Numerical modelling of fire-resistant glass

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OVERVIEW OF THE RESEARCH

The aim of the research is to create a numerical model for fire-resistant glass' behaviour at high temperatures, reaching up to 1000°C. It includes a numerical and an experimental part in order to define the properties of intumescent layer as well as to validate the model through fire tests.

The project is funded by the Walloon Region of Belgium as convention *doctorat en entreprise* and is being developed at the University of Liege (Belgium).

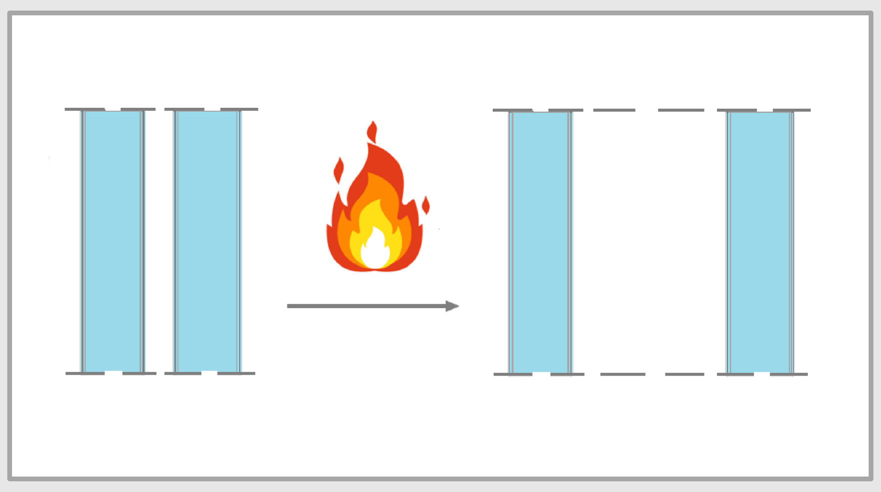
1. CONTEXT

Fire is a dangerous and fast-developing phenomena which threatens health and life of people. For this reason, there are many legal requirements on the fire resistance of buildings products to ensure time for evacuation.

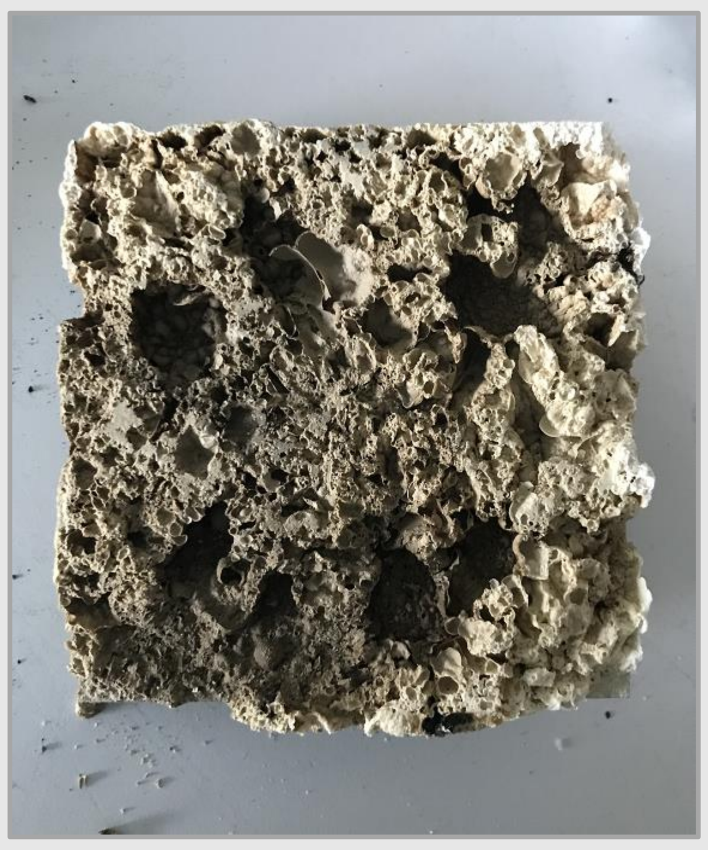
Many modern public buildings such as airports or offices use fire-resistant glazing and special frames to create compartments and decrease the risk of fire spreading.

Fire-resistant glazing consists of layers of glass with transparent silica gel between them. In fire conditions, due to high temperature, the gel starts swelling creating an opaque, porous foam which blocks the heat transfer to other compartments.

Fire-resistant products, including fire-resistant glass, are tested in a special furnace. If they meet all criteria, the products are certified with one of the classes of fire-resistance and can be used in structures.



2. METHODOLOGY



Based on the first modelling attempts, the missing thermal properties of the intumescent layer were identified. All of them depend on the temperature due to the phase change from gel to foam.

The following experiments were conducted in order to obtain the thermal properties:

- small scale tests on gel samples,
- medium scale tests on glazing samples,
- fire resistance tests on full frames.

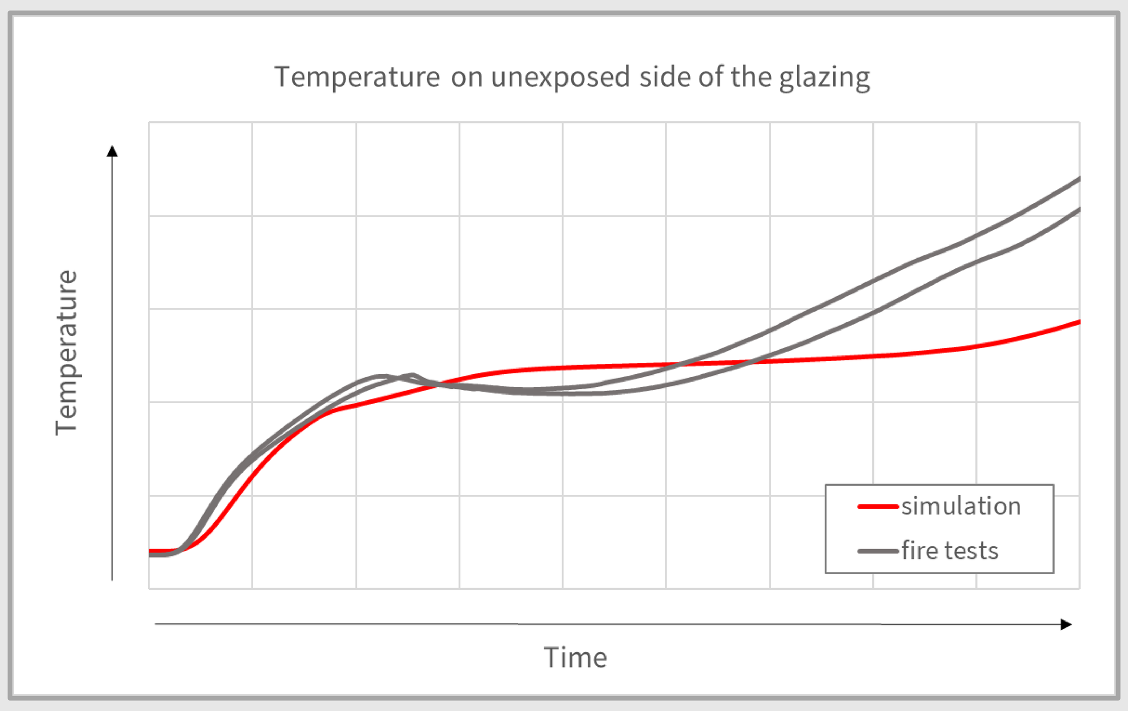
The boundary conditions included heat transfer through radiation and convection with gas temperatures:

- 20°C on unexposed side,
- ISO834 fire curve on exposed side, according to the function: $T=345\log_{10}(8t+1)+20$.

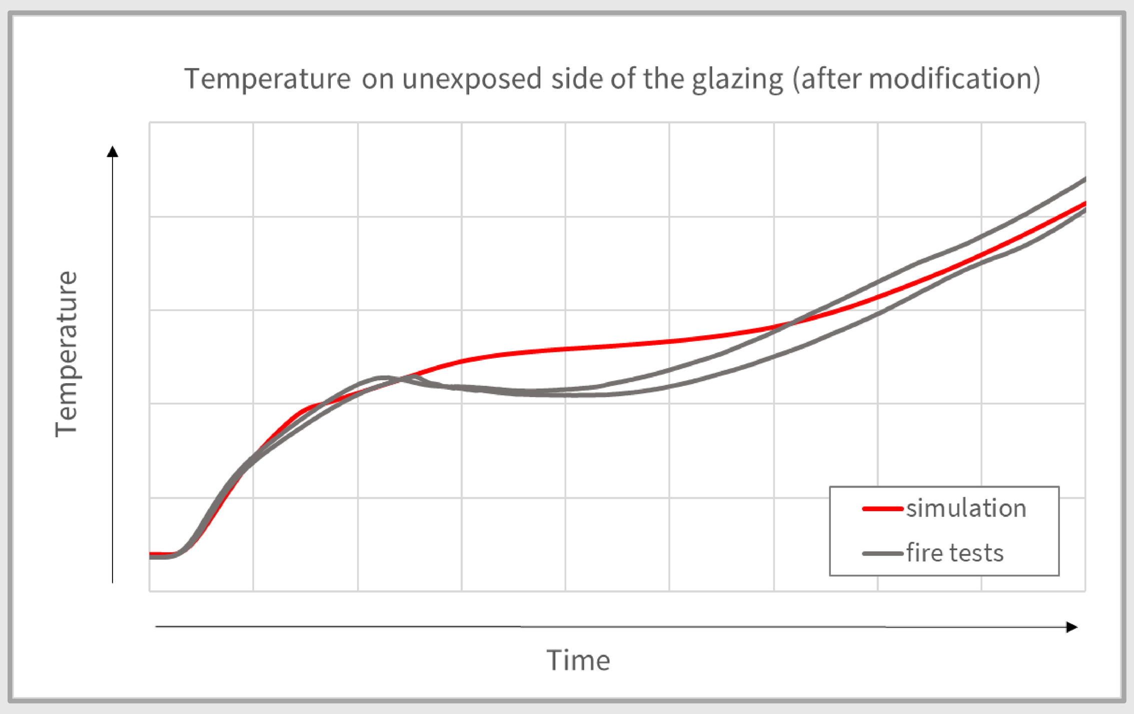
Besides all properties of the intumescent layer, the change in volume (swelling) should also be taken into account. This phenomena was integrated in the effective thermal properties applied in the model considering the initial thickness of gel and the thickness of foam layer after the reaction has finished.

3. RESULTS

The first results of the thermal simulation of the one-dimensional heat flow through glazing based on properties derived from small scale tests did not show a good fitting with the results of two full scale fire tests which were conducted in the purpose of the model validation. The plateau effect lasted too long comparing to the experiments. It was concluded that the intumescent layer's properties applied in the model were too insulating.



In order to improve the thermal properties, a new set of medium scale measurements was done using heating pads which can heat up to temperatures above 1000°C. Thermal properties of the intumescent layer were improved and modified in the numerical model.



The results of the latest simulations showed good agreement with experimental results, however, different additional factors still need to be further analyzed.

The following steps are planned to improve the model:

- analysis of the porosity of the foam created during the swelling phenomena,
- analysis of the influence of glass breakage on swelling behavior.

REFERENCES

[1] EN 1363-1:2020 Fire resistance tests - Part 1: General requirements, CEN (European Committee for Standardization), Brussels, Belgium

[2] EN 1634-1:2014 Fire resistance and smoke control tests for door and shutter assemblies, openable windows and elements of building hardware - Part 1: Fire resistance test for door and shutter assemblies and openable windows, CEN (European Committee for Standardization), Brussels, Belgium