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# Innovative Structural Engineering for Tall Buildings in Fire

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## Abstract

Structural engineers do not traditionally consider fire as a load on a structural frame. This is in contrast to other loads they must consider. Seismic design relies on modelling, risk analysis and changes to the structural stiffness. Wind design often relies on additional structural members and wind tunnel tests. Fire design relies on very simple, single element tests to calculate insulating material for a frame, in order to limit its temperature increase for specific fire resistance ratings. Thermal induced forces, as occur in fire, are generally not calculated or designed for.

The events of 9-11 and other tall building fires have meant that these fire resistance ratings are being scrutinised. The question being posed is, are they adequate if they do not address real structural response, or should there be alternative means of engineering structural resilience in fire? This becomes increasingly significant if total evacuations and extreme events like fire spread to multiple compartment floors are to form the basis of design for tall buildings in the future. It is also significant when it is becoming increasingly clear that specific structural geometries are weaker in fire than others.

In response to public demand for safer structures and the commercial drive for robust structural fire design post 9-11, Arup and The University of Edinburgh have carried out a number of analyses of the behaviour of long span floor systems including composite cellular beams and composite truss floors similar to the WTC 1 & 2 buildings. The research has considered single and multi-storey fires.

For scenarios where fires have been assumed to act over several storeys simultaneously this research is beginning to identify potential global progressive collapse mechanisms in the different long-span floor systems studied. Where possible, failure mechanisms are being validated against evidence from the real fires of WTC 1, 2 and 7.

The research studies thus far have provided a substantial increase in our understanding of the whole frame response of high-rise buildings in fire, but the work should be considered as ongoing.

The intent for now is that this new understanding will form the basis of future design including where appropriate, and always based on a risk assessment, design against structural failure for multi-floor fires. The aim is to propose structural designs that do not rely solely on traditional fire protection measures, but have specific structural detailing to withstand these

events. In other words they are intrinsically robust rather than totally reliant on other safety measures that can fail in extreme events.

This paper will present some of the results of this recent research and show how it is being implemented in design through a case study on a high rise office building proposed in the UK.

Keywords: Structure, Robustness, Risk, Fire, Extreme event