DTU Library

Analysis of numerical smoke development calculation methods in rooms with suspended beams

Winther, Jakob Bjellekjær ; Dederichs, Anne Simone; Sommerlund-Thorsen, Kim

Published in:
NFSD Nordic Fire & Safety Days 2019

Publication date:
2019

Document Version
Publisher's PDF, also known as Version of record

Analysis of numerical smoke development calculation methods in rooms with suspended beams

The uses and limits of the two-layer zone model method and computational fluid dynamic simulations

Jakob Bjellekjær Winther[*,**], Kim Sommerlund-Thorsen[**], Anne Dederichs [*,***]
[*]Department of Civil Engineering, Technical University of Denmark, Denmark
[**]Rambøll Denmark A/S, Copenhagen, Denmark
[***]RISE, Sweden

Keywords: smoke, two-layer zone model, CFD modeling, suspended beams, design process,

Abstract
Several reevaluations of the fire safety level are carried out during building design, as new proposals and design changes occur. In this process the fire engineer can use a variety of methods to investigate and verify the fire safety level of the design [1]. The most applied methods are (1) hand calculations, which provide an overview and a first good guess of the design [2], (2) the two-layer zone models, which gives a good estimate of the mass flow and smoke height in simple geometries [2] and (3) fire models, which uses a computational fluid dynamics code (CFD) and are able to provide precise results in complex designs, but are computationally expensive to preform [2].

Frequent changes during the design process favors faster methods for investigating smoke exposure and heat radiation etc. The method, which the fire engineer chooses to use, all have advantages and weaknesses when applied [2]. When calculating the smoke's mass flow, the design's complexity influences the chosen method – but how complex does the geometry have to be, before a two-layer zone model is invalid to use? This has not been specified – with good reason, as it is a hard question to answer. Where is the borderline of when the term *complex* applies in this context? It is therefore rephrased to the question: *when is the two-layer zone model justifiable to use instead of a CFD model?*

The question above is limited to the case of rooms with suspended beams or technical installation placed under the ceiling to narrow the question down. The obstacles under the ceiling affect the mass flow of the smoke due to turbulence and therefore the time until critical conditions is reached. In this analysis the use of two-layer zone method (Argos) is compared with a CFD model (FDS) [3] for a room with suspended beams.

In the current work, the beams size and distance of the beams creates different scenarios, see figure 1. The scenarios are applied for both calculation methods to investigate the difference of each result. The deviation is mainly an error in the two-zone layer method due to inaccuracy of the method. As an increasing amount of scenarios is investigated, a correlation between the beam's geometry and the size of deviation in the two-zone layer method is determined. To be able to distinguish whether or not the two-layer zone method is valid enough, the size of the deviation is discussed. This results in a set of boundary conditions, or *use boundaries,* where the two-zone method is justifiable able to perform a valid analysis – or when the two-zone method will be invalid and a CFD model will be required for the design.

The goal is to optimize the time versus reliability of the proposed design input provided by the fire safety engineer through the design process. The boundaries will serve as guidelines for fire engineers to assess, whether or not the simpler and quicker method can be efficient enough to perform the analysis.

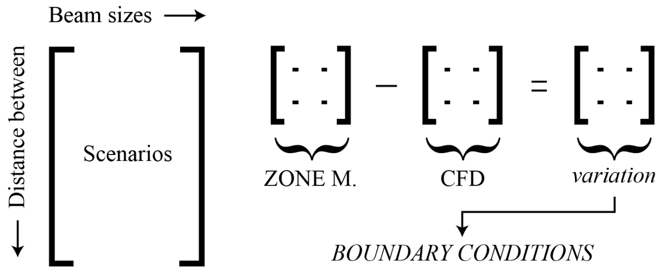

Figure 1. Scenarios of different dimensions is generated, investigated with each method and compared to create boundary conditions

References
[1] B. P. Husted, "Hvornår kan man anvende zone-modellering og hvornår skal der bruges CFD til brandsimulering i forbindelse med funktionsbaserede brandkrav", Dansk Brand- og sikringsteknisk Institut, April 2004

[2] R. Porowski, P. Tofiło and W. Węgrzyński, "Hand calculations, zone models and CFD – areas of disagreement and limits of application in practical fire protection engineering," Conference paper: SFPE 11th Conference on Performance-Based Codes and Fire Safety Design Methods, At Warsaw, Poland, May 2016.

[3] S. Tavelli, R. Rota and M. Derudi, "A Critical Comparison Between CFD and Zone Models for the Consequence Analysis of Fires in Congested Environments," Chemical Engineering Transactions Vol. 36, 2014