Progressive Collapse Analysis of Steel/Composite Frames under Fire Conditions

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Description: Structural engineers have a responsibility for incorporating fire safety into their building designs in order to minimize loss of life and property. The Cardington full-scale fire tests demonstrated that member-based structural fire engineering (SFE) simply does not work for large, complex buildings. Performance-based SFE building design inevitably has to depend on scenario-based non-linear numerical modelling of large sub-frames of the structure. If the building is to avoid the possibility of disproportionate collapse in fire, this numerical modelling must be capable of predicting real structural collapse, rather than just the first loss of stability.

In this project a numerical procedure in which the whole behaviour, from local instability to total collapse, can be modelled effectively, is developed in *Vulcan*. The model combines alternate static and dynamic analyses, to use both to best advantage. Static analysis is used to trace the behaviour of the structure at changing temperature until an instability happens; beyond this point an explicit dynamic procedure is activated to track the motion of the system until stability is regained. This has been comprehensively validated as an effective tool against practical cases, and has been shown to work well in a large number of robustness analyses in fire scenarios. The different forms of global (or severe local) failure are identified, and the sequence of progressive collapse mechanisms is captured. Several factors which either contribute to or mitigate a fire-induced progressive collapse are studied, including the loading level, the structural configuration and detailing, and the location of bracing systems.

It is logical that the connections in steel frames can have a considerable effect on progressive collapse induced by severe loading cases. Modelling the progressive failure of connections is within the scope of this project. A connection may be able to retain its robustness after the initial fracture of a component, or the first failure may trigger a cascade of failures of other components, leading to complete detachment of the members. This possibility should be considered in performance-based design when the structure is being tested for robustness. Combined with the parallel development of general component-based connection elements, this procedure can effectively trace the behaviour of connections, from the initial fracture of a component, via the failure of successive bolt-rows, to final detachment from the column. In fact the analysis carries on beyond connection fracture, until final structural collapse occurs due to column buckling at a higher temperature. This extension to *Vulcan* which allows all the states of the structure, including both its equilibrium and its dynamics, to be tracked as its loading or temperature increases, has created an effective tool for practical performance-based global analysis, including the prediction of progressive collapse or re-stabilization.