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Fire safety assessment of semi-open car parks based on validated CFD simulations

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Abstract

Guidelines for the safe design of semi-open car parks require a minimum amount of open facade in order to ensure an effective removal of heat and smoke during a car fire. In this study the fire safety level of semi-open car parks is assessed by the use of validated computational fluid dynamics (CFD) simulations for seven different variants. The validation of these simulations consisted of two analyses namely a comparison with measured data of a case study and secondly a comparison with the Alpert's correlations. The dimensions of the seven variants in the assessment are based on a survey of 75 semi-open car parks in the Netherlands, out of which a typical geometry could be determined. The reached fire safety of the car park variants which comply with the guideline NEN2443 are assessed using temperature and sight length criteria for safe deployment of the fire department. Results show that three out of seven studied variants did not meet these criteria, for one variant the safety level was questionable. It is therefore concluded that it is possible to design semi-open car parks which comply with the commonly used Dutch guideline, yet when assessed with criteria for safe deployment of the fire brigade have an insufficient fire safety level.

Keywords

fire safety,
car park,
computational fluid dynamics (CFD),
validation study,
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design guideline

Article History

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1 Introduction

U.S. vehicle research on fire trends and patterns in 2002 (Ahrens 2004) showed that there were about 329 500 vehicle fires that year, causing 17% of the total civilian fire deaths, 10% of the total civilian fire injuries and roughly 1.4 B$ in direct property damage. It appeared that more people died as a result of vehicle fires than was the case for apartment fires. At the same time it is clear from statistics in the Netherlands (CBS 2012) that the number of cars has grown from 7.1 million in January 2006 to 7.9 million in January 2012 which is an increase of 11% in the last six years. This increases the demand for additional car park area. This growing demand for car park area combined with unavailable usable land in major cities leads to the construction of car parks (Zhang et al. 2007) which are mainly constructed at the basements of commercial and residential buildings (Chow 1998). However, as illustrated above, car fires and thereby car park fires involve a significant risk.

Several studies on car fires and car park fires have been performed. The heat release of car fires is studied in several researches, e.g. Cheng and John (2002), Joyeux et al. (2001), Mangs and Keski-Rahkonen (1994a,b) and by Shipp and Spearpoint (1995) who concluded that a burning car can reach its maximum heat release in as short as 10 min after ignition, with a peak heat release of at least 7.5 MW (Shipp and Spearpoint 1995). In a study presented by Chow (1998) it is found that during a 5 MW car fire in a 3125m^3 car park, the average temperature will be higher than 191℃ in one third of the car park. This indicates that a smoke control system should be provided to ensure an adequate fire safety level (Chow 1998). The fire spread and smoke movement in an underground car park is studied by Zhang et al. (2007) using computational fluid dynamics (CFD) for a car park fire consisting of three burning cars. It is stated in the paper that detailed studies on fire spread and smoke movement are required in order to ensure a sufficient fire safety level in large underground car parks (Zhang et al. 2007). By

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