Lessons learned from recent fires in tall buildings

Fire safety of high-rise buildings

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In the Netherlands, buildings taller than 70 meter are considered high-rise buildings. This building height is beyond the scope of the Dutch building code (Bouwbesluit). Therefore, additional measures are necessary to guarantee a similar safety level as in low-rise buildings. The fire in the Grenfell residential tower in London started two discussions:

- **Are the requirements of the building code safe enough for high-rise buildings within the scope of the building code, e.g. with a building height between 40 and 70 meters?**
- **Do we need additional requirements for the reaction to fire for the facade in case of high-rise buildings?**

Building height between 40 and 70 meter
Since the building code contains requirements for buildings until 70 meters building height, there are no additional measures required for controlling fire and smoke in buildings between 40 and 70 meters tall in comparison to low-rise buildings. It is clear that fire safety risks of buildings between 40 and 70 meters is significantly larger than the fire safety risks of low-rise buildings. Both the probability of a fire start and the consequences increase because of the higher amount of floors in tall buildings.

The Grenfell tower is an example of a tall building between 40 and 70 meters. This raises the question whether a fire calamity like Grenfell would be possible in the Netherlands. And yes, of course that is possible. The building legislation in the Netherlands is not better than in the UK, the fire service in the Netherlands is neither, and the same goes for the building occupants. However, there is one important difference between the Netherlands and the UK: in the Netherlands there are not many buildings like the Grenfell tower. The building tradition in the Netherlands differs from the building tradition in the UK. In the 1970s, most new apartment buildings in the Netherlands had external traffic zones and escape routes (galleries) instead of an internal traffic zone. In the Grenfell tower, only one internal staircase was available as escape route. There was no redundancy for safe evacuation, while redundancy very effectively reduces risks.

Figure 1: Grenfell tower fire, London

In modern high-rise buildings, taller than 70 meters, al risk subsystems are redundant:

- safety of the building: redundant load bearing structure;
- limiting fire spread: sprinkler system and fire compartments;
- limiting spread of smoke: pressurized escape routes and smoke compartments;
- safety of escape and attack routes: at least two independent escape routes (staircases).

Engineering fire safety means engineering risk subsystems using a probabilistic approach. The probabilistic approach is necessary to take into account uncertainties in stochastic boundary conditions. In both building characteristics and fire characteristics the uncertainties in boundary conditions can be very large. Think about the fire load, the rate of heat release, the time constant for fire spread, the reaction to fire of load bearing elements and dividing structures, etc. In all risk subsystems, it is possible to compare the available safe time (AST) of the risk subsystem with the required safe time (RST). The required safe time can be determined by the thermal load, caused by a natural fire. At Eindhoven University of Technology, this is the core of the Fire Safety Engineering research program. With this research program, the Eindhoven University of Technology is distinctive compared to the Universities in Ghent, Lund, and Edinburgh, where fire engineering focuses on fire physics, fire dynamics, and loadbearing structures.

The research program already made clear that failure probabilities of fire resistant dividing structures is relatively high, even when they fulfill the requirements of the building code. A burn down scenario of the complete building is possible when there is no efficient support from the fire service. The former department Building and Architecture of Delft University of Technology is a good example of that scenario.

Figure 2: TU Delft department of Building and Architecture on fire: building completely demolished by a travelling compartment fire

Additional fire safety requirements for the facade?

In the Grenfell tower fire, the fire seemed to spread rapidly on the facade. The facade consisted of aluminium composite material (ACM) cladding with thermoplastic cores. Combustible materials in external dividing structures are acceptable according to the building code, as long as the reaction to fire (euroclass) meets the requirements. However, in the Grenfell case the cladding materials did not meet the euroclass according to the building code and the fire barriers at the story floors failed. The facade fire was able to easily spread to other compartments.

Figure 3: Residential tower 'Haut' Amsterdam

With efficient fire barriers in the facade at the story floors, combustible material in the facade is not a major issue. However, the detailing is more complex than when only non-combustible materials in the facade would have been applied. Therefore, the failure probability increases in case of fire in comparison to a facade containing non-combustible materials only.

Robust detailing is necessary to realize a fire resilient building. When failure probabilities of all risk subsystems (particularly the fire compartmentation) are low, a compartment fire remains a compartment fire. A traveling compartment fire, resulting in a burn down scenario of the whole building is unlikely. In that case, the building can be qualified as a fire resilient building, a sustainable concept.

Future developments

In Amsterdam, a tall residential building of 23 stories with a wooden load bearing structure will be realized (project 'Haut', Amsterdam, *Figure 3*). The load bearing structure consists of Cross Laminated Timber. It is possible to create a wooden loadbearing structure that can endure a compartment fire. Of course, it is absolutely necessary to prevent that the compartment fire becomes a traveling compartment fire. The fire compartment dividing structures have to be extremely reliable. In this project, a sprinkler system has been added to increase the reliability of the fire compartmentation.

On the other hand, the loadbearing structure may be sufficiently fire resistant, but it is not automatically fire resilient. After the fire, the affected wooden loadbearing elements should be replaced by new elements. This is a very complex operation, the question is whether this solution is really fire resilient. ◄

Figures:

3 Volkskrant, November 2nd, 2017