External fire spread and building separation distances

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Richard Chitty
Fire Safety Team, BRE Global
The Great Fire of...

Many cities have had one or more Great Fires

See http://en.wikipedia.org/wiki/List_of_fires (list of several hundred examples!)
Common factors

- Narrow streets
- Combustible building materials
- Hazardous activities involving fires or combustible materials
- Regulations not enforced
Fire spread between buildings

- How much radiation leaves the burning building?
- How much radiation is received by the adjacent building?
- How much radiation is needed to ignite items on the adjacent building?
Measures to reduce fire spread between buildings during World War II.

Tables and charts were developed to find percentage of windows that need to be bricked up to prevent fire spread between buildings.
Building Separation Requirements
1950 onwards

- National Building Studies continued to apply a scientific approach to understanding fire spread between buildings by thermal radiation.
  - “*Despite the importance of the subject, its fundamental aspects do not appear to have received previous attention*”

- Highlighted a need for:
  - More data on radiation from flames
  - A better understanding of how materials ignite
  - Ways to calculate heat transfer by radiation
Building Separation Requirements
1950 onwards

- Fire Research Station 1947-1960
  - Developed controlled sources of thermal radiation
    - Gas panels
    - Arc lamps
    - High speed shutters
  - Instruments to measure thermal radiation

- Experimental and theoretical studies of ignition and fire spread
- Measurements of thermal radiation from enclosures

- Methods to find view factors for thermal radiation heat transfer calculations
Practical Guidance

- Heat radiation from fires and building separation
  - Margret Law Fire Research Technical Paper 5 1963

- Fire and the External Wall
  - Gordon Langdon-Thomas and Margret Law Fire Note No 8 1966
Building Standards (Scotland) Regulations 1963

- Included details Technical Paper 5 and Fire Note 8 to determine boundary distances or maximum unprotected areas

- Later included in Regulations for England and Wales

- One of the first applications of “Fire Safety Engineering”
Current situation – Functional Requirements

Building Regulations 2000 (as amended)

Requirement B4 (1)

*The external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard for the height, use and position of the building.*

Requirement B4 (2)

*The roof of the building shall adequately resist the spread of fire over the roof and from one building to another, having regard for the height, use and position of the building.*
Current situation - Guidance

- Guidance to the building regulations (Approved Document B, Fire safety) provides simple tables but refers to BRE Report BR187 ‘External fire spread: building separation and boundary distances’ if more precise methods are required.

- Similar guidance is given in the Scottish Technical handbooks.

- BR187 (1991 & 2014) presents
  - Enclosed rectangles method (tables)
  - Aggregate area method (protractor)
  - Simplified calculation
  - Technical background by reproducing a 1965 report
  - Updated 2014
Recent Research

– As part of a recent DCLG project dealing with Compartment sizes, resistance to fire and fire safety BRE Global have undertaken research space separation
Compartment temperature

- Opening: 1.5m by 1m high
- Three insulation levels
  - 1: Very high
  - 2: High
  - 3: Low

- **Fire load 570MJ/m²** (80% Fractile for Offices from BS7974-1:2003)
- Residential, office or assembly and recreations purpose group; assumes radiation intensity at each unprotected area is 84 KW/m²
# Insulation levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Relative degree of insulation</th>
<th>Construction</th>
<th>Thermal properties</th>
<th>Compartment b value (J/m²s½K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Low</td>
<td>Walls: block work no lining</td>
<td>Conductivity 1.04 W/mK Thermal inertia 1500 J/m²s½K</td>
<td>1430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof: beam and block floor (concrete) no lining</td>
<td>Conductivity 1.04 W/mK Thermal inertia 1500 J/m²s½K</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Floor: sand</td>
<td>Conductivity 1.0 W/mK Thermal inertia 1185 J/m²s½K</td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>High</td>
<td>Walls: block work and plasterboard</td>
<td>Conductivity 0.24 W/mK Thermal inertia 520 J/m²s½K</td>
<td>666</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof: concrete lined with plasterboard</td>
<td>Conductivity 0.24 W/mK Thermal inertia 520 J/m²s½K</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Floor: sand</td>
<td>Conductivity 1.0 W/mK Thermal inertia 1185 J/m²s½K</td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td>Very high</td>
<td>Walls: Block work lined with ceramic fibre</td>
<td>Conductivity 0.02 W/mK Thermal inertia 54 J/m²s½K</td>
<td>156</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof: Concrete lined with ceramic fibre</td>
<td>Conductivity 0.02 W/mK Thermal inertia 54 J/m²s½K</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Floor: Plasterboard</td>
<td>Conductivity 0.24 W/mK Thermal inertia 520 J/m²s½K</td>
<td></td>
</tr>
</tbody>
</table>
Radiation intensity measurements

- Heat flux meter 1: Unshielded
- Measures radiation from window and external flames
Radiation intensity measurements

- Heat flux meter 2: Shielded
- Measures radiation from window only
Radiation intensity measurements

- Heat flux meter 1 : Total radiation intensity
- Heat flux meter 2 : Radiation intensity from opening
- Difference (1-2) : Radiation intensity from external flames

- Wood and PMMA targets at 2m and 3m from opening

- Calculated separation distances:
  - Reduced fire load 1.5m (2m from tables…rounds up)
  - Standard fire load 2.5m (2m from tables…rounds down)
Experiments 1 to 3

Compartment temperature

Temperature (°C) vs. Time (min)

- Very high insulation
- High insulation
- No insulation
- Standard FR test
- Hydrocarbon FR test
Radiation measurements at 4m

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Maximum radiation intensity measured at 4m</th>
<th>Calculated maximum radiation intensity at 2m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.6</td>
<td>38.4</td>
</tr>
<tr>
<td>2</td>
<td>11.8</td>
<td>42.5</td>
</tr>
<tr>
<td>3</td>
<td>4.0</td>
<td>14.5</td>
</tr>
</tbody>
</table>
## Experiments 1 to 3

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Time to flashover</th>
<th>Maximum temperature</th>
<th>Maximum radiation intensity at 4m</th>
<th>External flaming</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8 min</td>
<td>1296°C @45 min</td>
<td>10.6 kW/m²</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>10 min</td>
<td>1170°C @ 40 min</td>
<td>11.8 kW/m²</td>
<td>Some</td>
</tr>
<tr>
<td>3</td>
<td>23 min</td>
<td>850°C @ 35 min</td>
<td>4.0 kW/m²</td>
<td>A little</td>
</tr>
</tbody>
</table>
Work stream 6 Experiments - Summary

Increasing compartment insulation:
- Decreases time to flashover
- Increase compartment temperature
- Increases external flaming
- Increases radiation intensity from unprotected areas

- Confirms boundary distances for low levels of insulation
- Buildings with high levels of insulation may have high compartment temperatures during a fire
  - $\approx 1150^\circ$ C from Experiment 1
  - To meet current hazard criteria (12.6kWm$^2$ on adjacent building) would require:
    - Increased boundary distance
    - Reduced unprotected area
Impact on AD B

\[ U_{High} = U_{Low} \frac{T_{Low}^4}{T_{high}^4} \]

If \( T_{Low} = 1040^\circ C \) (1313K) and \( T_{high} = 1150^\circ C \) (1423K) then

\[ U_{High} = 0.72U_{Low} \]

Calculation methods need modification to include impact of high building insulation
Conclusions

– The Past
  – Does the history of regulations matter?
    • Yes.
      – Current regulations inherit features from the past
      – Have we forgotten the assumptions used by the current methods?
      – Many existing buildings were build using older guidance. Will there be conflicts if a neighbouring building is built using newer guidance?

– The Present
  – Separation distances for highly insulated buildings may be too low to prevent fire spread between buildings
  – Effects may be mitigated by:
    • More robust windows (double glazed)
    • Smaller windows (energy conservation)