

Hybrid Fire Testing: A new approach for fire labs

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1. Standard Testing Approach

Fire tests in laboratory remain crucial to understand the behavior of structures subjected to fire

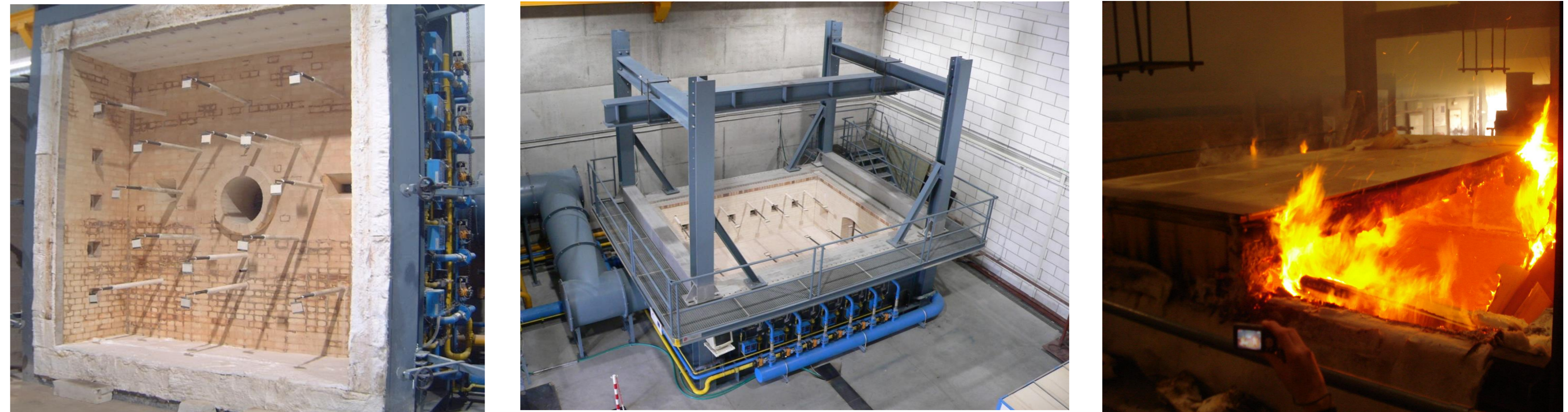
(LIEGE FIRE TESTING LABORATORY)

Standard testing

- Performed on individual elements
- Boundary conditions (loads or supports) kept constant
- Most common approach

Full scale testing

- Performed on entire structures
- The structural behavior can be more accurately reproduced
- Very expensive and time-consuming



Need for a method that allows considering the behavior of the surrounding structure in standard tests on individual elements

2. Hybrid Fire Testing (HFT)

Definition

- From a complex structure, one element is physically tested in a furnace while the rest of the structure is simulated numerically.
- Displacement or forces at the interface are continuously adjusted to take into account the influence from the rest of the structure on the tested element.
- As a result, the physical structure (PS) and the numerical structure (NS) interact in real-time during the test.

Development of the methodology

Sub-structuring

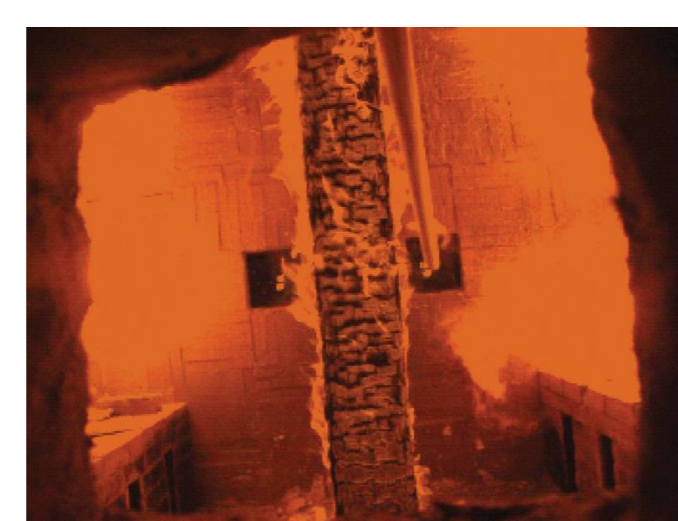


PS

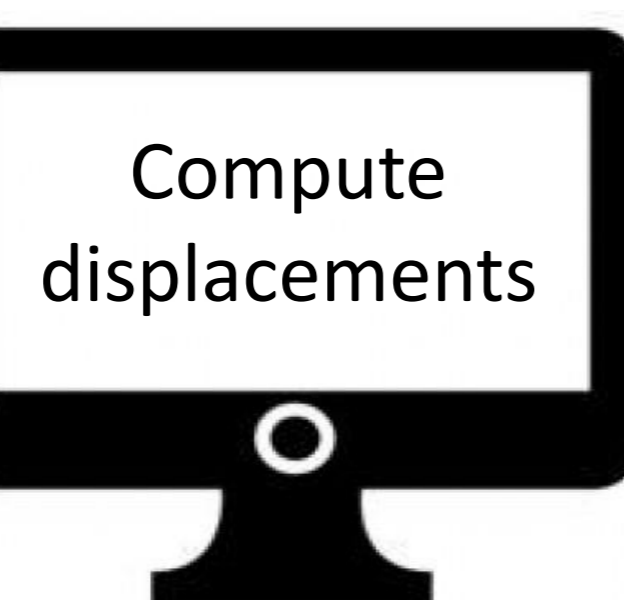
Measure forces at interface

NS

Hybrid Fire Test



Impose Displacements at interface



Validation of HFT in Liege Fire Testing Laboratory

Design of a small-scale setup to test the method experimentally

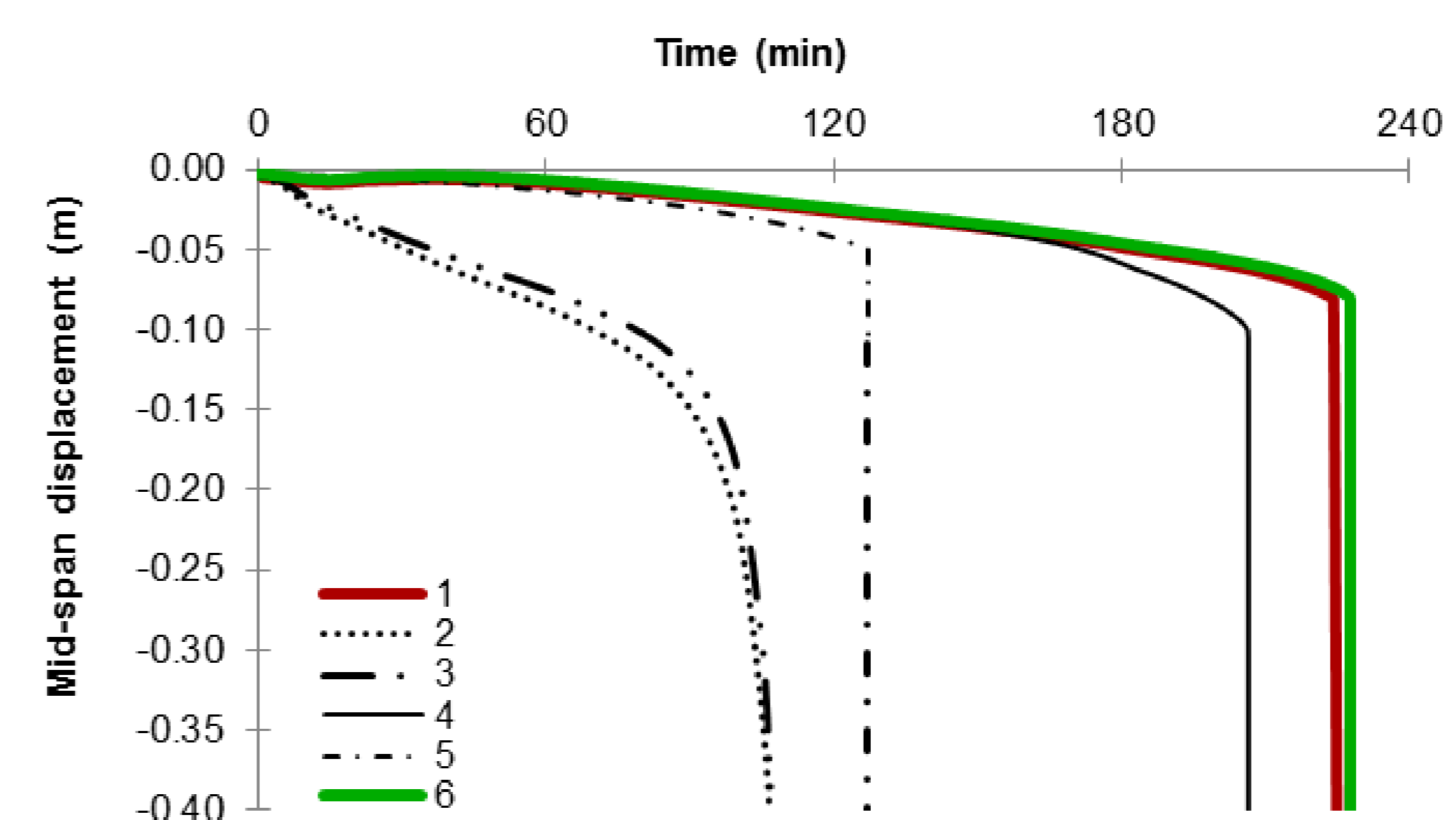


- Electrical heating system
- Steel column
- Control of 1 or 2 DoF at the interface

3. Numerical Results

HFT method implemented in a numerical environment to validate the method before going to real scale test

Example: concrete beam part of a building



Numerical simulation of different configurations:

1. Model of the **full building** – Full scale test
- 2.-5. Models of the **beam** with various boundary conditions – Standard test (simply supported beam without (2) and with (3) support bending moment, fixed supports of the beam with free thermal expansion (4), fixed supports of the beam including the thermal expansions (5))
6. **HFT** model

⇒ HFT yields the same response as the full building

⇒ Numerical validation of the **benefits of using HFT method in fire lab**

4. Conclusion

HFT

- Combines testing and numerical approaches
- Tests only an individual element (i.e. same as standard test)
- Yet captures the global behavior (i.e. same as full scale tests)

Future

- Validate the method on small-scale test setup at ULg fire lab
- Develop SAFIR® to enable performing HFT
- Adapt the testing facility for HFT on real size structural elements
- Advantage of ULg: in-house software SAFIR® + fire lab
- Hybrid Tests extended to other domains e.g. mechanical eng.

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