# Robustness in Tall Buildings: Earth, Wind & Fire

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## Summary

The aim of this paper is to introduce some of the key concepts in enhancing the robustness of tall buildings. The overarching objective of such a process should be the development of sensible hazard scenarios and realistic acceptance criteria to ensure cost-effective and sustainable design. Due to the complex structural behaviour exhibited, both in loading and response, under common identified hazards some degree of simplification is inevitable so it is important that any hazards considered are treated within a common performance based design framework.

An overview is presented of a design framework in which the performance of buildings under accidental and extreme events can be assessed. A range of analysis techniques is available to the engineer;which technique is chosen depends on the complexity and nature of the building, the specific hazards that the building will be subjected to and the degree of conservatism that can be tolerated in ensuring the robustness of that particular building. Some of the detailed assessment procedures available for such buildings under certain specific hazards within the framework are discussed.

**Keywords**: Robustness; Design Framework; Analysis Techniques; Fire; Blast, Alternate Load Path; Connection Performance.

## 1. Introduction

The financial and economic challenges of development on inner city sites are continuing to push building designs taller and taller. This gives the structural engineer numerous challenges in deriving designs which meet the competing functional requirements of tall buildings in a cost effective and sustainable manner.

A key functional requirement which is becoming increasingly important is the design of the structure to perform satisfactorily during accidental and extreme events. The need for this has been brought into focus by recent terrorist attacks which have led engineers to consider methods of assessing the vulnerability of tall buildings and to consider the measures that can be taken to make buildings more robust in such events.

Since 2004 in the UK and more recently with the introduction of the Eurocodes there is a need to design tall buildings considering the risks of progressive collapse under accidental events. Tall buildings (defined as over 15 storeys tall) fall in the highest risk category for which a systematic assessment of the risks posed by a variety of accidental events needs to be considered. Such accidental events include design against earthquake, blast, fire, vehicle impact, etc.

The attacks on the World Trade Center and subsequent terrorist attacks on other critical infrastructure have brought calls for tall buildings to withstand even more extreme events. However such events can place structural demands on buildings which if met by normal design processes would lead to buildings which are functionally, economically and, moreover, sustainably unviable. Therefore, if such events are to be taken account of in the design, it is important to establish the key performance goals of the structure under the events and establish the necessary

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