

# Zone models and natural ventilation through openings in separation walls

Zone models compared to CFD

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## Introduction

When openings in separation constructions are partly above and partly beneath the neutral pressure plane, natural supply and natural exhaust of air occur simultaneously. This creates a shortcut between supplied air and exhausted air (Fig. 1). Only a small part of the supplied air will mix with the entire volume of the room. The ventilation efficiency of openings in separation walls is overestimated by this effect in zone models. The ventilation efficiency characterizes the mixing behavior of air within a space and the removal of pollution from a source within that space and is described with a value from zero to one (Fig. 2).

*Is the ventilation efficiency in zone models overestimated because of a shortcut between supplied and exhausted air?*

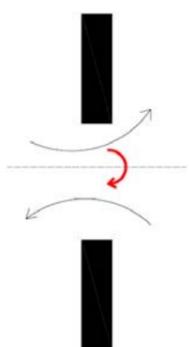


Fig. 1: Air flow shortcut

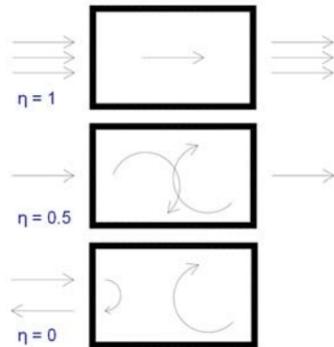


Fig. 2: Ventilation efficiency

## Method

To investigate the possible shortcomings in zone models regarding ventilation efficiency, the mass flow in zone models is compared to CFD calculations in which better resemblances of real world physics are expected. It is anticipated that CFD will take the air flow shortcut into account, in contrast to the zone model.

## Zone models

Zone models (Ozone and CFAST) predict fire development in an enclosed volume. The most common model is the two zone model (2-ZM), which divides the room into a hot upper control volume and a lower control volume (Fig. 3). After flashover, when the fire is fully developed, the single zone model (1-ZM) is applied. A homogeneous mixed zone develops and variables like temperature, pressure, mass and energy are equal over the total control volume (Fig. 4).

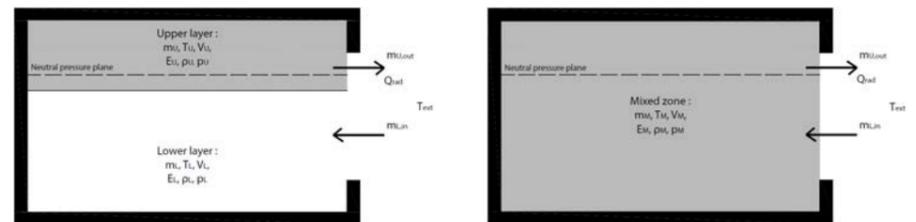


Fig. 3 and 4: Schematic overview zone models: 2-ZM and 1-ZM

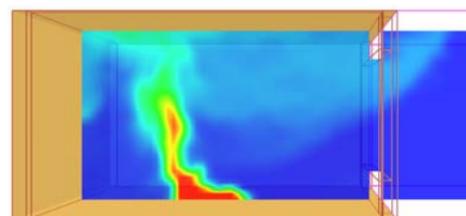


Fig. 5: Temperature (2-ZM)

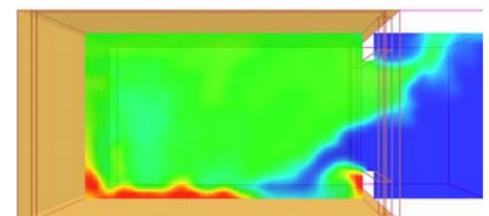


Fig. 7: Temperature (1-ZM)

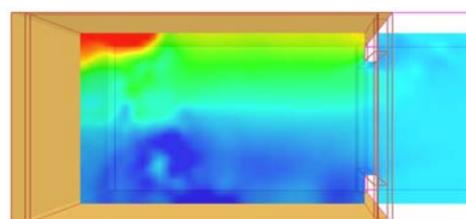


Fig. 6: Pressure (2-ZM)

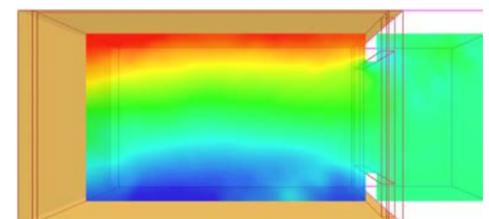


Fig. 8: Pressure (1-ZM)

## Computation Fluid Dynamics

Fire Dynamics Simulator, a CFD tool, is used to identify the "shortcut effect" in window openings. Several approaches have been unsuccessfully tested for expressing accurate ventilation efficiency values. Similarities with zone model assumptions can be identified like the homogenous temperature in the 1-ZM and the two distinct zones in the 2-ZM (Fig. 5-8).

## Results and Conclusion

The results of the base case situation are shown in Figure 9. It can be seen that the CFAST calculations for the 1-ZM and 2-ZM result in lower ventilation efficiencies compared to the FDS simulation. From this research it can be concluded that the ventilation efficiency of window openings is underestimated in zone models.

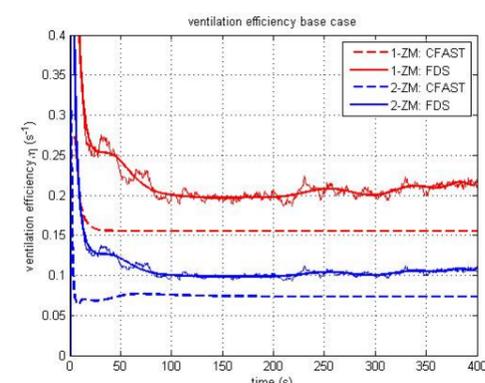


Fig. 9: Ventilation efficiency for 1-ZM and 2-ZM in the base case situation.