Shopping Centre Case Study –
SFPE United Kingdom Chapter

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The U.K. Team

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RIBA Plan of Work

RIBA Stage 2 – The Fire Engineers deliverable:

• **Provide advice** to the design team on items relating to the fire safety design of the building
• **Concept fire strategy report** – largely visual in format to build on feasibility report at previous stage
• **Identify fire safety goals** and requirements as set out by the client and insurers
• **Identify risks and opportunities** – understood going into Planning stages
Design Goals

Legislative:
A design that complies with:
- *Part B of the Building Regulations (2010) - England*
- constructed and managed in accordance with *Construction Design Management Regulation (2007) and the Regulatory Reform (Fire Safety Order) 2005*

Design team:
- Reduce the risk associated with the approvals process
- Provide sufficient information and options to allow the client to undertake review before moving to developed design stage (RIBA stage 3)

Client:
- Flexibility for future shop unit size change
- Flexibility for tenant fit-out design
- Limit impact of tenant fit-out construction phase on other areas of the mall
- Realistic Managing regime
- Limit smoke damage to the building and its facilities
* The location of the shopping centre determined as “Out of Town” with no significant constraints on access or for fire spread to/from the building.

** Kids Play moved to the ground level (BS 9999)
Design Approach Considerations

UK Design Guidance:

- **BS 9999** – Code of Practice for fire safety
- **BS PD 7974** – Code of Practice - Applications of Fire Safety Engineering (PBD approach)
- **BRE 368** – Design methodologies for smoke and heat
- **TM19** – CIBSE Technical Memoranda – Relationship for Smoke Control Calculations

Qualitative Design Review:

- **BS 7974** provides a performance based framework for an engineering approach to fire safety in buildings
- Framework - review of the *scheme*, identification of any overriding *constraints* and definition of the *design objectives*
### Identify Risk Profile: BS 9999

<table>
<thead>
<tr>
<th>Occupancy characteristic</th>
<th>Fire Growth Rate</th>
<th>Risk Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Occupants who are awake and familiar with the building)</td>
<td>1 Slow, 2 Medium, 3 Fast, 4 Ultra-fast</td>
<td>A1, A2, A3, A4</td>
</tr>
<tr>
<td>B (Occupants who are awake and unfamiliar with the building)</td>
<td>1 Slow, 2 Medium, 3 Fast, 4 Ultra-fast</td>
<td>B1, B2, B3, B4</td>
</tr>
<tr>
<td>C (Occupants who are likely to be asleep)</td>
<td>1 Slow, 2 Medium, 3 Fast, 4 Ultra-fast</td>
<td>C1, C2, C3, C4</td>
</tr>
</tbody>
</table>

### Shopping Centre risk profile

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Risk profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concourse or shopping mall</td>
<td>B2</td>
</tr>
<tr>
<td>Crèche (day care or nursery)</td>
<td>B2</td>
</tr>
<tr>
<td>Office (open-plan exceeding 60 m²)</td>
<td>A2</td>
</tr>
<tr>
<td>Shop sales area</td>
<td>B3</td>
</tr>
<tr>
<td>Restaurant</td>
<td>B2</td>
</tr>
<tr>
<td>Theatre/cinema/concert hall auditoria</td>
<td>B2</td>
</tr>
</tbody>
</table>

#SFPEPBD16
Additional Fire Safety Measures

**BS 9999 Guidance allows to amend provisions if systems/architecture installed is considered an additional fire safety measure:**

- **Sprinklers** ➔ Automatic sprinkler systems can provide an efficient means of fire control within a building compartment. If installed the fire growth rate can be reduced by one level.

- **Automatic Detection** ➔ Where a clear benefit resulting from the addition of detection and warning systems is demonstrated, a 15% increase in allowable travel distance and a 15% reduction in door width, corridor width and stair width can be applied.

- **Ceiling Heights** ➔ Rooms with high ceilings have a greater capacity to hold smoke and delay the time taken to fill with smoke to a level that affects escape.

<table>
<thead>
<tr>
<th>Room Height (m)</th>
<th>Maximum permissible increase in travel distance and reduction in door width, corridor width and stair width All risk profiles except Risk profiles A4, B4 and C4, which are “Not Allowable”</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;4, ≤5</td>
<td>10 %</td>
</tr>
<tr>
<td>&gt;5, ≤6</td>
<td>15 %</td>
</tr>
</tbody>
</table>

These values can be aggregated up to a maximum of 25% reduction in stair width.
## Minimum vs. Additional Fire Measures

### Example: Door widths for Shopping Centre

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Risk Profile</th>
<th>Management Level</th>
<th>Single Direction (m)</th>
<th>Multiple Directions (m)</th>
<th>Fire Alarm</th>
<th>Door Width (mm/person)</th>
<th>Door Width (mm/person) *additional measures considered</th>
<th>Stair Width (mm/person)</th>
<th>Absolute Minimum Stair Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concourse or shopping mall</td>
<td>B2</td>
<td>2</td>
<td>20</td>
<td>50</td>
<td>M</td>
<td>4.1</td>
<td>3.3</td>
<td>3.4</td>
<td>1100</td>
</tr>
<tr>
<td>Crèche (day care or nursery)</td>
<td>B2</td>
<td>2</td>
<td>20</td>
<td>50</td>
<td>M</td>
<td>4.1</td>
<td>3.3</td>
<td>3.4</td>
<td>1100</td>
</tr>
<tr>
<td>Office (open-plan exceeding 60 m²)</td>
<td>A2</td>
<td>2</td>
<td>22</td>
<td>55</td>
<td>M</td>
<td>3.6</td>
<td>3.0</td>
<td>3.25</td>
<td>1000</td>
</tr>
<tr>
<td>Shop sales area</td>
<td>B3</td>
<td>2</td>
<td>16</td>
<td>40</td>
<td>L2</td>
<td>6</td>
<td>5.3</td>
<td>5.3</td>
<td>1100</td>
</tr>
<tr>
<td>Restaurant</td>
<td>B2</td>
<td>2</td>
<td>20</td>
<td>50</td>
<td>M</td>
<td>4.1</td>
<td>3.3</td>
<td>3.4</td>
<td>1100</td>
</tr>
<tr>
<td>Theatre/cinema/concert hall/auditoria</td>
<td>B2</td>
<td>2</td>
<td>20</td>
<td>50</td>
<td>M</td>
<td>4.1</td>
<td>3.3</td>
<td>3.4</td>
<td>1100</td>
</tr>
</tbody>
</table>
Example of Egress Calculations – Mall Area

BS 9999 provides guidance:
1. Projected occupant load
2. Horizontal Evacuation
   • Number of exits
   • Travel distance (1 way and 2 way)
   • Door Exit width (mm/person)
3. Vertical Evacuation – simultaneous
   • Total exit per level (mm/person)

Example: Level 3 – Simultaneous Evacuation

<table>
<thead>
<tr>
<th>Occupancy Capacity (people)</th>
<th>5709</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Door Exit Width (m)</td>
<td>(5709*5.3/1000) 18.84m</td>
</tr>
<tr>
<td>Average Width for 5 Exits (m)</td>
<td>(18.84/5) 3.77m</td>
</tr>
<tr>
<td>Total Stair Width (m)</td>
<td>(5709*3.4/1000) 19.41m</td>
</tr>
<tr>
<td>Average Stair Width for 5 Exits (m)</td>
<td>(19.41/5) 3.88m</td>
</tr>
</tbody>
</table>
Internal Fire Spread

Internal Linings

<table>
<thead>
<tr>
<th>Location</th>
<th>UK National Class (tested to BS 476: Part 6 and 7)</th>
<th>European Class</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small rooms of area not more than 30m²</td>
<td>3</td>
<td>D-s3, d2</td>
<td>timber with a density greater than 400kg/m², timber particle board or glass reinforced polyesters</td>
</tr>
<tr>
<td>Other rooms</td>
<td>1</td>
<td>C-s3, d2</td>
<td></td>
</tr>
<tr>
<td>Other circulation spaces</td>
<td>0</td>
<td>B-s3, d2</td>
<td>concrete, ceramic tiles and plasterboard</td>
</tr>
</tbody>
</table>

Structural fire protection

All elements of structure provided with a period of fire resistance of **60 minutes**

Per BS 9999 → sprinklered retail or assembly building (top occupied story does not exceed 18m)

Sprinkler Protection:

- Fast response sprinkler heads (RTI 50, activation temperature 68°C)
- Sprinklers provided at false ceiling level and under floor slab (within ceiling void) → *ceiling void must remain fuel sterile*
Compartmentation Principles

Compartmentation within shopping mall building (excluding fire fighting shafts) →

60 minutes fire resisting construction (Integrity, Insulation, load bearing where appropriate) – per BS9999

Compartment walls located:
• between the retail units
• between the retail units and the Cinema.

** Fire resisting construction not required for adjacent shop front

Compartment floors located:
• between the retail units and any food and beverage units.
• between the retail units and the Cinema.

*All service penetrations through fire compartment walls should be adequately fire stopped/sealed to maintain the fire integrity of that wall.*
Smoke Control Strategy

• Mechanical smoke extraction within false ceiling void
• Downstand arrangement around all smoke zones to create reservoir

Section View

1. Smoke barrier (down-stand) located around the perimeter of each smoke zone
2. Perforated ceiling must be at least 25% open (aerodynamic free area)
3. Sprinkler pendant must be located below the perforated ceiling and within the ceiling void
4. Location and number of exhaust fans to be specified based on plugholing calculations
5. Exhaust duct located within false ceiling, to exhaust smoke directly outside the building
Smoke Control Zone Strategy

Zoning Strategy:
- Shop units > than 1300m²
- Shop units < 1300m² share smoke extraction system (shared ceiling void / smoke reservoir)
- Mall circulation space (zones can not exceed 1300m² or 60m in width)

- Smoke Zone Key
  - = Smoke zone defined per shop (individual shop greater than 1300m²)
  - = Smoke zone defined per multiple shops (ceiling plenum is shared between shops)
  - = Smoke zones within mall circulation space
  - = Atrium smoke control zone from roof level

*Smoke Zone principles described in Section XX
Design Fire Scenarios

<table>
<thead>
<tr>
<th>Design Fire Location</th>
<th>Size and Description</th>
</tr>
</thead>
</table>
| Fire in Shop (ground floor) | • Fuel load – retail items  
  • Fast response sprinkler  
  • 2.5MW used per BRE 368 |
| Fire in mall circulation space (ground floor) | • Fuel load – Kiosk (2x2m)  
  • Fast response sprinkler  
  • 2.5MW used per BRE368 (625kW/m2) |
| Fire in Atrium 2 (ground floor) | • Fuel load – Christmas tree  
  • 5MW used per BRE design fire guidance |
| Fire in Atrium 3 (ground floor) | • Fuel load – Kiosk (2m x 2m)  
  • Fire within void  
  • 2.5 MW used per BRE368 (625kW/m2) |
Shop Unit Smoke Control – Mechanical Exhaust

**Shop unit design:**

- Design Fire size – Retail shop (2.5MW)
- Mechanical extraction sized for 12.1 m³/s, to maintain clear layer above 4m in height (within ceiling void)
- Make-up air provided through entrance doors

**Mall circulation design:**

- Design Fire size – Kiosk (2.5MW)
- Mechanical extraction sized for 12.1 m³/s, to maintain clear layer above 4m in height (within ceiling void)
- Make-up air provided through power open final exit doors on ground level
Atrium Smoke Control – Mechanical Exhaust

- Design Fire size – Christmas Tree (5MW)
- Mechanical extraction sized for 130 m³/s, to maintain clear layer above 2.5m in height
- Downstand on top level to separate food court from atrium, full height wall to separate cinema and atrium
- Make-up air from final exit doors on ground floor (power open doors)

**BS9999 does not allow an open atrium to exceed 18m in height with fuel load at base**
Atrium Smoke Control — Mechanical Exhaust

Atrium 3 → 4m voids (16m²):

- Mechanical exhaust sized for axisymmetric plume (fire in between voids)
- Plume width considered – potential spill onto level 2 exhausted by local level 2 system

Plume diameter = \(0.5(\text{height above base of fire})\)

Large Dome design:

- BS 9999 requires **smoke clearance system** for fire fighter use after fire event (not for life safety purposes)
- Day-to-day HVAC system requires 4 air change per hour
Fire Fighting Access – Fire Fighting Shafts

Fire Fighting Shaft required *(floor area of greater than 900 m²)*

Fire-fighting shafts to be provided with (BS 9999):

- Minimum Stair width – 1100mm (stair 1 and 4 to be provided with 1800mm)
- No Lift required (less than 18m to top occupied floor)
- Lobby (minimum 5m²)
- Dry rising main (inlet at ground level – 18m from vehicular access point)
- Ventilation (natural and mechanical options)
- Hose distances subject to fit-out
- Compartment walls around FF shaft – 120 minutes

Figure 8 – Examples of protection of the fire-fighting shaft from external fire
Building Management

Define considerations and performance for (per BS 9999):

- Planning for changes
- Resources and authority
- Staff level
- Fire training
- Work control
- Communications and procedure
- Maintenance and testing of fire safety systems
- Liaison with fire service
- Contingency planning

Specifically for the SFPE Shopping Centre:

- Manage fire loading in mall circulation space (kiosk separation distance)
- Manage fuel sterile area (below dome)
- Attend to refuge area communication for *Persons with Restricted mobility*
- Fire Control Centre / fire control panel - to liaise with Fire Service upon arrival
Engineered Solutions - Risks and Opportunities

RIBA design Stage 2 → Offer options for stakeholders to consider for planning (developed design stage)

Sprinkler options in shop units

- Option for shop unit to only provide sprinklers below slab height (within ceiling void) → false ceiling must be 70% open
- Sprinklers must be included at floor slab level (within ceiling void) regardless of suspended ceiling design
- Design fire in retail not based on sprinkler height

Smoke control zoning options:

- Stakeholders to evaluate cost vs. flexibility required for all shop unit smoke zone approach
- Design fire size – further evaluate potential fire load (i.e. kiosk and shop fire)
- Downstand depth – mechanical exhaust sensitive to reservoir depth, possible to increase or decrease to amend exhaust requirements per zone
Thank You!

Questions?