Behaviour of Frame Columns in Localised Fires

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VULCAN

Objective

- Develop a procedure to overcome the propensity of static analysis to fail at singularity;
- Propose a simplified model to simulate the column behaviour under localised fire;

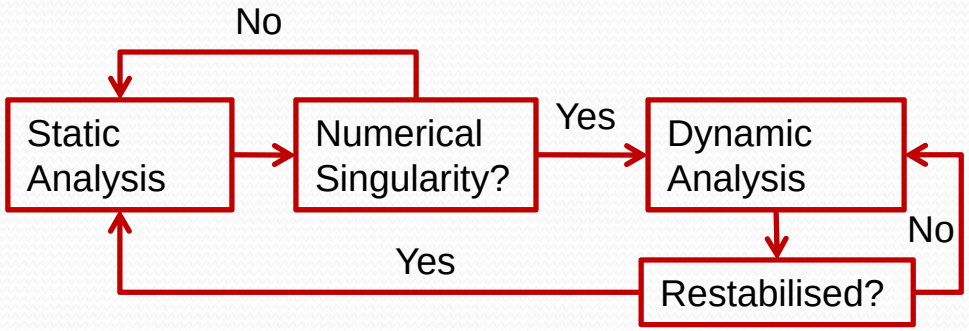
Static/Dynamic Procedure

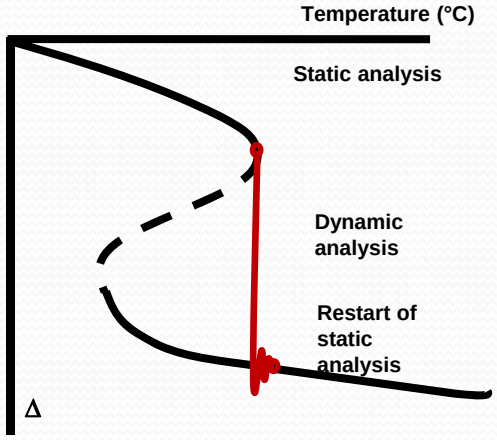
A Static/Dynamic version of *Vulcan* has been developed, to trace the structural behaviour of single members or whole frames from initial static response, through local failure or instability, to stable post-buckling behaviour.

Dynamic Procedure

$$A = \ddot{U}_n = M_n^{-1}(P_n - I_n - D_n)$$

where *A* is acceleration of DoF; *M* is mass of DoF; *P* external force; *I* is internal force; *D* is damping.





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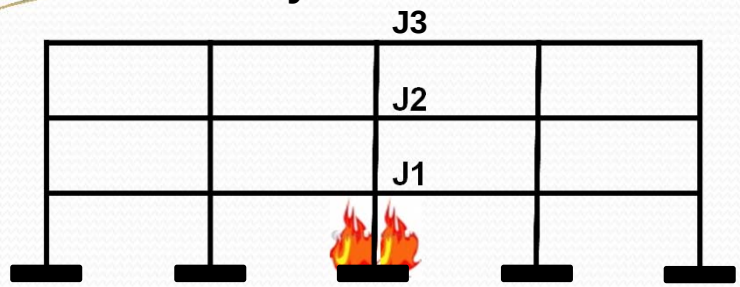
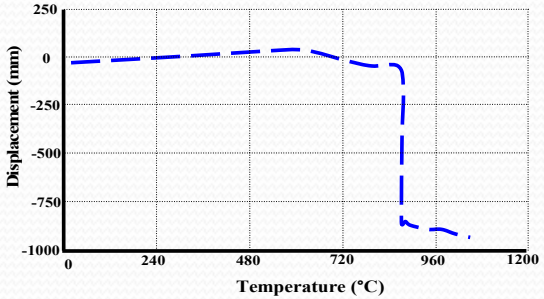
APPLICATION of STRUCTURAL FIRE ENGINEERING

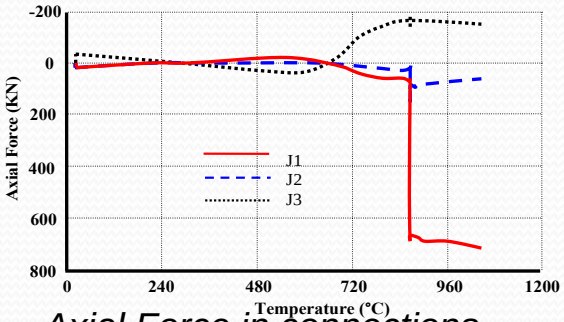
Full Frame Analysis



A planar frame has been tested under localised fire conditions. The central column at ground floor level is assumed to be heated by an standard fire curve.

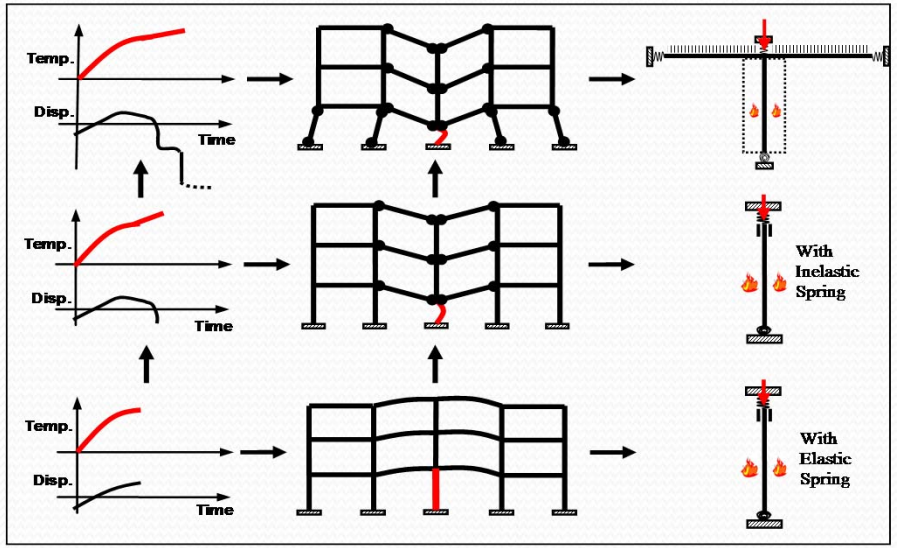


Displacement of top of heated column



Axial Force in connections

Failure Process and Simplified model



Stage I: Thermal expansion: Compressive force increasing- Column buckling;

Stage II: Larger displacement: Bending moment at ends of beams increasing-- beam yielding;

Stage III: Catenary action developing: Column pull-in re-stabilization or collapse.

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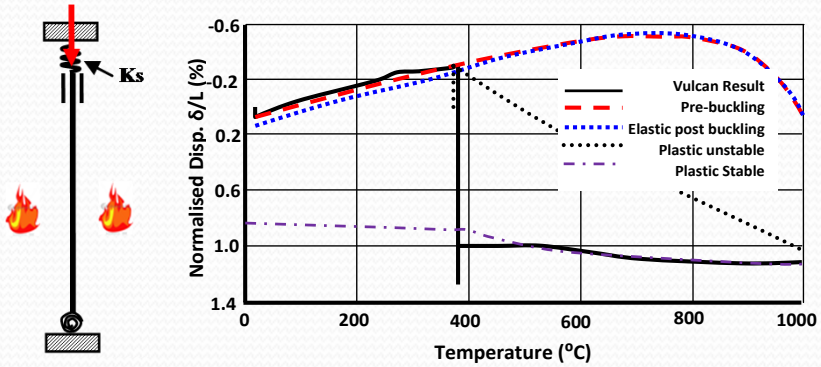
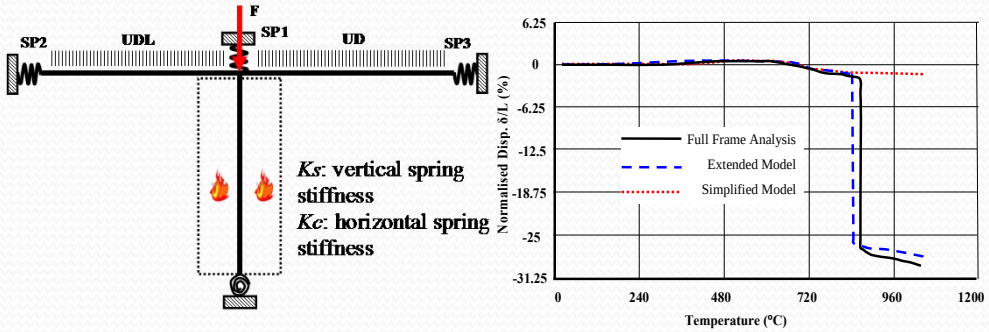
Validation

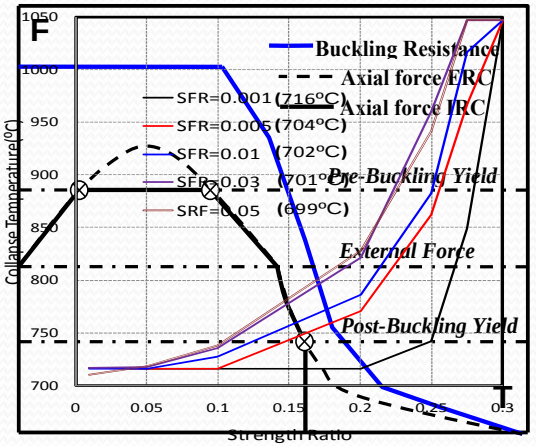


Comparison between simplified model and Spreadsheet calculation

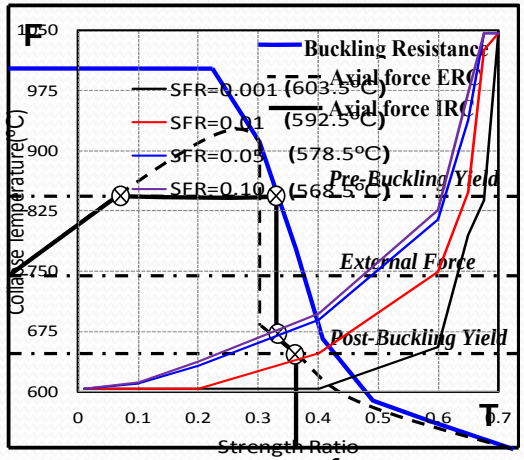


Comparison between simplified model and Full frame analysis

Influence of stiffness and restraints of column

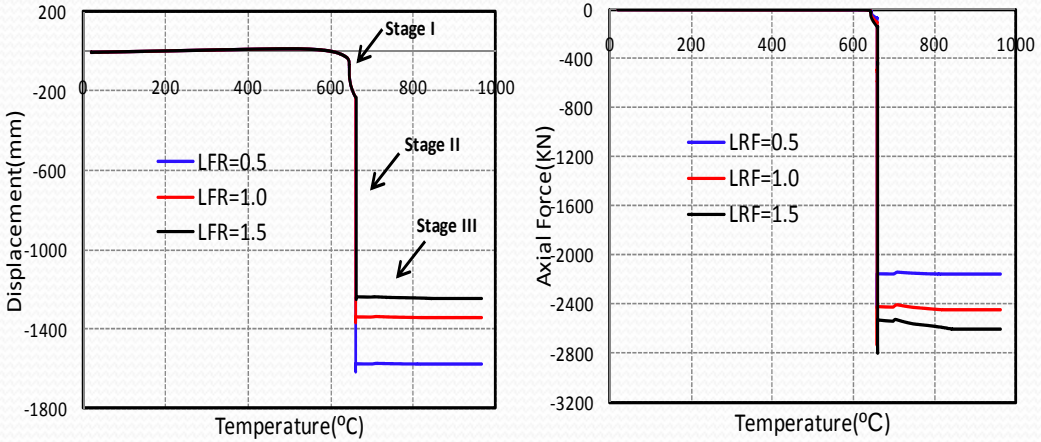


Development of axial force in column (Slenderness 60) with load ratio 0.3 considering the beam yielding

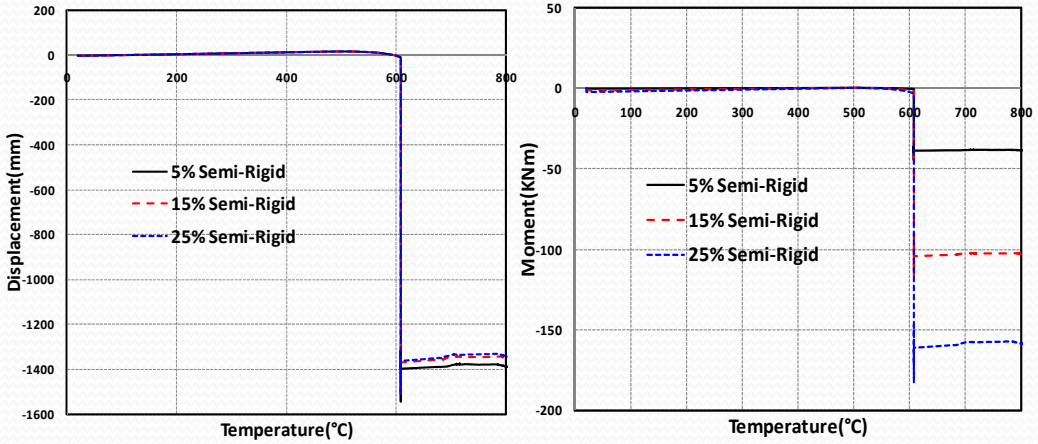


Development of axial force in column (Slenderness 60) with load ratio 0.7 considering the beam yielding

Influence of lateral restraints and connection rigidity



Displacement of column top and axial force in beam with different lateral restraint stiffness (LFR=K_s/K_c)



Displacement of column top and moment with semi-rigid connections

Conclusion and Further work

A simplified model has been proposed to study the column behaviour in framed structures under localised fire;

The column force development has been studied and the influence of stiffness and strength of axial restraint of column has been investigated;

The stiffness of lateral restraint has influence on the re-stabilization and the axial forces developing in beams, and the rigidity of connection has impact on the moment in connection rather than the re-stabilized position.

Further work

This model is based on 2D frame containing beams, columns and connections. It is also feasible to include slabs into simplified models to investigate behaviour of composite frame under fire scenarios.

The Static/Dynamic procedure will be combined with the component-based model to trace the progressive failure of connections in fire scenarios.

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