Fire Behaviour in Different Building Types
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Agenda

• Single Storey Steel Frame
• High Rise – Purpose Built – Domestic
• Modern Construction Materials / Methods
• Converted Buildings
• Evacuations
Building design shapes fire development...
Single Storey Steel Frame

- Typically industrial but can also have other applications – supermarkets, sports halls etc.
- Roof has no fire resistance (FR) – designed to collapse inwards. Critical Temp 400-550°C
- Collapse can occur quickly and suddenly (with 15 minutes of full involvement)
- Walls will require FR only if a boundary condition applies (if there is a risk of fire spread to an adjoining building should a wall collapse).
- The boundary condition rule also means that columns and footings designed to resist the force of the collapsing roof pulling them inwards.
- Means that the walls should remain upright when a boundary condition applies.
**Single Storey Steel Frame**

- Brick / block work is often used to provide FR.
- This may be a Dwarf or Dado wall.
- Brickwork / block work suggests that a boundary condition exists; therefore the columns are designed not to collapse.

- Panels or cladding has traditionally been used when there is no FR requirement (some modern panels do have FR properties but not as common).
- Single skin will fail quickly and transfer heat.
- Composite panels have good insulating properties.
- Delamination possible.
- Core may or may not be combustible.
- Fire spread in cores may be undetectable.
- Core produce toxic smoke and flaming droplets.
Single Storey Steel Frame

Portal Frame vs. Trusses

- The structure of trusses (often a lattice) gives greater resistance to twisting. This gives more stability.
- Portal frame designs put more pressure on joints sooner = earlier failure.
Single Storey Steel Frame

Sprinklers

In the UK, you can have a 20,000m$^2$ single storey, non-domestic building or compartment (not exceeding 18m high) before sprinklers are required. Nearly three football pitches.

Many developers keep under this limit but maximise space by putting in mezzanines which can be up to half of the floor area.

Sprinklers remove the need for single storey steel frames buildings to possess FR and resistance to walls overturning. **This is on the assumption that a sprinkler will prevent a fire from spreading and that rafter collapse is unlikely (UNLIKELY NOT ABSOLUTELTY).**

Therefore a failed sprinkler system can mean a high risk scenario.
Single Storey Steel Frame

Possible Fire Behaviour

Factors
- Large open compartment (lots of air)
- ‘Loose’ construction (airflow in and smoke out)
- Early roof failure
- PVC Roof lights designed to fail early to release smoke for escape

Fuel Limited
Fire likely.
(Fire growth dependent on fuel)

+ fire likely to be undetected for some time

Full Developed Fire likely.
- Structural failure of roof
- Integrity of walls?
- Large water requirement
  Area of fire involvement (m²) x 6 = minimum litre/min

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High Rise – Purpose Built – Domestic

Compartmentation separates each flat and level.

<table>
<thead>
<tr>
<th>Fire Resistance – Blocks of flats</th>
<th>Height of Top Floor Above Ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not more than 5m</td>
<td>Not more than 18m</td>
</tr>
<tr>
<td>30 min</td>
<td>60 min</td>
</tr>
<tr>
<td>90 min</td>
<td>120 min (But needs sprinklers as well.)</td>
</tr>
<tr>
<td>More than 30m</td>
<td></td>
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</tbody>
</table>

This will typically be 100mm thick clay brick, concrete brick or block.

Each compartment can be thought of as a concrete box
Fire Behaviour in Different Building Types

GUTTED BY FIRE

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COMPARTMENTATION WARNING

A 60 minute fire wall means that the material has resisted fire for 60 minutes in a lab test. In the real world it may react differently.

Also: compartment barrier damage over time and poor initial construction standards can result in unexpected fire/smoke spread.

Fireflash: Sub-Standard Fire Separation in the Built Environment
High Rise – Purpose Built – Domestic

Internal Compartmentation

- In the flat – will either have:
  - a protected hall (30 minutes);
  - or the flat will not have more than 9m travel distance to the flat entrance;
  - or have an alternative exit.

Therefore each flat will probably either be a small concrete box or have a protected hall in part of a larger concrete box.

Internal layout and openings depends a lot on the occupant.
Internal Compartmentation – Stairs

- Up to four storeys can have a single stair if:
  - Each flat is separated from the stair by a protected lobby or corridor
  - Travel distance does not exceed 7.5m
  - Stairs are protected
  - Smoke control / ventilation

- More than four storeys will have two staircases
  - Stairs will be protected
  - Smoke control in some areas
  - Longer travel distances.

There will be at least two Fire Doors between the stairs and the flat
(until we run hose and let smoke spread)
(would this affect evacuation plans?)
The four storey = two stair rule is not a hard and fast rule.

Beetham Tower in Manchester is a 47 storey mixed used residential and commercial tower with a single stair.

Smoke control, sprinklers in some areas and 2 hour compartmentation in between each flat.
High Rise – Purpose Built – Domestic

External Fire Spread

“external walls are constructed so that the risk of ignition from an external source, and the spread of fire over their surfaces, is restricted, by making provision for them to low rates of heat release”

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Some cladding options include a polystyrene (flammable) core that is rendered to give FR. If the render breaks down – the core is exposed.

This doesn’t mean that external walls are 100% fireproof.
High Rise – Purpose Built – Domestic

External Fire Spread – Coanda Effect

“The tendency of a jet of smoke and hot gases to be drawn back to the buildings surface.”

- Hot gases, flames and smoke drawn back to the face of the building
- Direct heating of spandrel and glazing
- Fire spreads into above compartment
- Effect exaggerated by short steps / balconies

Low pressure area created between the gas plume and the wall
High Rise – Purpose Built – Domestic

External Fire Spread – Balconies

- A grey-area – no specific guidance exists.
- More fires are starting on balconies – people having BBQs, smoking etc.
- Fire tends to spread upwards to the balcony and windows above – although the Coanda effect can be reduced if the balcony is deep enough
- Different linings, claddings, furniture and materials are used to make the balcony more homely – can lead to more developed fires
- Holes in the balcony base (for drains) provides a pathway for spread
- Dropping flaming items can spread fire downwards.

Fire in a 16 storey residential block. Spread attributed to:
- holes in compartmentation of balconies
- Combustible insulating panels used to line the underside of the balconies
- Plastic drain pipes
- Recess behind exterior wall fitted with combustible insulation material.
High Rise – Purpose Built – Domestic

Wind Driven Fire

Once the window is breeched, the external wind can force and pressurise fire spread into the building.

This super oxygenates the fire by mixing up the oxygen into the gases (a pre-mixed gas). This can create conditions for an accelerated flashover.

If an outlet is made (such as a BA crew opening the flat entrance door) the air track is completed and a blow torch effect can occur, advancing towards the outlet with great speed and temperature.

Conditions

+1000°C temperatures
High forces against FF
Unlikely to be able to advance / protect with jets
Water applied turned quickly to steam.
Steam pushed back towards FFs.

Considerations

Do crews need to be committed?
Alternative / suitability of entry points – wind at crews backs.
Covering jets to prevent fire spread.
Anti-ventilation (close doors and windows within compartments).
Modern Construction Materials

Modern techniques are highly insulating and are designed to keep heat and air in. This has two effects:

- Compartments are well insulated and more ‘air-tight’.
- Therefore heat and smoke can be contained within a room.
- Hotter fires.
- Less smoke escaping.
- Smoke banked down – backdraught conditions.
- Conditions less survivable.

Fires are hidden from outside.
TICs less effective.
Development is unknown.
Converted Buildings:

Offices / private houses are converted into care homes / flats. Occupants are a higher risk group than what the building was previously designed for – compartmentation may not be sufficient. Difficult to upgrade – gaps and holes and overall feasibility. Compensatory features – detection and suppression. Have a big effect on EVACUATION STRATEGIES.

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Evacuation:

Evacuation strategy is closely related to compartmentation and detection typically:

Care Home (purpose built):
- Clusters of 10 rooms compartmented.
- ‘Stay put’ often quoted – rarely true. Requires staff member to stay with occupant.
- Really it is progressive horizontal evacuation. Sometimes delayed.

Flats (purpose built):
- Each floor and flat is a compartment.
- Detection in each flat only alerts that flats occupier. This flat evacuates only.
- Other residents not intended to evacuate (– stay put). Doesn’t mean that they wont.

Converted properties may not have the structural provision to allow for these evacuation strategies to be implemented. This may mean that they have a full-evacuation strategy instead – depends on the premises.

Remember: (in non-dwellings), it’s our job to rescue not evacuate
Questions?