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The importance of the correct determination of the input parameters in the FDS software; the importance of validating numerical studies with experimental studies

Importanța determinării corecte a parametrilor de intrare în software-ul FDS; importanţa validării studiilor numerice cu studii experimentale

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Abstract
FDS is the software researchers use to simulate the evolution of a fire inside the buildings or to simulate exterior fires. FDS was used in research on modelling of the fire inside a room with dimensions of 3(m) x 6(m) x 2.7(m). The research included an experimental study and a computer modelling component to expand the probable scenarios. The research concludes that the FDS software can allow proper modelling of fire evolution, but an important stage is a phase of determining the model and calibrating it. Entering the input data correctly is an extremely important step.

Keywords:
FDS, CFD, fire, temperature, construction

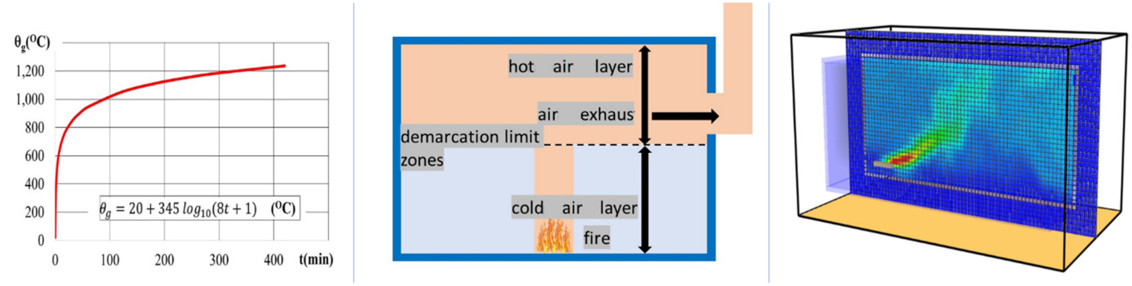
Introduction

During the lifetime of construction, it can be charged with normal current loads (for example, the own weight of the construction, the weight of users, the weight of furniture or other stored materials, the action of the wind, the action of the weight of snow) or it can be submitted to exceptional loads but with high intensity (i.e. seismic action, fire action).

Designers must consider all likely situations when conforming a building and designing the construction to standards.

A current concern of construction designers is to simulate the action of fires and how a fire evolves inside a building. The international trend is to offer a more realistic representation of the evolution of the fire, not only in the design phase but also in the expertise phase of a fire that has already occurred.

Nowadays, fire modeling methods can be divided into three broad categories: simple methods, zonal methods, and complex methods (Figure 1).



1) Simple model 2) Zonal model 3) Complex model in FDS

Figure 1 Types of models for describing fire action

Simple methods involve simple mathematical formulas, for example, the characterization of the space by the specific heat load. Zonal methods assume the division of spaces into two parts, the upper one with warm air and the lower one with cold air, each zone characterized by an average temperature and the height of the air layer. Complex methods involve modeling the fire as realistically as possible by solving complex equations describing fluid motion (CFD).

Areas covered

This opinion refers to the field of fire safety of constructions, being useful to building designers and researchers who use FDS in their studies.

This opinion refers to the importance of correctly establishing the input data in the FDS, this stage having extraordinarily large consequences for the results obtained.

Experiment

The research involved three main stages: carrying out the experiment, establishing the model and validating it, and carrying out numerical studies.

The experiment consisted in studying the internal temperature evolution inside a stand with dimensions of 3(m) x 6(m) x 2.7(m) (Figure 2).

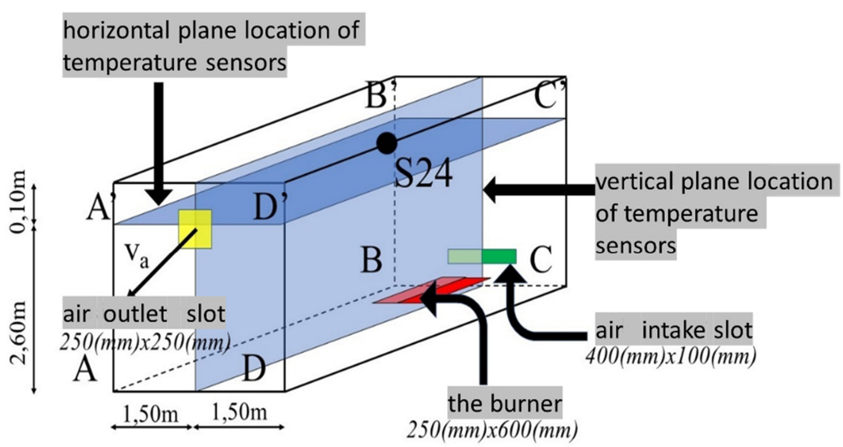


Figure 2 The experimental stand

Several K-type thermocouple sensors were mounted inside the stand, which recorded the interior temperature with the help of an ALMEMO data center.

The duration of data recording was 760 (s).

During the experiment, indoor temperatures rose from 20(ºC) and exceeded 100(ºC).

The heat source was represented by a burner that used LPG as fuel.

The evolution of interior temperatures at a given point during several experiments was recorded. The sensor was mounted almost centrally at the top of the stand, in the hot air area, where the sprinklers are usually located (sensor S24 from Figure 2).

Model setting and model validation

To be able to extend the research to hundreds of probable cases and to temperature ranges that cannot be safely reached with the help of an experiment, a mathematical model was made using the FDS software.

The modeling involved two main components: the establishment of the geometric characteristics and the establishment of the physical and chemical characteristics of the materials.

The geometrical characteristics of the components and their placement in space were achieved by direct measurement. This is about wall placement, hot air vents and cool air vents for compensation, fan placement, burner placement, and dimensions.

Physico-chemical characteristics imposed the need to determine the density of materials, thermal conductivity, specific heat, and other characteristics. Most of them were taken from product brochures, specialized literature, or other similar research.

Special attention was paid to the thermal conductivity of the outer walls of the experimental stand. The heat losses from inside the stand to the outside of the stand depending on the correct setting of the thermal conductivity.

The external components of the stand are the outer walls, the upper floor, the lower floor, the window that provides direct visual supervision of the experimental stand, and the door that provides access to the interior. To simplify the model, all these components with different thermal conductivities were not considered, but an equivalent thermal conductivity was established (Figure 3). The equivalent thermal conductivity also had to take into account the existing thermal bridges and the thermal conductivities of the actual components.

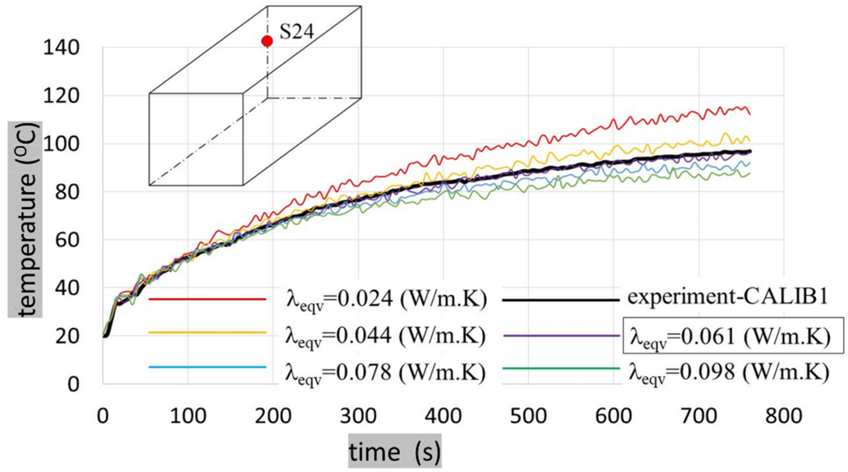


Figure 3 Temperature evolution graph at different values of the equivalent thermal conductivity

The equivalent thermal conductivity was established by successive iterations using FDS at different values until the deviations between the experimental indoor temperature records and those obtained from numerical modeling became minimal.

Conclusions

The FDS software is an extremely useful software tool in fire simulation and with very close to real results if the model is set up correctly.

It has been found that the correct determination of thermal conductivity has particular importance. Seemingly minor changes in these values lead to significantly different results. Taking the physico-chemical characteristics from the technical leaflets of the products used can lead to important errors.

Extending this observation to other input parameters, we can safely say that errors can accumulate, and this leads to significantly different output data.

If the analysis duration is longer, the accumulation of errors will become exponential, so at higher durations, it is necessary to use values as precise as possible and validated with more experimental results.

It is very important to use as many decimal places as possible. The level of detail can be established depending on the specifics of the study.

The validation of numerical studies with the help of experimental studies will certainly lead to a significant increase in the quality and correctness of the research.