How to increase fire safety in buildings: Fire safety engineering

Fire means beside direct (financial) damage often far more indirect costs caused by interruption of operations and loss in sales, market share, property and, in the worst case people can get injured or even get killed (on average around 80 persons a year). Fire in buildings is clearly a disaster and for this reason, fire prevention and fire protection must be given top priority in building design. Prevention consists of a combination of different measures meant to protect primarily the occupants of a building and to prevent damage to adjacent buildings as well as the environment. It is important to be aware that the fire-safety chain of the different fire prevention and protection measures is only as strong as its weakest link.

Fire safety engineering is the application of engineering principles, rules and expert judgments based on a scientific analysis of fire phenomena, of the effects of fire and of the reaction of people, in order to:

- save lives, protect property and
- preserve the heritage;
- quantify the hazards of fire, its effects and risks;
- evaluate analytically the level of protective and preventive measures necessary to limit, within prescribed levels, the effects and risks of fire.

As a result fire safety engineering is multidisciplinary, having substantial relations with the domains of architecture, building physics, building services, structural and civil engineering, assistance to fire repression. Traditionally, the way to increase fire safety is by a prescriptive approach, were all measures are written down in building codes and regulations to reach the minimum level of fire safety.

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Fire safety engineering specialists can suggest alternatives to prescriptive approaches, especially when designing for unusual or difficult' buildings. Using a more flexible probabilistic approach to building codes, focusing on risk objectives, may be the only viable way to achieve a satisfactory standard of fire safety in complex buildings. With a probabilistic approach of fire safety it is possible to optimize safety measures, regarding the fire and building characteristics. This approach can be used in different risk subsystems with their own specific objectives:

1. Safety of people in the threatened compartment (risk objective: the allowable failure probability of the safe evacuation time);
2. Safety of evacuation (risk objective: the allowable failure probability of evacuation routes);
3. Safety of other compartments in the building (risk objective: the allowable failure probability of compartment boundaries, fire spread to a multi-compartment fire);
4. Safety of building structure (risk objective: the allowable failure probability of the building structure);
5. Safety of the adjacent buildings and environment (risk objective: the allowable failure probability of building boundaries).

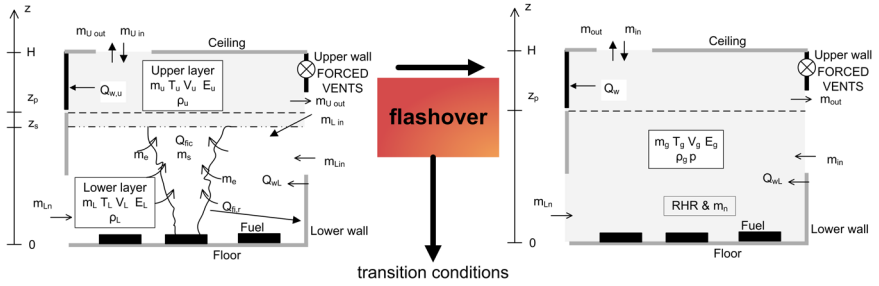
In order to establish the failure probability of the subsystem, the response under fire conditions has to be determined. In the first risk subsystem, the local fire in the threatened compartment is the main

event. In the other risk subsystems, the compartment fire is the main event. Both the probability of these main events are important as well as the consequences in the fire compartment. Modelling of fire development is crucial in a risk--based approach and essential in a consistent fire safety concept.

The natural fire concept (NEN 6055: 2011) describes the fire development in both the pre flashover as the post flashover phase in the compartment. The fire development depends on fuel (fire) characteristics and building characteristics. During the pre flashover phase the fuel characteristics are most important. These fuel characteristics are fire load, rate of heat release per unit area, time constant for fire spread, caloric value of the fuel, stoichiometric constant, soot production and extinction coefficient. Also during the post flashover phase the building characteristics are important such as dimensions of the fire compartment, openings in the compartment boundaries, material layers in the boundaries, ventilation devices, etc. With the natural fire concept the heat release rate can be calculated in the pre flashover and the post flashover phase. Also the time to flashover can be determined, taking into account fuel and building characteristics.

The rate of heat release determines the temperature development in the fire compartment. It is necessary to take into account the convective heat transport through openings in the compartment boundaries, the conductive heat transport in the compartment boundaries and the radiation heat transport between fire and boundaries. The building characteristics influence in that way the temperature development in the fire compartment.

Gas temperature, calculated according to the natural fire concept, is a project specific temperature-time curve, suitable to use as the thermal load in a probabilistic approach of fire safety. The



main events for a risk based approach (fire start and flashover) are clearly visible. The time lapse between these main events is important in a risk-based approach. Preventing flash-over may be possible with a large time lapse, while on the other hand this is almost impossible with a small time laps.

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Whilst many aspects of the analysis may be quantified, others will require expert judgment and will be subject to discussion with the building code and fire authorities. This may include, for example, the consequences of fire (which will be subject to construction standard and maintenance) or people movement (subject to a motivation or mobilization time which may be improved with training or stewarding). Whatever particular expertise the designer possesses, or whichever discipline the designer is from, it is important that he/she has an understanding of critical aspects of fire safety. At the TU/e several researchers from different units are involved in aspects of fire safety engineering. One of the most crucial aspects of a building's safety is safe escape in case of a fire. This aspect is one of the research topics of the group of Bauke de Vries. The structural strength of constructions in case of fire is studied by the group of Bert Snijder. In different courses there are lectures about specific aspects of fire. As such our faculty has the opportunity to give fire safety engineering the attention that it should have, given its importance to future occupants of buildings designed by our graduates. To further strengthen this topic there is an initiative to appoint a fellow Fire safety engineering to coordinate the domain of fire safety throughout our faculty.

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