

Technology Year 3



Fire Engineering

Source: Daily Telegraph 2012

Fire Engineering

- Understanding fire growth and development principles
- Determine compartment time/temperature response
- Heat transfer
- Structural response



Fire Engineering

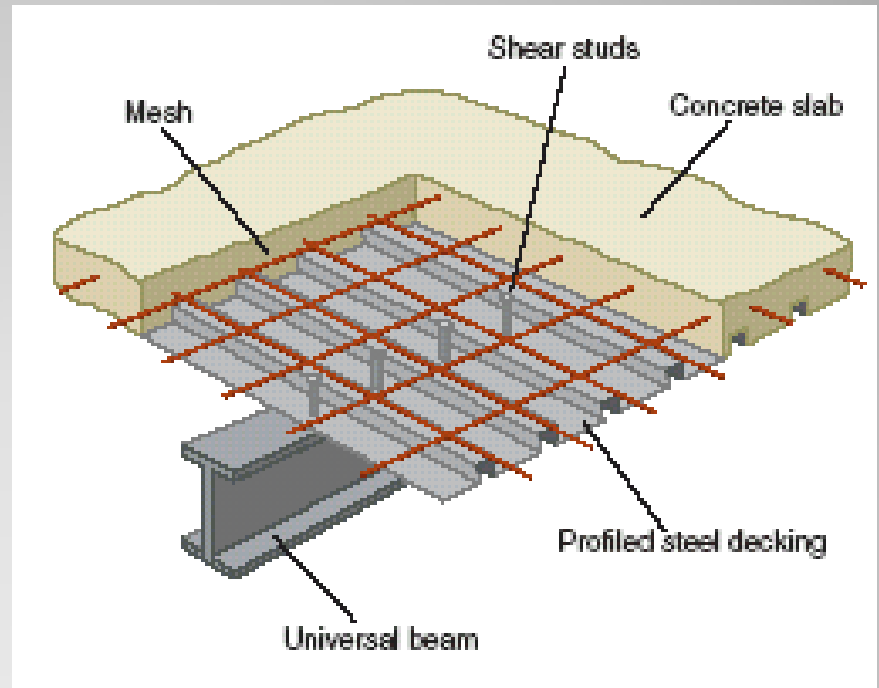
Laws of thermodynamics

1. You only get out what you put in
2. Heat flow is from a hotter object to a cooler object
3. If all the thermal motion of molecules could be removed then the temperature would be absolute zero ($0\text{ K} = -273.15^{\circ}\text{C}$)

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Material properties:

- Thermal conductivity
- Density
- Specific heat capacity



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Some key terms

Class 0: highest product performance classification for wall and ceiling linings

Compartmentation: separation of an area, a whole floor or building by enclosure within fire resisting construction

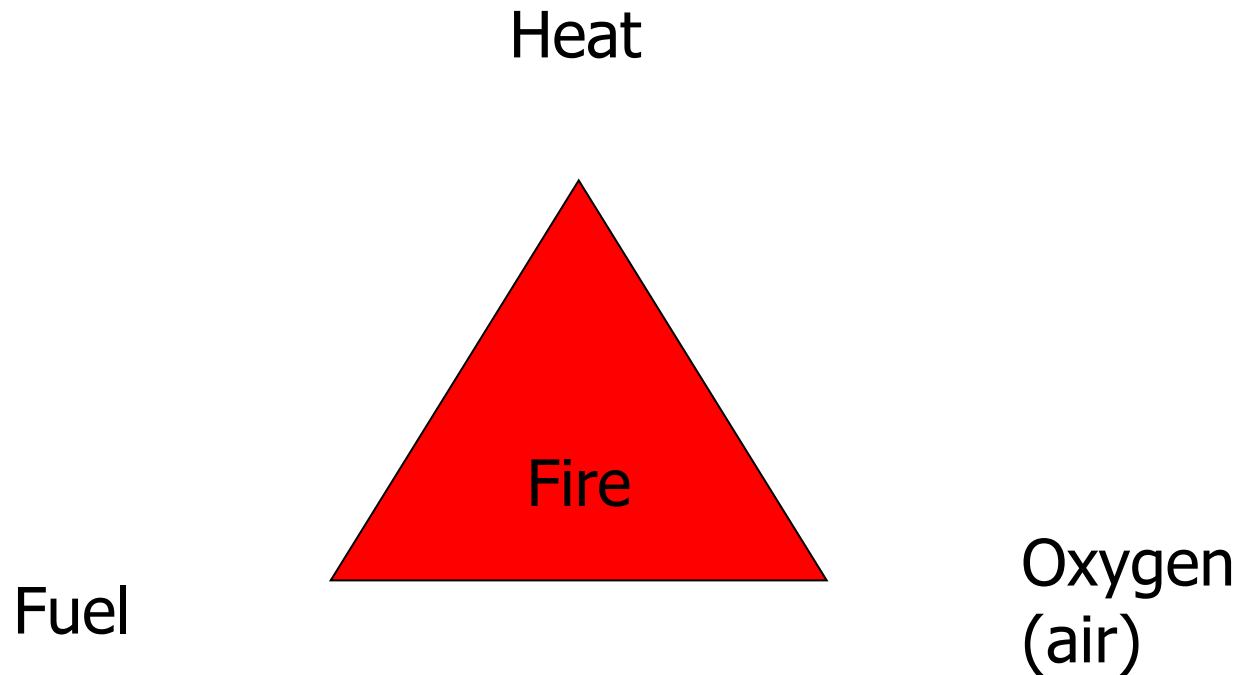
Fire load: the energy released by combustion of materials in a space

Flashover: transition between the fire which is essentially localised around the items first ignited and the general conflagration when all surfaces within the compartment are burning

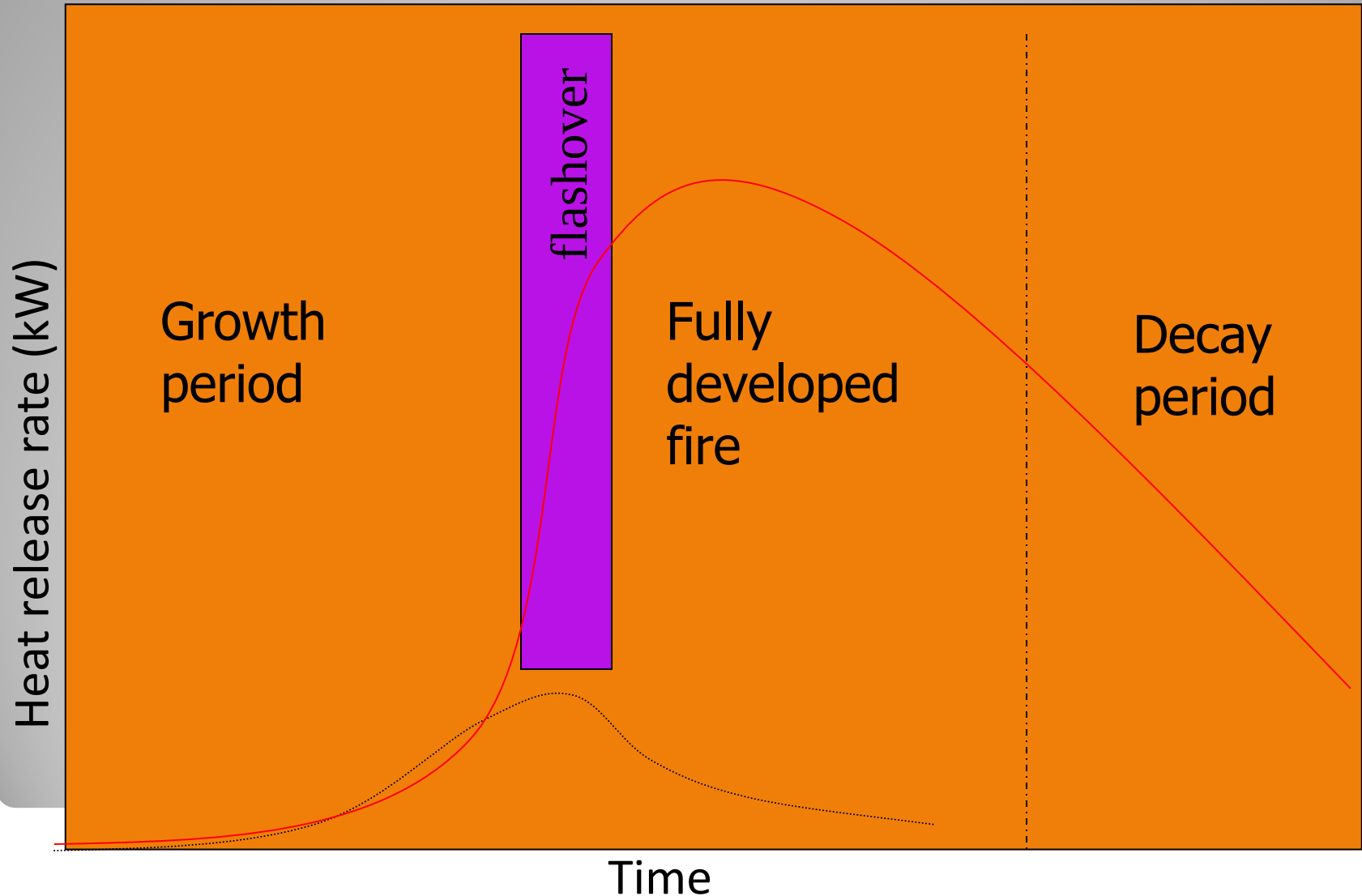
Spalling: loss of surface material from a concrete element and is dependent on aggregate, moisture content, stress level and temperature

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Constituent parts of a fire



Fire Engineering



Fire Engineering

Main approaches to fire engineering:

- Passive protection: means by which the building, its structure and fabric and installations resist the effects of fire.
 - Typical measures:
 - Fire protection of structural steel.
 - Fire resisting glazing.
 - Intumescent products.

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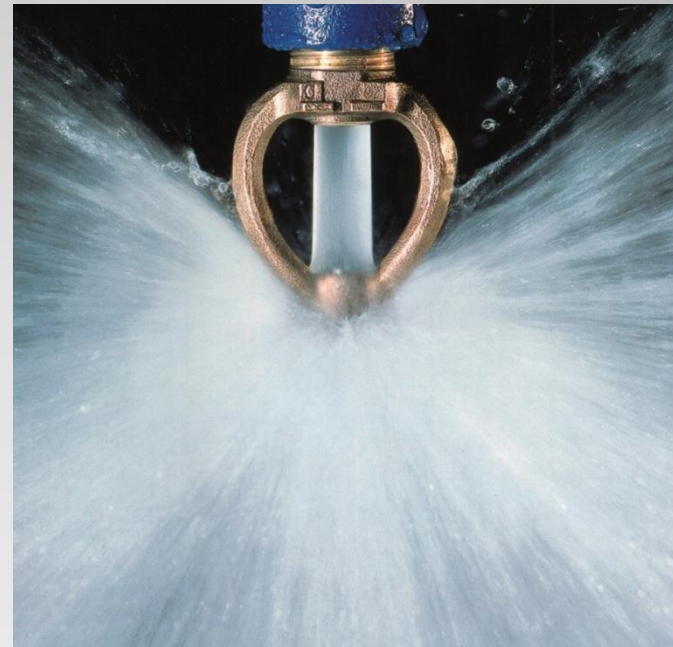
Main approaches to fire engineering:

- Active protection: means by which measures such as detectors and alarms, fire extinguishing equipment etc., are adopted to reduce or contain the effects of fire.
 - Typical measures:
 - Sprinklers
 - Detection systems
 - Smoke control systems

Fire Engineering

The use of sprinklers

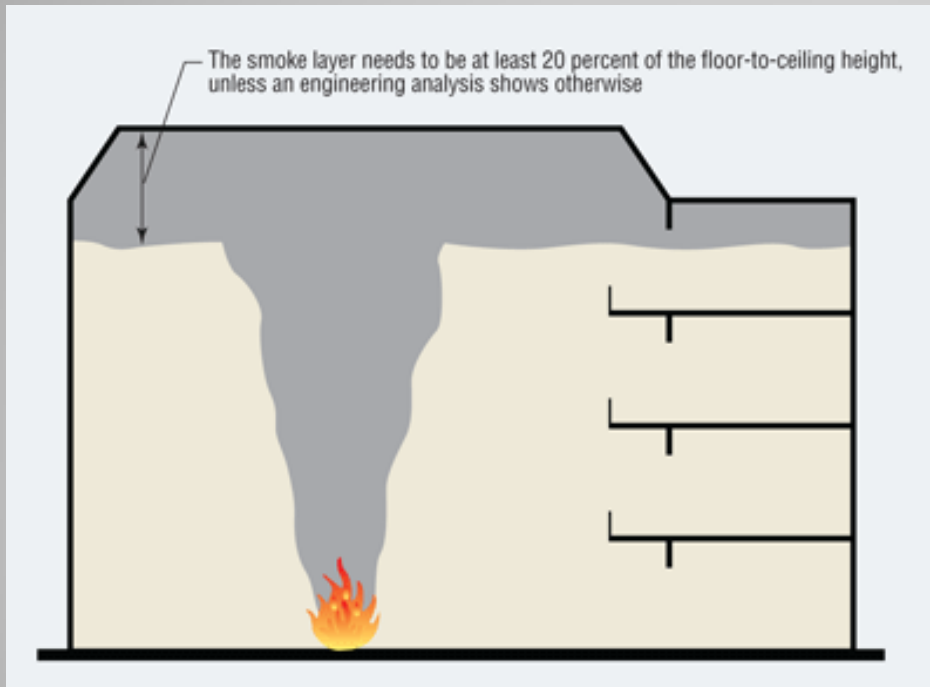
- Allows a degree of certainty over the design fire size
- Can perform the dual function of detection and suppression
- Increases allowable compartment size
- Increases the time for untenable conditions – increase evacuation time
- Reduces the fire size



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Properly designed smoke control systems will;

- Delay the advance of untenable conditions, increasing the time for people to evacuate the building
- Limit the fire size and reduce the risk of flashover



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Passive protection – three levels to consider...

1. Means of escape provision;

● Planning

- Safe route
- Corridors
- Staircases
- Windows

● Protection

- Shafts
- Window areas
- Surfaces
- Doors
- Pressurisation

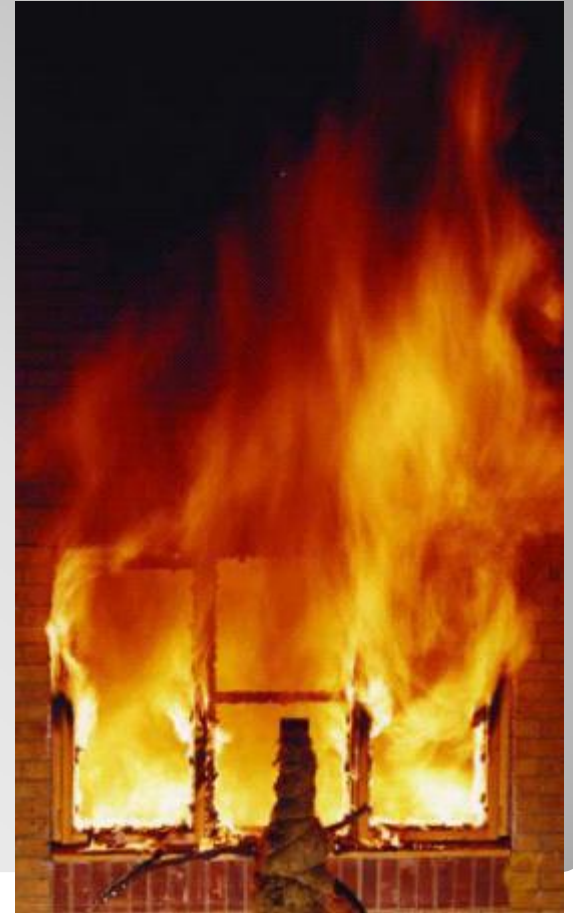


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Passive protection...

2. Reduce the spread of fire

- Reducing fire spread on surfaces
- Provision of barriers
 - Compartmentation
 - Fire barriers
 - Cavity barriers
 - Fire stopping



Minimum periods of fire resistance (Building Regulations Approved Document 'B', 2000 edition)

Purpose group		Minimum periods of fire resistance (minutes)					
		Depth of lowest basement		Height of top floor above ground			
		>10m	≤10m	≤ 5m	≤ 18m	≤ 30m	> 30m
Residential flats and maisonettes	Unsprink'ed	90	60	30	60	90	120
office	Unsprink'ed	90	60	30	60	90	Not permitted
	Sprink'ed	60	60	30	30	60	120
Shops and commercial	Unsprink'ed	90	60	60	60	90	Not permitted
	Sprink'ed	60	60	30	60	60	120
Assembly and recreational	Unsprink'ed	90	60	60	60	90	Not permitted
	Sprink'ed	60	60	30	60	60	120
industrial	Unsprink'ed	120	90	60	90	120	Not permitted
	Sprink'ed	90	60	30	60	90	120

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Passive protection

Design criteria

Providing integrity – no hole burnt through

And

Insulation – reduces heat transfer

Will give

Stability – will not collapse

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Passive protection

3. Maintaining structural stability

- Material selection
- Cover to concrete
- Protection to steel
- Sacrificial design



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Material selection

Materials relate to construction systems which respond to fire in different ways dependent upon their constituent properties:

- Chemical
- Physical
- Mechanical
- Thermal



Source BBC News 2012

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Concrete...

- Structural elements
 - Flexural
 - Compression
- Key factors to consider
 - Supports
 - Restraint
 - Slenderness
 - Thickness

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Fire resistance of concrete is dependent upon:

- Thermal properties
- Concrete cover to the reinforcement
- Amount of reinforcement
- Ratio between applied load and ultimate load



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Concrete's
excellent fire
resistant
properties

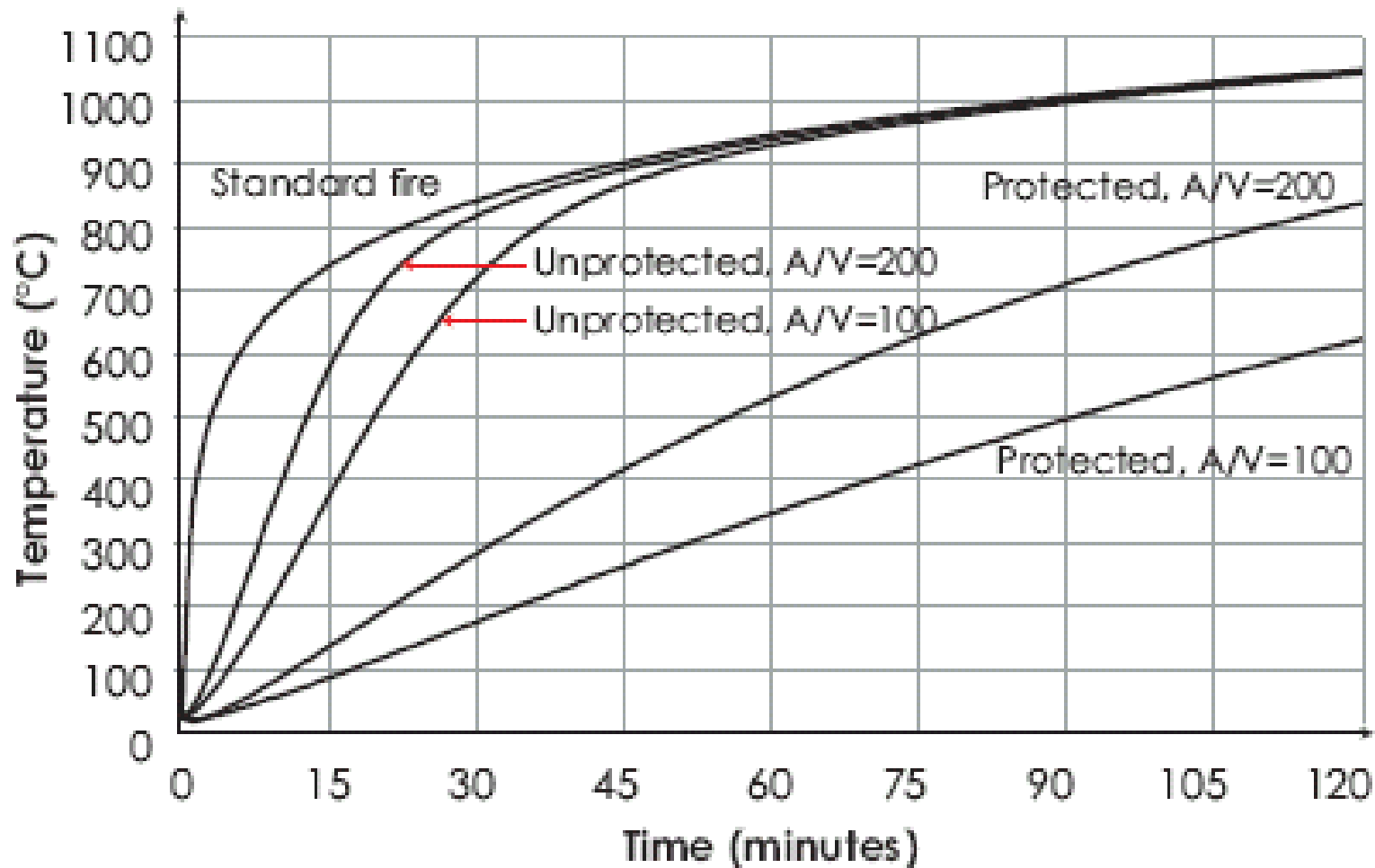
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Steel structures

- Steel loses strength and stiffness at high temperatures
- Steel can be protected with lightweight materials
- Both structural calculations and the use of design guidance can result in minimising fire protection

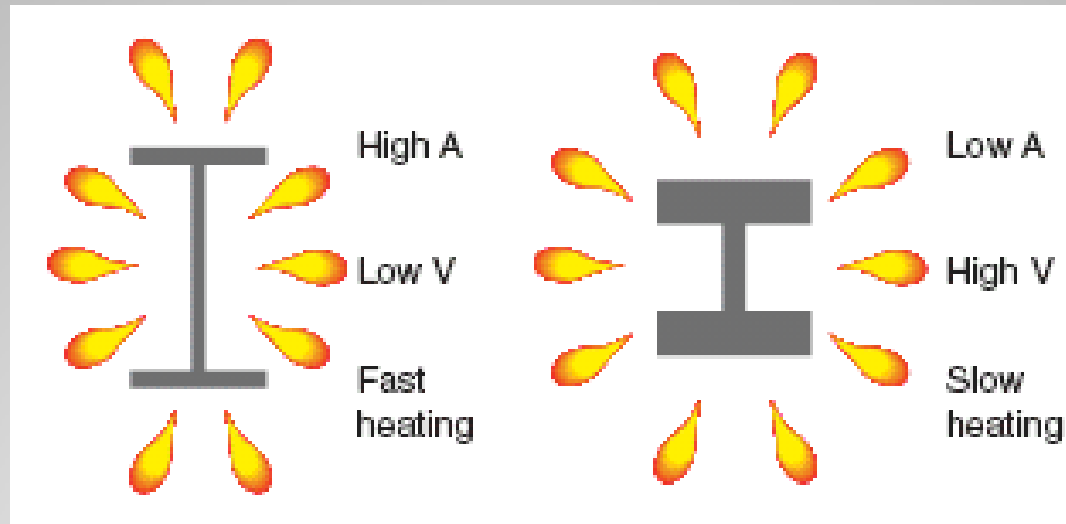


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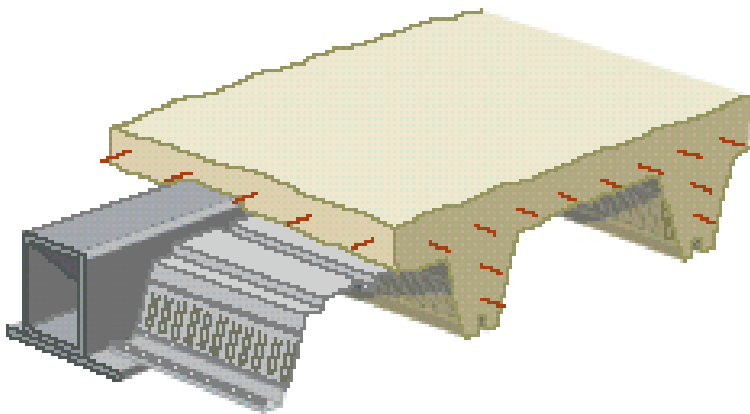
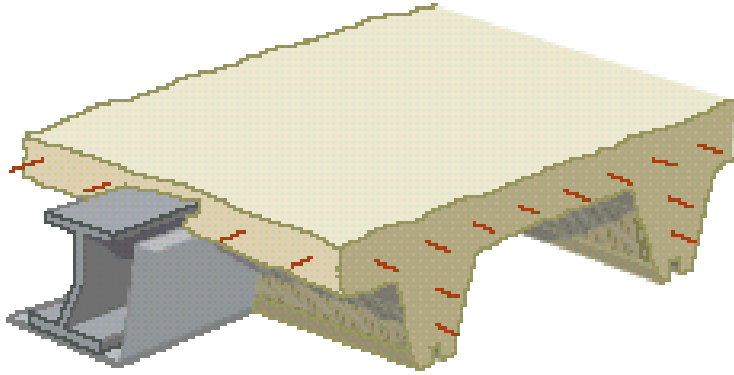
Heating rates of protected and unprotected steel beams

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A = surface area of steel exposed to fire per unit length
 V = volume of the section per unit length

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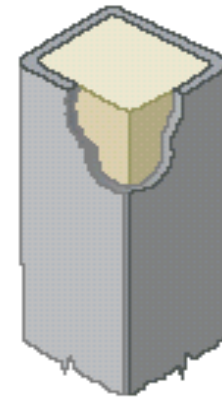
Composite construction

- Top – universal column with plate welded to beam
- Bottom – rectangular hollow section with plate welded to bottom flange

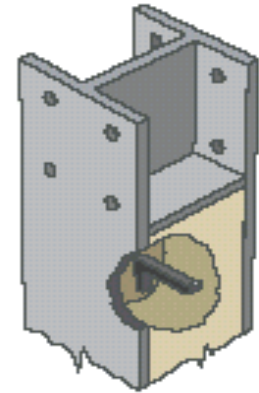
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In-filled steel sections

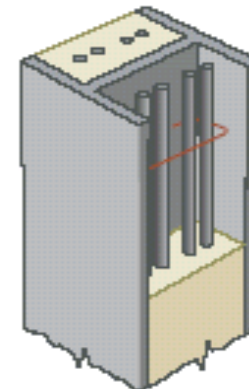
- Steel shell left unprotected
- Load redistributed to inner concrete core
- Will require larger cross-sections



Concrete filled steel section



Partially encased steel column (unreinforced)



Partially encased steel column (reinforced)

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Unprotected steel

- Where an exposed structure is part of the design objective
- Where it is cost effective to design elements in such a way that they are not fully exposed to fire
- Where it is more reliable to design members so they do not need fire protection

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Timber structures: some key issues...

- Combustibility
- Density
- Fissures
- Retardants
- Simplicity
- Connections and detailing
- Temperature and moisture content



Bridport House, London

Fire Engineering



The globe Theatre – an example of a timber structure where large timbers provide the necessary fire resistance without any additional fire protection

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Balancing aesthetics with fire protection

- Construction and detailing
- Structural connections
- Exposed connections
- Fire testing



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The use of exposed connections



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Masonry structures

- Excellent performance in fire
- Thermal and mechanical properties
- Thermal gradients
- Fire research shy

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- Construction and detailing masonry walls
 - Fire stopping
 - Recesses and chases
 - Movement joints



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- Fire stopping

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Fire protection materials

- Sprays
- Boards
- Intumescent coatings



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Sprayed
protection
applied to
complex
beam detail



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Boards and
blankets /
curtains

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Pin-fixed blanket
applied to truss



Fire board

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Thin film intumescent
coating being applied

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Workshop.

You are part of the design team for the construction of a fifteen storey office block to be constructed on the outskirts of a major town.

Put forward the key factors that should be considered for the design and planning of the means of escape in the event of a fire occurring in the building.

References

- [1] British Standards Institution.** Application of fire safety engineering principles to the design of buildings. Code of Practice. *British Standard* BS 7974:2001. London, BSI, 2001.
- [2] British Standards Institution.** Code of Practice for fire safety in the design, construction and use of buildings. (Draft for public comment.) *British Standard* BS 9999-2:2001 published as 01/540751 DC. London, BSI, 2001.
- [3] British Standards Institution.** Eurocode 1. Actions on structures. General actions. Actions on structures exposed to fire. *British Standard* BS EN 1991-1-2:2002. London, BSI, 2002.
- [4] European Committee for Standardisation.** Eurocode 2. Design of concrete structures. General rules. Structural fire design. Revised project team draft. prEN 1992-1-2:2002.
- [5] European Committee for Standardisation.** Eurocode 3. Design of steel structures. General rules. Structural fire design. Final draft. prEN 1993-1-2:2002.
- [6] European Committee for Standardisation.** Eurocode 4. Design of composite steel and concrete structures. General rules. Structural fire design. prEN 1994-1-2:2002.
- [7] European Committee for Standardisation.** Eurocode 5. Design of timber structures. General rules. Structural fire design. Final draft. Stage 49. prEN 1995-1-2:2003.
- [8] European Committee for Standardisation.** Eurocode 6. Design of masonry structures. General rules. Structural fire design. First draft, revision 1. prEN 1996-1-2:2001.