

2.3 Structural fire engineering - the need for robustness (short version)

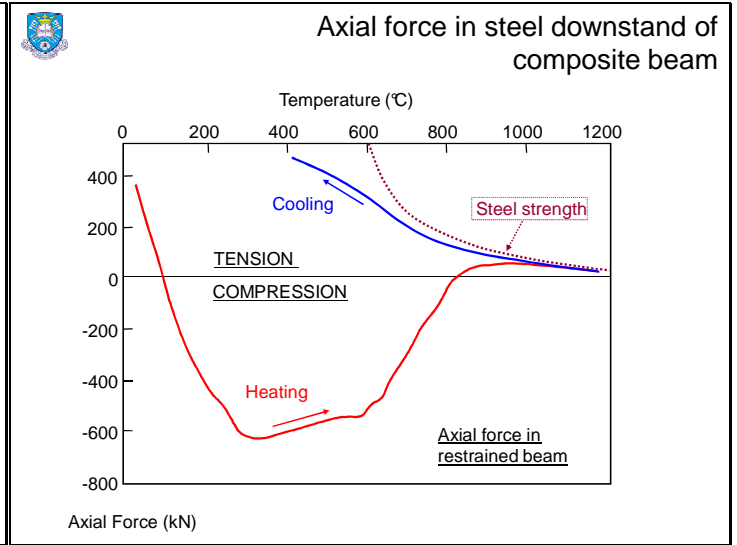
Burgess I., United Kingdom

The University Of Sheffield.

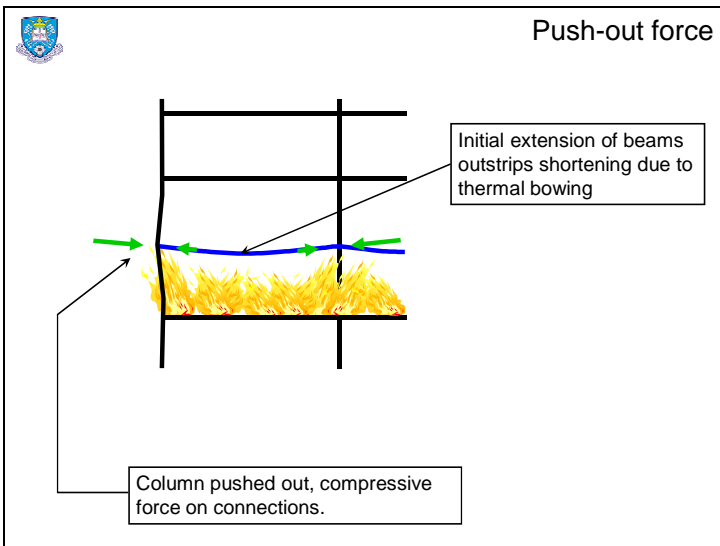
Structural Fire Engineering – the Need for Robustness

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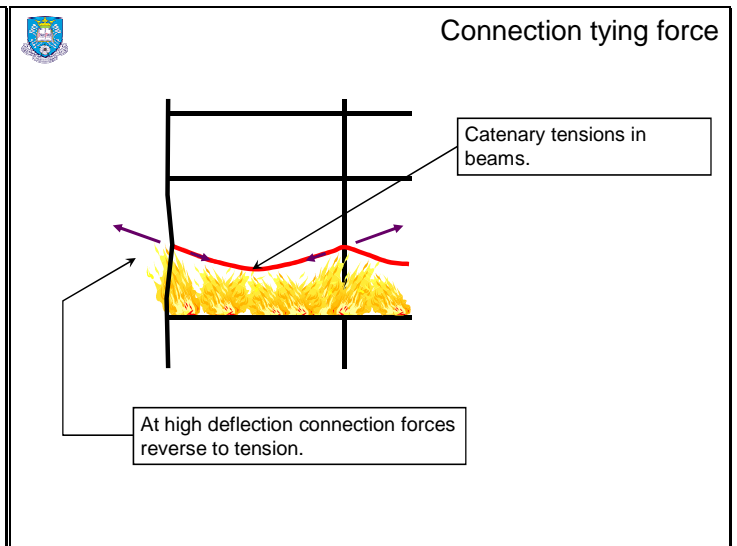
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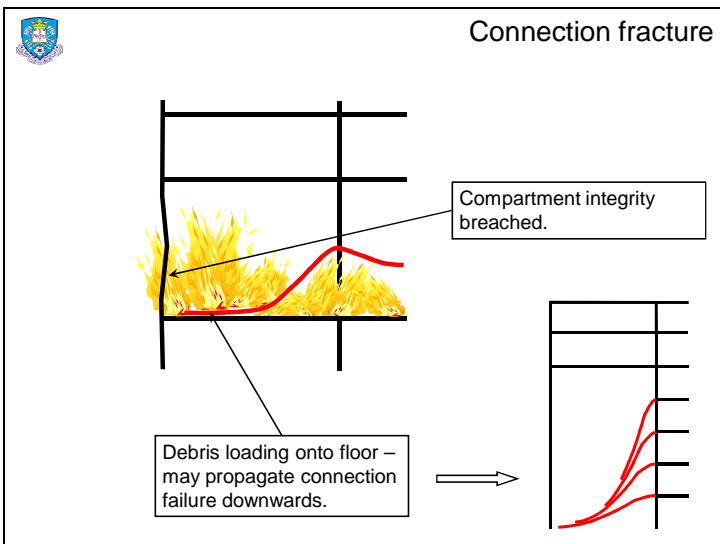
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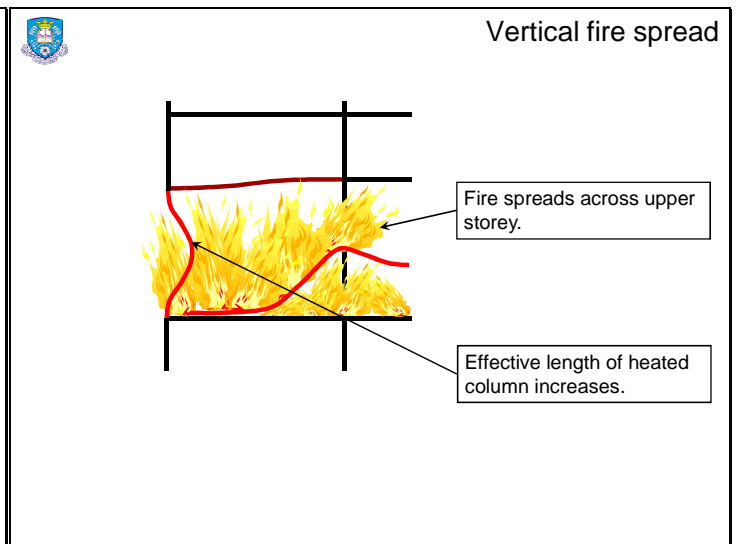
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6

Fracture in cooling at Cardington

Partial fracture

- One-sided failure of partial-depth end plates during cooling phase.
- Reduced stiffness retains the integrity of the joint.
- Partial fracture may happen when cooling from net compression ...
- ... or when the net force remains compressive.
- Shear failure of bolts also observed in fin-plates during cooling.

Temperature

Axial Force in restrained beam

Cooling

Heating

TENSION

COMPRESSION

AXIAL FORCE IN RESTRAINED BEAM

7

Typical floor of WTC7

- Secondary beams from perimeter do not frame directly into Column 79.
- No directly opposed secondary beams on critical primary beams between columns 44-79 and 80-79.
- Primary beams ("girders") not made composite with slab.

8

Component method with axial force

Axial compression acts together with moment due to restraint to thermal expansion.

9

Possible component assembly for reverse channel joint

10

Possible component assembly for reverse channel joint

11

Thoughts ...

Problems

1. Building structure is optimised by designers – and is therefore vulnerable to actions which have not been explicitly considered in design.
2. This can include local fractures and consequential progressive collapse of floors under impact and overload. Finally collapse of columns without support over multiple floors.

Evidence of connection behaviour

1. Cardington shows connection phenomena which can happen.
2. WTC7 shows how design which is OK for normal temperatures can go disastrously wrong in fire.

Predicting behaviour

1. Fire-resistant design based on isolated members simply is not adequate to predict connection fracture in complex structures.
2. The only feasible way for design seems to be global modelling with component-based models.

12