FDS2FEM – a tool for coupling fire and structural analyses

Antti Paajanen
Research Scientist
VTT Technical Research Centre of Finland
Espoo, FINLAND
Antti.Paajanen@vtt.fi

Timo Korhonen
Senior Scientist
VTT Technical Research Centre of Finland
Espoo, FINLAND
Timo.Korhonen@vtt.fi

Merja Sippola
Senior Scientist
VTT Technical Research Centre of Finland
Espoo, FINLAND
Merja.Sippola@vtt.fi

Simo Hostikka
Principal Scientist
VTT Technical Research Centre of Finland
Espoo, FINLAND
Simo.Hostikka@vtt.fi

Michał Malendowski
Research Scientist
Poznań University of Technology
Poznań, POLAND
michal.malendowski@put.poznan.pl

Renaud Gutkin
Research Engineer
Swerea SICOMP
Gothenburg, SWEDEN
Renaud.Gutkin@swerea.se

Summary

Computational modelling of fire-structural response requires interoperability of various models describing different physical phenomena. Typically, the most advanced sub-models are found within independent simulation software incapable of interoperability. To address this issue, we have developed a tool for coupling two of such programs: Fire Dynamics Simulator and ABAQUS. We present the main features and theory behind the coupling approach and use an example case to demonstrate how a coupled fire-structural analysis is set up. We also discuss potential applications and present limitations of our approach.

Keywords: fire-structural analysis; Fire Dynamics Simulator; Abaqus; fds2fem

1. Introduction

Fire-induced damage along with thermal and mechanical strains can have a significant influence on the integrity, insulation and load bearing capacity of a structural element and the overall performance of a larger structure. Theoretical estimates for the fire-performance of structures have traditionally relied on analytical expressions for the temperature of the fire environment. This means a uniform and well-behaved heat exposure — something that might be far from reality. This is especially true in the case of fires in large open spaces. The traditional approach might be overly conservative in some cases, and even unconservative in others.

Present-day computational fire models enable the prediction of realistic, temporally and spatially varying, heat exposures. These can be used as a basis for advanced fire-structural analyses that take into account the dynamic and non-uniform nature of fire-induced thermal stresses. However, the presently available fire simulation tools do not include sub-models for the prediction of structural response. This kind of functionality is available in other software tools developed for continuum-level mechanics modelling. These tools are in turn incapable of predicting the fire environment.

Computational modelling of the fire-structural response can be divided into four steps: modelling of (i) the fire environment, (ii) thermal response of materials, (iii) fire-induced damage and weakening of materials, and (iv) the mechanical response of the structure. Advanced fire-structural modelling requires either integration of these models into a single piece of software or coupling of software developed for the specific tasks. To the best of our knowledge, the former approach has not been realised to date. The latter approach has been utilized in various studies (e.g. [1-4]), including ones related to the investigation of the World Trade Center disaster [1,4]. In this approach, two major problems have to be solved. Firstly, the simulation tools from different developers are seldom able to communicate with each other. An interface that enables data exchange has to be set up. Secondly, there will be differences in the spatial and temporal discretizations. Due to this, also the model geometries are prone to differ. The data that is transferred from one program to another has also to

https://doi.org/10.2749/222137813807054629
Distributed by structurae