Title: **Verifying trade-offs when using sprinklers in fire safety design**

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Existing Nordic building regulations are performance-based and specifically state fire safety goals and reference acceptable methods that can be used to demonstrate compliance with the requirements. A performance-based code is a necessity to allow trade-offs between different fire safety features, enabling performance-based fire protection. All Nordic countries also have a set of deemed-to-satisfy solutions that fit most buildings and simplify the design process.

However, when a trial design is subject to deviation from the deemed to satisfy solutions, it is necessary to adopt an analytical approach called performance-based design. The Nordic countries has recently initiated a joint effort to develop a method that could be used when verifying possible trade-offs if a building is equipped with fire sprinklers. This paper will present the verification method, as well as interesting findings on the effort to express and measure fire safety in terms of risk.

Previous work related to sprinklers and trade-offs has limited applicability as combinations of trade-offs are not allowed. The main effort of this ongoing project is to produce a verification method that allows for combinations of trade-offs with a safety level that is equivalent or better than the one achieved with deemed-to-satisfy solutions. On an overall level, the building regulations do not differ between the Nordic countries. Existing differences are mainly related to the prescribed solutions in the compliance documents of each country and these differences are not important when developing a common Nordic verification method. It is therefore possible to proceed with a methodology that focuses on how to measure risk related to each technical requirement and how to evaluate of a specific trade-off gives an acceptable level of safety.

Existing fire risk models developed in Canada (FiRECAM) and Australia (FIRE-RISK) have been briefly analysed with the purpose of examine their usefulness to this project. These models have the similar structure and assess the fire safety performance of a specific design in terms of the expected risk to life and the fire-cost expectation. However, many identified design needs are very detailed and their "performance" is not possible to evaluate with these existing fire risk models. These design needs requires a different, more specific, approach when evaluated. The main priority of this research project will be to develop such a suitable verification method by carrying out the follow activities.

1. List existing fire safety measures in each barrier group, i.e. the deemed-to-satisfy solutions required to prevent fire initiation, control fire growth and smoke spread, expedite occupant evacuation as well as expedite fire department response. Fault trees and event trees could be used to illustrate the role of each fire safety measure and how they are related to the overall objective.

2. Determine which risk measures that should be used when evaluating equivalent safety for each technical requirement (barrier group).

3. Analyse how the proposed deemed-to-satisfy solutions are used to control the fire risk within the barrier group by expressing their relative importance. Some measures are more important than others and quantify their contribution to the accepted safety level is crucial in order to evaluate trade-offs.

4. Quantitatively analyse how fire sprinklers effects each barrier group in order to estimate the positive contribution to the safety level of the system.

5. Analyse how trade-offs can be combined within the same barrier group. This work is the basis of the verification method and will quantitatively express the safety level for each technical requirement. The method could be preferable be transformed to a semi-quantitative methodology.

6. Analyse if it is possible to perform trade-offs related to different barrier groups. The analysis will focus on how a "saved" safety margin could be used for trade-offs related to another technical requirement.

7. The proposed method need to be validated by comparing the results of the method with result from other risk analysis methods. It is necessary to check that the proposed method delivers results that are consistent with all requirements on fire safety in the building regulations of the Nordic countries.

The paper will present the results and recommendation from the above activities.