Fire Engineering in High Rise

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Contents

• How do we protect against fire?
• How do we know this works?
• Why evacuate?
• What assumptions are made?
• How are buildings procured?
• What are the alternatives?
• Total Fire Engineering – an integrated approach.
Caveat

• Talking in very generic terms!
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:**
  - Sprinklers
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  - Smoke Control

- **Prevent collapse**
  - Fire resistance
Typical High Rise Strategy Components

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- **Evacuation**
  - Detect and alarm
  - Stairs
  - Evacuate pairs of floors
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• Fire fighting
  - Provide access
Acceptability through Precedent
Fire Strategy Development

• Build what we want

• Learn from fire incidents and disasters

• Amend legislation and guidance 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>
<td>Tens</td>
<td>10,000</td>
</tr>
<tr>
<td>Super-high</td>
<td>Hundreds?</td>
<td>Tens</td>
<td>1,000</td>
</tr>
</tbody>
</table>
Theme (guidance vs. risk)
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?
Why evacuate?
If fire and smoke protection works…

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

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

• **Prevent collapse**
  - Fire resistance

• **Evacuation**
  - Detect and alarm
  - Stairs
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• **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

Not at risk
Not at risk
Not at risk
Not at risk
Not at risk
Many Reasons not to Evacuate

- Space requirements (evacuation points)
- Mobility impairments
- Fatigue
- Trips and falls
- Business disruption
- Paperwork
- Security breeches
- Complaints
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

- **Inhibit** fire and smoke spread
- **Reasonable** stability
- **Phased** evacuation strategy
- **Evacuation period is relatively short!**
Super-high Rise – 100+ Storeys

- 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
What assumptions are made?
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Causes of Failure

• Accidental failure
  - Poor design, specification, construction or use
  - System failure
  - Cause and effect failure
  - Combined accidental loads

• Deliberate failure
  - Larger fire or multiple fires
  - Sabotage of systems
  - Combined events

• Low Probability but Extreme Consequence = High Risk?
Building Procurement
Building Procurement

- **Means of escape**
  - Can people really walk down?

- **Smoke control**
  - Stack and wind effect, building systems, cause and effect

- **Fire control**
  - Changing fire load

- **Fire Resistance**
  - Assume single storey fire
  - Don’t assess overall stability

- **Fire Fighting**
  - Assume single storey fire
Fire Engineering

- Disconnect between design and specification

Diagram:

- Preparation
  - Design
  - Specification
  - Construction
  - Use
  - Fire fighting
Fire Engineering

- Construction quality
  - Fire stopping
- Commissioning
  - Systems commissioned separately
Fire Engineering

- **Quality of Handover**
  - Do users know what has been built?

- **Building Management**
  - Quality of house-keeping
  - Quality of maintenance
  - Quality of training and staff

- **Apparent Simplicity masks Actual Complexity**
What information about the assumptions in the original design are available.
Alternatives
Capability
Fire Scientists
Fire and smoke modelling
Computational Evacuation Simulation
Computational Fluid Dynamics
Structural Fire Modelling
Fire systems specialists
All Design Decisions

All credible scenarios

- Evacuation
- Containment
- Suppression
- Resistance
Integrate Design

Safety Strategy

- Prepare
- Design
- Specify
- Construct
- Use
- Fire fighting
Organised Team

- Structure
- MEP
- Safety Strategy
- Security
- Fire
- Etc.
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."
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Safety is relevant and must be integrated into design.