Open floor plan compartment fires: Characterisation of the ‘Malveira Fire Test’

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INTRODUCTION

• Main input for designing fire safe structures relies on characterising the fire dynamics of the fully-developed stage. The compartment fire framework is used, simple analysis tools developed between the 1950s and 1990s that can be applied to structures to define the fire as a function of the ventilation conditions, applicable to Regime I ventilation controlled fires.
• Disconnect: Key trend in the modern built environment is the presence of open, flexible volumes saturated by natural light through multiple, large openings.
• This leads to Regime II, fuel controlled fires and a disparity between applied fire dynamics & realistic structures.
• Regime I is traditionally deemed worst case, this may not be true due to the poor characterisation of Regime II

THE TEST & RESEARCH OBJECTIVES

In 2014, a large-scale fire experiment was carried out in Malveira, Portugal to observe fire dynamics in open-plan compartments. The test exhibited three distinct domains:

I. Domain One: Travelling fire that lasted several hours
II. Domain Two: Transition from travelling to fully-developed fire
III. Domain Three: Fully-developed fire that required extinguishment.

Test was densely instrumented in a 4.7 x 21 x 2.8 m compartment with 5 openings on one side and wood cribs for fuel load.

Preliminary Results

Above is shown the total HRR of the fire. To the right is shown a temperature contour taken along the centre length of the compartment, and below is the incident heat flux along the window side ceiling and flow velocity along the height of window 1.

PROCESSING METHODOLOGY

Data was cleaned of faulty sensors, noise was smoothed with regresional LOESS analysis and sensors were organised into tress etc.;

• Thermocouple trees to plot temperature evolution slices
• TSCs processed methodology established by Hidalgo et al (2016)
• Processing the flow velocities using the calibration conducted by Gupta (2018)

FUTURE STEPS – CHARACTERISATION METHODOLOGY

Using the processed data, the conditions of the three domains will be characterised:

I. Domain I: $V_s = V_{100}$
II. Domain II: $V_s > V_{100}$
III. Domain III: $V_s > V_{100}$

The spread velocities of the domains will be established:

$q_{10}^* = V_s = f(T_{pc}, q_{in})$
$q_{10}^* \rightarrow m^*_s = f(q_{in}, m_{mean})$

Once the spread velocities have been established, a full energy balance of the compartment throughout the stages of the test will be conducted to determine the reduction in HRR due to insulating cork.

CONCLUDING REMARKS

Clear that there is phenomena involved in open plan compartment fires that is not well characterised. The next steps include:

1. Quantify effect of cork on fire spread and energy
2. Conduct energy balance of whole compartment at all stages
3. Characterise requirements for the transition of stages of the fire
4. Develop method of applying the results to open plan compartments

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