STRUCTURES IN FIRE FORUM

STRUCTURES IN FIRE FORUM – 10TH MAY 2024

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Novotel Liverpool Paddington Village

3 Paddington Village, Off Grove Street, Liverpool, L7 3FA

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Agenda (20 minute talks with 10 mins Q&A):

09:30 – 10.00 Registration and Coffee

"Defining fire safety in existing buildings – Retrofit projects".
Eoin O'Loughlin & Frederik Poulsen, Arup

Building reuse presents challenges for demonstrating satisfactory structural fire performance. Designers may need to apply surveys, historic and current codes, and first principles structural checks. Expert judgement is often essential, as well as collaboration between fire and structural engineers. However, there is a lack of guidance… What surveys are required? How much survey data? What can visual inspections tell us? What are the big watch-its? What levels of certainty/risk are acceptable? When is remediation necessary, and how should this be specified and evidenced? In this talk, we will explore these questions through a variety of recent projects.

"Structural performance and particularities of multi-storey intermodal steel container structures at elevated temperatures".
Tabea Uhr, SOCOTEC UK

This presentation examines the structural design of a multi-storey residential building using intermodal steel container modules. The study employs a performance-based analysis of the steel structural system under real fire scenarios, represented by Eurocode parametric fire curves. Results highlight the impact of heat development on passive fire protection and steel elements, emphasizing transient dynamic interactions among structural members. The unique structural system reveals that fire engineers must cautiously approach the design and fire protection of such structures. Structural engineers should consider that design details enhancing robustness under normal conditions may lead to unfavourable dynamics at elevated temperatures, as revealed in the performance-based analysis.

"Practical Framework for Quantified Risk Assessment for Bridge Structures against Fire Hazards".
Anna Benoit, Arup

This talk presents an analysis framework for fire risk assessments of bridge structures (both existing and new), aimed to provide stakeholders with detailed risk profiles appraising both the frequency and consequence of analysed fire hazards. The framework also helps with quantification of the likely risk reduction of different mitigation strategies. The outputs can inform cost-benefit assessments, ALARP assessments, and compliance with regulatory requirements. The proposed framework considers four assessment stages: 1) probability of ignition, 2) thermal impact, 3) consequence frequency, 4) mitigation strategy. An overview of the benefits, challenges and implementation techniques for each stage will be explored via project case studies.

"Numerical investigation of the structural behaviour of rectangular tunnels exposed to fire".
Thomas Thienpont, Ghent University

Spalling can severely affect the structural performance of concrete tunnel structures. Whilst several studies have been carried out on the structural fire performance of (deep) circular tunnels, there have been few investigations into the response of (shallow) rectangular tunnels. The latter are often applied in urban areas in major cities, to move large traffic streams underground. This presentation gives an overview of the results from a numerical study of a large road tunnel with a rectangular cross-section, taking into account the effect of spalling.

12.00 – 13.00 Lunch

"Multi-fidelity modelling of glulam beam and column connection under scenario fire load".
Solomon Tesfamariam, University of Waterloo

This presentation presents multi-fidelity numerical modelling technique for timber beam-column joint under fire. First, high-fidelity model was developed and its mechanical and thermal properties were calibrated based on the loading test under normal conditions and fire resistance test. Subsequently, simplified numerical beam-column joint model, i.e., the nonlinear connector, was developed and its mechanical properties were calibrated with the high-fidelity model under different temperatures. The simplified beam-column joint model provides a

feasible approach for incorporating the timber beam-column joint model into the large-scale building model under fire.

"Flame spread in large compartment experiments: comparison of Obora and CodeRed".

Harry Mitchell, Imperial College London

Flame spread is an important consideration in the fire safety of large compartments. To facilitate this understanding, two experimental series have been conducted to investigate flame spread in large compartments with both concrete and mass timber ceilings: the Obora and CodeRed experiments, the largest compartment fire experiments to date. These experiments were carried out in compartments of very similar layouts, ventilation conditions, and fuel load, allowing for direct comparison between the two experiment series. This presentation provides comparison and insight into flame spread behaviour along the wood crib and ceiling in large timber and concrete compartments, and the influence of other design parameters including fuel load, ventilation, and timber encapsulation.

"Structural fire simulations: small-scale to large-scale fires".

Wulan Shofa Aisyah, University College London

This presentation focuses on the intricate process of modelling fire dynamics within structures, particularly those made of timber, to tackle the difficulties associated with fire and structural viewpoints. The Fire Dynamics Simulator (FDS) model, developed by NIST, was selected and assessed to simulate fire in documented timber fires at various scales, beginning with small-scale setups, and then moving to larger-scale experiments: CodeRed. The study evaluates the capability of FDS to model fire behaviour, explores uncertainties, and offers valuable insights for forensic analysis. Overall, the research highlights the advantages and drawbacks of numerical simulations in understanding fire dynamics and emphasizes the necessity for further validation, especially concerning timber structures.

14.30 – 15.00 Coffee

"Influence of Temperature and Strain Rate on Bolt Strength Reduction Factors: Experimental Study".

Diana Duma, BRE

The presentation explores the often-overlooked interplay between temperature, strain rate, and bolt strength reduction factors. This is an important aspect omitted in existing fire design methods. The experimental study, conducted at the Politehnica University Timișoara, entails 106 tensile tests on specimens using a 250 kN testing machine. Tests cover temperatures from 20°C to 800°C and strain rates from 0.000033 s^{-1} to 0.06 s^{-1}. The research unveils new equations considering strain rate, offering insights into grade 10.9 bolt strength reduction under elevated temperatures. These factors show a 40% variation from Eurocode recommendations above 400°C, dependent on applied strain rates. The study's significance lies in quantifying the strain rate's impact on bolt material behavior, underscoring the need for its consideration in bolted connection design to enhance structural integrity under elevated temperatures.

"Structural Response of Beam-End Shear Connections - Estimating the total axial forces via strain gauges".

Xu Dai, University of Liverpool

The role of steel connections is essential in structural fire design and analysis for steel-framed composite structures. The current structural design provisions provide strength reduction factors of load-carrying members and their end-connection elements (e.g. bolts) at elevated temperatures, based on small-scale experiments under uniform heating conditions. The realistic temperature evolution in member connections, especially as part of full-scale floor assemblies exposed to a large compartment fire, has not been well characterized. This presentation will present an exercise on interpreting over 70+ strain gauge data for the total axial forces of a prototype steel-composite floor structure during a large compartment fire.

16.00 – 17.00/17.30 END (Optional Campus Tour of the University of Liverpool)