Life safety assessment in multi-storey building fires

Life safety assessment in multi-storey building fires

Ada MALAGNINO[a], Angelo CORALLO[a], Giorgio ZAVARISE[b], Simo HOSTIKKA[c]

a) Università del Salento b) Politecnico di Torino c) Aalto University

RESEARCH OBJECTIVES

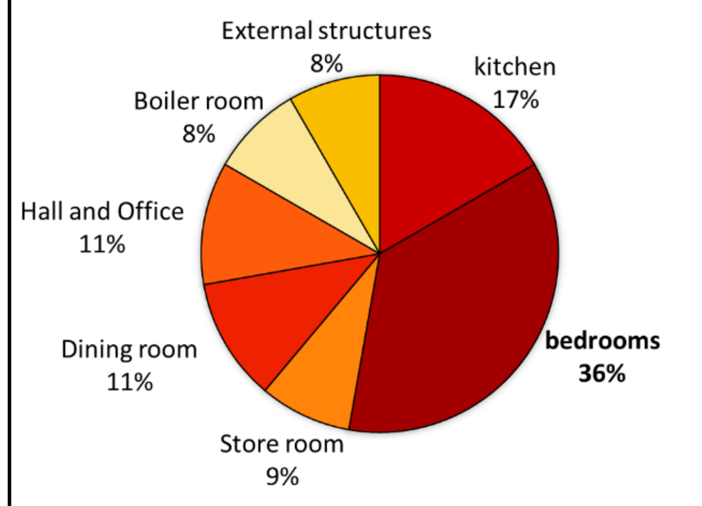
Life safety is one of the most important objectives of Performance Based Fire-Design and is commonly considered to be achieved if building occupants escape the effects of the fire unharmed. Numerical simulations are often used to predict fire dynamics and factors affecting the evacuation capabilities of occupants.

The main scope of this research is to assess life safety in a multi-storey building fire. Statistics based fire risk assessment is used to choose the scenario to be simulated taking into consideration the damage severity and likelihood of occurrence. In the fire simulations, particular attention is given to the fuel modelling to consider the toxicity of combustion products and thus, its effects on the building occupants. Fire simulations results are then integrated with evacuation simulations. The fire risk assessment and fire/evacuation simulations are performed for a multi-storey hotel building located in Lecce, Italy.

Grenfell Tower fire, 2017, 72 victims

Distribution of hotel fires that can cause casualties or fatalities

Source: UK statistics – Home Office

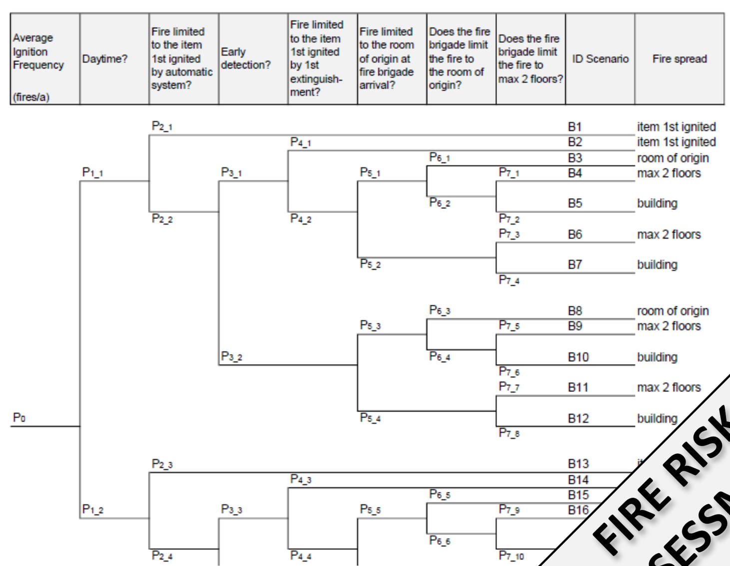


The **fire start location** for the simulations is set in the **hotel bedroom,** whose position in the building is considered to be the most onerous.

The most frequent scenario is related to fires wich are confined to the room of origin:

Estimated frequency = $5.7 \cdot 10^{-4}$ 1/a

Event tree designed to calculate frequencies associated to fire scenarios

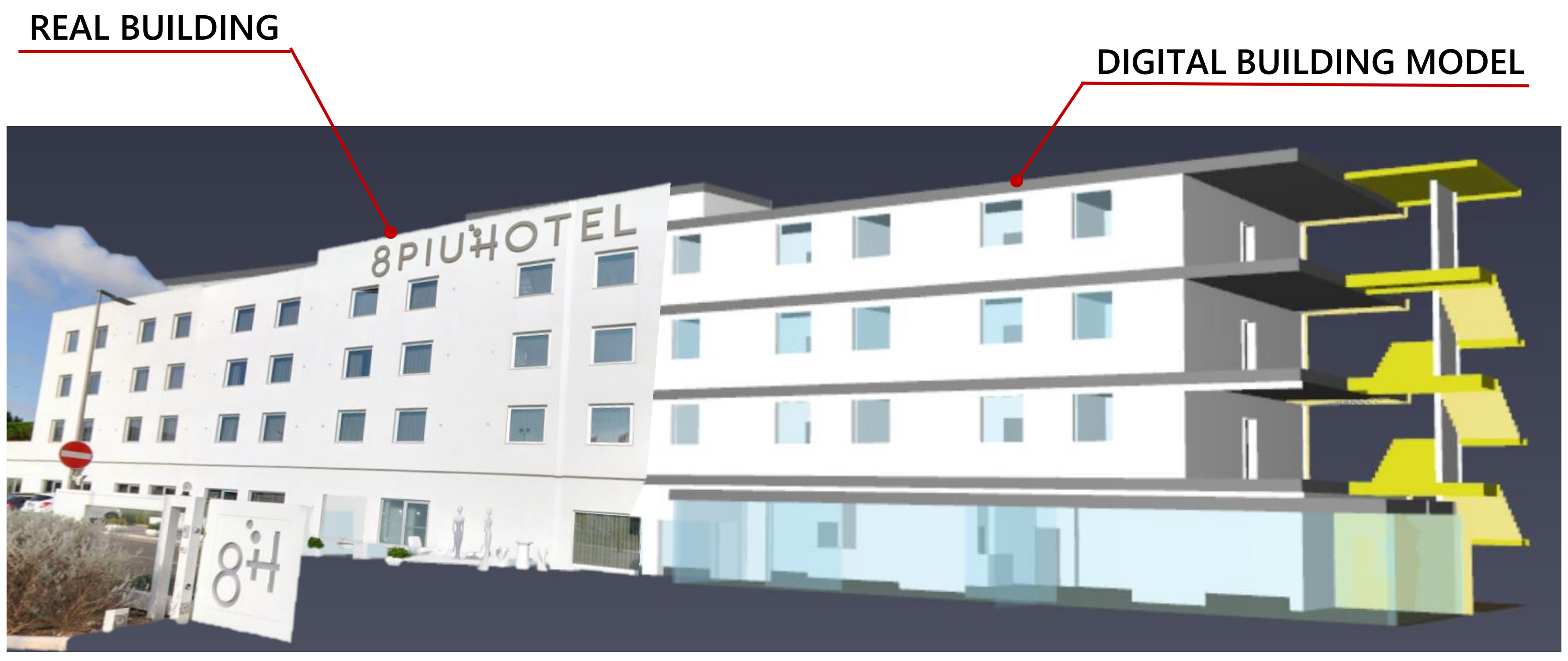


If the room door is left open, fire and smoke can easily spread. By combining the probability for this to happen, the frequency of the scenario to be simulated becomes: $5.7 \cdot 10^{-5}$1/a, extremely unlikely according to SFPE risk ranking.

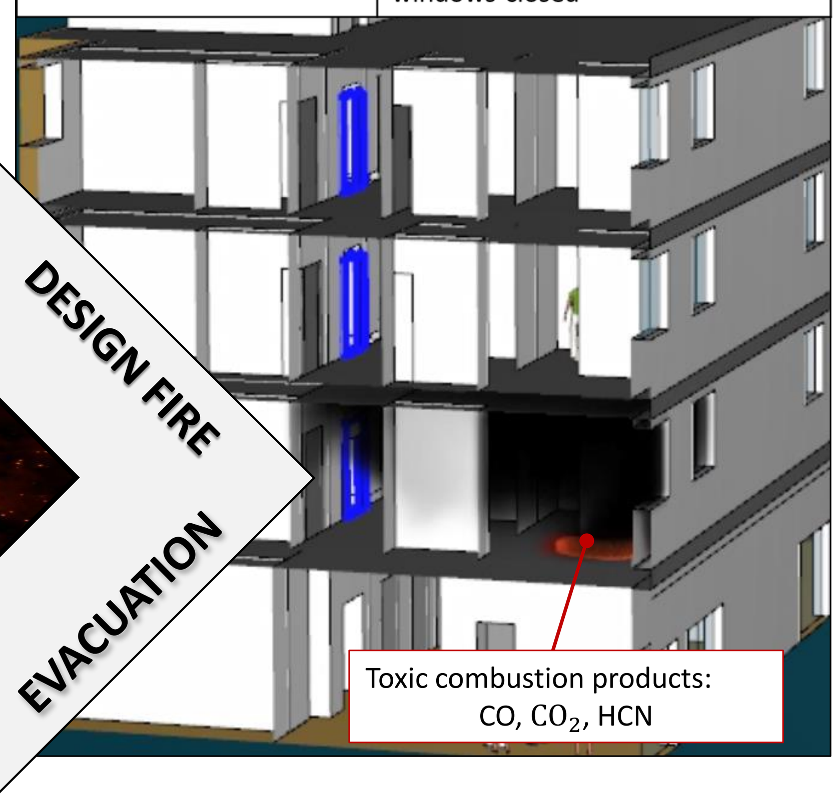
FIRE RISK ASSESSMENT · DESIGN FIRE · BUILDING MODEL · EVACUATION

The curved shape of the glass walls was linearized in order to optimize CFD simulations in relation to the mesh refinement.

The external and internal characteristics of the building were modelled according to the real hotel configuration.



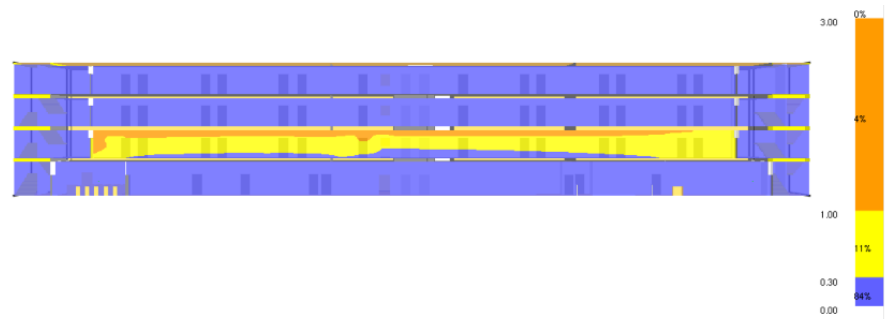
FIRE SIMULATION		
Software		FDS 6.7.1
Mesh resolution		20 cm
Total number of grid cells		1.998.708
Simulation time		1200 s
Computational time (parallel computation)		34 h
Design fire	model	t^2 fire
		Pool fire (A= 2 m^2)
	Fire growth	Medium, fast
	HRRPUA	500 kW/m^2
Ignited Material		Polyurethan foam
Door leakage area		0,016 m^2
HVAC system		Not modelled
Scenario	Fire confined to the room of origin, open doors along the egress path, windows closed	



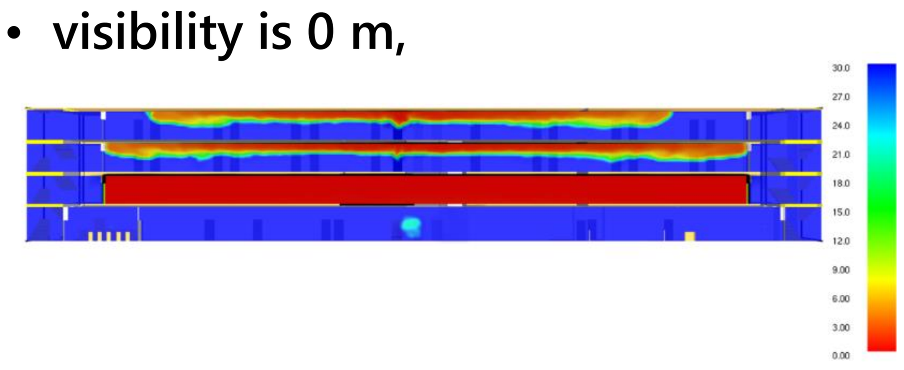
RESULTS

In a fast fire, already **at 420 seconds from ignition** (alarm time + pre-evacuation time set for unfamiliar and asleep occupants) the two lateral exits on the floor of fire origin are both characterized by **untenable conditions**:

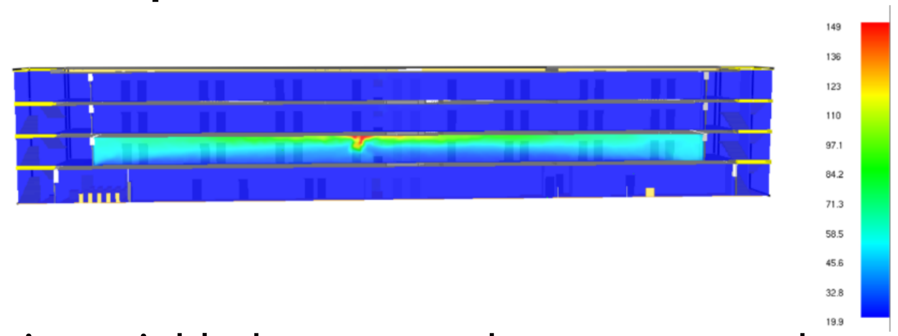
- **FED index between 0.3 and 1,**



- **visibility is 0 m,**



- **temperature of 60 °C.**



The conditions on the floor of fire origin quickly becomes dangerous and all **occupants on this floor** are considered **victims**.

Evacuation simulation results (software used: Pathfinder) demonstrate that **people on other floors manage to escape** before untenable conditions are reached.

EVACUATION SIMULATION	
Total number of people	**274**
People type distribution	Adults, 20% over 60, 1 person with disabilities per floor
People gender distribution	50% male, 50% female

PROFILES	hotel guests	restaurant guests	meeting rooms guests	staff
type	adults, elderly, people with disabilities	adults, elderly, people with disabilities	adults, elderly, people with disabilities	adults
gender	male, female	male, female	male, female	male, female
ages	15-60, over60	15-60, over60	15-60, over60	15-60
people with disabilities	1 per floor=3	1	1	0
familiarity	not familiar	not familiar	not familiar	familiar
training	not trained	not trained	not trained	trained
awake/asleep	asleep/awake	awake	awake	awake
social grouping	individuals, couples	individuals, couples	individuals	individuals

CONCLUSIONS

In this research, fire and evacuation simulations are used to evaluate life safety in case of fire in a hotel. The most frequent fire spread scenario according to statistics is simulated, while the most dangerous conditions are set in relation to fire start location, fire growth, combustion products and compartmentalization (room door open). Results show that untenable conditions are reached rapidly in the floor of origin if the room door is left open. The quantitative fire risk assessment can be seen as a tool to support the selection of fire scenarios and to associate an approximate likelihood of occurrence to them.

The availability of innovative tools and methodologies, and the increasing knowledge about fire phenomena are compelling factors for the application of Performance Based Design in common practice. Numerical simulations are a key aspect of the digital transformation process and their integration in the Building Life-cycle Management approach is gaining increasing attention both from the academic and industrial world.