7º Congreso Internacional de Ingeniería de Seguridad contra Incendios
7th International Congress on Fire Safety Engineering

Structural Fire Engineering
State-of-the-Art & Future Prognosis

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Centro de Convenciones Mapfre

The BRE Centre *for* Fire Safety Engineering

A leading fire research centre with 50+ members from 18+ countries, we exist to:

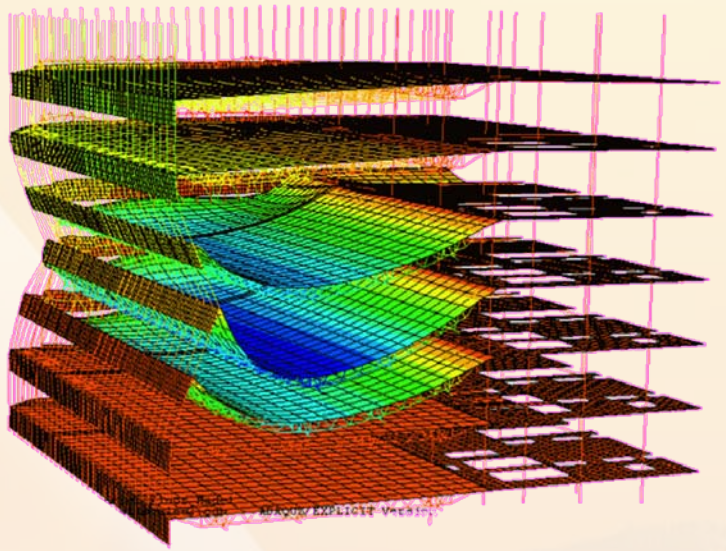
- Equip **tomorrow's leaders** in the field with the skills they require
- Support proactive fire safety through **multidisciplinary research**
- 1st class **unique education** in Fire Safety & Structural Fire Eng.
- Fire safety **consultancy services** to industry & other consultancies
- Promote & **disseminate information** about advances & research in fire safety engineering

What is Structural Fire Engineering?

Structural fire engineering assesses the ***structural response to heat*** from a fire and uses this as the basis for fire protection requirements and structural detailing ***to meet the fundamental design objectives*** for a structure

Fundamental Objectives

- **R** – Load capacity (collapse prevention)
- **E** – Integrity (compartmentation)
- **I** – Insulation (compartmentation)

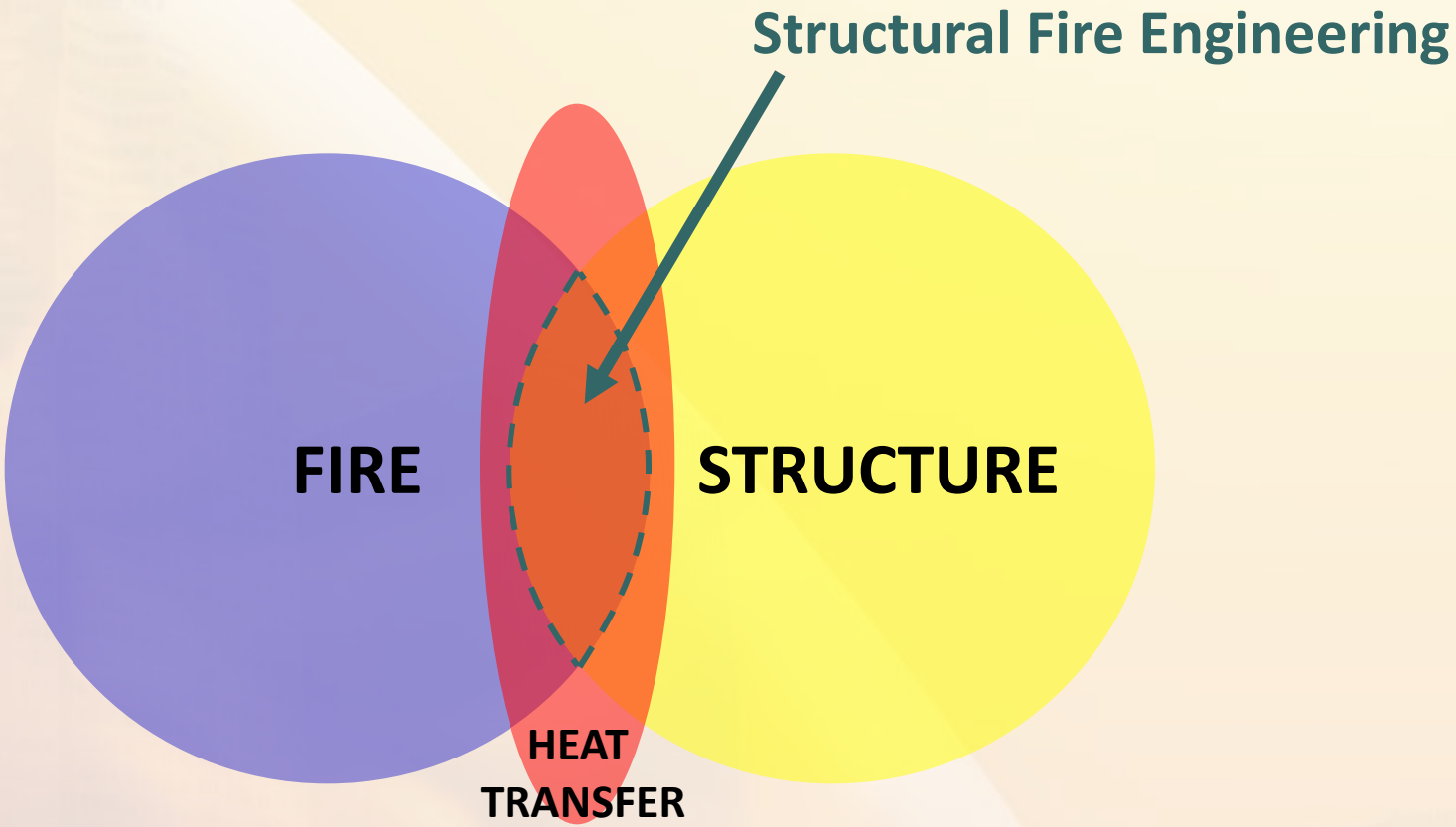


Fundamental Unknowns/Issues

- Credible worst case design fire?
- Response of structure (REI)?
- Design objectives?

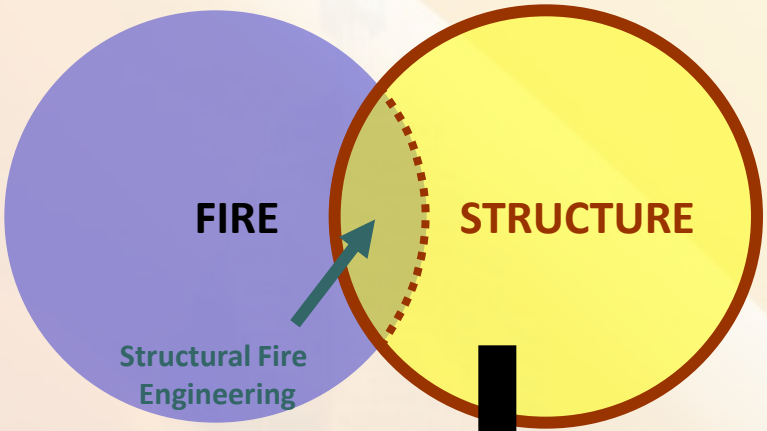
How do we deal with the unknowns?

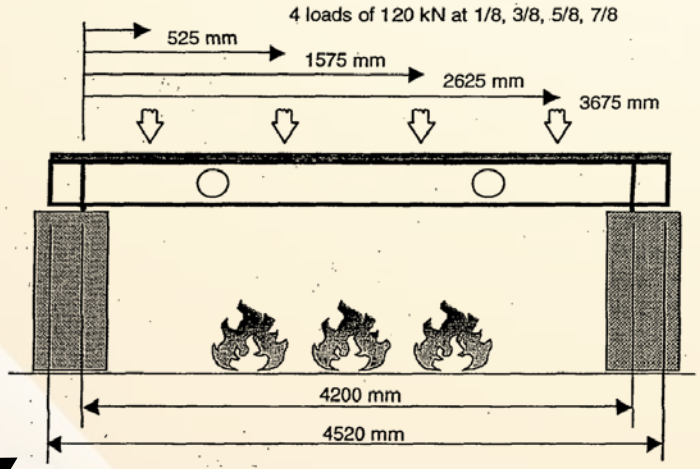
Rein's "Lame Substitutions"*



*a term coined by Dr Guillermo Rein, Imperial College

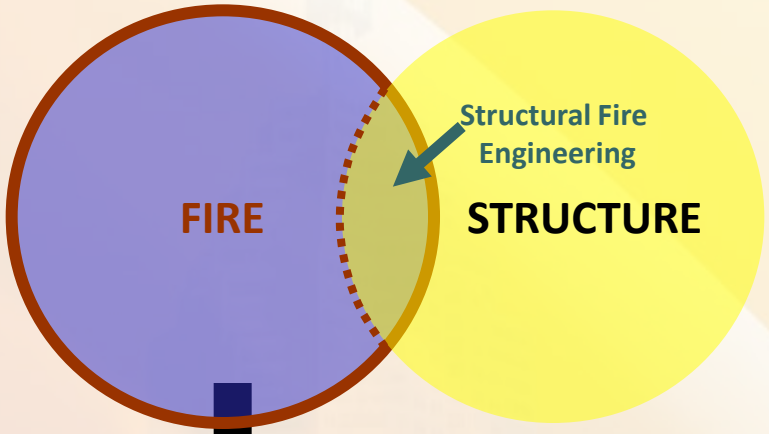
Lame Substitution 1 – By “Fire” Engineers

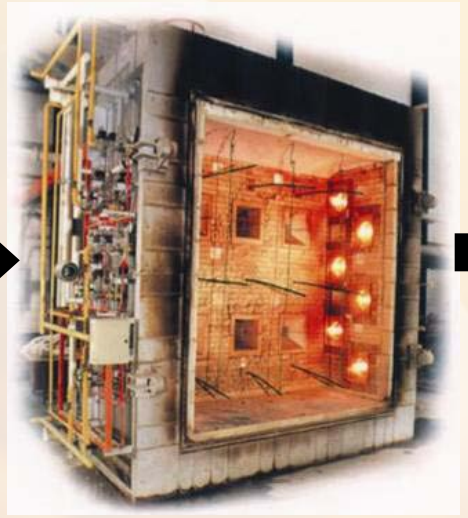


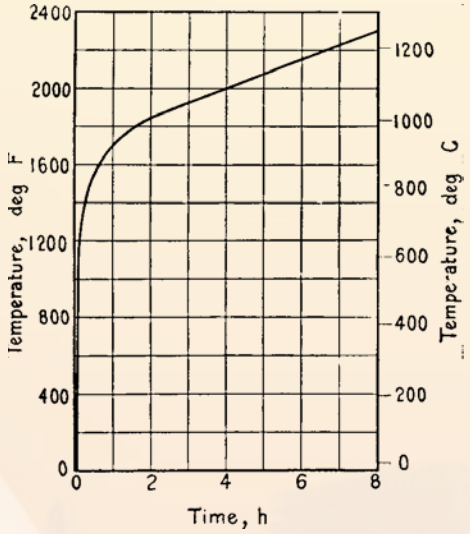


$$T_{critical} = (550 + ?)^{o}C$$

Lame Substitution 2 – By “Structural” Engineers

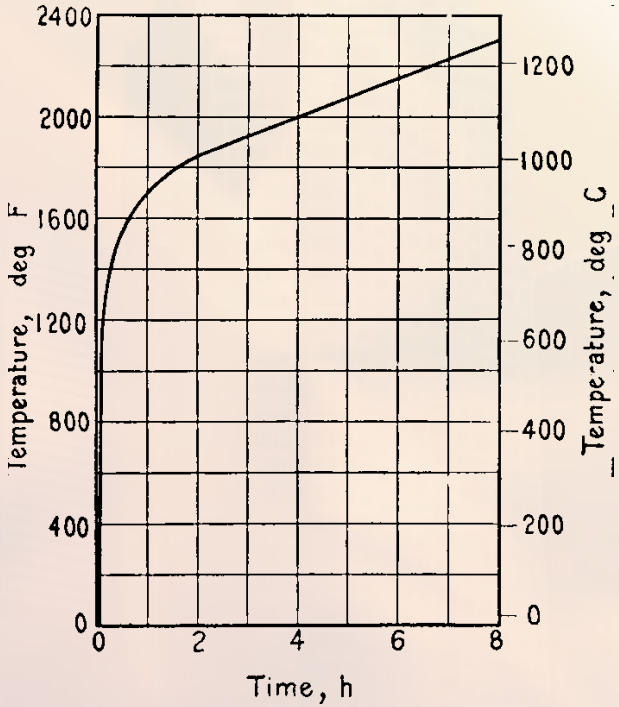


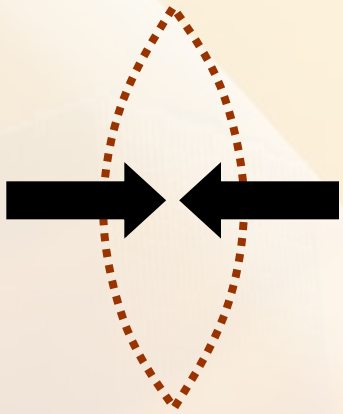




Lame Substitution 3 – What we actually do…

Structural Fire Engineering?!





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My Assertion (#1)

Use of prescriptive guidance for structural fire resistance is **not engineering**…

… it is **lucky pretence**

So what is better than lame substitutions and lucky pretence?

The State-of-the-Art: Heron Tower, London

- 46 Storey Office Building in the City of London, UK
- 3-storey atriums forming ‘villages’
- First ever project to consider the robustness of a structure in a multi-storey fire

Heron Tower, London

Compartment floors

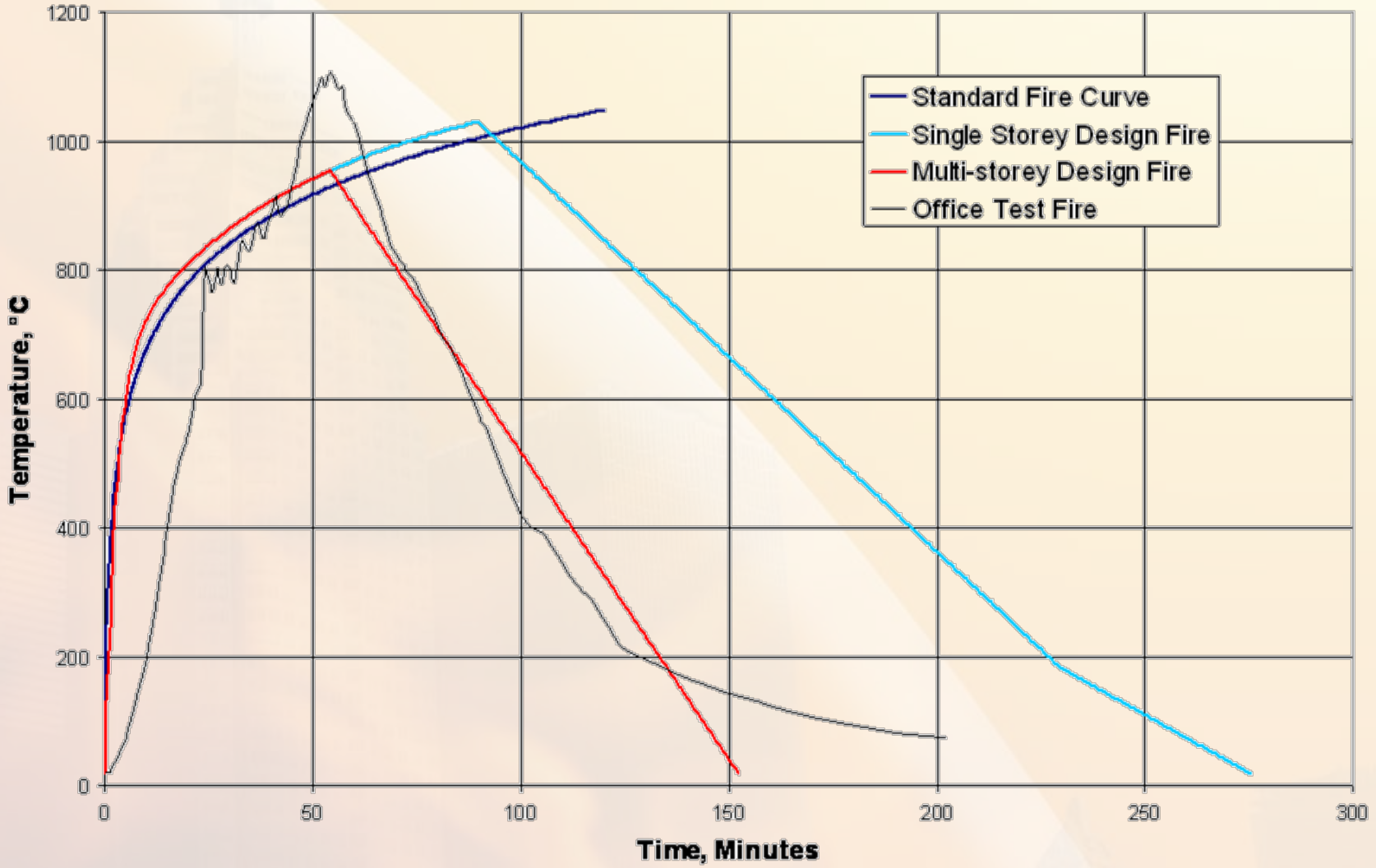
Atrium floors

Typical ‘Village’

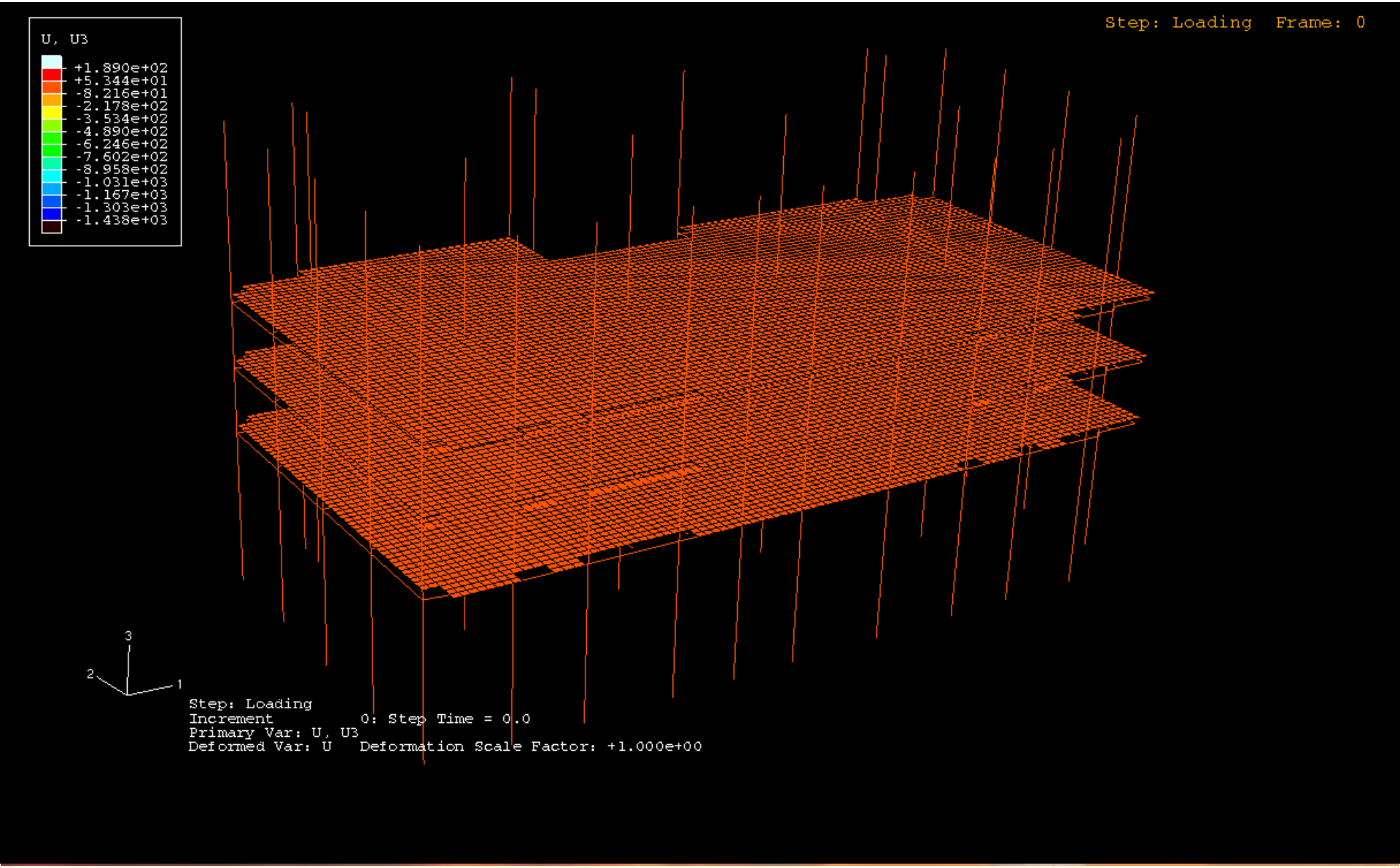
Key Design Issues?

1. Optimisation of **structural fire protection** scheme
2. Potential for **fire occurring over three floors** due to atria
3. Structural fire analysis undertaken for **three full floors heated simultaneously**

Heron Tower: Design Fires



Heron Tower: Multi-Storey Fire



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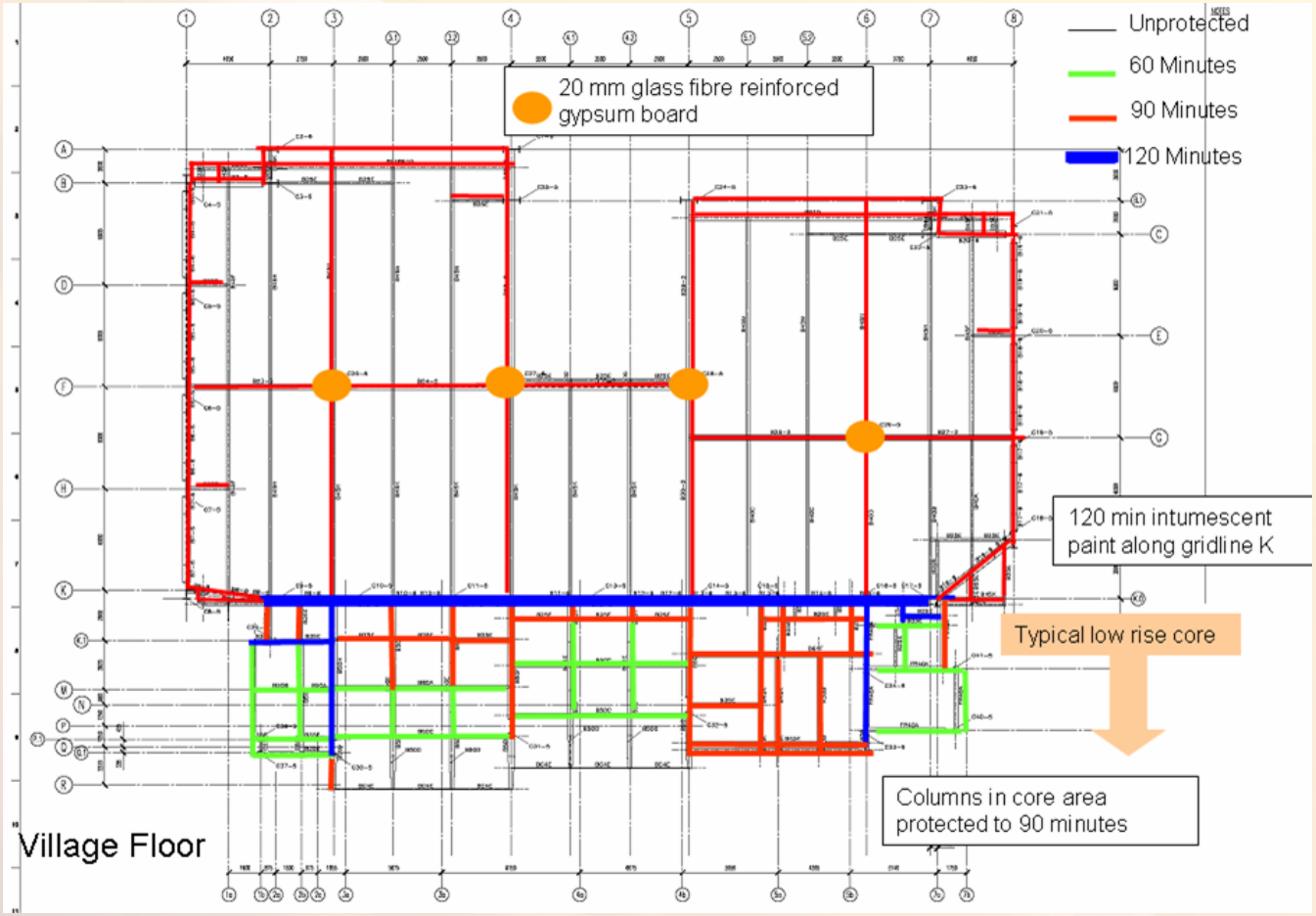
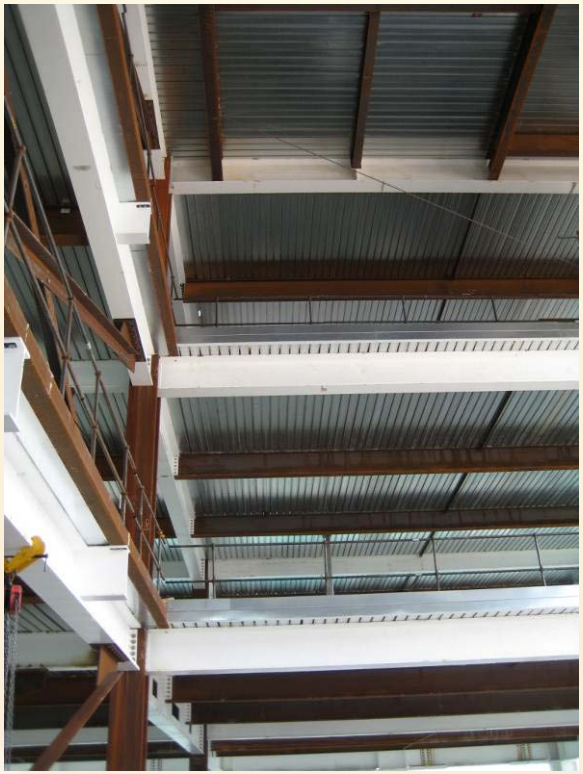
Cost savings to project

- **‘Reduction’** in the overall building fire resistance **‘rating’**
- Removal of passive fire protection material from **infill secondary beams**



Heron Tower: Findings of Analyses

- **Stability & compartmentation** maintained
- **Robust** response:
  - Use of solid section members
  - Increased protection to internal columns
  - Additional reinforcement in key areas of the floor slab & enhanced ductility for the beam to column connections
- **Safety demonstrated, *not* assumed**
- **First *approval* in UK using multi-storey fire**



Why does this work (for steel-framed structures)?

1) There is an obvious **driver** (remove fire protection = $£€)
2) There is an obvious **benefactor** (the Steel Industry)
3) A **massive research effort** was expended (Cardington tests and ongoing projects more than 20 years later)
4) Defensible computational capabilities (**FE Modelling**)
5) Regulatory changes occurred to allow performance-based design by **demonstrably achieving functional objectives**
6) We **focus only on life safety** (Property protection? Business continuity? Sustainability? Indirect losses?)

Is this all that Structural Fire Engineering has to offer?

My Assertion (#2)

Structural Fire Engineering does not have a sufficiently well-defined **purpose** or **ultimate goal**

Future Prognosis: We must aim for balance

Aspirations

We have to understand the significance/expectations that society allocates to each aspiration with respect to fire safety

Costs

We must understand the true cost of the available resources and of failure to meet the aspirations

If we don't effectively fire engineer our structures we will either:

1. **Waste resources** on them; or
2. Their performance will **not meet our expectations**; or
3. In the worst case, **we will squander resources *and* fail to meet expectations** (is this what we are unwittingly doing?)

Conclusions

- **Considerable research in this field (ongoing)**
- **Advanced methods are now being used in practice:**
  - Test the structure
  - Allow unprotected secondary steel
  - Prescriptive fire resistance ratings not always conservative
  - Enables innovative designs and architectural freedom
  - Understanding of structural response informs robust design
- **Performance-based structural fire engineering supports:**
  - Cost savings
  - Innovative spaces/designs/materials/systems
  - Sustainability goals
  - Demonstrated, rather than presumed, safety

If you remember nothing else…

Assertion #1

Use of prescriptive guidance for structural fire resistance design is not engineering; in most cases it is little more than lucky pretence

(we ***can*** do better)

Assertion #2

Structural Fire Engineering does not currently have a sufficiently well defined purpose or ultimate goal

(we ***should*** do better)

Gracias por su atención
Thanks for your attention

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