Simulation of Propagation of Compartment Fire on Building Facades

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Abstract. The façade fire simulation of buildings is carried out with Pyrosim numerical fire modeling program, following the implementation of a fire scenario in this simulation program. The scenario that was implemented in the Pyrosim program by researchers from the INCERC Fire Safety Research and Testing Laboratory complied with the requirements of BS 8414. The results obtained following the run of the computational program led to the visual validation of effluents at different time points from the beginning of the thermal load burning, as well as the validation in terms of recorded temperatures. It is considered that the results obtained are reasonable, the test being fully validated from the point of view of the implementation of the fire scenario, of the correct development of the effluents and of the temperature values [1].

1. Introduction
Theoretical studies and existing experimental research have highlighted the fact that each fire has its own evolution that individualizes it, with no two fires of identical evolution [2]. Uniqueness of the event should be understood as referring to the whole set of factors and consequences of a fire [3]. Under these conditions, it is logical to conclude that it is impossible to make an accurate forecasting of the fires that can occur in a given system and in a particular context. A systematic study path is represented by the so-called fire modelling - schematically described in Figure 1 - which is an inherent part of the research evolution [4].

Fire models are used in various aspects of fire safety management:
- before fire, to estimate the risk of fire - this helps the specialists who intervene to identify areas of major risk;
- during fires, to determine the firefighting strategy - this would help the intervention teams to limit their losses and intervene safely;
- after fire, for the investigation and determination of fire causes - these are a useful tool for intervention forces, researchers and experts [5].

![Figure 1. Fire block modelling scheme.](image)

### 2. Experimental procedures

In the following lines, the Pyrosim fire modeling program is used to model field faults according to the BS 8414 standard. The modeling was done using the Pyrosim (FDS) program, and the Smokeview utility was used to view the results. part of the freeware FDS package [6].

The input data for the Pyrosim program for BS 8414 simulation are listed in the following Table 1.

**Table 1. Input data of the simulation.**

| Category                     | Parameters         | Value                                                                 |
|------------------------------|--------------------|----------------------------------------------------------------------|
| Domain of calculation        | Building area      | Building 8.5 m high, P + 2                                           |
| Calculation cell size        |                    | 0.05 m                                                               |
| Total cell number            |                    | 446520                                                               |
| Other Information            | Fire chamber       | Rectangle (1m x 1.5m), located right above the stack built according to the standard. The released heat flow of 1668.4 kW / m² |
| Calculation time             |                    | 1800 seconds                                                         |

The implementation of the scenario in the simulation program according to the BS 8414 geometric requirements, is as follows:
Figure 2. Viewing 3D viewing of the test stand, identifying the location of the thermocouples.

Figure 3. Visualization of the computational domains (eng: mesh) in the Pyrosim program and the standardized stand (wood stack) according to BS 8414.
3. Results and discussions
Modeling results: As can be seen in Figure 4, the development of smoke and flames over time follows the normal evolution of a classic fire. Also, Figure 5 shows a similar development of the dynamics of the flames on the facade between the two situations: simulation and experimental stand.

**Figure 4.** Visualization in the Pyrosim program of the simulation performed according to BS 8414 at \( t = 36 \) s and 108 s.

**Figure 5.** Visualization of the simulation performed in the Pyrosim program, in parallel with the actual testing performed according to the standard. It is observed a similar development of the dynamics of the flames on the facade between the two situations: simulation and experimental stand.
Figure 6 shows views of section flame temperatures at two different time points.

![Figure 6. Viewing sectional flame temperatures at t = 360 s and t = 1044 s.](image)

Regarding the temperature values, Figures 7 to 9 show comparative pairs of temperature graphs recorded by thermocouples in the real and simulated experiments. Generally, there is a 15-30% margin of valid value differences in the value.

![Figure 7. Graphical representation of temperature variation in the combustion chamber of the test bench.](image)
4. Conclusions
The purpose of the paper is to implement the scenario in the simulation program according to the BS 8414 geometrical requirements and visual validation of the effluents at different moments from the initiation of the combustion as well as the validation in terms of temperatures. The results are considered reasonable, the test being fully validated in terms of scenario implementation and proper effluent development as well as temperature readings. The resulting HRRPUA value used in the simulation is 1668.4 kW (Heat Release Rate per Unit area)
The maximum HRR of 2500 kW (ie 1668.4 kW × 1.5 mp) can be considered as the optimal fire exposure value by testing and validation by mathematical simulations on a computer. According to good practices in numerical fire modelling, it is well known that each practical test is different in several ways:
- it is difficult to control the heat exposure of the façade due to the movement of the air around the combustion chamber or the movement of the air in the test area (wind);
- degradation and destruction of the façade;
- geometry is never identical from one test to another;
- the initial temperature of the walls before testing may influence the test result.

Therefore, a modelling attempt to reproduce such a phenomenon as burning is a difficult challenge for modelling researchers. But it is important to take steps towards validation, because such destructive tests on a real scale can not always be carried out. After complete validation, it is possible to use the data of a scenario in a multitude of tests that would not destroy anything, only would require the computing power of a computer.

As input data for the simulation performed in this report, a HRR curve, not a self-sustaining outbreak, was used, as there was no information on the loss of mass in the outbreak (the stack of wood).

5. References
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