

Combined fire and thermo-mechanical analyses of steel-concrete composite structures under fire

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ABSTRACT

In this study, a new modeling framework for predicting temperature and structural behaviors of structures under fire condition is proposed. The proposed modeling framework including fire simulation, heat transfer and structural analysis is applied to simulate fire tests performed on the steel-concrete composite structures in Cardington, UK, for model validations. Good predictions are shown for spatial-temporal temperatures and deflections of fire-damaged steel-concrete structures.

1. Introduction

Coupled fire and thermo-mechanical analyses of the structures under fire condition is critical for predicting temperature and structural response of fire damaged structures, yet has not been fully developed.

2. Analytical modeling framework

The proposed modeling framework consists of three simulation parts. First analysis is done to simulate fire situation using a Computational Fluid Dynamics(CFD) tool, Fire Dynamic Simulator(FDS)^{1,2,3}. From the fire dynamic analysis, temperature and heat flux of the interior structural surfaces profiles due to fire are obtained, then are used in subsequent simulation parts. Next, heat transfer and structural analyses are performed sequentially to get temperature propagation within the structural members and mechanical behaviors of the structures due to thermal and structural loading, respectively. The latter two simulations are done using commercial Finite Element Analysis(FEA) tool, ABAQUS, with written user subroutine codes in order to take account for temperature dependent thermal and mechanical material characteristics^{1,2,3}. The third Cardington fire test performed on the first floor of the building is used to validate the proposed modeling framework. The simulated compartment area includes steel frame with light weight concrete slabs and is located at the South East corner of the building as shown in Figure 1. From the tests, temperatures and deflections at selective locations are measured.

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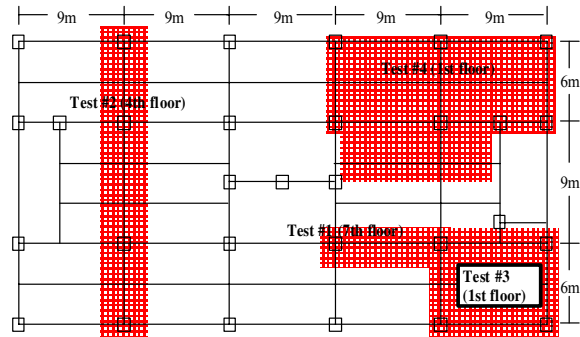


Figure 1. Layout of the British steel Cardington frame fire tests

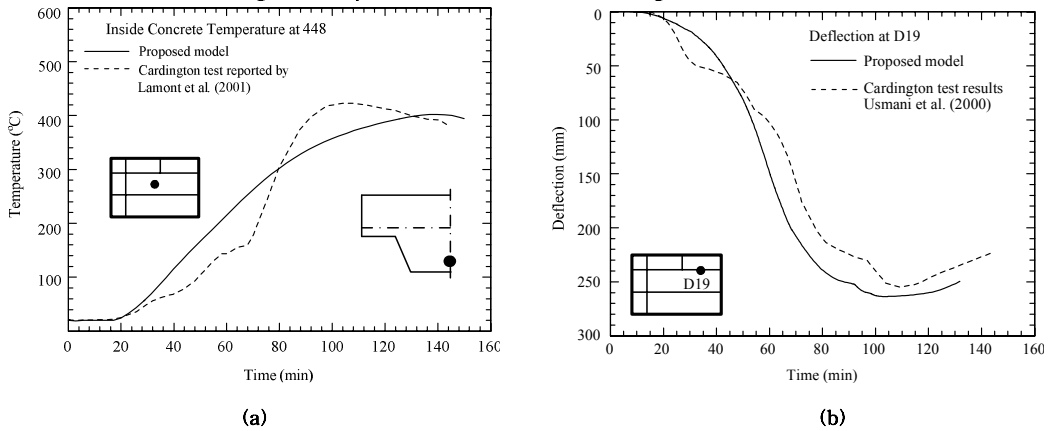


Figure 2. Predicted (a) temperature history ; (b) deflection results at a certain point in the concrete slab from heat transfer and structural analysis of the proposed model compared with experimental data.

CONCLUSIONS

A new modeling framework consisting three subsequent analyses of fire dynamic, heat transfer and structural analyses is proposed and good predictions of 3-dimensional thermo-mechanical behaviors of steel-concrete structures under fire situation are shown from the model validation.

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