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Abstract
With biobased buildings making the transition into mainstream construction, the safety of their occupants needs to be adequately ensured, since the introduction of combustible building materials is bearing fundamental ramifications for fire safety strategies of such buildings. The present work introduces a research project on safe evacuation of timber buildings. More specifically, it targets to investigate the effects from evacuation training of building occupants on the required safe egress time (RSET).

Introduction
To reduce the carbon emissions of the construction industry, an increasing emphasis is placed on the use of sustainable, biobased building materials, like timber, in Denmark and globally, due to their potential to emit up to 75% less CO2 compared to commonly used building materials (e.g., steel), while also sequestering carbon in even larger amounts [1].

While this will potentially have a great impact building sustainability [2], many unknowns remain for their implications on fire safety. Biobased building materials affect the fire dynamics in compartments through additional energy release [3] resulting in accelerated fire growth, spread, and increased intensity [4, 5], with further implications on the decay phase [6]. Therefore, building designers are faced with novel challenges that must be solved when evaluating the interactions between the fire, the building, and its occupants in detail to ensure safety when employing green materials.

Egress Safety Strategies
A successful evacuation relies on the availability of sufficient time to reach a safe place, meaning it is necessary to ensure tenable conditions until the evacuation is completed. In this context, two parallel approaches exist to improve safety in hazardous fire scenarios, namely 1) to make sure that the conditions are tenable for a longer time or 2) to decrease the time to reach a safe place. Since for the combustible nature of biobased materials, their use may impede solutions aimed at improving the tenability of the environment, subsequently affecting the time available for evacuation, it is important to counterbalance their use with solutions aimed at ensuring adequate evacuation. A more holistic approach to evacuation safety for buildings including combustible materials is currently missing, as most of the research emphasis in the field has been put on ensuring tenable conditions for longer times rather than systematically identifying solutions aimed at reducing evacuation times in parallel.

Evacuation Training
The evacuation process can be characterized in many ways and terminology way vary across sources, but it is often described using two distinct periods: a pre-movement phase, and a movement phase. Possible solutions to reduce evacuation times are, for example, increasing movement speeds and wayfinding for evacuation.

However, the entire evacuation process consists of a chain of complex decision-making processes, which are described using psychological behavioural models, for instance, the behavioural sequence model by Canter et al. [7] (included in Figure 1) and the Protective Action Decision Model (PADM) by Lindell and Perry [8]. The role of decision-making in evacuation becomes evident considering the pre-movement time and its dependence on the time to reach a decision to evacuate. Hence, this decision governs the evacuation process in the first place, but also during the movement phase evacuee behaviour could be improved. For example, the effect from affiliation behaviour could be reduced, where people tend to stick to known exit routines rather than the most suitable or shortest egress solution in emergencies [9].

Thus, a key aspect to lower egress times is the identification of solutions aimed at improving human risk perception and decision-making for evacuation. In this context, evacuation safety training can play a fundamental role by affecting the components underlying of the evacuation process to ultimately reduce time scales to reach an evacuation decision and the overall RSET (Figure 1).

However, only limited research has been conducted on quantifying the effect of training on evacuation and the benefits that it can have on individual and group decision making [10]. In fact, many national regulatory frameworks focus on egress drills to prescribe the assessment of evacuation performance or evacuation training [11]. However, the regulations are highly inconsistent with one another in terms of objectives, training requirements, and documentation [11], while seemingly also lacking a clear scientific basis that informed their implementation.

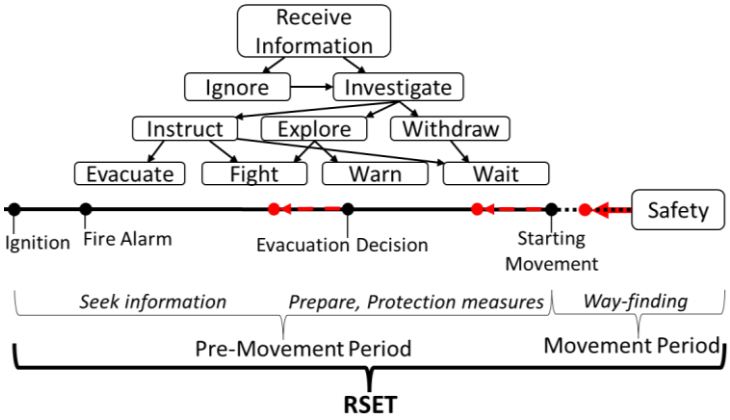

Figure 1. The evacuation process (black) and potential impacts from evacuation training (red) on decision-making processes and behavioural actions during emergencies and fire evacuation. Partly based on illustrations in [7] and [17].

A current approach for fire evacuation training is the application of 'serious games' [12,13]. Training methodologies include the use of simulation tools in the context of serious gaming for evacuation, such as Virtual Reality [14] and Augmented Reality [15], whose potential have been well documented in the literature [16]. Practical issues linked to their implementation, on the other hand, are scarcely investigated.

Research Project

With the goal to generate a scientific basis for the employment of evacuation training, a research project is carried out by DBI in cooperation with Lund University. The aim of this work is to review and analyze existing training methodologies and to study their effect on building evacuation.

Aspects this research will investigate, employing both qualitative and quantitative methods, include the scientific state of the art of behavioural training and training methodologies, the perception of risk and fire safety in timber buildings among occupants, as well as the quantification of the effects from evacuation training and their translation into knowledge applicable to building design.

Outlook

The use of innovative training methods would require a careful assessment of their potential users since the level of familiarity with new technology may vary greatly among building users. Therefore, a systematic study of the validity and quantification of the impact of innovative evacuation training methods for different contexts, like building types (e.g., office or residential), populations (e.g., adults, elderly, residents, visitors), and environments (e.g., working space, dwellings), is a key milestone towards their successful implementation in buildings. This will contribute towards rapid evacuations [18] and subsequently ensure an adequate safety level in biobased buildings.

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