

The Minefields of Performance-Based Fire Safety Design

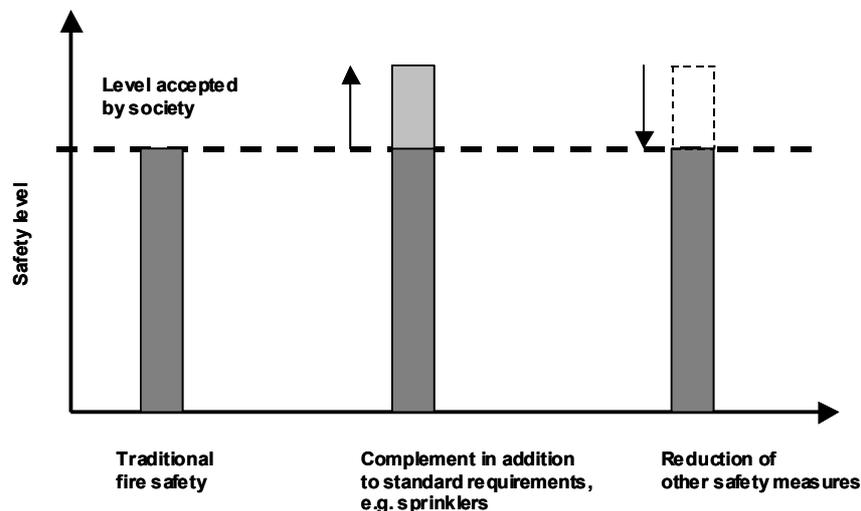
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INTRODUCTION

Swedish building regulations are performance-based since 1994. The regulations contain both mandatory provisions and general recommendations. The performance requirements are covered in the mandatory provisions and the general recommendations give the engineer proposals on how the requirements could be met. In order to comply with the building codes the engineer could chose either a prescriptive design method or an analytical method. When the prescriptive method is used, deemed to satisfy solutions must be applied without any trade-offs. Analytical methods do, however, consider the overall fire safety and make it possible to do certain trade-offs. Design freedoms are allowed and the fire protection could be optimised.

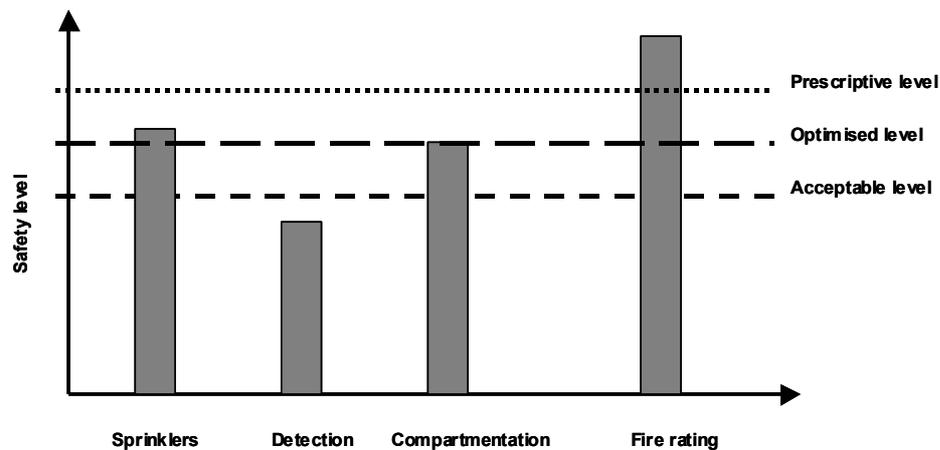
In the performance-based environment optimisation is a key element. The fire safety design could be optimised from various aspects such as occupant safety, property protection and cost-effectiveness. The aim with the optimisation is to find the most suitable level of safety for the specific building. When the optimised level is identified certain trade-offs are performed. The figure below shows the principle behind such trade-offs.



Installing a sprinkler system could make it possible to perform trade-offs on other safety measures as fire compartmentation and fire ratings on load-bearing structures, if verification can show that the performance requirements in the regulations are fulfilled.

IDENTIFYING THE MINEFIELDS

In a traditional prescriptive design there are a number of conservative estimates and safety factors incorporated in the deemed to satisfy solutions for the different design aspects (escape, compartmentation, rescue, etc.) In the optimised performance-based design these safety factors are not taken into account that explicitly. The fire safety design of a building involves various measures that could be divided into passive, active and organisational ones. Such measures are fire alarm, sprinkler, smoke management, compartmentation, ratings on fire-separating structures, number of escape routes etc. In comparison with the prescriptive solution all or some of these measures are modified to become either more or less extensive. The figure on the principle of optimisation given above could be modified (as shown below) to illustrate the concept of performance-based design.



The concept of optimisation therefore results in limited robustness to future changes of the building and its use and the following minefields are identified:

- Performance based design might not always be practical for the owner of a building even though the builder is satisfied as the degree of freedom is limited.
- The engineers are responsible of producing a design solution that is economical and practical for the builder as well as maintainable for the owner.
- If the design solutions is too close to the minimum acceptable fire safety level, this could cause problems for late changes in design and/or construction of a building
- Performance based design with risk analysis, as base for the verification needs well-trained participants.

The final paper will examine a number of cases where an optimised level of safety, resulting from a performance-based design has caused conflicts with other interest. These cases involve type of fire and escape alarm, type of smoke ventilation (forced or natural), number of escape routes, the role of maintenance, activation of escape alarm and changes in occupancy.

NAVIGATING THE MINEFIELDS

It has been learned that it is important to work very close to the design team during the whole design of a building. There is otherwise a huge risk that rather small changes, which the design team are in a prescriptive designed are used to do, become fatal for the fire safety in the building. The proposed fire safety concept has to be possible to tighten in as the design becomes more detailed. The engineer must at an initial stage of the project very clearly explain the limitations of the performance-based design and communicate this with both the builder and the owner. It is always possible to detected and manage changes to the building design at a late stage, but with a performance-based design based on risk analysis such changes might end up at completely redoing the whole analysis.

The final paper will, on the basis of the presented cases, go into detail on how to navigate and explore the minefields of the performance-based design.