

Fire Safety in Buildings

Dr Keerthi Ranasinghe

Senior Lecturer & Programme Director
for Civil Engineering and Quantity Surveying
UWTSD

Contents

- History
- Current Legislation
- Approved Documents
- European and British Standards
- Passive Fire Safety Measures in Detail
- Active Fire Safety Measures in Detail

History

Great Fire of London (2-6 September, 1666)

- Started at the baker's house of Thomas Farynor on Pudding Lane. Burnt for 4 days
- 13,200 houses, 87 parish churches, St Paul's Cathedral
- 70,000 out of the 80,000 inhabitants of London became homeless
- Only 6 verified deaths (possibility that the poor and the middle class deaths were not recorded. Also, the heat was so high, it is possible that no remains were found of the many who perished)
- Archeological finds indicate that the heat may be as high as 1250C
- Firefighting technique of the time: create firebreaks by demolition



History

Eastwood Mills Fire in Yorkshire (23 February, 1956)

- Caused by a blowtorch, used to install hot water pipes, setting fire to a rope
- 10 fire brigades & 15 fire engines attended, but mostly were helpless at the beginning because the fire was so intense
- 60 foot high, three-storey building burnt to the ground in no time
- 5 casualties. Mostly trapped behind closed doors. No fire escapes, or wooden fire escapes. No fire alarms
- Robert E Franklin Ltd (mill owners) were fined £15
- 40,000 factories were surveyed as a result, leading to the 1959 amendment to the Factories Act 1937 (rewritten in 1961 to consolidate the original document)



History

Henderson's Department Store Fire in Liverpool (22 June, 1960)

- Opened in 1828, bought by Harrod's in 1949, burned down in just over an hour
- Caused by arcing on an armoured steel electricity cable. 11 lives were lost
- Extremely rapid spread of fire meant the fire crews had to be withdrawn
- What remained afterwards was very unstable, so had to be demolished
- As a result, the government at the time brought in the "Offices, Shops and Railway Premises Act"
- The legislation gave the fire brigades the power to inspect offices, high street stores and railways for fire safety



History

Rose and Crown fire in Saffron Walden (26 December, 1971)

- Believed to be caused by an overheated TV in the lounge
- Two guests raised the alarm, many were trapped on the floors above
- 33 people staying in the hotel that night. 11 people died, all from the 2nd and 3rd floors
- 15th Century building. Raised questions about the safety of the premises
- Lead to the “Fire Precautions Act 1971”. The act gave the Secretary of State the power to designate the types of premises he/she wanted to be covered by the act
- Hotels and boarding houses were the first to be designated as requiring a certificate issued by the fire brigade. Factories, Shops and Railways soon followed, thus replacing the Fire Precautions Act



Current Legislation

All fire safety legislation in England and Wales is now collected under “The Regulatory Reform (Fire Safety) Order, 2005”

- Designed to simplify all the regulations by repealing 118 existing fire regulations
- All non-domestic premises fall under this
- A shift in emphasis from fire protection to fire prevention
- Abolition of fire certificates
- Every business premises must have a “Responsible Person” whose job is to make sure certain duties are carried out in relation to fire safety. Most businesses employ specialists to look after the duties

Current Legislation

Fire Risk Assessment

- All businesses must have a “Fire Risk Assessment”, which should be presented to any fire authority requesting to inspect the premises
- Need not be written down unless there are 4 employees or the premises require a license to operate. However, documentation is recommended
- Fire Risk Assessment must;
 - Be reviewed regularly and amended and updated as necessary on an ongoing basis
 - Record any alterations made as requested by fire authorities
 - Record any findings and actions to be taken
 - Preferably be done by a professional “Fire Risk Assessor”, who is able to identify potential causes for fire, people at risk and assess the fire safety measures in place and their ongoing management
- Government’s guidelines on Fire Risk Assessments are found at (<https://www.gov.uk/workplace-fire-safety-your-responsibilities>)

Current Legislation

Fire Extinguishers

- UK Fire Safety Legislation states that “appropriate fire-fighting equipment” must be provided
- Usually means fire extinguishers for most businesses, but some higher-risk premises may also need hose reels or sprinklers
- Fire extinguishers must;
 - Be the right type for the business and the location
 - Be maintained in good working order
 - Undergo an annual maintenance test by a “competent person”
 - Be certified to industry standards
 - Will look at these in detail later

Current Legislation

Fire Safety Signs

- Often overlooked, but at least the first two are mandatory for all businesses
 - Fire Action Notices - what to do in case of fire
 - Fire Extinguisher ID Signs - explains and locates each type of extinguisher
 - Fire Exit Signs - how/where/routes to exit in case of fire. Needed for all but the most basic operations
 - Fire Alarm Call Points - identifies where to activate the fire alarms. Mandatory if an alarm is available
 - Warning and Prohibition Signs - highlights danger. Needed when there is a high risk of fire
 - Other Fire Equipment Signs - signposts to hose reels, dry risers etc.

Current Legislation

Fire Alarm Systems

- May not be needed if operating out of a small premises, where a fire could be readily seen and a simple shout of FIRE would be heard by everyone
- Higher-risk businesses such as restaurants are recommended to have one
- All other businesses must have an alarm system;
 - That is either automatic or manual
 - Which is automatic if a fire is unlikely to go un-noticed or likely to block exit routes
 - That could be clearly heard by all occupants
 - That is installed with alarm call points at every exit point of the building
 - Supported by a well maintained fire detection system
 - That is tested weekly and serviced every 6 months by competent personnel and be approved to industry standards

Current Legislation

Emergency Lighting

- UK Fire Safety Legislation stipulates that emergency lighting are required if normal lights fail during a fire
- Buildings require emergency lighting especially when areas are identified as high risk. Also needed when rooms are larger than 60m²
- 3 main purposes of emergency lighting
 - Escape route lighting - illuminates exit routes and helps find fire fighting equipment
 - Open Area Lighting - also called “panic lighting”, keeps communal areas lit to reduce panic
 - High Risk Task Area Lighting - provides lighting to enable shutting down of dangerous processes, for example
- All lights should be “flick-tested” (turned off and on) once a month and fully serviced once a year
- Latest British standard recommends a 3 hour emergency light test once a year, during which main lighting circuit should be switched off and the emergency lights left on for a 3 hour period. 3 hours is the time stipulated as required by the fire brigades to work during a fire event
- Alternatively, 1 hour tests may be carried out once a year

Current Legislation

Fire Safety Training

- Entire team should know what to do in the event of a fire and new employees must be shown what to do when they join
- UK Fire Safety Legislation stipulates that;
 - Refresher training be delivered regularly - typically annually
 - Training updates be done if building alterations are carried out
 - Regular fire drills are carried out
 - Fire marshals (or wardens) be appointed to;
 - Use fire extinguishers where appropriate
 - Assist with the evacuation
 - Make contact with the emergency services

Approved Documents

Approved Documents (AD's) are “a series of documents approved and issued by the Secretary of State for the purposes of providing practical guidance with respect to the requirements of Building Regulations 2010 for England and Wales”

Similar documents are available for Scotland (Technical Standards D and E) and Northern Ireland (Technical Booklet E)

AD's are intended to provide guidance for some of the more common building situations and do not claim to be the only means of achieving compliance with the requirements of the Building Regulations 2010

Approved Document B - Fire Safety

- Published in 2 volumes, provides guidance and methods for;
 - Dwelling houses in volume 1
 - Buildings other than dwelling houses in volume 2
- Applies to new buildings and to existing buildings undergoing substantial alterations and/or change of use
- Places a high importance on life safety and seeks to provide building occupants with sufficient means of escape to reach places of safety before the building environment becomes life threatening
- Both volumes set out provisions under 5 sub-headings as given in the next slide

Approved Document B

- **B1: Means of warning and escape** - Provide satisfactory means of giving alarm of fire and a satisfactory standard of means of escape for building occupants
- **B2: Internal fire spread (linings)** - Ensure fire spread over the internal linings of the buildings is inhibited
- **B3: Internal fire spread (structure)** - Ensure the stability of buildings in the event of a fire. Ensure that there is sufficient degree of fire separation within buildings and between adjoining buildings. Provide automatic fire suppression where necessary. Inhibit unseen spread of fire and smoke in concealed spaces in buildings
- **B4: External fire spread** - Ensure that external walls and roofs have adequate resistance to the spread of fire over the external envelope and that spread of fire from one building to another is restricted
- **B5: Access and facilities for the fire service** - Provide satisfactory access for fire appliances to buildings and the provision of facilities within buildings to assist fire-fighters in the saving of life of people in and around buildings

B1 - Requirements of Part B of Schedule 1 (Building Regulations 2010)

“The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and appropriate 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 times”

The above will be met, if;

Dwelling Houses	Other Buildings
There is sufficient means for giving early warning of fire for persons in the building	
There are routes of sufficient number and capacity, which are suitably located to enable persons to escape to a place of safety in the event of fire	
The routes are sufficiently protected from the effects of fire when necessary	
	The routes are adequately lit
	The exits are suitably signed
	There are appropriate facilities to either limit the ingress of smoke to the escape route(s) or to restrict the fire and remove the smoke
	All to an extent necessary that is dependant on the use of the building, its size and height

B2 - Requirements of Part B of Schedule 1 (Building Regulations 2010)

“(1) To inhibit the spread of fire within the building, the internal lining shall:

(a) adequately resist the spread of flame over their surfaces; and

(b) have, if ignited, a rate of heat release or a rate of fire growth, which is reasonable in the circumstances

(2) In this paragraph ‘internal linings’ mean the materials or products used in lining any partition, wall, ceiling or other internal structure”

B3 - Requirements of Part B of Schedule 1 (Building Regulations 2010)

“(1) The building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period (*comment – loadbearing elements)

(2) A wall common to two or more buildings shall be designed and constructed so that it adequately resists the spread of fire between those 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 (*comment – compartmentation)

(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 (*comment – the continuity of fire separation)

(b) installation of suitable automatic fire suppression systems

(4) The building shall be designed and constructed so that the unseen spread of fire and smoke within concealed spaces in its structure and fabric is inhibited”

B4 - Requirements of Part B of Schedule 1 (Building Regulations 2010)

“(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”

The above will be met, if;

(a) the 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 have low rates of heat release

(b) the amount of unprotected area in the side of the building is restricted so as to limit the amount of thermal radiation that can pass through the wall, taking the distance between the wall and the boundary into account

(c) the roof is constructed so that the risk of spread of flame and/or fire penetration from an external fire source is restricted

B5 - Requirements of Part B of Schedule 1 (Building Regulations 2010)

“(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 and gain access to the building”

The above will be met, if;

(a) there is sufficient means of external access to enable fire appliances to be brought near to the building for effective use

(b) there is sufficient means of access into, and within, the building for firefighting personnel to effect search and rescue and fight fire

(c) the building is provided with sufficient internal fire mains and other facilities to assist firefighters in their tasks

(d) the building is provided with adequate means for venting heat and smoke from a fire in a basement

European and British Standards

Reaction to fire (B2)

- BS 476 series of standards for both reaction to fire and fire resistance
 - BS 476: Part 6 – fire propagation for products
 - BS 476: Part 7 – surface spread of flame of products
- To be replaced by a set of European Standards
 - BS EN ISO 1716 – Reaction to fire tests for building products – determination of heat of combustion
 - BS EN ISO 1182 – Reaction to fire tests for building products – non-combustibility test
 - BS EN 13502-1 – Fire classification of construction products and building elements Part 1: classification using test data from reaction to fire tests

European and British Standards

Fire resistance (B3)

- BS 476 series of standards for both reaction to fire and fire resistance
 - BS 476: Part 20 – fire tests on building materials and structures – Part 20: Method for the determination of the fire resistance of elements of construction (general principles)
 - Integrity
 - Insulation
 - Load bearing capacity
 - BS 476: Part 21 – fire tests on building materials and structures – Part 21: Methods for the determination of the fire resistance of loadbearing elements of construction
 - BS 476: Part 24 – fire tests on building materials and structures – Part 24: Method for the determination of the fire resistance of ventilation ducts
- Corresponding European Standards – BS EN 1363

European and British Standards

Fire performance of external cladding systems (B4)

- BS 8414
 - BS 8414-1 – deals with systems fixed directly to the face of the building
 - BS 8414-2 – deals with systems fixed to an supported by a structural steel frame
- Developed after a number of high-profile fires where the external façade of tall buildings provided a route for vertical fire spread
- Determines;
 - Fire spread over the external surface
 - Fire spread internally within the system under test
 - Mechanical response, i.e. the degree of distortion and collapse

Minimum Periods of Fire Resistance

Type	Minimum periods of fire resistance in minutes					
	Basement storeys		Ground or upper storeys (height of top floor in m)			
	Not more than 10m deep	More than 10m deep	Not more than 5	Not more than 18	Not more than 30	More than 30
Residential, blocks of flats (sprinklered or not), Institutional, Other residential	60	90	30*	60	90	120 (not permitted when not sprinklered)
Office – not sprinklered	60	90	30*	60	90	Not permitted
Office – sprinklered	60	60	30*	30*	60	120
Shop & Commercial – not sprinklered	60	90	60	60	90	Not permitted
Shop & Commercial – sprinklered	60	60	30*	60	60	120
Industrial – not sprinklered	90	120	60	90	120	Not permitted
Industrial – sprinklered	60	90	30*	60	90	120

* - increased to a minimum of 60 minutes for compartment walls separating buildings

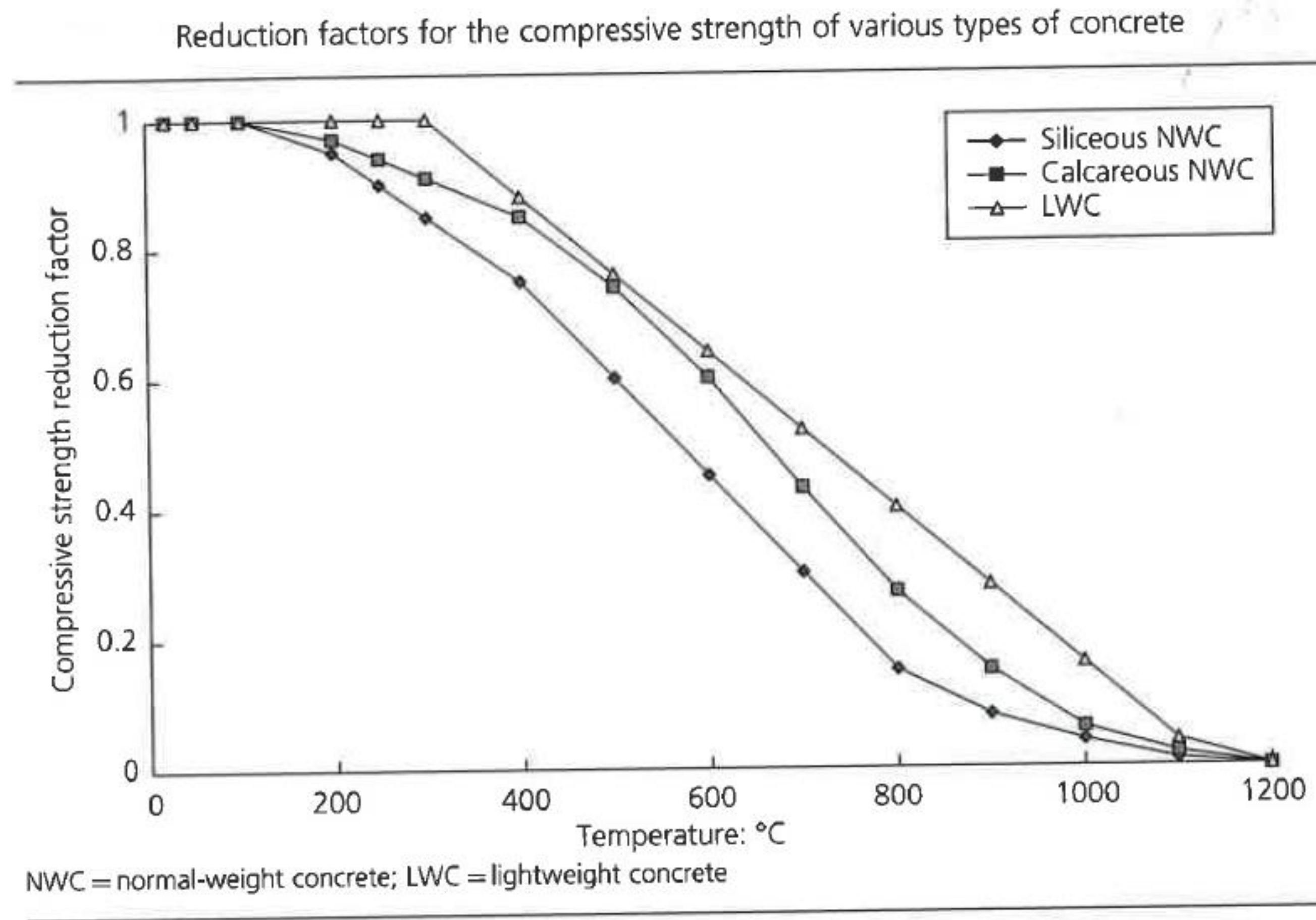
Passive Fire Safety Measures

“Passive fire protection is provided by building elements which are designed and constructed in such a way as to maintain their load-bearing and/or separating function for the required minimum duration of fire exposure”

Passive fire protection measures are usually;

- Adequate compartmentation to inhibit the spread of heat, smoke and gases
- Limitation of fire compartment size
- Control of flammability/combustibility of wall linings – particularly on escape routes
- Provision of protected escape routes
- Provision of adequate thermal insulation, stability and structural performance
- Fire stopping

Fire in Concrete Structures

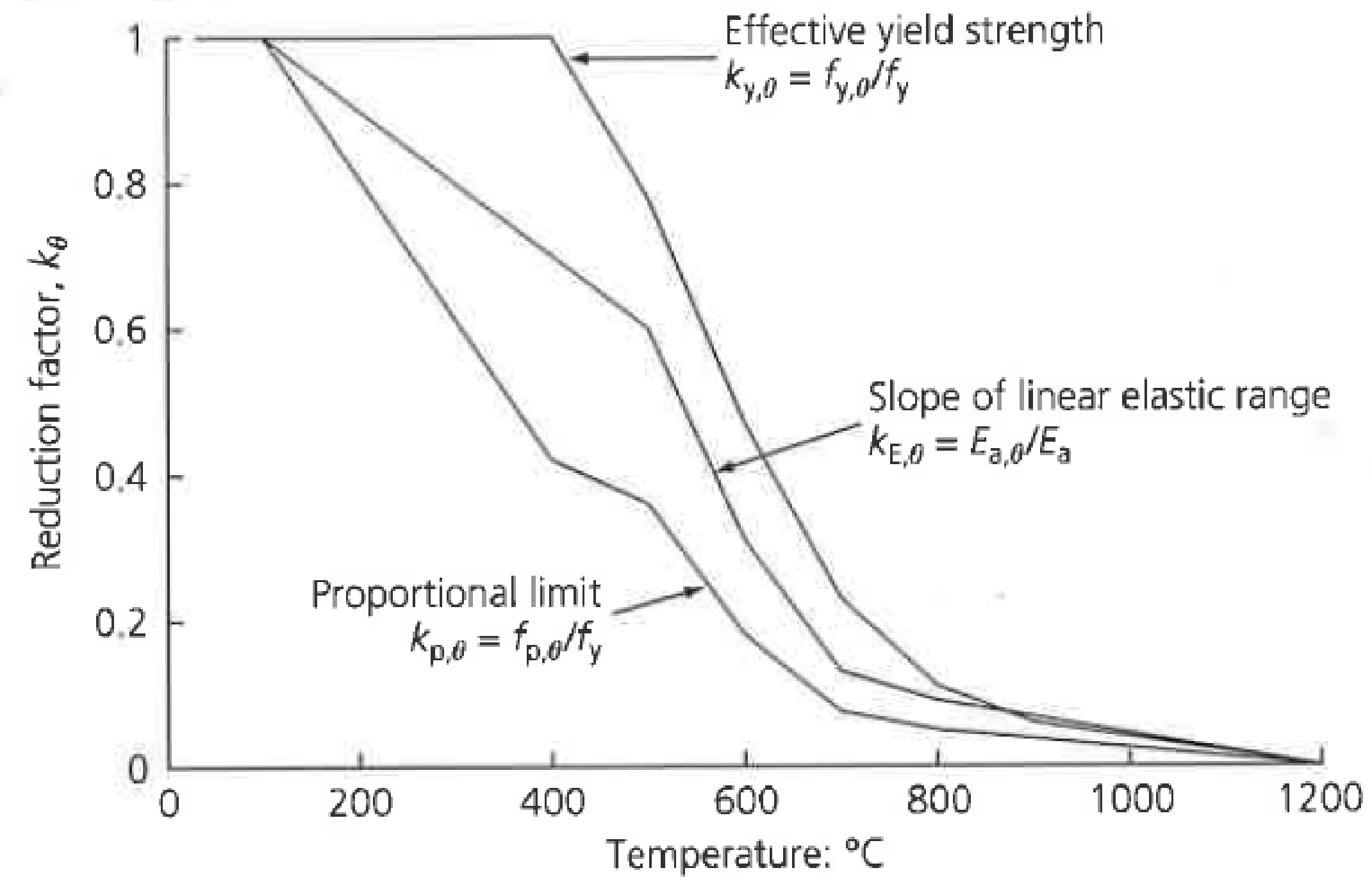


Fire in Concrete Structures

- Performs well during and after a fire
- Can usually be repaired after a fire in the majority of fire situations
- Non-combustible, high thermal mass (ability to absorb and store heat)
- Design has traditionally been limited to maintaining minimum dimensions so as not to get high temperatures;
 - on the unexposed faces that could ignite combustible materials on that side of the structure
 - on the reinforcing and/or pre-stressing bars that could compromise their performance
- During recent years the focus has shifted to more scientific areas such as spalling of concrete during a fire
- Properties of concrete do degrade with increasing temperatures so this has also been taken into account in new standards

Fire in Steel Structures

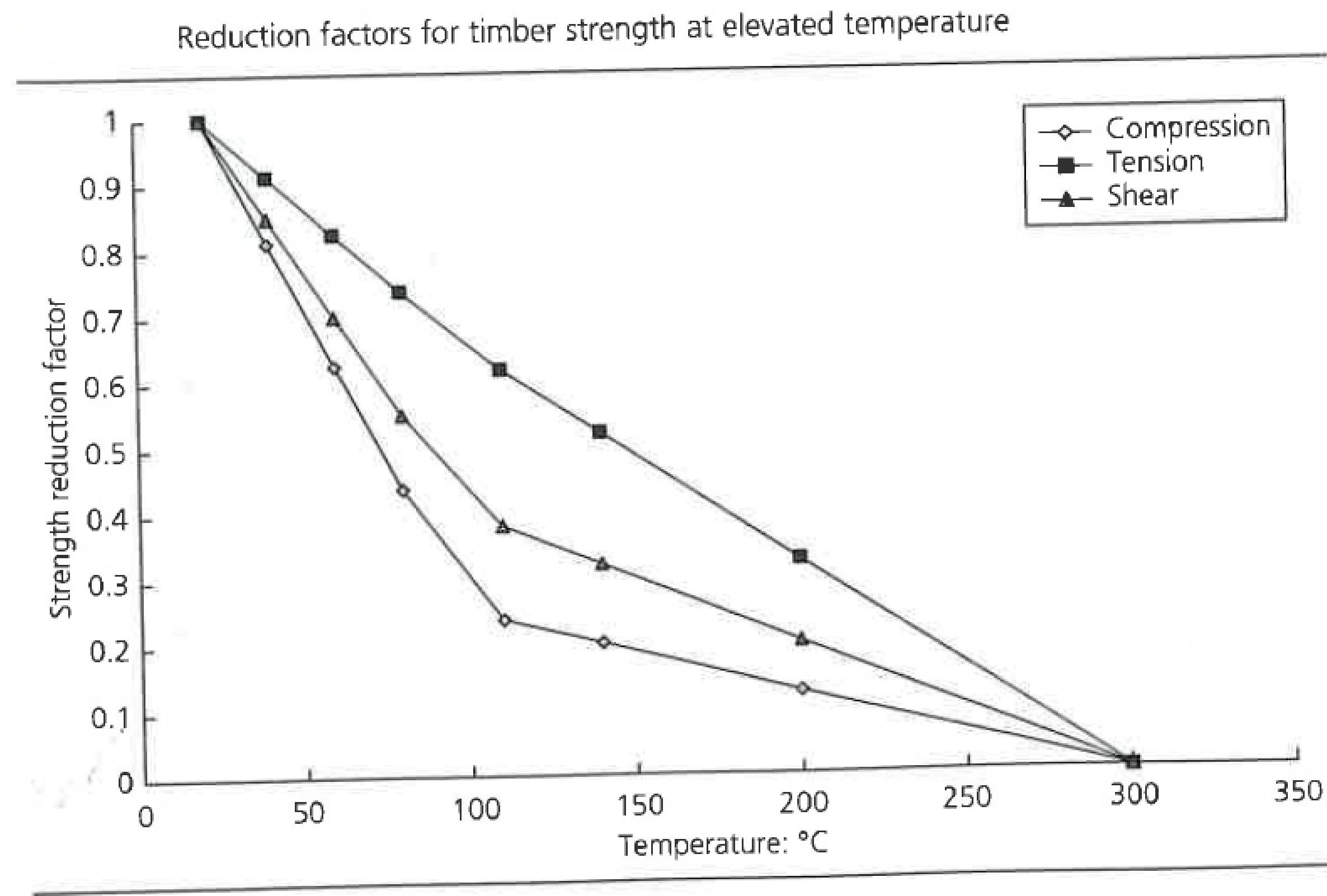
Reduction factors for the stress-strain relationship of carbon steel at elevated temperatures



Fire in Steel Structures

- Steel loses both strength and stiffness with increasing temperatures
- Significant losses around 400-600⁰c
- Usual method is to design for the ambient temperature loading conditions and then to protect the steel with proprietary protection materials to ensure that either;
 - a specific temperature is not exceeded in the member, or
 - a specified percentage of the ambient temperature loading capacity is retained
- BS 5950: Part 8 recognises that there is no single “failure temperature” for steel members and that structural failure is influenced by both the temperature as well as the loading on the member
- BS 5950 gives two methods for calculations;
 - limiting temperature method
 - moment capacity method

Fire in Timber Structures



Fire in Timber Structures

- Is a combustible material
- However, the rate of burning (charring) is very predictable
- When charred, timber outer layers provide thermal insulation to the inner layers, which are at lower temperatures and continue to carry loads
- Usually designed by using;
 - an insulation method – where the member is protected by a protective layer such as plasterboard,
 - or a residual cross section method – where the capacity of the uncharred section is considered
 - or a combination of both these methods
- During charring, if more than one surface is exposed, “corner” rounding effects should also be taken in to account

Active Fire Safety Measures

Active fire protection measures are usually;

- Provision of alarm systems – audible (voice alarms, sirens, bells), visual (strobes), tactile (vibrating pagers)
- Provision of automatic fire detection – smoke, heat, flame, combustion gas to trigger alarms and/or protection systems
- Indication of the location of a fire on a visual display, mimic diagram etc.
- Provision of smoke/heat venting & exhaust control systems to extend escape time (but not designed to control the fire)
- Closing of smoke dampers in ducts, closing of doors to create fire compartments, refuges etc. – sometimes it is possible for the fire to self-extinguish in a well sealed compartment due to lack of oxygen
- Release of access control systems on doors, gates, turnstiles etc., to facilitate escape
- Provision of automatic fire suppression systems – Water (sprinklers, mist, drenchers), foam, chemical agents, inert gases

Active Fire Safety Measures

- All active measures remain “inactive” until they are triggered
- Fire alarms are the most common measures – a requirement. In cases where hearing difficulties can occur (for example high ambient noise, or occupants with hearing impairment) flashing strobes may be linked to the system
- Zoning systems may be available depending on the building type – “total evacuation”, “phased evacuation” or “progressive horizontal evacuation”
- Automatic fire detection linked to the alarms may be required, where;
 - occupants sleep, such as hotels and hostels
 - people work in remote and/or isolated areas within the premises
 - there could be lone workers
- Automatic fire detection can be linked to smoke, heat (absolute or rate of rise), flame (infra-red, ultra-violet, gas, carbon monoxide

Active Fire Safety Measures

Smoke detectors

- Are primarily particle detectors, so false alarms are possible when exposed to aerosols, dusts, exhaust fumes etc.
- Optical type point detectors are the most common ones, where larger particles such as from smouldering fires are quickly recognised
- Ionisation chamber smoke detectors are sensitive to fast flaming fires
- Infrared beam detectors (by obscuration of the beam by particles)

Heat detectors

- Fitted where smoke detectors are impractical, such as in kitchens, boiler rooms and laundries
- May detect temperature thresholds or the rate of rise of temperature

Active Fire Safety Measures

Sprinkler Systems

- Developed by the insurance industry mostly for asset and property protection
- Now used to prevent loss of life too
- Could be used for the whole building or areas or high risk
- Needs a reliable (uninterrupted) water supply (could be the water mains or a pumped system), feeding an array of sprinkler heads, mounted at correct spacing on appropriately sized network of pipes
- Each sprinkler head is a heat detector (typically 68⁰C), so all sprinklers may not operate at the same time

