?
- IS IT NECESSARY TO MODIFY THE
GLASS FURNACE OPERATIONS ?

The Aim of The Model

- **Study** Thermo-Mechanical behavior during the lifetime (heat-up + campaign)
- **Identify** thermal gradient, critical creep & mechanical stress
- **Compare** crowns designs & operating conditions
- **Optimize** thermal & mechanical performance

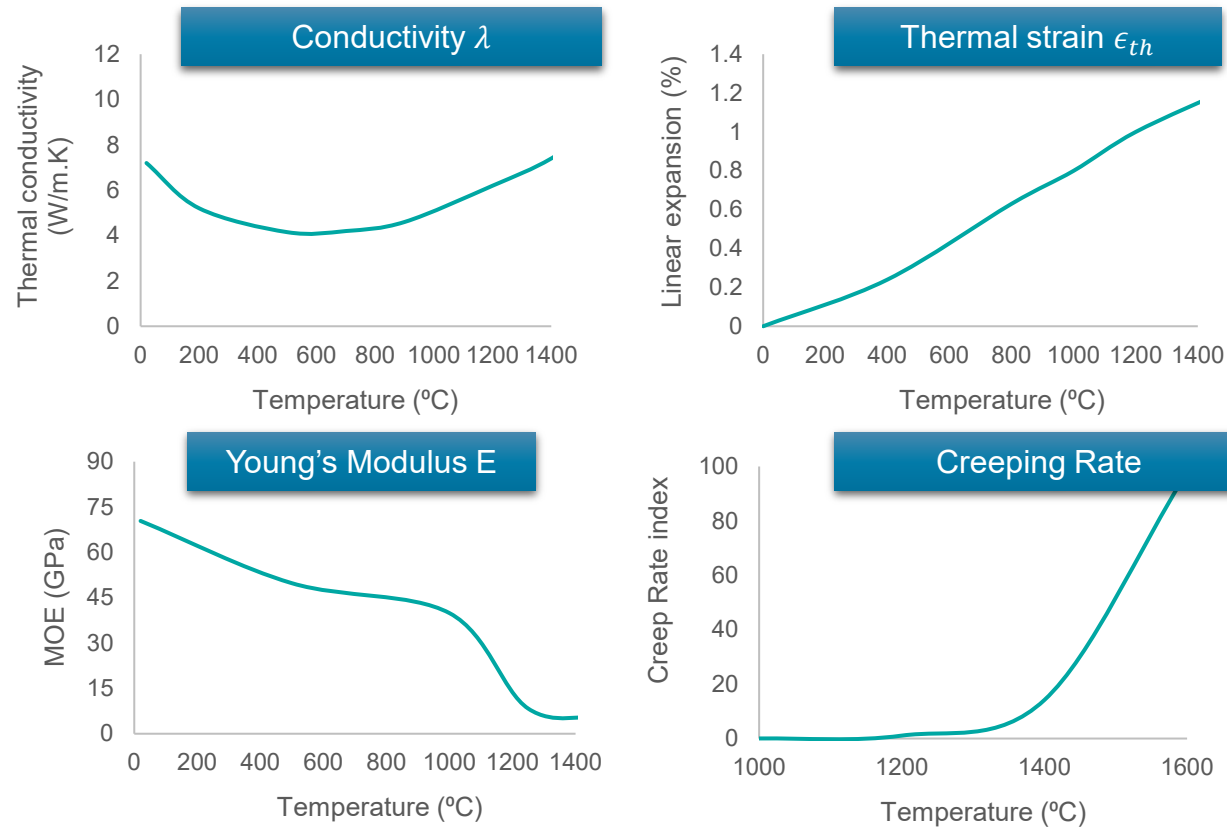
2D Thermo-Mechanical Modeling

- **2D FEM Model**
- **Fully Coupled Thermomechanical Model**
- **High SEFPRO Knowledge of Refractory thermophysical properties**



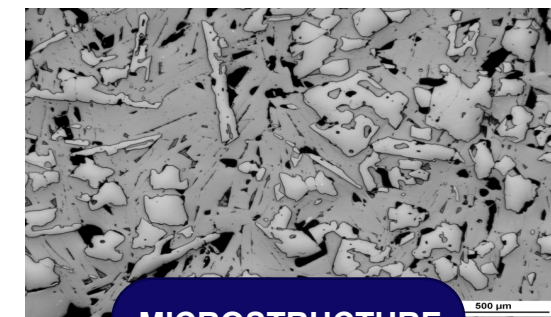
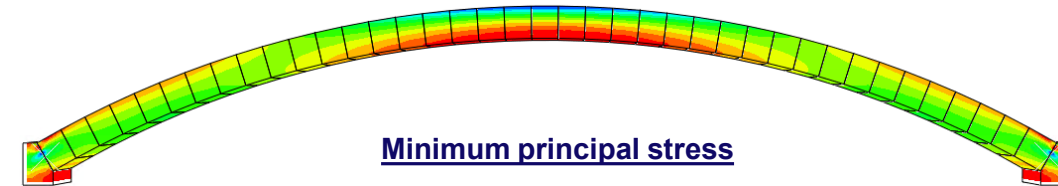
PHYSICAL PROPERTIES OF ELECTRO-FUSED CROWN BLOCKS

SEFPRO – JARGAL M : electro-fused 95% alumina



HIGH COMPLEXITY CHALLENGE :

- LIFETIME HAS TO EXCEED THE CAMPAIGN
- EXCELLENT CREEP RESISTANCE REQUIRED
- HIGH THERMAL GRADIENT
- HIGH TEMPERATURE APPLICATION
- HIGH MECHANICAL LOAD



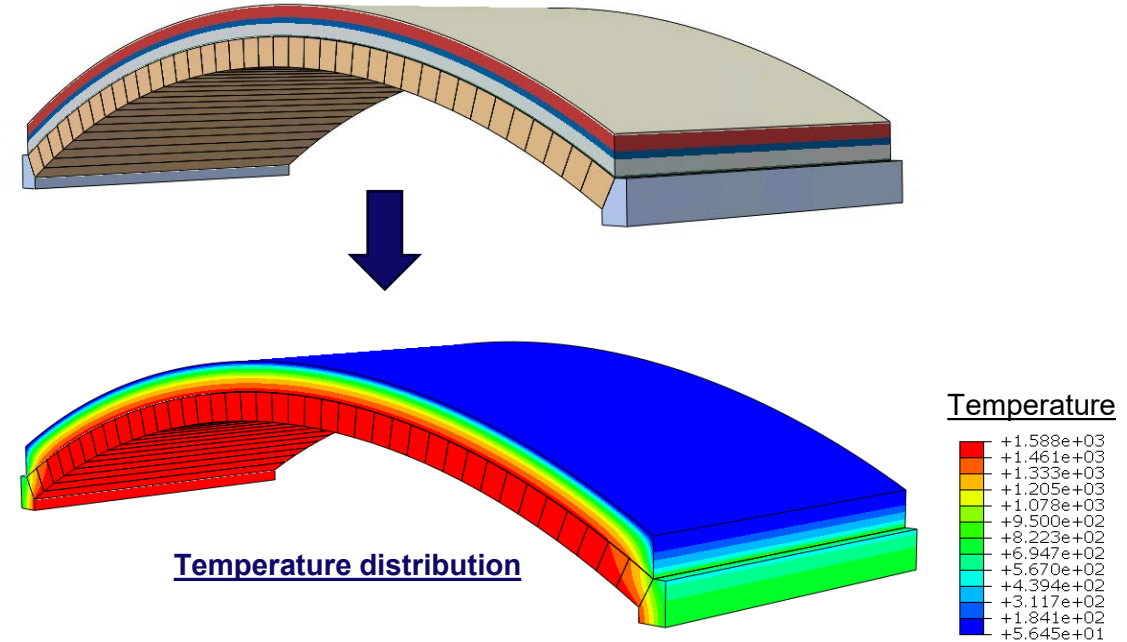
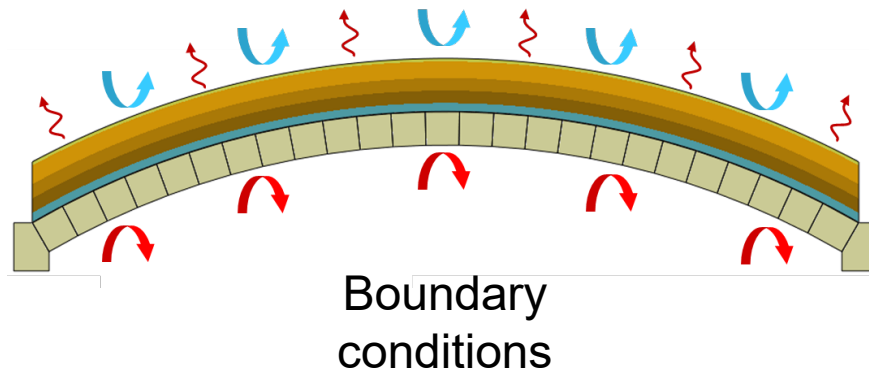
Typical Chemical Composition

	Al_2O_3	SiO_2	Na_2O	$CaO + TiO_2 + Fe_2O_3$
JARGAL M	95 %	0.5 %	4 %	0.3 %

Application 1 : Thermal study of the crown

Thermal study

- A model serving glassmakers
 - **Evaluate** the impact of furnace modifications without industrial trials
 - Predict temperature distribution
 - Assess new operating conditions
 - A **flexible** model to satisfy all the designs
 - A time dependent model to **adapt** to the production fluctuation

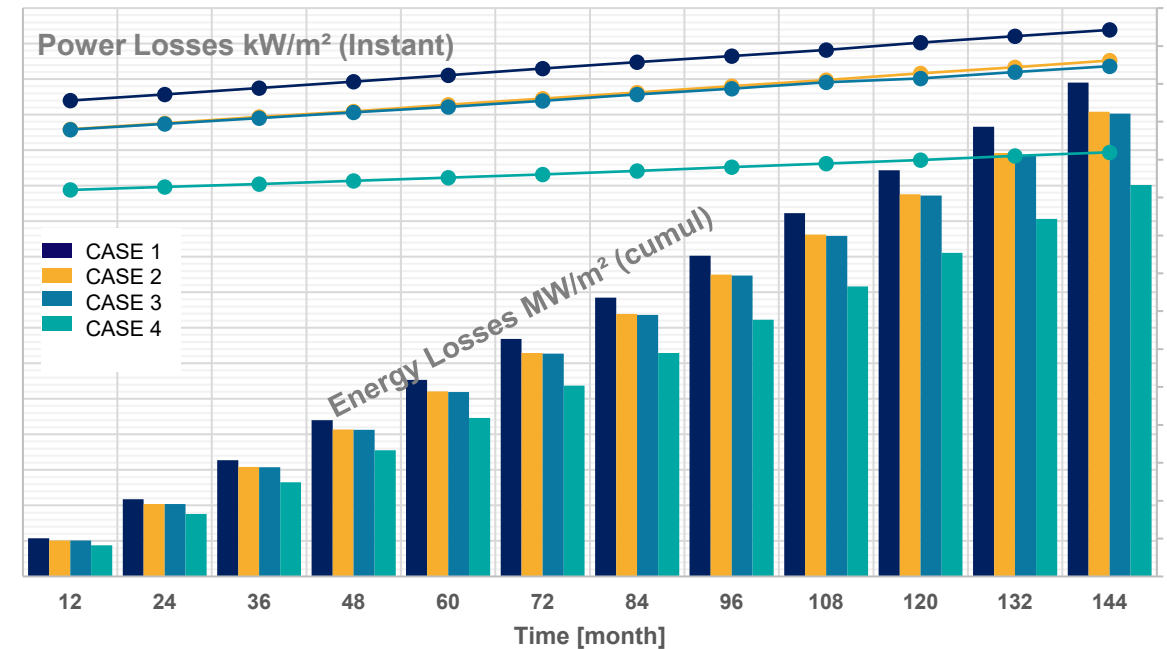
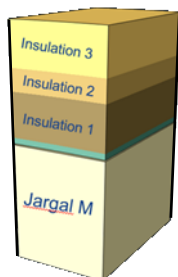


Application 1 : Thermal study of the crown

Thermal study

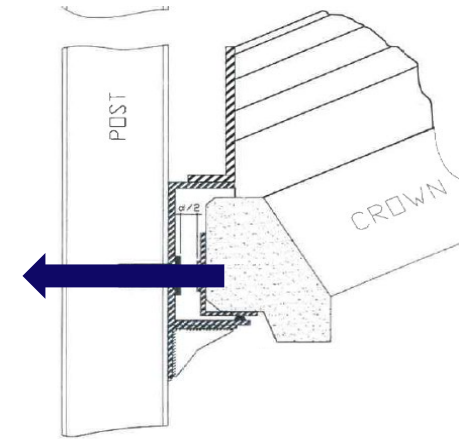
- Support Energy Efficiency & Decarbonization
 - Quantify and compare the energy efficiency of crowns design
 - Justify a material upgrade (return on investment)

	Number of insulation layers	Total thickness of the insulation package (in mm)	Crown totally covered by the insulation package
CASE 1	2	150	NO
CASE 2	2	250	YES
CASE 3	3	250	YES
CASE 4	4	400	YES

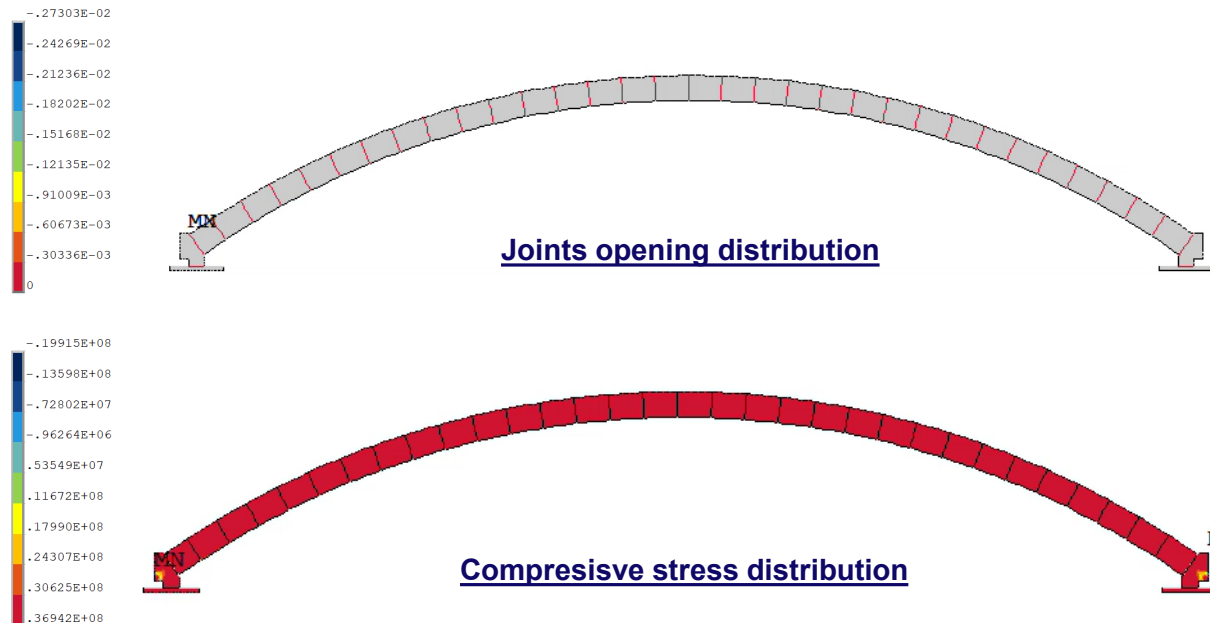


Application 2 : Thermo-mechanical study of the Heat-up

- Heat-up : a critical stage for crown lifetime
 - How to **optimize** the **crown lifetime** through the heat up procedure
 - Minimize** the stress induce in the crown blocks
 - Reduce the maintenance time** (by increasing the heat up rate)

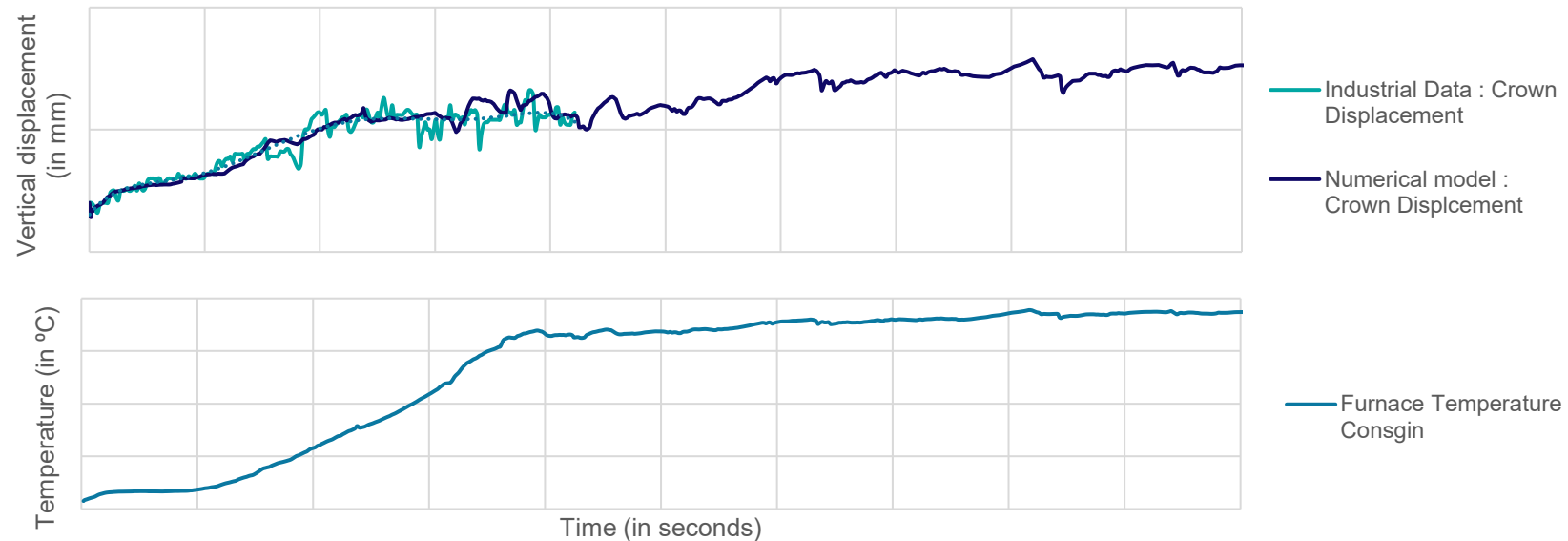
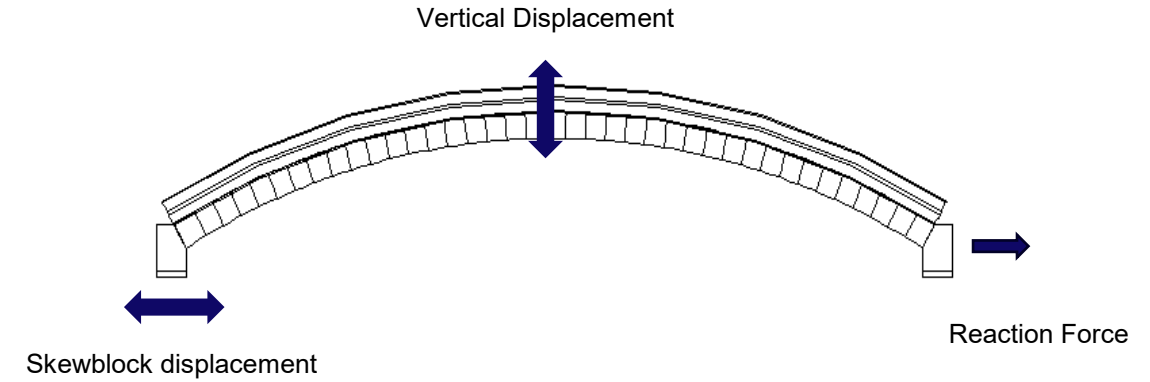


FURNACE CROWN :
PRINCIPLE OF STEEL-WORK



Application 2 : Thermo-mechanical study of the Heat-up

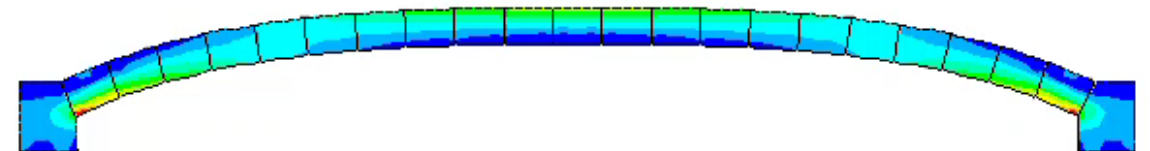
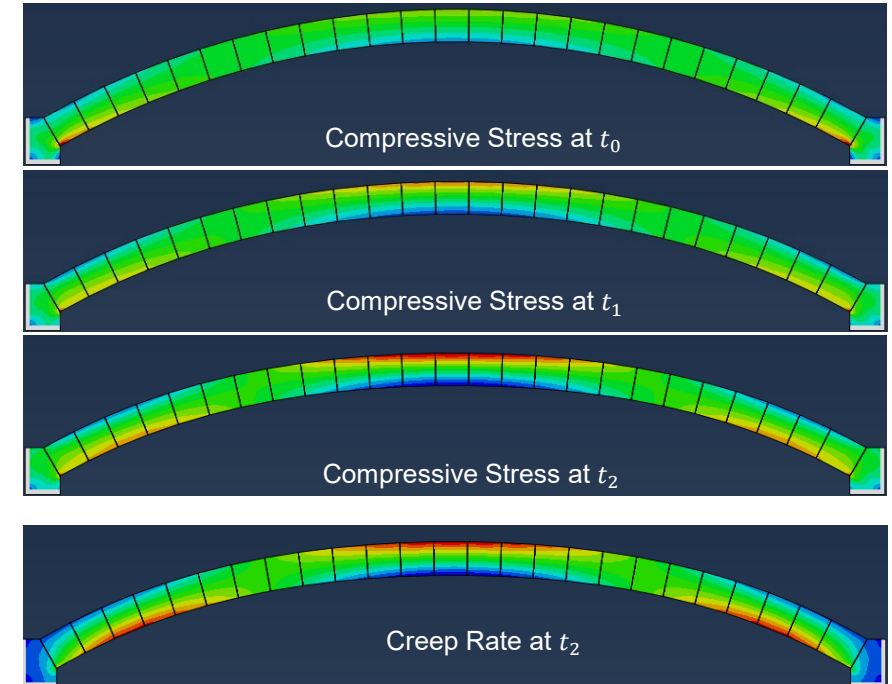
- **Parametric thermo-mechanical model**
 - **Optimize** skew block displacement strategy
 - **Quantify** reaction **forces** during thermal expansion
 - Predict crown displacement throughout heat-up



Application 3 : Crown deflection during the campaign

- **Thermal constraints :**
 - Moderate to severe thermal cycles
- **Mechanical loads :**
 - The crown has to last the whole campaign despite :
 - **Mechanical** solicitation (loads)
 - **Creep** deformation
 - **Joints opening** (at the intrados)
 - Reduce the contact surface between the blocks
 - Reduce the crown stability
 - Increase the cold face temperature
 - Leads to an increased creep rate

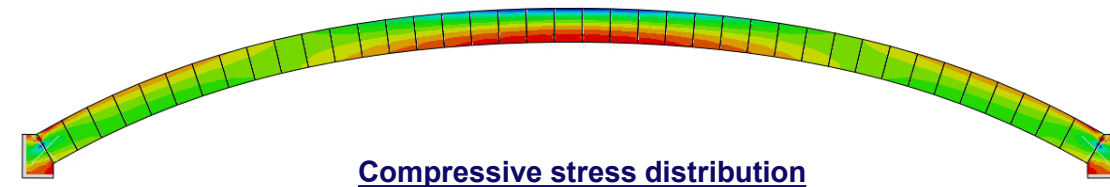
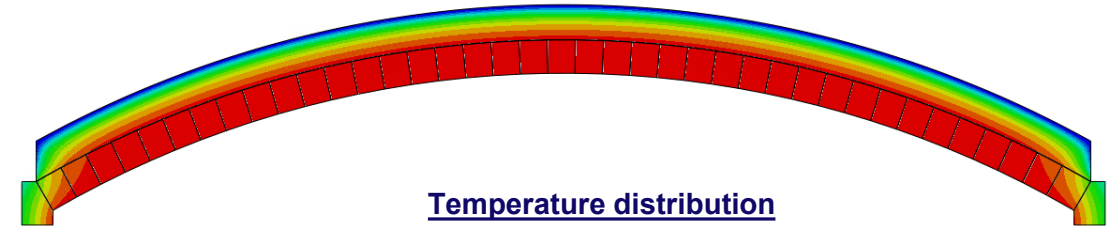
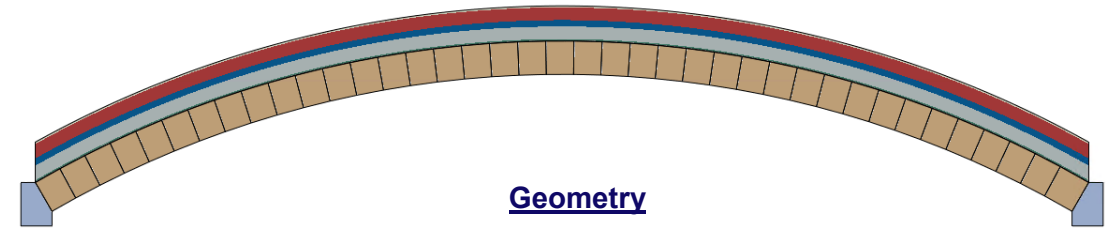
Compressive Stress evolution during the campaign



Conclusion

From numerical simulation to industrial decisions

- **Thermal model**
 - Temperature distribution
 - Energy efficiency
- **Thermo-mechanical model**
 - Heat-up optimization
 - Stress prediction
 - Creep behavior
- **Industrial benefits**
 - Predict before building
 - Compare before investing
 - Optimize before operating



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THANK YOU
for your attention



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