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Modelling total evacuation strategies for high-rise buildings

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Abstract

This paper focuses on the use of egress models to assess the optimal strategy in the case of total evacuation in high-rise buildings. The model case study consists of two identical twin towers linked with two sky-bridges at different heights. Each tower is a 50-floor office building. The use of either horizontal or vertical egress components or a combination of them is simulated. The egress components under consideration are stairs (either 2 or 3 stairs), occupant evacuation elevators, service elevators (available or not for the evacuation of the occupants), transfer floors and sky-bridges. Seven different evacuation strategies have been tested which consider the total evacuation of a single tower. The evacuation scenarios have been simulated with a continuous spatial representation evacuation model (Pathfinder). In order to perform a cross validation of the model results, two strategies involving the evacuation using stairs or occupant evacuation elevators have also been simulated using a fine network model (STEPS). Results refer to the analysis of total evacuation times. The simulation work highlights the assumptions required to represent the possible behaviours of the occupants in order to qualitatively rank the strategies. The lowest evacuation times are obtained simulating strategies involving the sole use of occupant evacuation elevators and the combined use of transfer floors and sky-bridges. This study suggests that the effectiveness of evacuation strategies involving the combination of stairs and elevators significantly decreases in high-rise buildings if they are not combined with appropriate messaging/signage to guide occupants in their behaviours.

Keywords

Evacuation modelling,
high-rise building,
emergency evacuation,
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sky-bridge,
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1 Introduction

Building codes such as the International Building Code 2012 (International Code Council 2012) establish the minimum requirements for the safe design of a high-rise building. Nevertheless, additional life safety measures are often necessary to mitigate the risks that arise from the complexity of these types of buildings and the possible difficulties in fire-fighting and rescue operations.

Recent events such as the World Trade Centre evacuation have raised a greater sense of awareness on this topic (Averill et al. 2005). This event has resulted in a paradigm shift in the assessment of high-rise building safety. It demonstrated the importance of providing robust means of egress and the need for further investigating the interactions between the infrastructure, the evacuation procedures and the behaviour of the occupants (Galea et al. 2008).

Several questions have been prompted about the adequacy of the current emergency procedures for high-rise buildings. What type of evacuation scenarios should be considered when designing high-rise buildings? What egress components (e.g., stairs, elevators, refuge floors, sky-bridges, etc.) are suitable to evacuate high-rise buildings? What emergency procedures should be employed to improve evacuation efficiency? All these questions do not have simple answers and they often depend on the specifics of the building under consideration (Sekizawa et al. 2009). The role of safety designers is made even more difficult by the fact that there is still a lack of knowledge about occupants' behavioural processes that may take place during the evacuation of a high-rise building (Kuligowski 2011).

If a model user is aware of the intrinsic limitations of these models and the subsequent variability of the results, egress models are efficient tools to analyse and compare

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