



# Evacuation and Fire Engineering

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# Fire Dynamics

- The reality is somewhat different from the images portrayed by Hollywood
- Tenability thresholds in terms of:
  - toxicity of fire effluent,
  - visibility and
  - heat from the compartmentwould have been exceeded well before anyone without protective respiratory apparatus and personal protective equipment was in the vicinity of any flames

# Requirements

- Building Regulations (England and Wales)
  - Schedule 1 to and Regulation 7 of part B
- Functional Requirements (Part B of
  - (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

They are written in a form which allows a good deal of freedom when deciding on how to meet the requirement

# Requirements

- **(B1) Means of warning and escape**
  - The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and means of escape in case of fire from the building to a place of safety outside the building capable of being safely and effectively used at all material

# Requirements

- **(B2) Internal fire spread (linings)**
  - (1) To inhibit the spread of fire within the building, the internal linings shall:
    - (a) adequately resist the spread of flame over their surfaces; and
    - (b) have if ignited, a rate of heat release rate of fire growth which is reasonable in the circumstances
  - (2) In this paragraph “internal linings” mean the material or products used in lining any partition, wall, ceiling or other internal structure

# Requirements

- **(B3) Internal fire spread (structure)**
  - (1) The building shall be designed and constructed so that in the event of fire, its stability will be maintained for a reasonable period.
  - (2) A wall common to two or more parts shall be designed and constructed so that it adequately resists the spread of fire between those two buildings. For the purposes of this sub-paragraph a house in a terrace and a semi-detached house are each to be treated as a separate building

# Requirements

- **(B3) Internal fire spread (structure)**
  - (3) Where reasonably necessary to inhibit the spread of fire within the building, measures shall be taken, to an extent appropriate to the size and intended use of the building, comprising either or both of the following.
    - (a) sub-division of the building with fire –resisting construction:
    - (b) installation of suitable automatic fire suppression systems

# Requirements

- **(B3) Internal fire spread (structure)**
  - (4) The building shall be designed and constructed so that unseen spread of fire and smoke within concealed spaces in its structure and fabric is inhibited.

# Requirements

- **(B4) External fire spread**
  - (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 to the height, use and position of the building.
  - (2) The roof of the building shall adequately resist the spread of fire over the roof and from one building to another, having regard to the use and position of the building.

# Requirements

- **(B5) Access and facilities for the fire service**
  - (1) The building shall be designed and constructed so as to provide reasonable facilities to assist firefighters in the protection of life.
  - (2) Reasonable provision shall be made within the site of the building to enable fire appliances to gain access to the building.

# Requirements

- Evacuation
  - Not just about means of escape and warning but is recognised as encompassing an holistic view of all the measures within a building.

# Recommendations

- Approved Documents/Codes of Practice
  - Approved Document B
    - Details what is considered to be reasonable, appropriate and acceptable to meet functional requirements
    - No obligation to adopt a particular solution in an Approved Document if it is preferred to meet the relevant requirement in some other way.
    - Considered to be the benchmark

# Recommendations

- Approved Documents/Codes of Practice
  - BS 5588 Suite of Documents
  - BS 9999
    - Both Codes of practice dealing with:
      - Fire precautions in the design, construction and use of buildings
  - BS 7974 Suite of Published Documents (PD)
    - Application of fire engineering principles to the design of buildings

# Understanding the process

- Evacuation is a complex event and forms only one element of matters to be considered within a fire engineered building

# Evacuation

- The evaluation and management of occupant behaviour
  - Particularly escape behaviour, during a fire emergency and for the evaluation of occupant condition, especially in relation to exposure to fire effluent and heat
- Most cases of fire this involves the evacuation of the occupants

# Evacuation

- A Basic Principle of Performance-based design.
- Establishing the Available Safe Escape Time  
ASET
- Ensuring that this is greater than the Required safe  
escape time RSET
- Ensuring an adequate margin of safety
  - Taking into consideration the associated risks with  
different potential fire scenarios and uncertainties in the  
prediction of ASET/RSET calculations.

# Evaluation

- In order to achieve the evaluation of ASET, detailed input information is required in four main areas
  - The building design and emergency life safety management strategy;
  - The occupant characteristics;
  - The fire simulation dynamics
  - Intervention effects

# Evaluation

- The response of occupants to fire conditions is influenced by many variable factors within these four categories related to the characterisation of the occupants in terms of:
  - their number,
  - distribution,
  - familiarity with the building
  - Their abilities, behaviours and other attributes

# Evaluation

- The characterization of the building including:
  - its use,
  - layout and services,
  - the provision for warnings,
  - means of escape and emergency management strategy,
  - the interaction with all these factors with a developing fire scenario

# Evaluation

- In order to achieve the evaluation of RSET, detailed input information is required in the following main areas:
  - The time from ignition to detection
  - Time from detection to warning
  - Evacuation time (Contains two major phases)
    - Pre-movement time
    - Travel time

# Evaluation

(Extract from PD6 BS 7974)

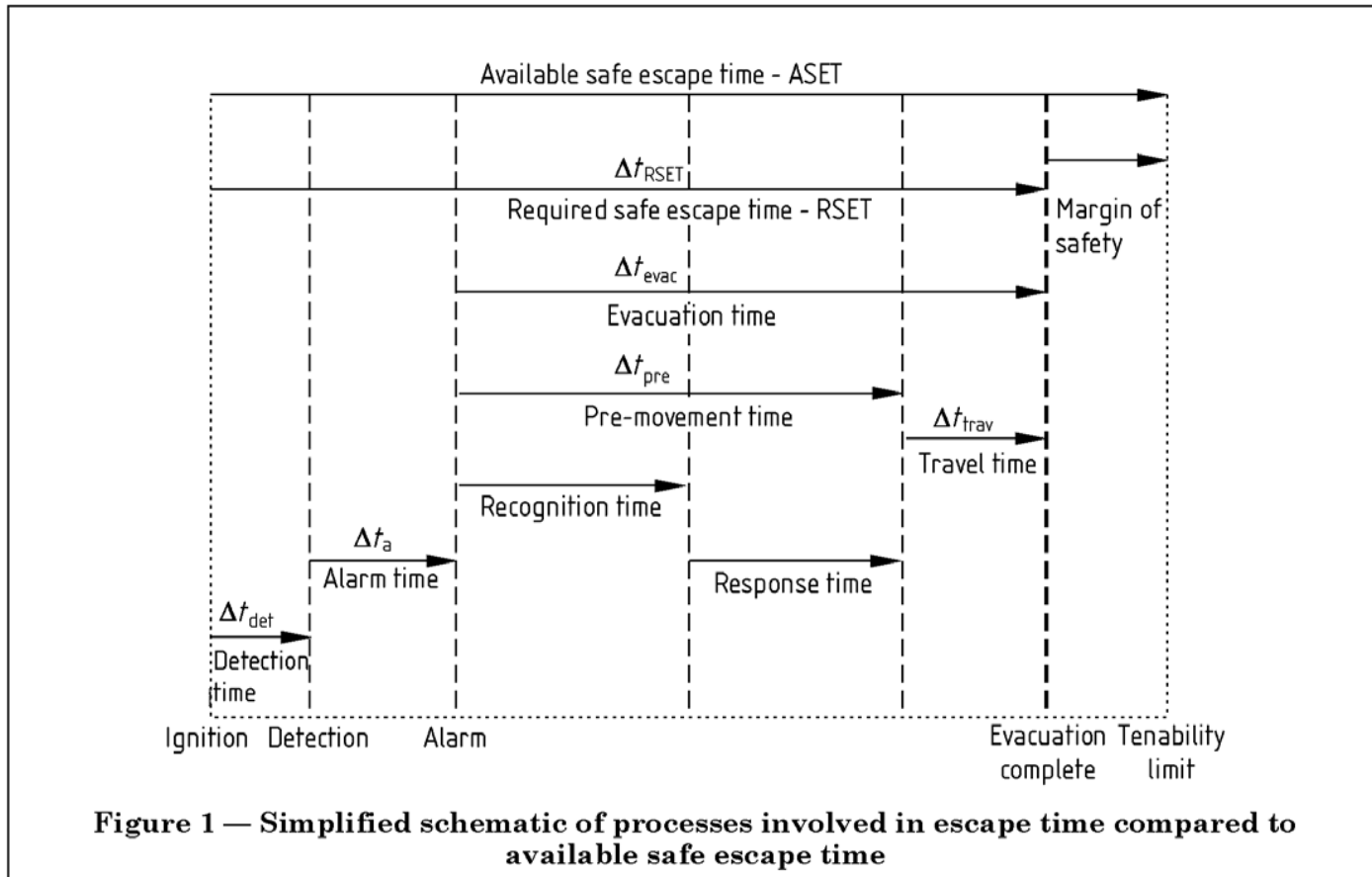


Figure 1 — Simplified schematic of processes involved in escape time compared to available safe escape time

# Evaluation

(Extract from PD6 BS 7974)

**Table 1 – Design behavioural scenarios and occupancy types**

Category	Occupant alertness	Occupant familiarity	Occupant density	Enclosures/ complexity	Examples of Occupancy types
A	Awake	Familiar	Low	One or many	Office or industrial
B1	Awake	Unfamiliar	High	One or few	Shop, restaurant, circulation space
B2	Awake	Unfamiliar	High	One with focal point	Cinema, theatre
Ci	Asleep Long term: individual occupancy.	Familiar	Low	Few	Dwelling Without 24 h on site management.
Cii	Managed occupancy:				Serviced flats, halls of residence, etc.
Ciii	Asleep	Unfamiliar	Low	Many	Hotel, hostel
D	Medical care	Unfamiliar	Low	Many	Residential (institutional)
E	Transportation	Unfamiliar	High	Many	Railway station/Airport

# Human Behaviour

- Common misconceptions
  - People’s safety cannot be guaranteed since in certain circumstances they “panic” leading to “inappropriate” behaviour.
  - Individuals start to move as soon as they hear the alarm.

# Human Behaviour

- Time taken for people to evacuate a floor depends on the time it takes them to physically move to and through the exit
- movement in fire is characterised by the aim of escaping

# Human Behaviour

- People are most likely to move to the exit they are nearest to
- People move independently of each other (unless in a large crowd)
- Fire exit signs help ensure people find a route to safety
- People are unlikely to use a smoke filled escape route

# Video Clip



# Images to focus the mind





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# Madrid Fire

- 12<sup>th</sup> Feb 2005
- Fire Development
- Extensive damage
- Structural response

# Lessons to be learned

- Provisions for speedy access to the fire floor via protected fire fighting lifts and use of wet risers
- Effective compartmentation measures, including sprinkler protection for high-rise buildings
- Good coordination of fire safety measures with refurbishment works and programme, especially in an occupied building
- Structural fire full frame analysis, rather than single element small-scale fire tests, as a basis for design

# Lessons to be learned

- The central concrete core performed well in the fire and seems to have played a major role in ensuring the stability of the building throughout the incident.
- A thermo-mechanical assessment of this structural design, an understanding of why the structure performed as it did and why total collapse did not occur would provide valuable information for future structural fire analysis in design.

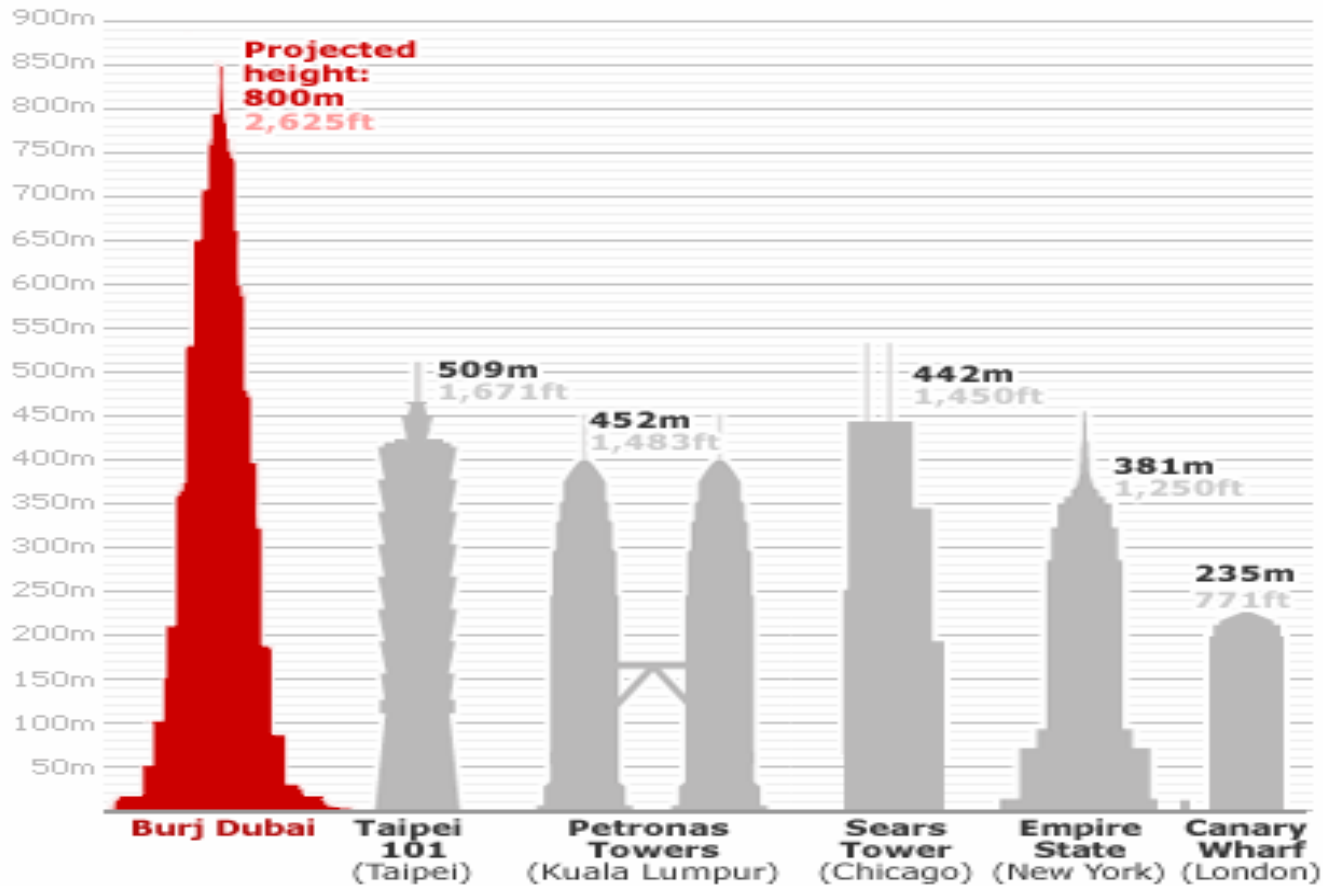
# Lessons to be learned

- It would assist in the strong move now towards structural fire engineered buildings, and therefore help with the move away from reliance on Building Code based single element testing and associated fire proofing techniques which do not address real and structural behaviour in real fires.

# Imagine



# Burj Dubai Tower



# Research on Egress Elevators

- Work done by NIST in the early 1990s identified several key advantages when using elevators
  - Occupants usually exit the building the same way they enter
  - Evacuation takes less physical effort
  - Reduces stair congestion
  - Elderly/mobility impaired occupants only viable option.

# Research on Egress Elevators

- Conversely with an elevator evacuation plan there are many issues to consider and prepare for in an emergency
  - Overcoming the traditional campaign of not using elevators during evacuation.
  - Impatience at waiting in lobbies leading to possibility of overcrowding causing the lift car to become stranded at the floor until overcrowding is resolved

# The Challenge

- For fire engineers to develop greater understanding of elevator performance and develop strategies integrating lifts to allow mass evacuation of occupants.
  - Greater expertise in the use of elevator evacuation models
  - This may include the use of refuge floors to provide a strategy of phased vertical and possibly horizontal evacuation

# The Challenge

- This may involve the use of horizontal movement as well as vertical.
- The elevator industry to integrate with the wider community in developing a greater acceptance of the use of lifts for evacuation from empyreal places.



# Thank you

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