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Security of health and life of the occupants in case of a fire hazard is one of the main goals of a fire safety engineer. Frequently, this is achieved by assuring the possibility of a safe evacuation from the building before the various effects of the fire cause harm on the occupants.[1]

In order to maintain the required safety level, as a part of a holistic fire safety approach, performance-based engineering methods have been deployed and supported by fire risk assessments. Yet, the numerical simulations carried out as a part of performance-based analysis are built on both, deterministic and probabilistic input parameters, subjected to major uncertainties. These uncertainties may become unrecognized or neglected during design, while trying to overcome them can lead to costly and unnecessary overestimated degree of safety predicted through this design approach [2].

Within a recent master thesis[3], a methodology was developed to assess the level of safety during emergency evacuation and to quantify the fire risk to life, by accounting for the variability and uncertainty in the design parameters of a fire safety analysis. Starting from the definition of risk and its relationship with reliability of fire safety barriers, a simple event tree analysis of a fire scenario occurring in a complex building (chosen as study case) is initially showcased, all with the intention of highlighting the shortcomings of the current risk analysis methods. It is shown that uncertainties sources are diverse, ranging from variables that are built into the analytical tools and methods, unpredictability in human behavior and reaction in case of fire emergency, uncertainties associated with criteria and values selected for assessing tenability conditions, to variations into the operational and performance reliability of fire protection measures.

Based on the findings, a new alternative approach is constructed. A single simulation model is developed to model the various uncertain parameters. Each parameter is assigned a suitable individual probability distributions that can reflect their innate variability. This sort of probabilistic data is used as input parameters, while the processes of interest for fire protection practitioners are treated as deterministic.

By means of Discrete Event Simulation method [3], the physical phenomena (ignition, heat radiation, combustion products development) and the real technological processes (detection, warning, suppression, evacuation) are simulated in their natural order, enabling the dynamic interactions that are assumed to exist in between them in a real situation. In order to capture the whole range of possible outputs expected from a fire event, Monte Carlo procedure [3] is applied, involving 5000 repeated random sampling of the inputs, followed by the corresponding simulation iterations. This analysis is performed on the same complex building, considered as study case, and the results are briefly shown in *figure 1,* as an overall distribution of the evacuation safety levels achieved for the 5000 generated fire scenarios.

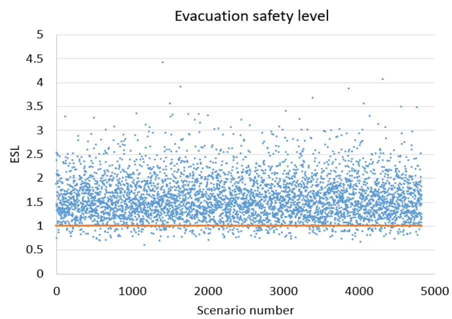

Figure 1. Distribution of the evacuation safety level values obtained for 5000 generated fire scenarios, with respect to ESL=1 line.

As each scenario is built on different probability of failure of safety barriers, the associated fire risk can be subsequently assessed. Also, the deterministic parameters governing the fire development and the evacuation process are readily accessible for any scenario of interest.

Additionally, different fire safety barriers (i.e. sprinkler system) are subsequently included into the model, allowing for a comparison of their quantitative effect on the final evacuation safety level.

Thus, the proposed methodology provides an alternative way for handling risk-informed and performance-based life safety design throughout a transparent, verifiable and ready to be used in practice framework.

References

[1] C. Albrecht, "A risk-informed and performance-based life safety concept in case of fire" - Institut für Baustoffe, Massivbau und Brandschutz (IBMB), 2012
[2] Hede M. B, "Comparative evaluation of prescriptive, performance-based and risk-based fire safety in an office building", Technical University of Denmark, 2011
[3] A. Radulescu, F. Markert, "Application of dynamic risk assessment as an alternative method for estimation of the evacuation safety level of a complex building", Technical University of Denmark, 2019
[4] William G.B. Phillips, Rita F. Fahy, Revised by Douglas K., "Computer Simulation for Fire Risk Analysis", SFPE Handbook of Fire Protection Engineering, Fifth edition, pp.3117-3136, 2016