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The use of fractional factorial design for atrium fires prediction

P. Ayala Santamaría; A. Cantizano González; E.F. Sánchez Úbeda; C. Gutiérrez Montes

Abstract-

In order to mitigate the excessive computational cost of atrium fire simulations, a novel methodology based on the use of the Fractional Factorial Design technique to obtain an experimental validated tool, in the form of a surface response model, capable to predict fire induced conditions is proposed. This methodology is supported by results from a Design of Experiments benchmark, which consists of a set of FDS simulations in the present work. Specifically, a 2 6?2 IV 2IV6?2 approach has been considered and applied to a 20 m cubic atrium. Thus, six factors have been considered, namely the fire Heat Release Rate (HRR) and location, the exhaust flow rate, the exhaust location and activation time, and the inlet vents area. Furthermore, the smoke temperature at the roof and 15 m high and the smoke layer height have been considered the variables of interest. Subsequently, a multiple linear regression analysis has been performed to predict and compare the steady and non-steady temperature profiles and the smoke layer drop with six novel full-scale atrium fire tests, and also with specific adjusted FDS models. In addition, this methodology has been extended successfully to predict the non-steady behaviour of the fire tests. At the steady state, the HRR and the exhaust flow rate have been found to be the most relevant factors. The results obtained with the proposed methodology show a good fit both with the fire tests and with the adjusted FDS models, with discrepancies mostly below 14%. For non-steady conditions, a time analysis of the influence of the six factors has been carried out. Again, remarkable good agreement with the time-dependent experimental results is achieved, with average discrepancies below 12%, being the larger differences found in the prediction of local effects, such as the smoke ceiling jet, for high HRR or when the make-up air influence is significant. The results turn this methodology into a powerful and useful tool for fire safety designs.

Index Terms- Atrium fire; Smoke temperature prediction; Smoke layer prediction; CFD simulation; FDSv6; Fractional factorial design

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