FDS Modeling of the Sensitivity of the Smoke Potential Values Used in Fire Safety Strategies - DTU Orbit (06/12/2018)

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Performance-based analysis is commonly used for fire safety strategies in Denmark. In order to evaluate the safety level of buildings, a time comparison between the available safe egress time (ASET) and the required safe egress time (RSET) is established. As the buildings are becoming more complex both from a geometrical and functional point of view, this type of comparison typically rely on numerical simulation methods, such as, computation fluid dynamics (CFD), to assess the amount of heat and smoke produced during fires and to estimate the transport of the combustion products.

After the numerical simulation methods were adopted to simulate fires in buildings in Denmark, it has been observed that, for a majority of fire strategy reports, the optical properties of the smoke determine the available safe egress time. These critical times are most often defined by the visibility criteria defined in the Danish performance-based fire design code [1]. As there is no uniform test method to measure the optical properties of the smoke, values from different experiments are used in engineering analysis to express the properties that determine the decrease of visibility through smoke [2-6]. Furthermore, it has been observed that the selection of the smoke potential value used as input in the numerical simulation models to a high extent determine the results obtained using the CFD simulation tools.

To investigate the sensitivity of the numerical methods in respect to the input data, a parametric study was performed for relevant fire scenarios in a typical office building. By analysing the optical properties of the smoke and the soot production phenomena it was determined that the mass concentration of soot particles in the gaseous phase determine the optical properties of the smoke. Moreover, by examining the combustion model in Fire Dynamics Simulator (FDS) [7] it was observed that the optical properties of the smoke are determined primarily by the yield of soot and the effective heat of combustion. Therefore, these parameters were selected for the parametric investigation.

A probabilistic method and a numerical model were used in order to determine the sensitivity of the FDS simulations. The probabilistic approach was used to determine the most representative values of the input parameters. This probabilistic approach was applied on a database of smoke potential values and effective heat of combustion for building materials and furniture elements. The numerical model was based on a simplified model of a four-story office building with a central atrium. This method was used to determine the sensitivity of the simulation results with respect to the time until untenable conditions and the activation time of the smoke detectors for different smoke potential and effective heat of combustion values.

It was shown that for approximately 70% of the building materials and furniture elements included in the extensive database developed during this study, the selection of the effective heat of combustion and smoke potential value determine the outcome, both for the visibility level and smoke detector response. On the other hand, for materials with a smoke potential value higher than 2.0 ob∙m³/g (solid plastics, thermoplastic polymers and halogenated materials), it was observed that the fire simulation results are less dependent upon the values of the input parameters. The current approach is considered a valuable contribution, because it creates an overview of how important it is to use the correct values for the smoke potential and the effective heat of combustion in fire safety strategies and for fire safety design. In addition, it provides a database of values that can be used in fire safety strategies according to the design fire scenario.

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