MEASUREMENTS AND MODELLING OF FIRE SMOKE AND TOXICITY

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Performance based design for life safety in residential and commercial buildings is based on ensuring a safe evacuation from the building before the fire or its products can cause them any harm. In fire engineering technical terminology, the Available Egress Time (ASET) must exceed the Required Safe Egress Time (RSET) with an appropriate margin of safety. RSET depends on the interaction between people and layout of the building, while ASET depends on the interaction between development of fire and the layout of the building. Fire can harm the safety of life by thermal effect, reduction of visibility and toxicity (asphyxiant and irritant gas effects). Fire products are most likely to compromise the escape of the occupants before flames reach them, recently published fire statistics in Great Britain show that in 2011 the most dominant cause of death in fire incidents was being overcome by smoke and toxic products (which is the same conclusion for the past few decades).

Quantifying the smoke products and their effects on people is a challenging task. Because every fire is different; fuel type, layout of fuel, ignition location, size of compartment and ventilation mechanism. Some fire dynamics correlations partially address these factors and are able to give some guiding quantitative approximation for limited and simplistic fire scenarios. Most of the available smoke toxicity measurements are based on fully ventilated fire conditions and therefore are not representative of many real compartment fire scenarios.

Full scale experiment is the ultimate simulation of a fire that would produce reliable measurements, however the high financial and time cost of conducting such experiments limits the amount and speed at which such data can be obtained.

The main objective of the project is to develop and validate a suitable bench-scale test setup (based on the popular apparatus Cone Calorimeter) as a method for evaluating toxicity of materials in enclosed air starved compartment fires. Such setup would enable the fast production of detailed toxicity data in relevant and varied fire scenarios.

As part of this project eight real scale experiments have already been conducted in Jersey, Channel Islands and these would form the main validation bench mark for the bench scale testing method.

The project involves 3 distinct phases

- Design (with the aid of CFD modelling) and implement changes to the cone calorimeter that would variable ventilation toxicity measurements to be carried out reliably.
- Carry out full scale tests and compare these toxicity measurements (and others in the literature) to the modified Cone data
- Develop suitable correlations of toxicity data that could feed into modelling tools such as zone and field models.

Modifications to the standard cone equipment included enclosing the heater in an enclosure with controlled air supply and adding a chimney to prevent/minimise post flame oxidation and to allow sampling of raw fire effluents without air dilution (as is the usual practice).

Examples of specific challenges and solution approaches:

There was uncertainty on the induced flow patterns of these modifications and CFD was utilised to understand the flow dynamics and adjust the design.

As a test of the occurrence of post-flame oxidation two thermocouples were added to the cone chimney, one next to the sampling point and the other at the chimney exit at an adjustable height. Significant changes/differences in temperature between the two thermocouples would indicate that post-oxidation occurred.