Fire Spread - The Issues

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Background

- 160 million buildings use over 40% of Europe's Energy

- Produce over 40% of Europe's Carbon Dioxide Emissions

Background

- EU responded with Energy Performance of Buildings Directive requiring
  - A methodology to calculate integrated energy performance of buildings
  - Minimum energy requirements for new buildings
  - Minimum energy requirements for large existing buildings being renovated
  - Energy certification of buildings
  - Regular inspection of boilers and air conditioning

Background

- Driving changes in construction sector
  - Facing challenges
    - *Low environmental impact materials*
    - *Skills shortages resulting for a period of de-skilling (lack of apprenticeships / training schemes for craftsmen)*
    - *Quality issues (lack of knowledge / training)*
    - *Speed/efficiency of construction (build it faster, leaner)*

Background

- Driving changes in construction sector
  - Potential impacts on
    - *Fire performance*
    - *Life safety*
    - *Property protection*

Meeting the Challenges -Sustainability

- Increased use of recycled materials (e.g. mobiles, tyres, pallets, bottles)
- Construction site waste reduction leading to development of better/innovative construction methods/techniques – Modern Methods of Construction (MMC)
- Novel design and use of materials
- Increased thicknesses of insulation to improve energy efficiency

Meeting the Challenges -Sustainability

- The impact of fires on the environment
  - Generation of carbon dioxide, toxic species
  - Pollution of water courses
  - Business interruption
  - Property damage
  - Societal - local community

Fire spread – Timber Frame Issues

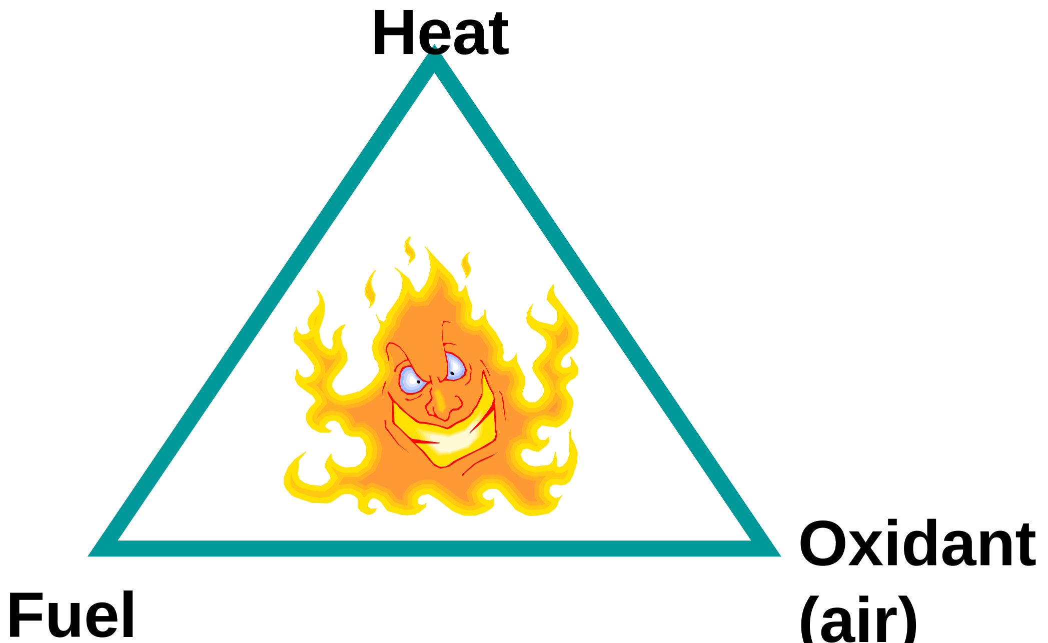
- Fire spread 2 separate issues:
    - *Fire spread during construction*
    - *Fire spread post completion i.e. during occupancy*

Fires during construction – issues arising

- Type of construction
  - frame / panellised
- Material of construction
  - timber / timber + other materials
- Cross section of structural components

Fires during construction – issues arising

- Ignition sources
- Sustained fire propagation



Fires during construction – issues arising

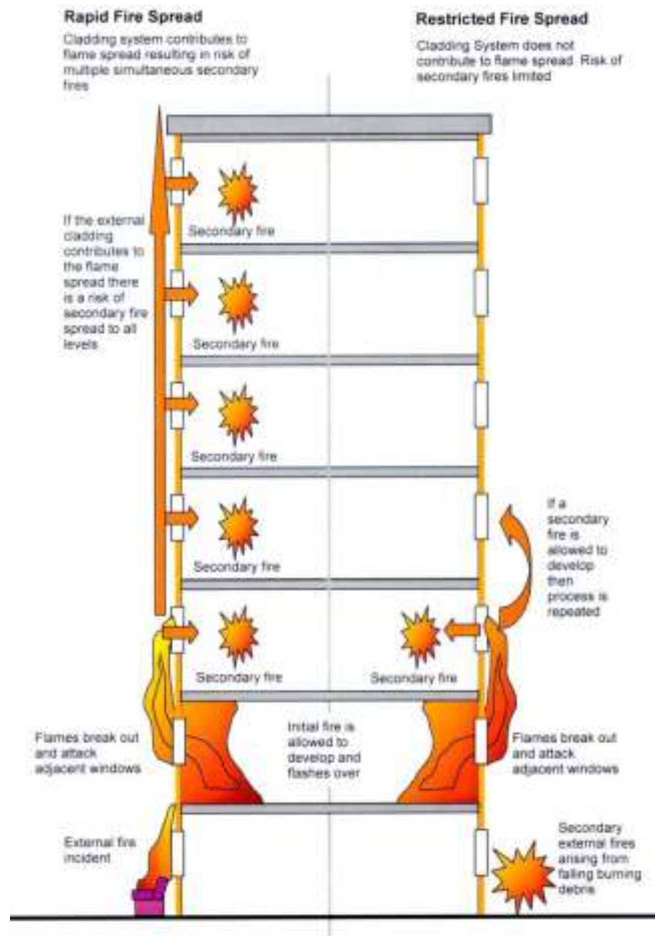
- Speed of fire spread and extent of spread
  - impact on operational fire fighting
- Damage to adjacent buildings
  - level of radiated heat
- Partial occupation of buildings
  - responsible authority (HSE/Fire Service/Building Regs)
- Arson often a factor

Fire Spread & Design Calculations

- Radiation calculations
- Flame shapes/heights
- Flame thicknesses
- Separation distances - Calculations founded on same fundamental understanding of heat transfer as BR 187
- Easy to validate based on real data – i.e. forensic recreation
- Effects such as wind unknown
- Real expertise is needed to predict what will happen

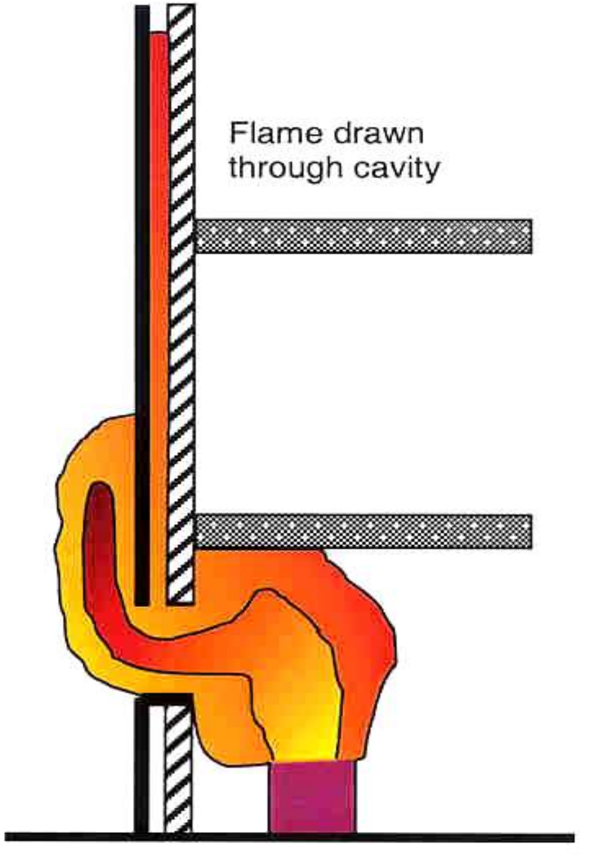
External Fire Spread

- Fires allowed to develop may flash over and break out through windows.
- Flames spread up over or through the cladding.
- Flames can extend over 2m above window opening. Regardless of cladding materials.
- If fire re-enters building secondary fires may then develop

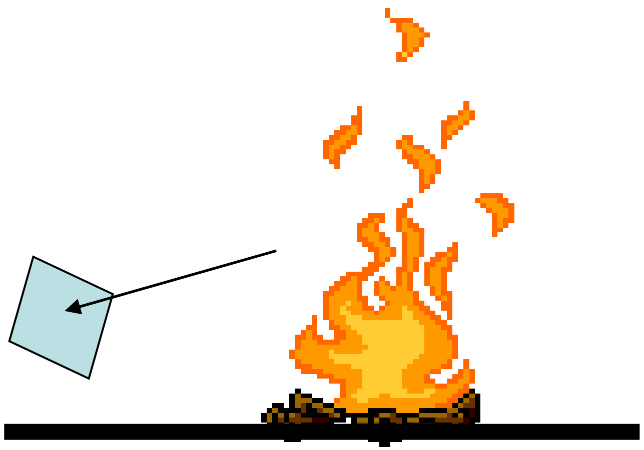


Mechanisms of External Fire Spread

- Combustible materials
- Cavities either
  - Part of system.
  - Created by delamination.
- Flames can extend 5 to ten times original length regardless of materials present.



Radiation from flames



- Calculation of heat flux

$$q'' = \sigma \phi \varepsilon T^4$$

σ = Stefan-Boltzman constant, 5.67×10^{-8} W/m^2/K^4

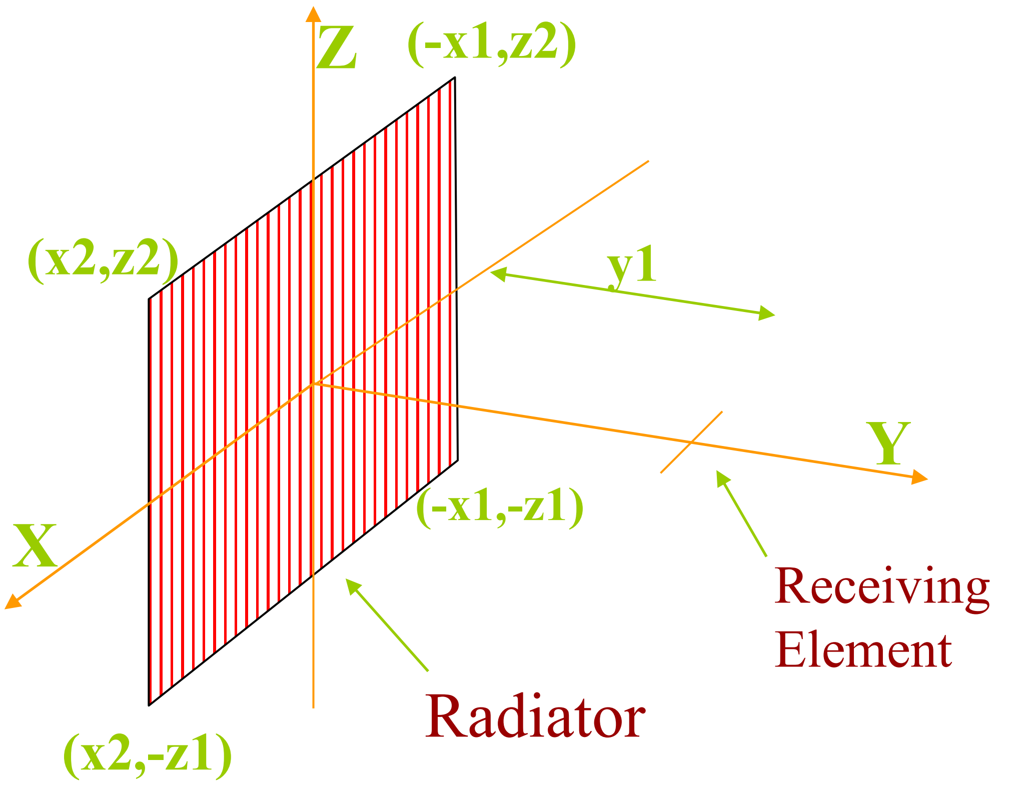
ϕ = View factor (0.0-1.0)

ε = Emissivity (0.0-1.0)

T = Flame temperature (K)

View Factor

Rectangle to parallel receiver



View Factor

$$\phi = \frac{1}{2\pi}\left[\begin{aligned}
&\frac{x_2}{\sqrt{x_2^2+y_1^2}}\left(\tan^{-1}\frac{z_2}{\sqrt{x_2^2+y_1^2}}+\tan^{-1}\frac{z_1}{\sqrt{x_2^2+y_1^2}}\right)+\\
&\frac{x_1}{\sqrt{x_1^2+y_1^2}}\left(\tan^{-1}\frac{z_2}{\sqrt{x_1^2+y_1^2}}+\tan^{-1}\frac{z_1}{\sqrt{x_1^2+y_1^2}}\right)+\\
&\frac{z_2}{\sqrt{z_2^2+y_1^2}}\left(\tan^{-1}\frac{x_2}{\sqrt{z_2^2+y_1^2}}+\tan^{-1}\frac{x_1}{\sqrt{z_2^2+y_1^2}}\right)+\\
&\frac{z_1}{\sqrt{z_1^2+y_1^2}}\left(\tan^{-1}\frac{x_2}{\sqrt{z_1^2+y_1^2}}+\tan^{-1}\frac{x_1}{\sqrt{z_1^2+y_1^2}}\right)
\end{aligned}\right]$$

View Factor

Values are tabulated in:

Fire Research Technical Paper 2

Simplified Approximations

- For building separation calculations are available in BR187
- SFPE Handbook of fire protection engineering

Emissivity

Quantifies the "transparency" of the flame

$$\varepsilon = 1 - \exp\left(-k\lambda_f\right)$$

k = effective emission coefficient (m^{-1})

λ_f = thickness of the flame (m)

For flame thicknesses greater than 1m then it is common to assume emissivity = 1.0

Flame temperature

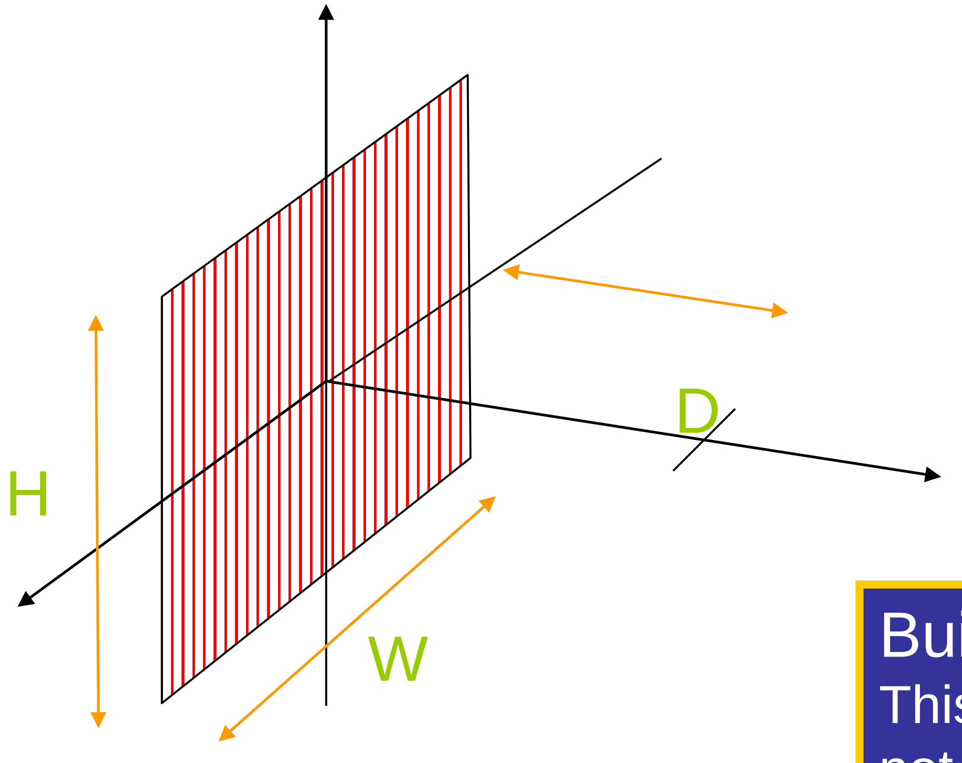
- BR187
  - High fire load (>25kg/m²) T = 1100° C
  - Low fire load (<25kg/m²) T = 800° C

Temperature('C)	colour
550	Red glow
700	Dull red
900	Cherry red
1100	Orange
1400	White

From Drysdale

Heat flux from a hot surface

- Specify size of surface, temperature and emissivity



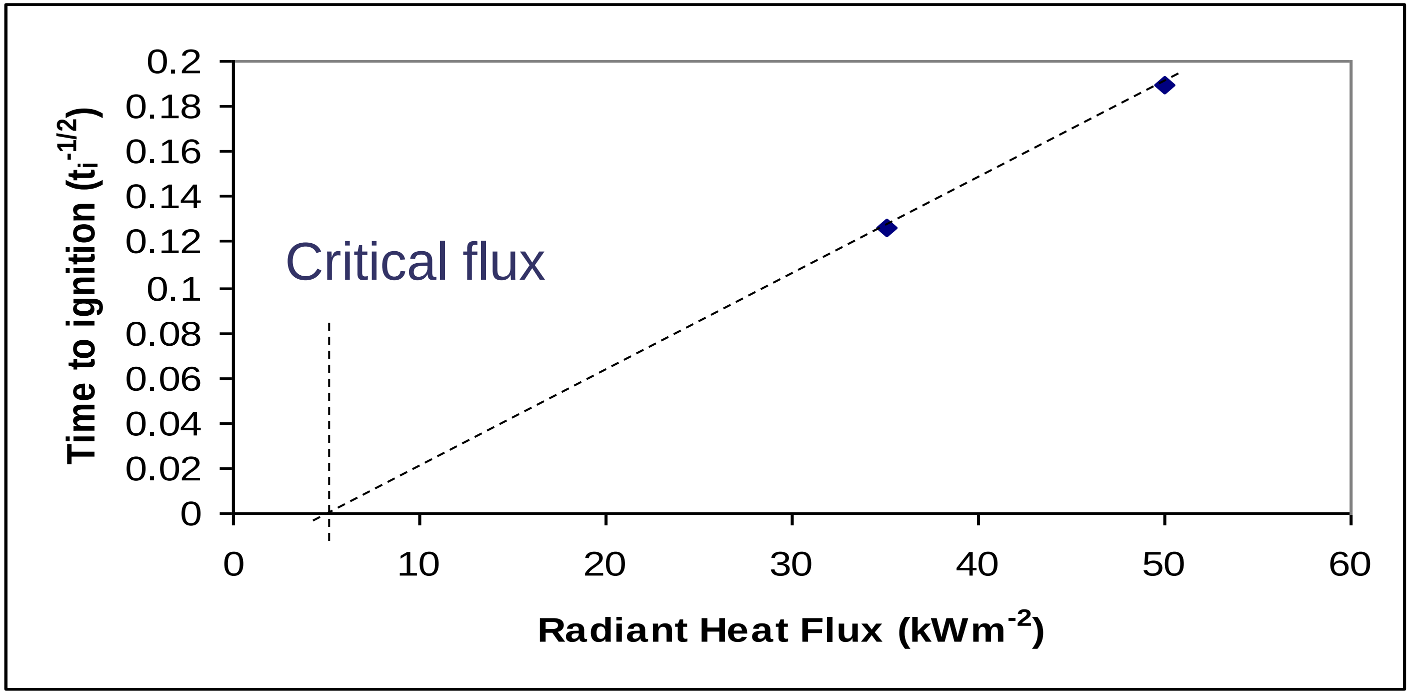
Building Separation:
This calculates separation distance not boundary distance

Effects of thermal radiation

Heat flux (kWm^{-2})	Effect	Source
0.6	Summer sunshine (UK)	1
10.5	Pain after 3s	1
12.6	**Pilot ignition of wood**	**1**
42.0	Ignition of cotton fabric(5s)	1
52.5	Ignition of fibre board (10s)	1
54.6	Ignition of oak (10s)	1
21	Ignition of PMMA (pilot)	2
16	Ignition of Flexible PUF (pilot)	2

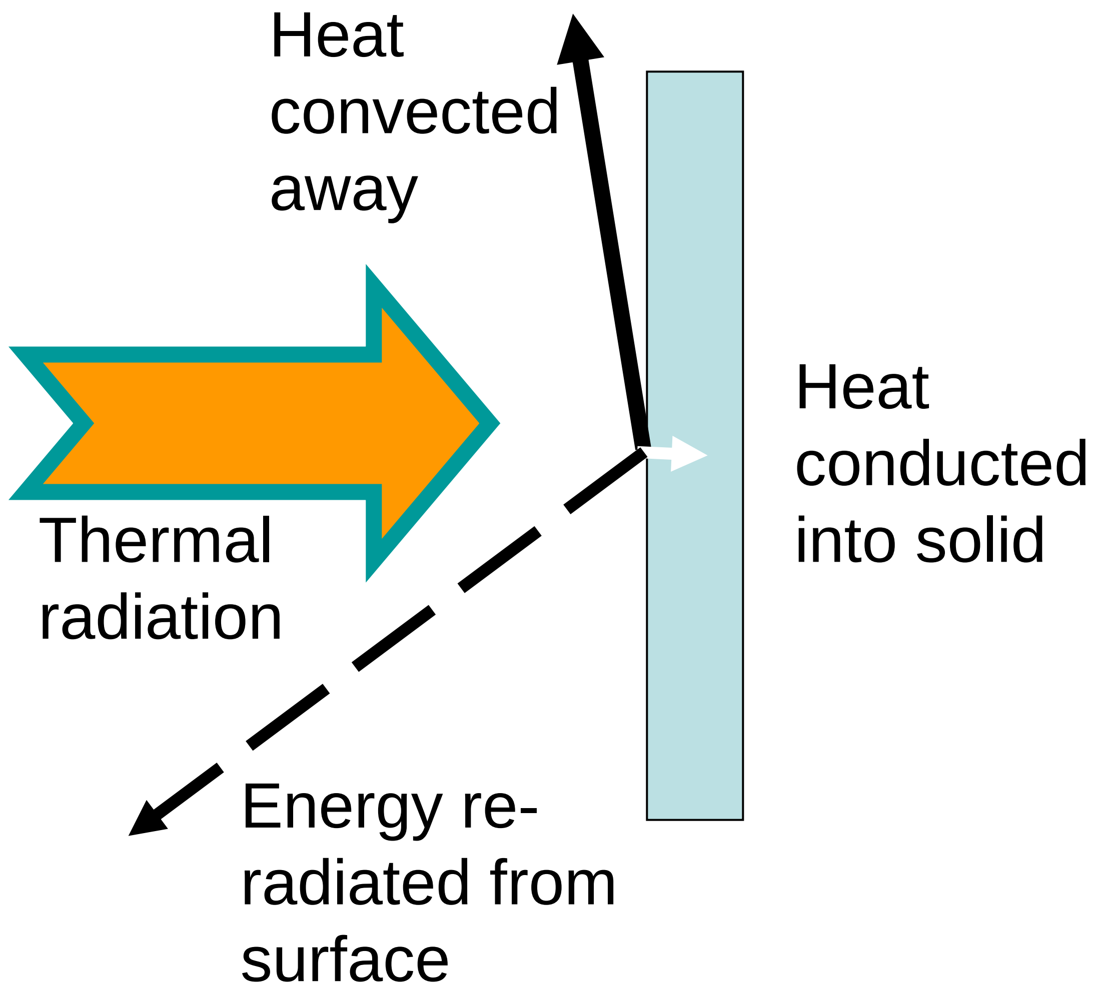
1. ‘Fire and the Atomic Bomb’ (HMSO 1954)
2. ‘Fire dynamics’ Drysdale

Critical flux for ignition



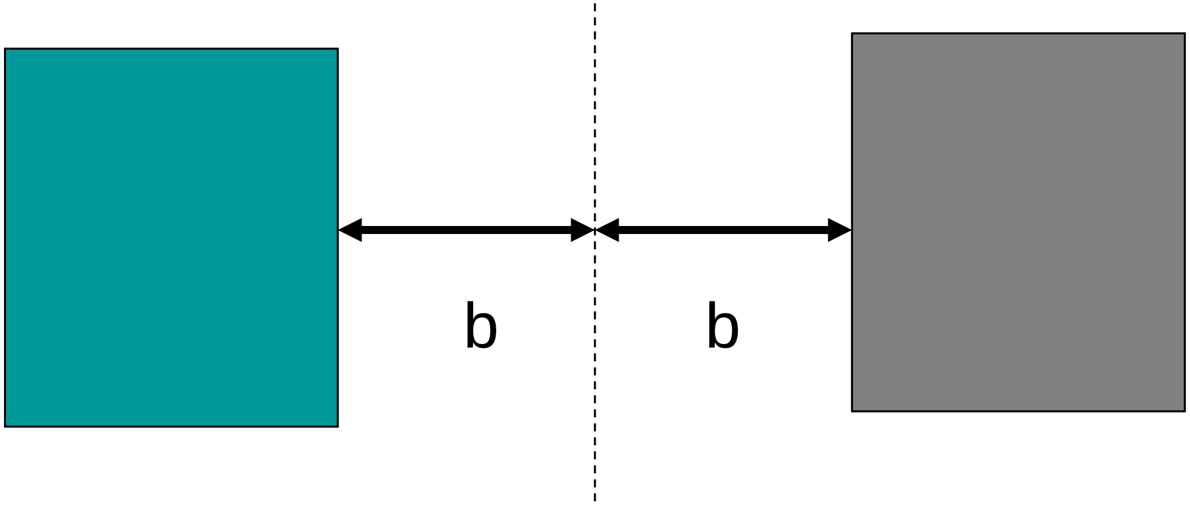
- Plotting (1/time to ignition)$^{1/2}$ against heat flux shows a value below which ignition does not occur

Heating of objects by thermal radiation



Building Separation – Technical Standards

- Assumes buildings each side of boundary are identical



- Tables give distance to BOUNDARY (b)
- Calculations give distance between BUILDINGS (2b)

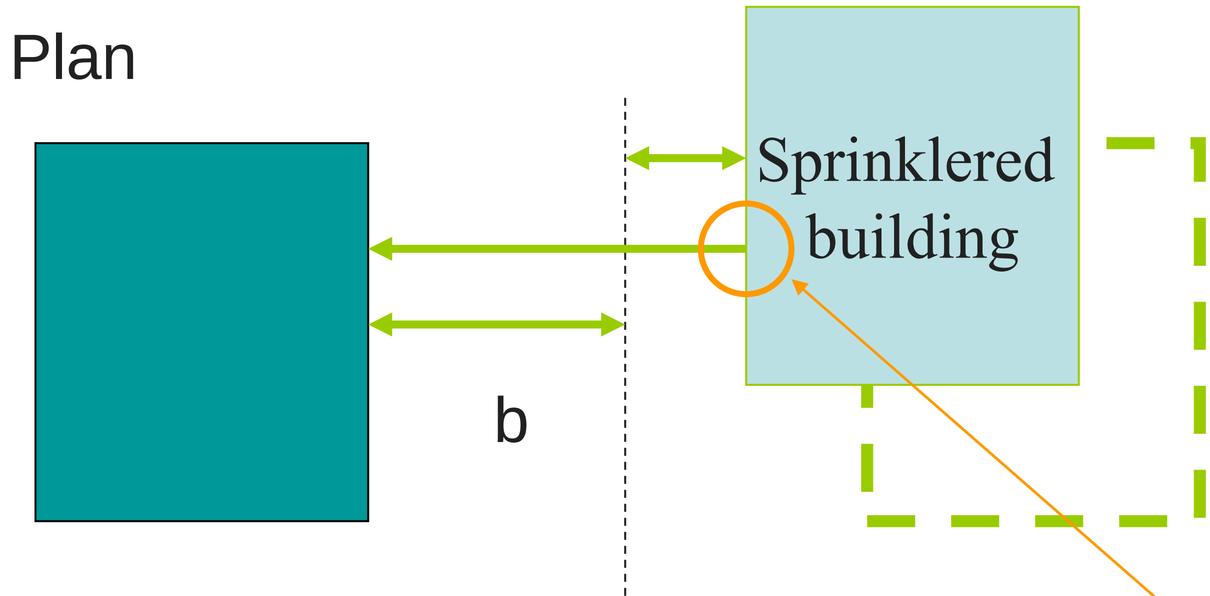
Building Separation - Guidance

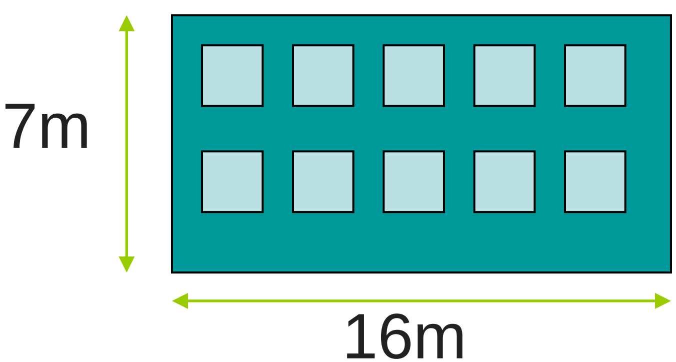
- Boundary distance depends on:
  - Compartmentation
  - Unprotected areas (e.g. windows)
  - Purpose group (fire load, compartment temperature)
  - Installation of sprinklers (halve boundary distance)

- Technical Standard has “simple tables” for small buildings in some purpose groups, other methods are given in BR187

- More complex designs require expert analysis

Building Separation





Windows 2m x 2m
Total area = 40m^2
Unprotected % = 36%
b = 9m (Method 2)

Flux > 12.6 kW/m^2

FIRE SPREAD POST COMPLETION

Common mode of failure

- Cavity fires
  - *Common to all Modern construction methods*
  - *Occurs in combustible cavities*
  - *Cavity barriers and compartmentation not adequate*

Case Study - Apartment building, London

- Small fire in patio area – external wall construction failed to provide adequate resistance to the passage of smoke between apartments and floors.
- Amount of damage out of proportion to the size of the incident

Building regulations compliance or third party certification ?

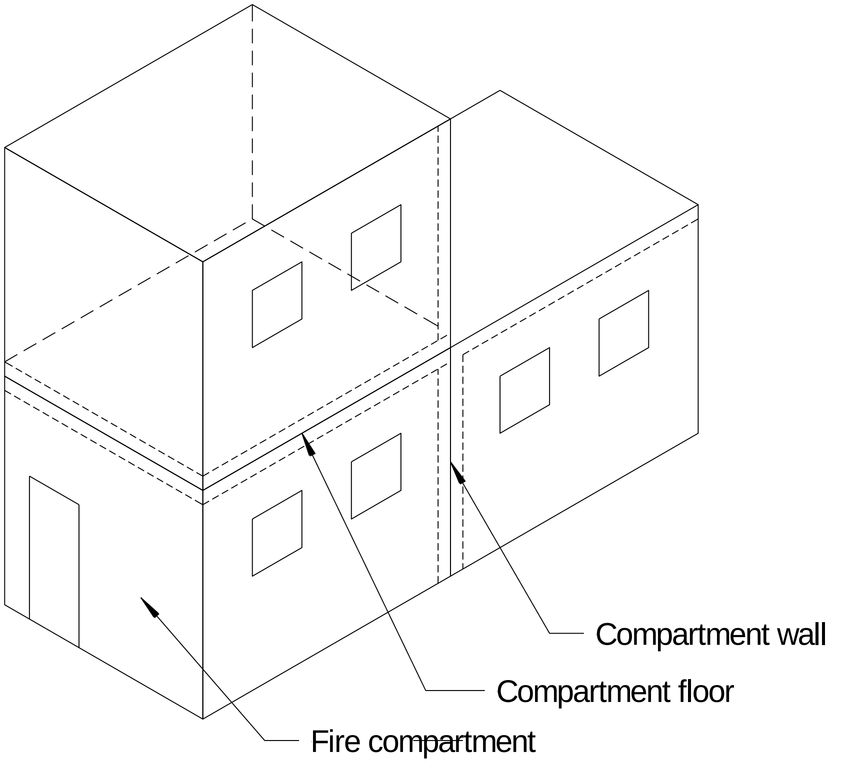
- Fire testing
  - Snap shot of product performance
  - Relates to performance of product as supplied by manufacturer
  - Test report issued
  - Manufacturer's responsibility
- Third party certification or approval is different

What is Approval?

- **Independent** third party confirmation that a product or Service complies and continues to comply with a specific standard through:
  - independent assessment of manufacturing facility and/or processes
  - independent and competent testing/assessment
  - independent review of test results against a technical standard
  - ongoing surveillance of production and assessment of management system
  - ongoing audit sampling and testing

LPS 1501 - Standard for fire performance assessment of MMC

- Assessment for fire performance against LPS 1501



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LPS 1501

- The standard incorporates a large scale fire test to investigate **system** performance in relation to structural behaviour and fire spread between units including the performance of fire stopping and cavity barriers

Why test at full scale?

- Relationship between performance in real fires and performance derived from standard fire tests (thermal and structural response)
- Importance of workmanship issues
- Importance of detailing
- Cavity barriers and fire stopping
- Impact of thermal insulation requirements (creation of unstopped cavities)
- Alternative load carrying mechanisms and alternative modes of failure

Why test innovative building systems at full scale?

- No historical database available to assess performance
- Previous experience with system built housing
- Possibility of systematic faults
- Use of new materials (in particular increasing use of highly insulating combustible materials)
- Housing systems designed for purpose to limit state principals – levels of safety unknown
- Possibility of disproportionate damage

Installation

- Best product in the world can perform poorly in a fire if not installed properly
- Concerns have led to development of installers schemes for (often driven by manufacturers with approved products);
  - Suppression systems (sprinklers, gaseous)
  - Detection systems
  - Passive fire protection systems e.g. LPS 1531 for installers of LPCB approved products (to LPS 1181 and LPS 1208 (fire resistance/compartmentation))

Proposition

bretrust

- BRE Trust (the charity that owns BRE Group and invests funds in research) is prepared to contribute funding towards a project to carry out research to identify the real issues associated with timber-frame during construction fires AND fires in post occupancy buildings

- Project will enable robust assessment of proposed mitigation measures.

- BRE Trust is looking for stakeholder partners to collaborate in this project by contributing cash and contributions in kind

Summary

- Climate change issues driving changes in the construction sector
- These changes are challenging our regulatory test methods developed for traditional construction products and methods
- Material and component testing of products is not necessarily adequate for controlling the hazards
- System test methods are in development for providing data relevant to end use
- Third party certification is being used to fill this gap and improve market confidence
- Costs for the manufacturer/producer so must be relevant and justifiable

Summary

- The importance of installation is becoming more widely recognised and understood
- Approved installers are being required by major contractors
- Traceability of MMC in dwellings is recognised as important but requires engagement/commitment of Key Stakeholders
- The BRE Trust is commissioning BRE Global to carry out much needed research – other partners are being sought

Thank you

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