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Evacuation strategy design for a medium size auditorium using CFD

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Abstract

Romanian fire safety regulations concerning the rooms with high density of people, as conference halls, auditoria, theatres, are based on prescriptions. The Eurocode SR EN 1991-1-2 allows the application of alternative design employing CFD methods, without specifying any further guidance to their practical praxis. This study case is intended to give a better insight of the use of CFD for a code compliant fire safety design. The results from the hand calculation of the available safe egress time are compared with the numerical simulations results in order to prove that the proposed ventilation strategy is in line with the fire safety code requirements.

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Keywords: auditorium; evacuation analysis; ventilation strategy; numerical simulations.

1. Introduction

Auditoria spaces are assembly places, with a high density of persons which are not familiar with the building. The occupants can have a wide variety of different age, culture, affiliation, therefore the life and safety provisions will need to cover the whole range of variables in order to design a building having a satisfactory safety level. The most of the building design codes have general requirements as: "Buildings shall be designed so that satisfactory escape can be provided in the event of fire", stated by the Swedish legislation [1].

Assembly occupancy has special provisions within each country, due to the higher design occupant densities. A survey, carried out by Forell and co. [2], compared the standard codes for evacuation of eight European countries

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and China and USA and revealed that there is a disperse range of the results differing by a factor of three, related to hand calculations and correlations of traveling times, travel distances and occupant density.

Romanian fire safety regulations [3] concerning the rooms with high density of people, as conference halls, auditoria, theatres, are based on prescriptions. According to the occupancy type, it is specified a maximum travel distance and a maximum time for evacuation on one or two separate ways. Based on the required figures, it results a constant walking speed of 0.4 m/s and there is no mention of other factors as occupant's age, sex, familiarity with the building, etc.

In order to demonstrate that a building is safe, according to Romanian regulations [3], one should only compare the walking distances on the building plans to the required distances and to mention the egress times. However, it is often the case that the new buildings and special structures do not fit within the code requirements. The revision of fire safety regulations is much slower than the industrial and technological progress, slowing the adoption of some new sustainable materials or design solutions.

The Eurocode SR EN 1991-1-2 allows the application of alternative design employing CFD methods, without specifying any further guidance to their practical application.

This research paper is intended to give a better insight into the use of CFD for a code compliant fire safety design and a way of overcoming the prescriptive regulations drawbacks by applying a performance based design solution to a medium size auditorium, having three levels of sitting places.

Nomenclature

AJV	Authority Having Jurisdiction
ASET	Available Safe Egress Time
CFD	Computational Fluid Dynamics
Code	A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.
FDS	Fluid Dynamics Simulator
ppm	parts per million
RSET	Required Safe Egress Time
Shall	Indicates a mandatory requirement.
Should	indicate a recommendation or that certain provision is advised but not required.

1.1. Tenability criteria

The Rumanian Fire Safety Code [3] does not have any mention about the tenability criteria; therefore, within this paper, it has been taken into account the international guidance and standards.

According to the NFPA 5000 [4], when an engineering analysis is performed, it shall demonstrate "that the building is designed to keep the smoke layer interface above the highest unprotected opening to adjoining spaces, or 1830 mm above the highest floor level of exit access open to the atrium, for a period equal to 1½ times the calculated egress time or 20 minutes, whichever is greater."

NFPA 101 [5] and SFPE Handbook of Fire Protection Engineering [6] specify three sets of criteria to be met along the escape routes, in order to prove compliance with the accepted tenability limits.

1.1.1. Criteria 1 – Smoke layer 2m above the floor

The limiting heat radiation received by a person from a hot smoke layer or other fire condition is 2.5 kW/m^2. This radiant heat level generally occurs when temperatures are approximately 200ºC in small enclosures with relatively low ceiling heights. Therefore, the acceptance criterion is when the smoke layer height is greater than 2 m above the floor and the smoke temperature is less than 200ºC.