High Rise Fire Strategies

ASFP: 13th May 2013

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Contents

• Importance of prevention of vertical fire spread

• Conflict between insulation and safety
Contents

• Importance of prevention of vertical fire spread

• Conflict between insulation and safety

• A robust approach to safety
Part 1

• Importance of prevention of vertical fire spread

• Conflict between insulation and safety

• A robust approach to safety
Typical Fire Strategy Concepts
Typical High Rise Strategy Components
Typical High Rise Strategy Components

- Contain fire:
  - Sprinklers
  - Compartments
Typical High Rise Strategy Components

• Contain fire:
  - Sprinklers
  - Compartments

• Contain smoke
  - Compartments
  - Smoke Control
Typical High Rise Strategy Components

- Contain fire:
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- Prevent collapse
  - Fire resistance
Typical High Rise Strategy Components

• Contain fire:
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• Prevent collapse
  - Fire resistance

• Evacuation
  - Detect and alarm
  - Stairs
  - Evacuate pairs of floors
Typical High Rise Strategy Components

• Contain fire:
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• Prevent collapse
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• Evacuation
  - Detect and alarm
  - Stairs
  - Evacuate pairs of floors

• Fire fighting
  - Provide access
Acceptability through Precedent
Fire Strategy Development

• Build what we want

• Learn from fire incidents and disasters

• Amend legislation and strategies when risk is unacceptable.

• This has led to established fire strategy concepts for:
  - Low rise,
  - Medium rise, and
  - High rise.
Low Rise – 1 to 2 Storeys

- Evacuation possible directly to outside
- Rescue possible from outside
- Collapse not a significant risk
- Fire spread not a significant life risk
- Fire fighting possible from outside

- Limited protection to evacuation routes
- Single stairs permissible
- Limited fire resistance requirements
- Limited compartmentation
- No specific fire fighting provisions
Medium Rise – 3 to 8 storeys

- Evacuation reliance on stairs
- Rescue not possible from outside
- Stability required for a short period
- Fire spread starts to impact on risk
- Fire fighting difficult from outside

- At least two protected stairs
- Medium fire resistance requirements
- Some compartmentation required
- Fire fighting shafts introduced
High Rise – 8+ Storeys

- Prolonged evacuation
- Rescue not possible from outside
- Stability required for a long period
- Risk associated with vertical
- Fire fighting difficult from inside

- Phased evacuation strategy
- High fire resistance requirements
- Compartment floors
- Sprinklers
## Precedent

<table>
<thead>
<tr>
<th>Height</th>
<th>Buildings</th>
<th>Time (years)</th>
<th>Building Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Many millions</td>
<td>Thousands</td>
<td>1,000,000,000</td>
</tr>
<tr>
<td>Medium</td>
<td>Many hundred thousands</td>
<td>Hundreds</td>
<td>10,000,000</td>
</tr>
<tr>
<td>High</td>
<td>Many thousands</td>
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<tr>
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<td>Many thousands</td>
<td>Tens</td>
<td>10,000</td>
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<tr>
<td>Super-high</td>
<td>Hundreds?</td>
<td>Tens</td>
<td>1,000</td>
</tr>
</tbody>
</table>
Reliability
If fire and smoke protection works…

- **Contain fire:**
  - Sprinklers
  - Compartments

- **Contain smoke**
  - Compartments
  - Smoke Control

- **Prevent collapse**
  - Fire resistance

- **Evacuation**
  - Detect and alarm
  - Stairs
  - Evacuate pairs of floors

- **Fire fighting**
  - Provide access
Why Evacuate?

- Fire and smoke are contained
- Structural stability will be maintained
- Only those in immediate vicinity at risk
- Fire service can extinguish any fire that is not already extinguished
We are worried about unknown failures

- Detection and alarm failure
- Evacuation sequencing failure
- Smoke leakage
- Fire spread
- Active system failure
- Passive system failure
- Causational failure
- Construction failure
- Management failure
Consequence
Evacuation Time

- Typical Stair 1100mm

- Capacity 220 people

- 2.5 minutes to enter stair
  - Approx. 1 minute per storey

- 4 minutes to clear stair
  - Approx. 2 minutes per storey
Impact of vertical fire spread

- Reasonable time for fire spread?
- 15 minutes per storey?
High Rise – 10 storeys

- **Prolonged** evacuation
- Rescue not possible from outside
- Stability required for a **long** period
- Risk associated with vertical
- Fire fighting difficult from inside

- **Inhibit** fire and smoke spread
- **Reasonable** stability
- **Phased** evacuation strategy
- Evacuation period is relatively short!
## Approximate Evacuation Times

<table>
<thead>
<tr>
<th>Height</th>
<th>Time to Relative Safety</th>
<th>Evacuation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 storeys</td>
<td>10 minutes</td>
<td>20 minutes</td>
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<td>20 storeys</td>
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<tr>
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<td>60 minutes</td>
</tr>
<tr>
<td>40 storeys</td>
<td>40 minutes</td>
<td>80 minutes</td>
</tr>
</tbody>
</table>
Super-high rise Strategy?

- Prolonged evacuation
- Rescue not possible from outside
- Stability required for a long period
- Risk associated with vertical
- Fire fighting difficult from inside

- Evacuation very long / impossible
- Rescue not possible from outside
- Collapse unacceptable
- High risk associated with vertical
- Fire fighting difficult from inside

Super-high rise risks are different from high rise – shouldn’t the strategies be different?
Conclusions – Part 1

• High rise strategies rely on prevention of vertical fire spread

• Risk of failure in “short” high rise is acceptable:
  • Likelihood of failure is low
  • Consequence is tolerable

• Consequence of vertical fire spread is high in ‘tall’ high rise:
  • Must ensure likelihood of failure is sufficiently low, or
  • Reduce consequence
Part 2

• Importance of prevention of vertical fire spread

• Conflict between insulation and safety

• A robust approach to safety
The need for insulation
Impact of insulation on fire
Design Fire
Design Fire
Design Fire
Design Fire
Impact of Insulation on Fires

• Heat is contained
• Fire grow quicker?
• Fires are hotter and longer?

• Therefore:
  - Should fire resistance be increased?
  - Fire fighting procedures?
Impact of fire on insulation
Rapid vertical fire spread
Conclusions – Part 2

- Acceptability of fire safety is judged by precedent
- We have hundreds of years’ experience with:
  - Stone, concrete, steel, etc.
- Is the rapid introduction in quantity and type of new insulation material:
  - Changing the behaviour of fires?
  - Providing a mechanism for rapid fire spread?
Part 3

- Importance of prevention of vertical fire spread
- Conflict between insulation and safety
- A robust approach to safety
Capability
Fire Scientists
Fire and smoke modelling
Computational Evacuation Simulation
Computational Fluid Dynamics
Structural Fire Modelling
Fire systems specialists
Total Design
All Design Decisions

- Evacuation
- Containment
- Resistance
- Suppression

All credible scenarios & failures
Integrate Design

Prepare

Design

Use

Specify

Construct

Safety Strategy
Organised Team

- Client
- Design Team
- Systems Specialists
- Security
- Fire

Safety Strategy
Conclusions
Conclusions

- Rapid advanced in building design mean that acceptability by precedent is no longer possible.
- Consequence of fire spread in super-tall buildings are very high

- We must proactively identify acceptable levels of risk and design accordingly.
Conclusions

• Great reliance is placed on the efficacy of the fire protection features and systems that we incorporate into our strategies.

• There is limited margin of safety for failure.

• We must design, specify, install, operate and maintain our systems correctly.
Conclusions

- Design assumptions that are valid for high rise design are not necessarily appropriate for super-high rise strategies.
- The consequence of incorrect assumptions is very high.

- **We must consider all relevant design fire scenarios and test against potential system failure.**
Conclusions

• We have the capability, and the tools but…

• Fire can no longer be considered in isolation.
Great things can happen when, "all relevant design decisions have been considered together and have been integrated into a whole by a well organised team."
Great things can happen when, "all relevant design decisions have been considered together and have been integrated into a whole by a well organised team."

Safety is relevant and must be integrated into design.
BRE: The Fire Performance of Building Envelopes

Stephen Howard
Passive Fire
May 2013
Objectives

Façade systems

Examples of fires involving building envelope

Mechanisms of fire spread

Regulation in the UK

Testing and Third party approval
Test Facilities
Façades
What is a Façade?

- The building envelope (typically 15° to the building face)
- Materials
  - Timber
  - Plastics
  - GRP
  - Glazing
  - Polymeric composites
  - Cement based products
  - With and without insulation
  - ‘Green’
- It is frequently a kit of parts
Façade Fire Examples
Fire Spread in Building Envelopes

– Fires involving multi-storey buildings
  – are a risk to life
  – property loss
  – disruption to commercial business or
  – domestic life if dwellings are involved.

– You Tube
Fire Spread in Building Envelopes

- Knowsley Heights - 1991
- Basingstoke - 1992
- Irvine - 1999
- The Edge, Manchester – 2004
- Windsor Tower, Madrid – 2005
- Berlin 2005
- Hungary 2009
- Dijon France 2010
- Chechnya
- UAE
- USA
Fire Spread in Building Envelopes

– Al Nahda Tower, Sharjah 28th April 2012
– Mermoz Roubaix, France 15th May 2012
– Polat Tower, Istanbul, Turkey, 17th July 2012
– Tamweel Tower, Dubai, 18th November 2012
Knowsley Heights - 1991
Knowsley Heights – 1991
In the summer of 1999, a Parliamentary inquiry into the potential risk of fire spread in buildings via External Cladding was held by the Environment Sub-committee of the Environment Transport and Regional affairs committee.
External Fire Spread – Basingstoke 1992
Mechanisms of fire spread in Façades
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 in cavities can extend 5 to 10 times original length regardless of materials present.
Experimental Programmes – Fire Spread

14 min
Experimental investigations
Building Regulation Guidance – Approved Document B
Building Regulations - Fire safety
Functional Requirements

B1 Means of Warning and Escape

B2 Internal Fire Spread (Linings)

B3 Internal Fire Spread (Structure)

B4 External Fire Spread

B5 Access and Facilities for the Fire Service

Address Life Safety Issues
Building Regulations (Fire Safety) – Guidance

- Approved Document B (ADB)
  - Two Volumes

[Images of Approved Document B volumes]

B2 B3 & B4 – Limiting fire spread

**B2** Internal Fire Spread (Linings)

- Compartmentation
- Loadbearing elements
- Cavity barriers

**B3** Internal Fire Spread (Structure)

- Compartmentation
- Loadbearing elements
- Cavity barriers

**B4** External Fire Spread

- External Walls
- Roofs
ADB - External Surfaces

- Approved Document B (ADB) considers:
  - Building Use; schools, dwellings, industrial etc
  - Building Heights
  - Distances to Boundaries
  - Fire Performance Characteristics of:
    • Components and / or
    • Complete systems for use over 18m
ADB - External Surfaces

Diagram 40, restricts the combustibility of external walls of high buildings, to reduce the danger from fire spread up the external face of the building.
External Walls over 18m in Height

- A summary of Volume 2 Section 12 guidance based on components for Buildings Over 18m
  - External surfaces comply with Diagram 40
  - All insulation and filler materials should be A2-s3,d2 or better
  - All cavity barriers and fire stopping guidance needs to be followed

- OR
  - Test the complete system to BS 8414
BS 8414: Part 1: 2002

- Test method for non-load bearing external cladding systems applied to the face of the building

- This test method was developed to address systems installed to masonry structures.
Test Facility

- Minimum height of sample:
  - 6 m above chamber opening
  - ground to full height on wing
- Width:
  - 2.8 m main face
  - 1.5 m wing
- Depth:
  - Part 1 - Maximum sample depth 200 mm
Location of Thermocouples at Level 2

Internal structure

Internal wall of test facility

Thermocouple located at the mid-depth of the cavity (if present)

Thermocouple located at the mid-depth of the insulating material layer

External finish. No mid-depth temperature monitoring if layer is <10 mm thick

External thermocouple
Test Principles

The duration of the fire load is 30 minutes. Test runs up to 60 minutes.
Post Test

- Damage is recorded in the following areas:
  - flame spread on surface
  - flame spread in cavities or insulation
  - area of façade damaged or detached

- Primary Pass/Failure criteria
  - Time/temperature at Level 2, 600 deg C at 15 minutes
Graphical Output

Sample Graph

Origin of time axis passes through ts

Temperature rise, above Ts (°C)

Time (mins)
Set two
Assessment of System Performance
– Test method to assess whole system performance including fire breaks
BS 8414 series for Full Scale testing
Classification to BR135

External Fire Spread Classification

- Second Edition of BR 135
- Sets the performance criteria
- Third edition of BR 135 currently in draft, to be published shortly.
Lightweight Frame Systems
Modern Methods of Construction

- BS 8414 - 2 : 2005
  - For systems where the masonry structure is no longer present.
  - Same fire load and methodology at BS 8414-1:2002
  - Classification is in Annex B to BR135
Europe

- ETAG 004 – no large-scale fire test specified

- Many European states have similar tests for façade systems recognising the need to understand the system interactions.

- EOTA group now working developing a full scale test method.
Property Protection - Insurers
LPS Schemes & Technical Approval

– Building Regulations and Approved Document B only address Life Safety

– LPS approval provides on going certification and market support for products against both life safety and property protection performance criteria.
Loss Prevention schemes

– LPS 1581 Based on BS 8414-1 for masonry backed systems

– LPS 1582 Based on BS 8414-2 for non-masonry backed systems

Standards and listings are free to download from:
www.redbooklive.com
Thank you


- You Tube

- howards@bre.co.uk
Andy Dean
BSc (Hons), MCIOB, FSFE

Al Futtaim Exova, & Exova Warringtonfire

Middle Eastern Perspective
Agenda

• Geographies
• Regulatory overview
  - products
  - installation
  - inspection
• Codes
• Facades in particular
Geographical Focus

**GCC and Levant**

**GCC**
- United Arab Emirates
- Qatar
- (Ko) Saudi Arabia
- Kuwait
- Bahrain
- Oman

**Levant +**
- Jordan
- Syria
- Iran
- Iraq
- Palestine
- Israel
- Egypt
Specific Examples (1)

Sharjah
Specific Examples (2)

Abu Dhabi
Specific Examples

(3)

Tamweel Tower
General Context

- Developing markets
  - maturing
  - new concepts (eg FR & RTF)
  - old perspectives
  - highly aspirational

- Highly multicultural
  - a variety of expectations
  - variety in cultural norms

- Regulation of products and processes
  - products, installation and inspection
Regulation of Approvals (Products)

- Regulation of products and processes
  - products, installation and inspection
- Previously testing
- Now certification
- ISO Guide 67, System 5
- Independent sampling
Products – Certification Process

- Application
- Document review
- Factory Production Control (FPC) audit
- Quality Management System (QMS) audit
- Product sampling (must be independent)
- Type testing
- Assessment
- Certification decision

- On-going monitoring (periodical audits and audit testing)
Regulation of Approvals (Installation)

- Regulation of products and processes
  - products, installation and inspection

- Rarely structured
- Usually in-house training
- Could be multi-layered
Regulation of Approvals (Inspections)

- Regulation of products and processes
  - products, installation and inspections
- Outsourced
- Construction stage (HoE)
- CD at completion
- Occasionally during operation
Codes

- Still a combination
  - British
  - American
- Can cause issues
- British / European products annexed
- Need to focus on equivalence in standards
- Needs coordination and leadership
Facades in Particular

Videos:
- Fire rated
- Non-fire rated
Facades in Particular

Three main issues:

• Fire compartmentation (FR)
  - unusual
  - normal rules apply

• Flame spread (RTF)
  - materials issue
  - beginning to be understood
  - comb’n of large & small tests

• Perimeter firestopping
  - a challenge for architects
Fire-stopping in High Rise Cladding Construction
Cavity Fire Barriers for Curtain Wall & Rainscreen Façades
30 different façade types
Curtain Wall

- Gap between slab edge and façade
- Inside the building
- Contributes to compartmentation
- Fire
- Smoke
- Sound
- Water
- Horizontal and vertical
- Must accommodate façade movement
...the product should be in accordance with a specification or design which has been shown by test to capable of meeting that performance; or have been assessed from test evidence against appropriate standards...
Typical Specification

All cavity barriers shall be capable of accommodating all structural, settlement, drying shrinkage, creep, thermal and moisture movements of the building frame and/or façade without dislodging.
Torre Windsor Madrid

- Built in 1970’s
- No slab edge firestops
Torre Windsor Madrid

- Built in 1970’s
- No slab edge firestops
- Fire started on 21st floor
Torre Windsor Madrid

- Built in 1970’s
- No slab edge firestops
- Fire started on 21st floor
- Between 3.00 am and 7.00 am the fire spread to all 29 above ground floors
- Basement floors untouched
- Burning droplets
Rainscreen

- Gap between external skin and façade
- Outside the building
- Fire
- Must accommodate air flow
- Closure time critical
- Horizontal and vertical
- Age resistant
CWCT Performance Standard

Cavity barriers shall be provided

- On the line of any compartment wall or floor
- To close the cavity around penetrations through the rainscreen for windows or doors
- Sub-divide the cavity with horizontal and vertical barriers
Compartmentation
AD B

Vertical Barrier at edge of cavity

Vertical Barriers @ max 20m centres *

Horizontal Barriers to all compartment floors

Barriers to all openings
Limit spread of fire in cavity

England, Wales, NI

30 minutes integrity
15 minutes insulation

Scotland

30 minutes integrity
No requirement for insulation
Design of Cavity Barriers

• Seals cavity in the event of a fire

• Activated at critical temperature

• ‘Integrity’ re-established

• Continues to expand to close void.
DIFFERENT MATERIALS

DIFFERENT PROPERTIES

DIFFERENT INSTALLS
3rd Party Certified Product

3rd Party Certified Installation
Thank You!