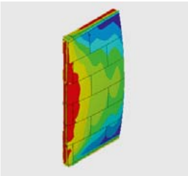
dynardo
dynamic software & engineering

SIMULATION OF FIRE RESISTANCE

Development of a realistic simulation model as a basis for the prognosis of material behaviour and the fire resistance of calcium silicate masonry walls.



Optimization Task

The aim of a joint research project of the European Calcium Silicate Producers Association (ECSPA) was a fundamental investigation of the behaviour of calcium silicate masonry walls subjected to fire load as well as the relevant influences on the fire resistance. These investigations were accomplished both by simulations and an accompanying test programme

Solution Methodology

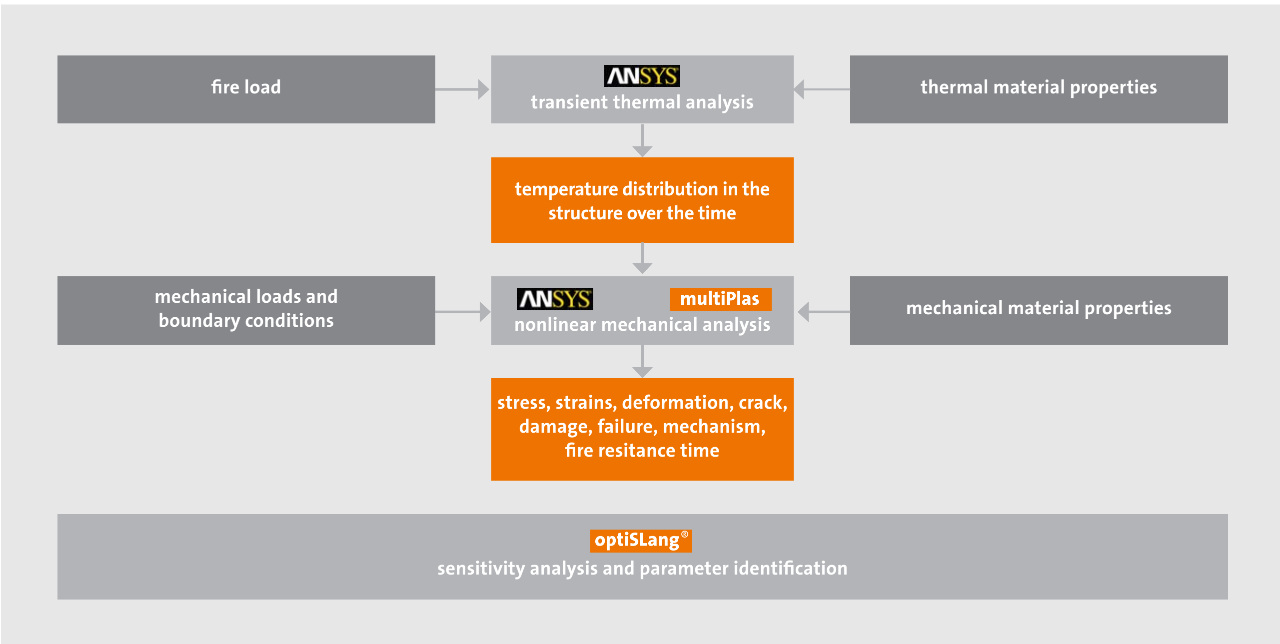
First of all, using ANSYS, a transient thermal finite element analysis was carried out to determine the time-dependent temperature distribution in the wall structure.
Then, a coupled nonlinear mechanical finite element analysis of the deformation behaviour and the final structural failure was exercised with ANSYS and Dynardo's material library **multiPlas**. The library contains efficient, realistic material models for masonry and many other materials. The models are based on elasto-plastic flow criterion with associated and non-associated flow rules.
Finally, a sensitivity analysis was run with **optiSLang**. The Dynardo software uses stochastic Latin Hypercube Sampling with efficient genetic and evolutionary optimization algorithms for parameter identification. With minimal effort a sensitivity analysis can be set up and important parameters will be identified automatically.

Simulation Process

For the entire process of the coupled thermal-mechanical FE-analysis, a parameterized approach (variable model parameters instead of distinct values) was chosen. The input parameters describe the loads, boundary conditions and material properties (see grey boxes in Figure below). The response values are the computation results such as temperatures, deformations, fire resistance (see orange boxes in figure below and figures a-c on back page).

Fire loaded calcium silicate masonry walls show particularly three phenomena:

- desiccation and consequently a progressing dampness front,
- chemical conversion respectively material deterioration at approx. 550 to 600 °C,
- three-dimensional deformation behaviour because of the one-sided fire load.



Simulation process

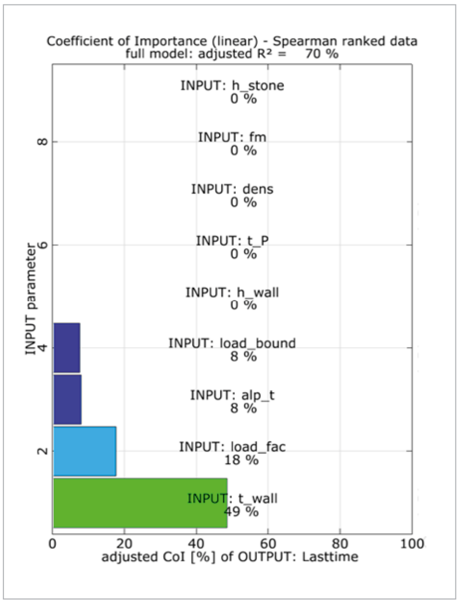
Customer Benefits

With the developed simulation model, using Dynardo's optimization platform **optiSLang** and the material library **multiPlas**, it was possible to predict the fire resistance time as well as the damage caused by fire load.

Dynardo developed the **Metamodel of Optimal Prognosis (MoP)** and the **Coefficient of Prognosis (CoP)** as key algorithms for a sensitivity analysis with quantifiable solutions. This approach provides a specific benefit by automatic variable reduction and verification of the forecast quality with a minimum of solver calls.

The sensitivity analysis, implemented by optiSLang, showed important correlations between input parameters and response values and identified the potential parameters which allowed an alignment between measurement (test) and simulation by means of inverse computing (parameter identification).

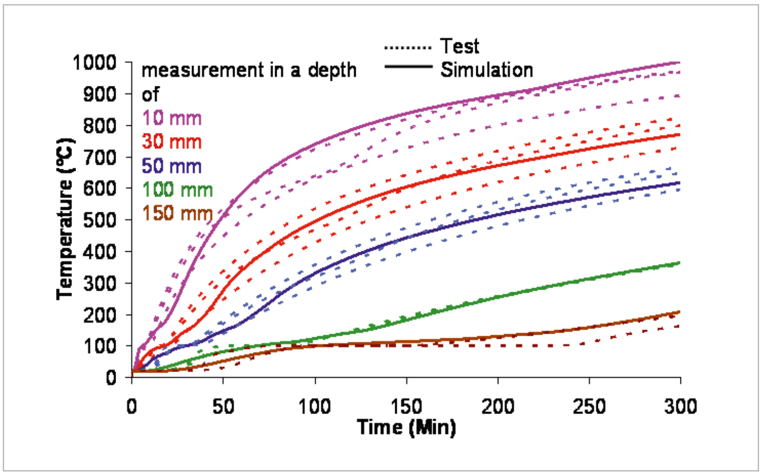
In addition, the applied approach shows high potential for optimizing building materials with regards to their structural fire resistance.



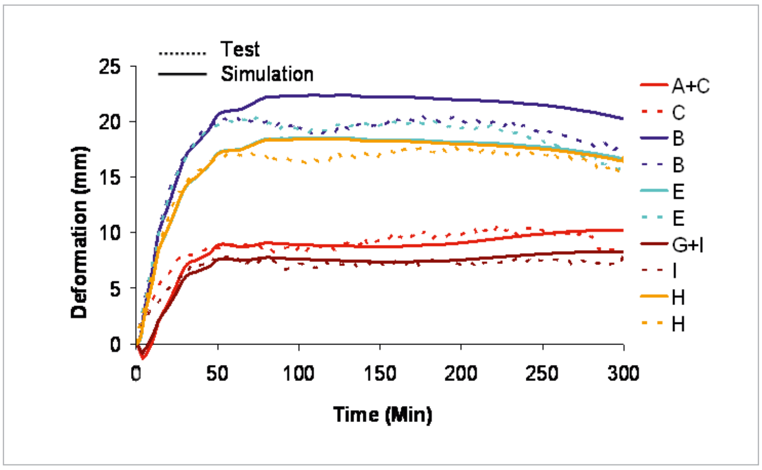
Coefficient of importance of all input parameter versus fire resistance time (walls without plaster)

Relevant parameters:

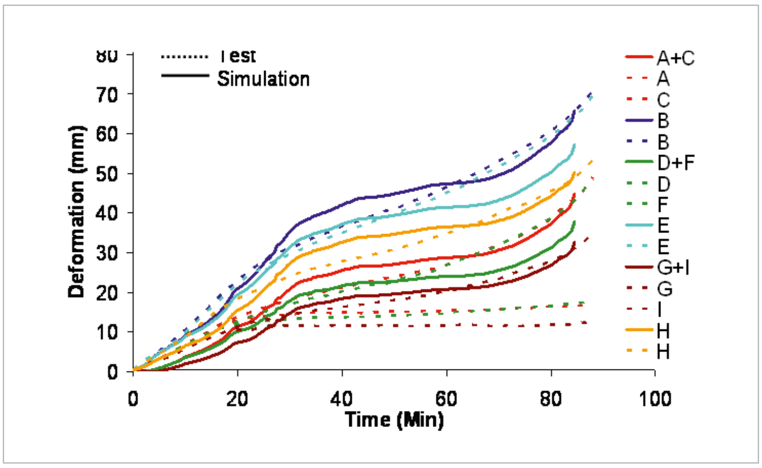
- boundary conditions at the wall head
- thermal strain
- level of vertical load
- wall thickness



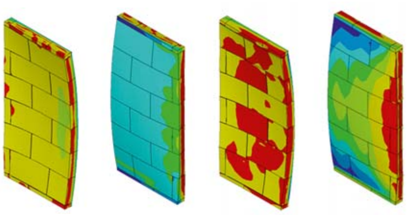
a) Temperature signal – measurement versus simulation (example wall 2)



b) Wall 3 (d = 0,214 m) deformation signal – measurement versus simulation



c) Wall 4 (d = 0,15 m) deformation signal – measurement versus simulation



Visualization of vertical and horizontal stress

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