Fire Engineering Design Approaches
A consistent level of sophistication

Safety Design in Buildings, Bahrain 8th June 2015

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Bahrain Conference
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ARUP

Course Description

This speaker presents a discussion on an approach to fire safety design, using a fire engineering framework, to identify design goals and objectives in order to arrive at a holistic and practical fire safety design solution. In certain buildings this is often the only means to achieve the design intent and client goals.

The speaker follows by introducing design solutions and software tools utilised as an integral part of the approach including structural fire engineering analysis to evaluate fire resistance of structural members and frames, use of computational fluid dynamics for smoke management strategies, and evacuation modelling software in determining evacuations provisions for populated environments.

Presenter

Dermot O'Donnell

Senior Fire Engineer – Arup

Dermot is a Senior Fire Engineer with Arup and a Chartered Engineer with Engineers Ireland. He holds an Honours Degree in Building Services Engineering from Dublin Institute of Technology.

Dermot has a wide range of experience in fire engineering in Ireland, UK, Continental Europe, Russia and the Middle East.

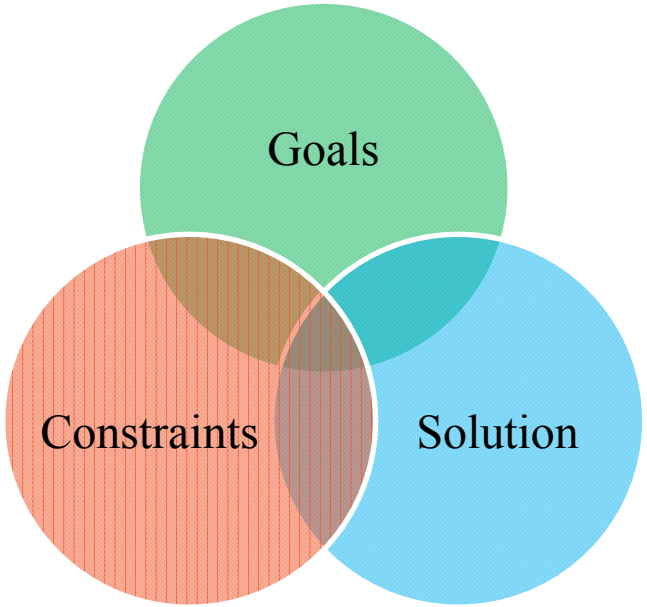
His experience ranges from code knowledge to the development and application of holistic performance based designs. Dermot also has substantial experience in on-site implementation of his and others fire life safety designs.

Dermot is also an practiced in evacuation and people movement analysis. He is involved in the continuing development of Arup's commercially available evacuation modelling software MassMotion as a tester and European champion within Arup.

Learning Objectives

1. *Goals and Objectives*
   - *How to define fire engineering goals and objectives?*
   - *Examples of fire engineering goals and objectives*
   - *Are alternative approaches available?*
   - *How to demonstrate an acceptable level of safety?*
2. *Example of Alternative approaches to allow for design flexibility*
   - *Structural Fire Analysis*
   - *Extended travel distances*
   - *Atrium design*
3. *Example of Tools available to achieve alternative approaches.*
   - *Structural assessment tools*
   - *Use of Computational Fluid Dynamics (CFD)*
   - *Use of evacuation modelling software*

Goals and Objectives

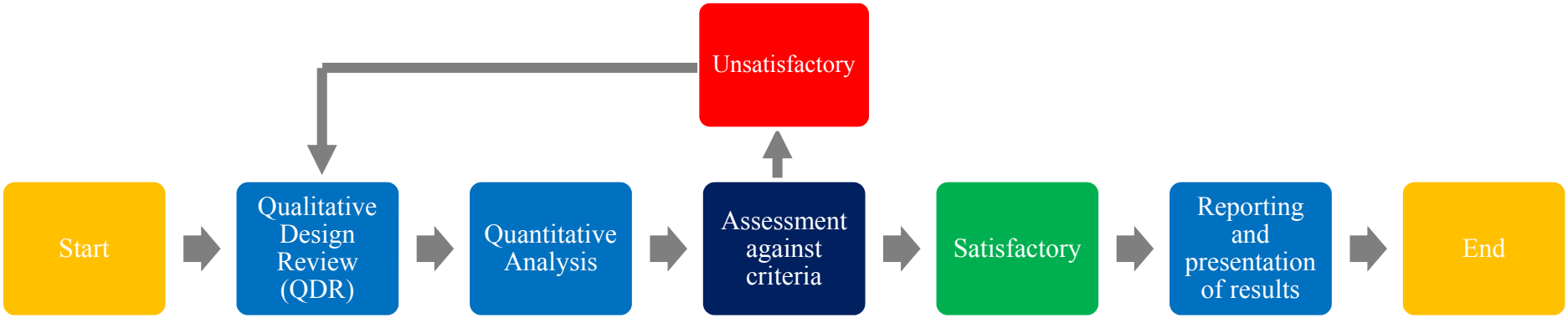


Enhancing / Optimising Fire Safety – Key Points

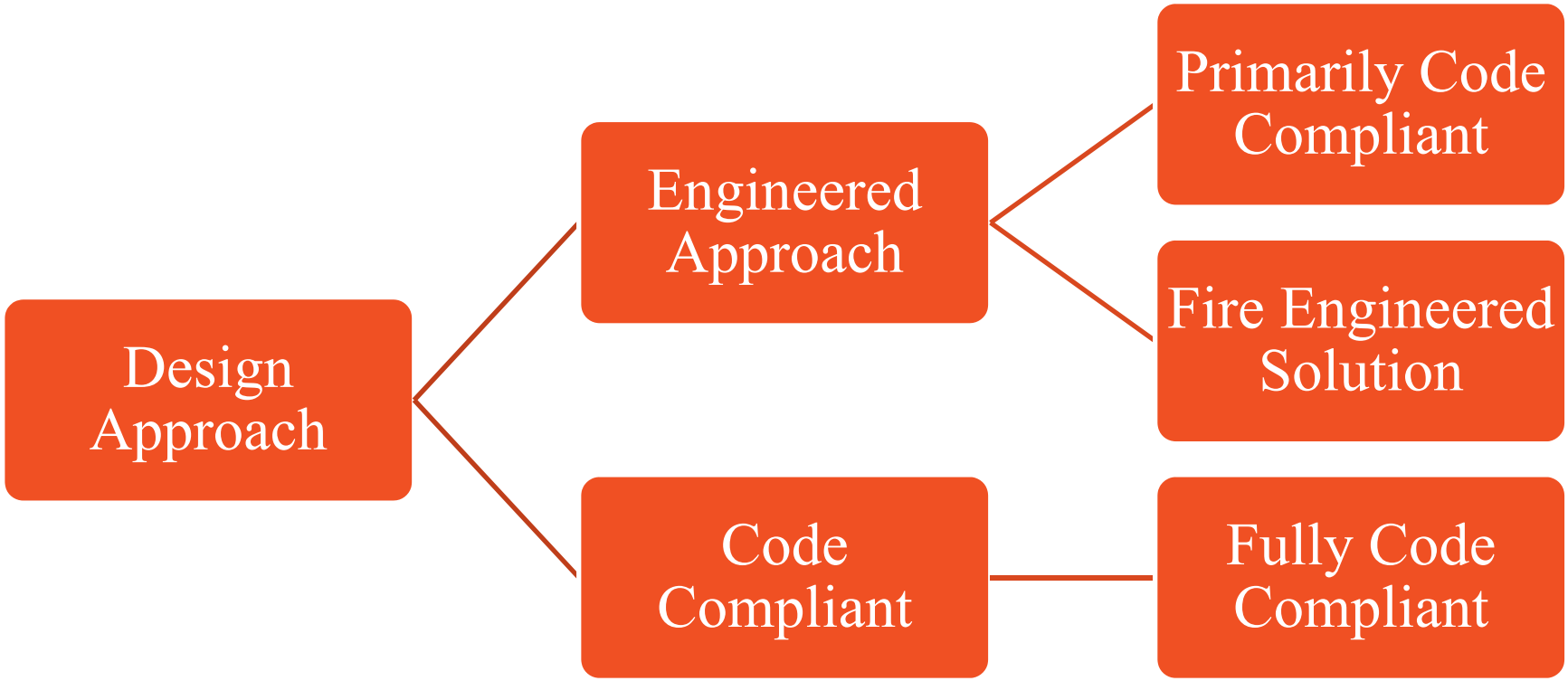
- Operational and business continuity
- Quality and functionality of space
- Enhancing Fire Safety
- Prescriptive solution may not be possible

Establish Framework & Benchmarks for Design

- **Framework – Define Fire Engineering Brief**
  - IFEG
  - SFPE
  - BS 7974



Goals and Objectives



Concept of Equivalency (NFPA 5000)

NFPA 5000:1.5 Equivalency.

1.5.1 General. Nothing in this Code shall prohibit methods of construction, materials, and designs not specifically prescribed in this Code where equivalent alternatives are approved by the authority having jurisdiction (AHJ).

1.5.2 Approval of Alternatives. Alternative systems, methods, or devices approved as equivalent by the authority having jurisdiction shall be recognized as being in compliance with this Code.

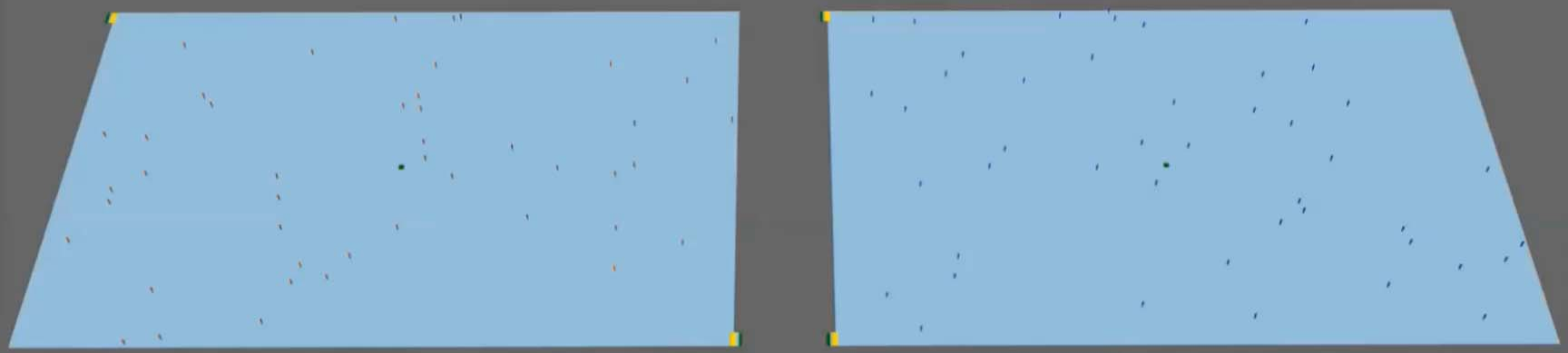
Concept of Equivalency

Code Compliant Scenario

Room: 130m x 80m = 10,400m²
10,400m² @ 9.3m²/pers = 1,120 ppl
Exit capacity = 1,120 x 5mm = 5.6m
Total travel distance = 76m

Non Code Compliant Scenario

Room: 130m x 80m = 10,400m²
10,400m² @ 9.3m²/pers = 1,120 ppl
Exit capacity = 1,120 x 5mm = 5.6m
Total travel distance = 135m



Goals and Objectives

Buildings benefiting from this approach include:

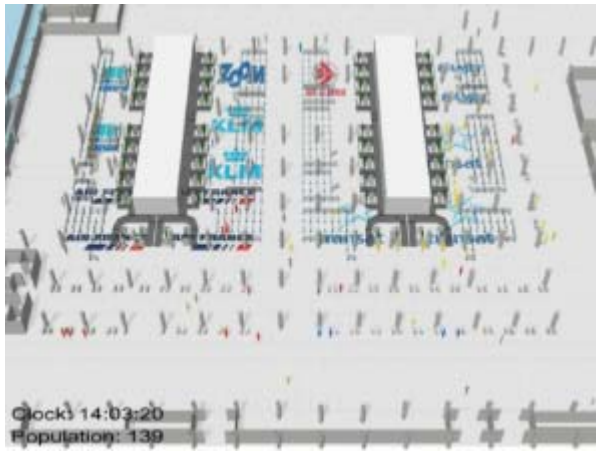
- Airports (Extended Evacuation Time, Business Continuity)
- Public Buildings (Management may wish to remain during fire)
- Heritage buildings (Protection of valuable Assets)
- Train stations (Business Continuity)
- Tunnels (Asset Protection, Business Continuity, Life Safety)
- Power Stations (Societal acceptability)

Alternative Approaches

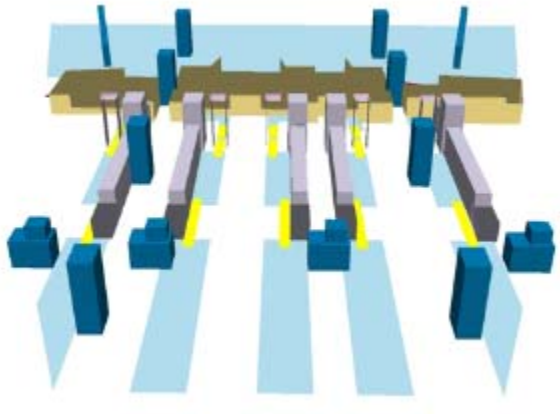
1. Evacuation Modelling

Evacuation Modelling Potential

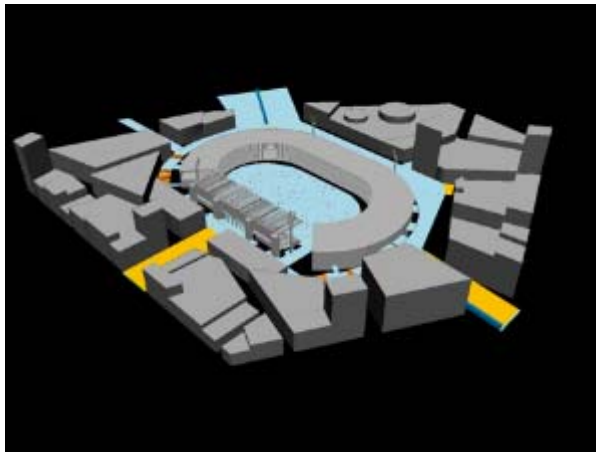
Transport facilities



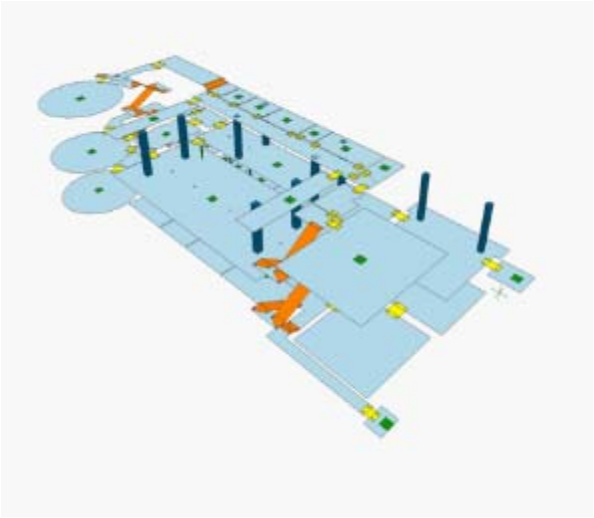
Process modelling



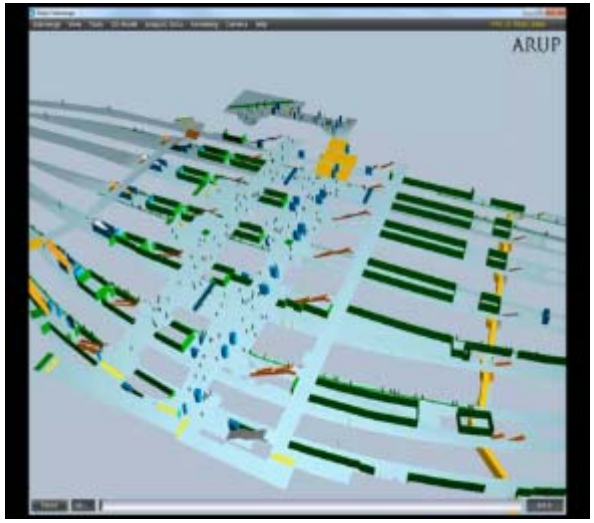
Crowd management



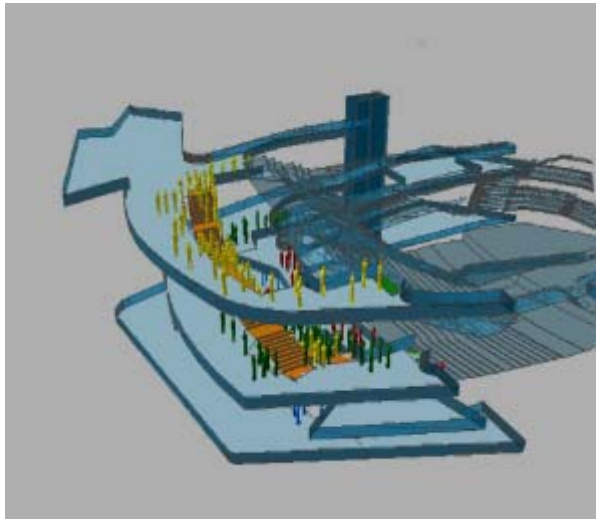
Existing buildings



Live construction environments



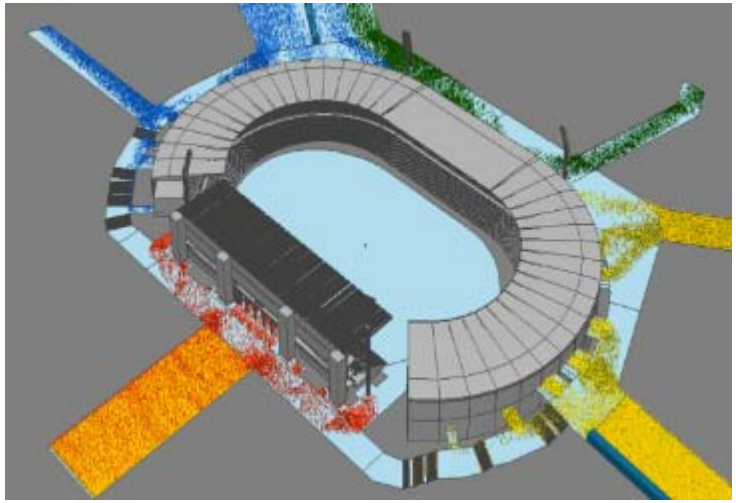
Stadia and venues



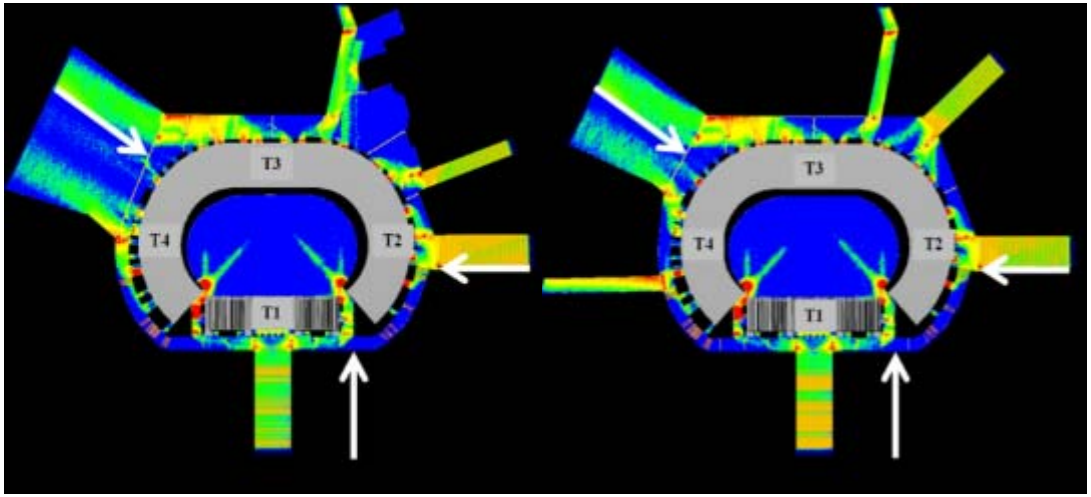
European Stadium – Our approach

Proposed master plan with constrained space

Modelling approach simulated 80,000 persons for a concert mode



MassMotion model visual



Crowd density maps for different phases

Summary of Applications (Fire)

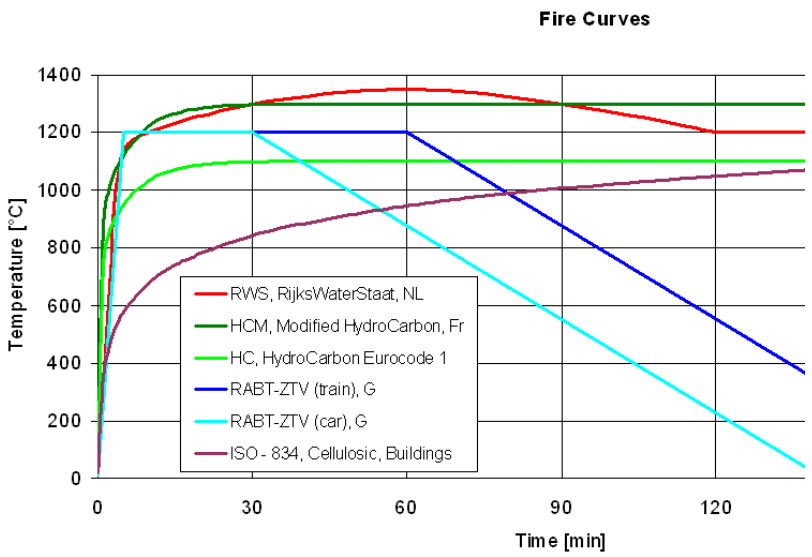
- Large exhibition spaces – Indoor/outdoor events
- Airports
- Construction phasing
- Phased Evacuation/Progressive horizontal Evacuation
- Masterplanning
- Transport facilities – Rail/Underground
- Sports Stadia
- Duplicate Services – Ped Planning, Security etc

Alternative Approaches

2. Structural Fire Engineering Analysis

Structural Fire Resistance

Bored Tunnel Example



Temperature Time Fire Curve

Increased Protection

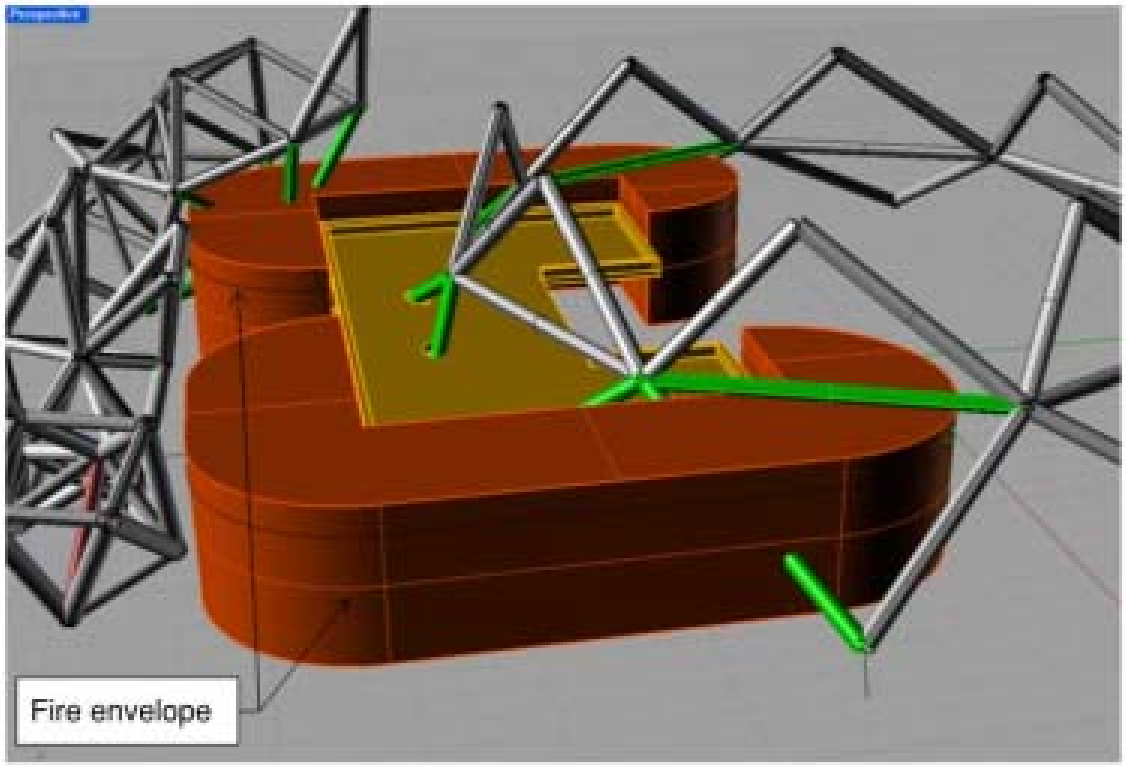
- Fibres to mitigate Spalling
- Consider Temperature-Time Curves
- Increased Fire Resistance may be required

Structural Fire Resistance

Fire Protection to the Structure?

- Common approach in large single storey spaces.
- Common in Airports

Structural Fire Resistance



- Fire load assessment and flame envelope undertaken to determine which members might be affected by a fire.

- Robustness checks done in concert with the ambient structural design team to determine robustness of space frame system.

Alternative Approaches

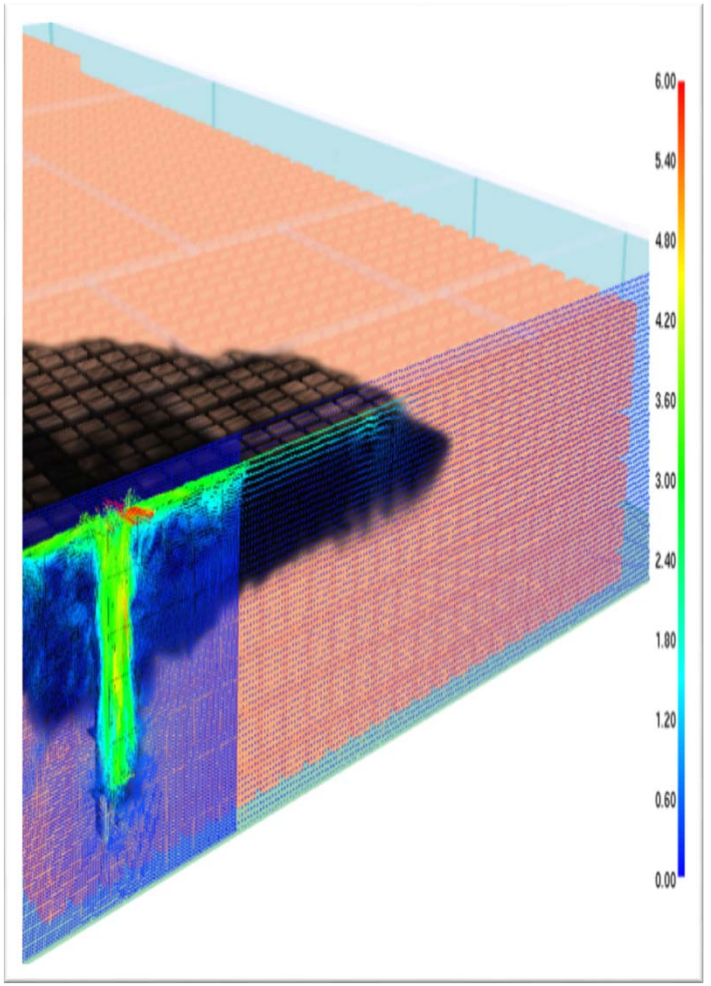
3. CFD Modelling

CFD Modelling

- NFPA Fire Code Recognises the use of CFD modelling for

  specific smoke control purposes.

- CFD modelling can be used for other aspects:
  - Assessment of conditions for evacuation
  - Assessment of thermal conditions in the fire compartment
  - Fire investigations
  - Research (NIST, BRE)



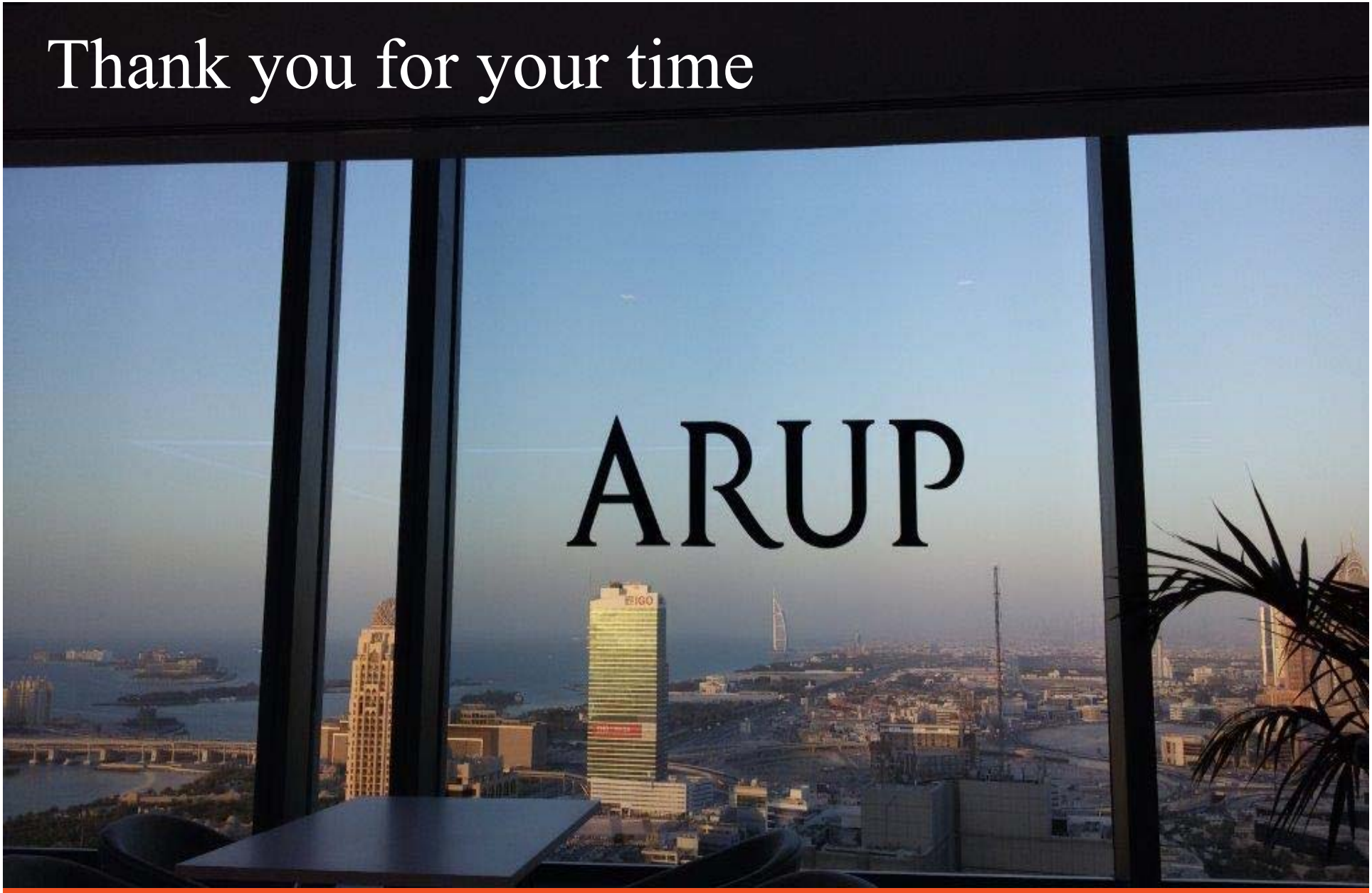
Open planning

- Fire Engineering can help enable Architectural visions towards open plan design
- It is a common Architectural desire to avoid heavy doors and partitions as reasonably feasible.

Concluding Remarks

- **Clearly Define Goals and Objectives**
- **Apply Fire Engineering Framework to Design to meet Goals and Objectives**
- **Example of Tools available to achieve alternative approaches and demonstrate appropriate Level of safety.**
  - Structural assessment tools
  - Use of Computational Fluid Dynamics (CFD)
  - Use of evacuation modelling software

Thank you for your time



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