Bachelor Degree in Business Studies
Fire Safety, Engineering & Design: 2025-2026
Stage 2: BSEMS_B_Y2 : DAY 2 of 5

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Introduction

- Credit – Michael P. Lyons CEng MIEI MIFireE Michael P. Lyons & Associates for presentation and handout materials
- Emails / Handouts
- Class President
- Phones etc.
- 4 DAYS
- Exam
  - Summer
  - Assignment

A	FSED-INTRODUCTION
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1.2	Understanding Structures
1.3	Fire Safety in Buildings
1.4	Fire Severity / Fire & Heat
1.5	Fire Resistance
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1.7	Compartment Fires
1.8	Aspects of Design - B1 & B3

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2.2	SM at elevated temperatures
2.3	Design of structures exposed to fire
2.4	Steel structures
2.5	Concrete structures
2.6	Timber structures
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D	Engineering Fire Safety
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2.1-2.8 Fire Safety, Engineering & Design -MATERIALS

1. Structural materials
2. SM at elevated temperatures
3. Design of structures exposed to fire
4. Steel structures
5. Concrete structures
6. Timber structures
7. Light frame construction
8. Construction Fire Technology

Assignment

- A new six storey luxury hotel development is being prepared for design in a city centre location. The development comprises of a 3,000m2 leisure centre at ground floor level (Level 1), the First floor (Level 2) comprises of a reception, bar and breakfast room/restaurant and ancillary accommodation with 30 bedrooms per floor on Level 3 and Level 4. Level 5 and Level 6 comprise of two-storey private penthouse apartments. Each upper floor area is 1,500 m^2. A 3,000 m^2 of car parking space will be provided in the basement of the building. You are to prepare a briefing document for the client in relation to fire safety design considerations and challenges which will be pertinent to the brief.
- You are to prepare a briefing document for the client in relation to fire safety design considerations and challenges which will be pertinent to the brief.
- (a) Present and explain the main considerations for compliance with building regulation B1 in designing this building on the basis of complying with current fire safety design standards. 80 marks.
- (b) Evaluate the requirements for natural ventilation of the basement car park in accordance with regulation B3. 20 marks.

Assignment

The aim of the assignment is for you to apply the course material to a real-life situation by considering the issues relevant to the module.

Your written assignment should incorporate *all* of the following:

1. An executive summary explanation for the client, relevant to her/him as a lay person, of the challenges you have identified in your assignment.

   [*20 marks*]
2. A demonstration of your awareness of the factors involved in identification of the principal considerations. [*50 marks*]
3. Evidence of a good command of the subject. [20 marks]
4. Check for learning, summary and conclusions. [10 marks]

Stage 2: BBS DAY 2 of 5

2.1 Structural materials & Fire Testing

Behaviour of structural materials in fire

- Concrete
- Plasterboard
- Timber
- Masonry
- Cast Iron
- Steel
- Gypsum
- Glass
- Fibreglass

Structural Steel

- Basic concept
  - – Keep steel element below its critical temperature, which is between 500 and 560°C, depending on which standard and which country one regards
  - – Retard exposure time and
  - – Degrade the fire's severity on the structural members
- At elevated temperatures
  - – steel first expands.
  - – After critical temperature
    - – softens and ceases to render any structural support
    - – Strength and Stiffness lost at high temperature levels
- Instead, its collapse is actually a drain on that, which it was meant to uphold
- Section factor Hp/A in Ireland, now changed to Eurocode A/V

- For unprotected metallic materials: High Hp & Low A: Fast Heating Low Hp & High A: Slow Heating
- Convenient parameter to measure the thermal response
- Heating Rate proportional to the surface area (A) of steel exposed to the fire and inversely proportional to the mass or volume (V) of the section.
- Lower section factors heats up at a slower rate
  - – Terms A/V and Hp/A have exactly the same meaning

Concrete (reinforced)

- Steel rods or mesh give tensile strength
- inherent compression strength
- limits fire spread, but vulnerable under very high heat conditions
- Spalling and cracking - indicators of loss of integrity
  - Do not assume adequacy because of concrete
- Non-combustible - very slow rate of heat transfer
- Minimum size and depth of cover to all reinforcement
  - limiting the acquired temperature of reinforcement
- BS8110-1:1997
  - as well as by the use of BS8110-2:1985
- Lightweight concrete and retro-checking fire resistance
  - Eurocode I.S. EN1991-1-2
- Tabulated data of EN1991-1-2 more extensive than that of BS8110-2

Plasterboard

- Gypsum plasterboard or Gypsum board
- Rigid sheets of building material - gypsum plaster and other materials
  - Can contain sand, perlite or vermiculite
  - Gypsum is a crystalline mineral
  - de-hydrated gypsum is referred to as 'plaster of paris'
- Quality of the Board critically affects fire performance of an assembly
- Most boards are a sandwich of plaster between sheets of paper chemically and mechanically bound
- 'Sheetrock' in North America
  - used to create light-frame construction with fire resistance (dry-walling)
- Fibrous board has no paper
  - relies on glass fibre or sisal reinforcing within the plaster for strength
  - silicone additives are used for moisture resistance
- Specifications denote dimensional tolerances, minimum flexural strength, hardness and nail-pull resistance under normal temp conditions, as well as fire resistance
  - GF glass-fibre reinforcing board in EU and Type X board in the USA

Structural Timber

- Used in several structural areas in different types of construction.
- Plywood, composite sheets, solid dimensional timber (lumber), and laminate beams are used in floors, walls,

  partitions, ceilings and roofs.
  - The reaction of wood to heat and to fire depends on moisture content and section size.
- The larger the dimensions, the longer wood can retain structural integrity.
- The higher the moisture content also limits the rate of burning.
- Composite sheets contain wood chips or fibres glued and pressed into sheets.
  - This material can produce toxic gases and rapidly deteriorate in fire conditions.

Euroclass System

- A1 non-combustible
- A2 limited-combustibility
- B similar to Class O
- C similar to Class 1
- D similar to Class 2
- E similar to Class 3
- F no performance

Fire Resistance Test Standards

- EN 1364 Non-loadbearing Elements (6 standards)
- EN 1365 Loadbearing Elements (6 standards)
- EN 1366 Service Installations (10 standards)
- EN 1634 Fire Doors & Shutters (3 standards)
- EN 13381 Contribution to Fire Resistance (7 standards)
- EN 1363-2 Alternative & Additional Requirements
- EN 1363-1 General Requirements

EN 1363-1 General Requirements

- Methodology of fire resistance test
- General information relating to FR testing
  - Standard ISO time/temperature curve
  - Performance criteria for test
  - Tolerances, specifications, equipment, etc.
  - Plate thermometer used to control furnace temperature
- Helps to standardise thermal dose between different furnace designs

Reaction To Fire Tests

- Pre-flashover scenario
  - Less severe exposure
- Testing of materials
  - E.g. Wall & ceiling linings
  - Small/medium scale tests
  - Defined relationship with real and reference fire scenarios• Fire Resistance Test
  - Post-flashover scenario
  - Severe exposure

Test of construction
  - Large scale test
  - element (e.g. wall, door)
  - Standard Fire
- Less well defined relationship with real fire scenarios

Fire scenarios:

- Ignition – where and when?
- Fire growth rate?
- Peak rate of heat release?
- Duration?

Test Apparatus

SBI (Single Burning Item) Test Apparatus EN 13823

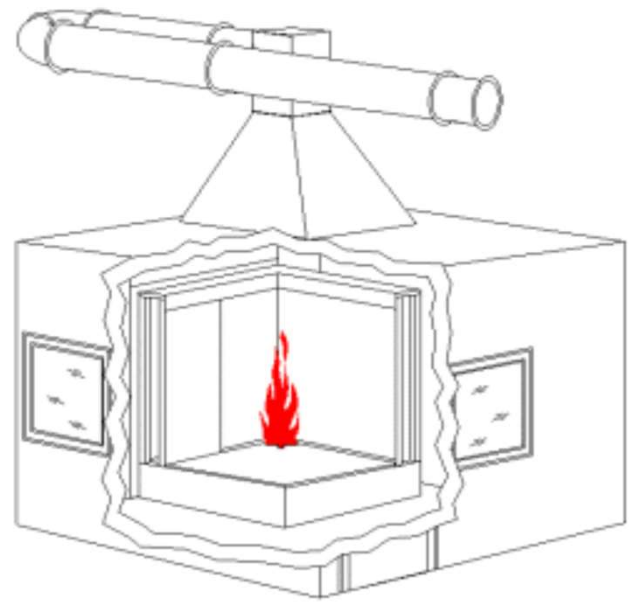
- SBI Test is needed to classify all non flooring products into the to Classes A2, B, C and D
  - Duration 20 minutes
  - Heat flux 40 kW/m2
- The main components of the SBI are: -

1. The Test Apparatus.
2. Gas Analysis Instrumentation for Heat Release Measurement.
3. Smoke Measurement System.
4. Burner, Gas Train and Controls.
5. Data Acquisition and Analysis Software.

Test Apparatus

SPECIMEN TROLLEY

PROPANE BURNER
EXHAUST SYSTEM

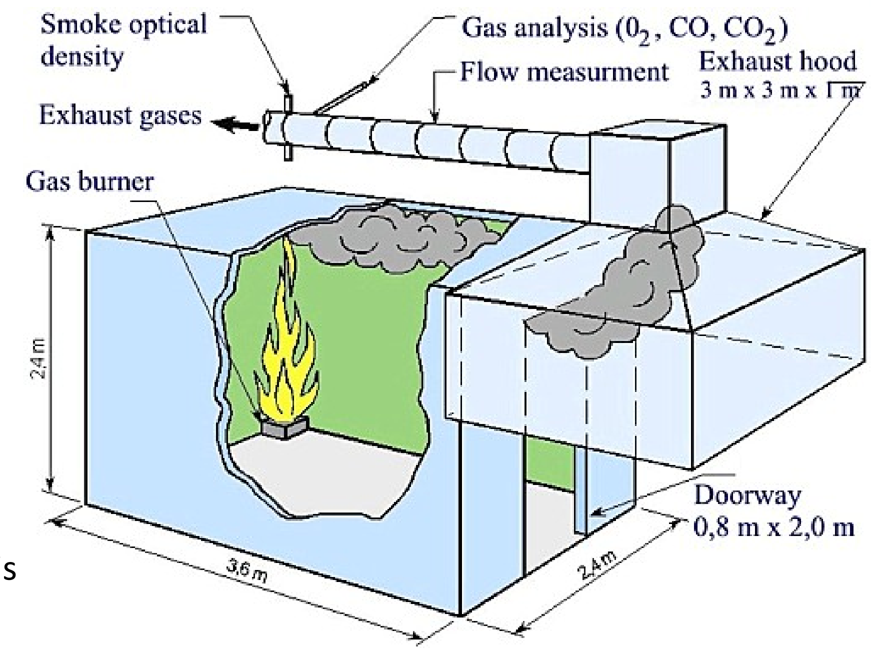


TEST APPARATUS

Reaction to fire – Room Corner Test

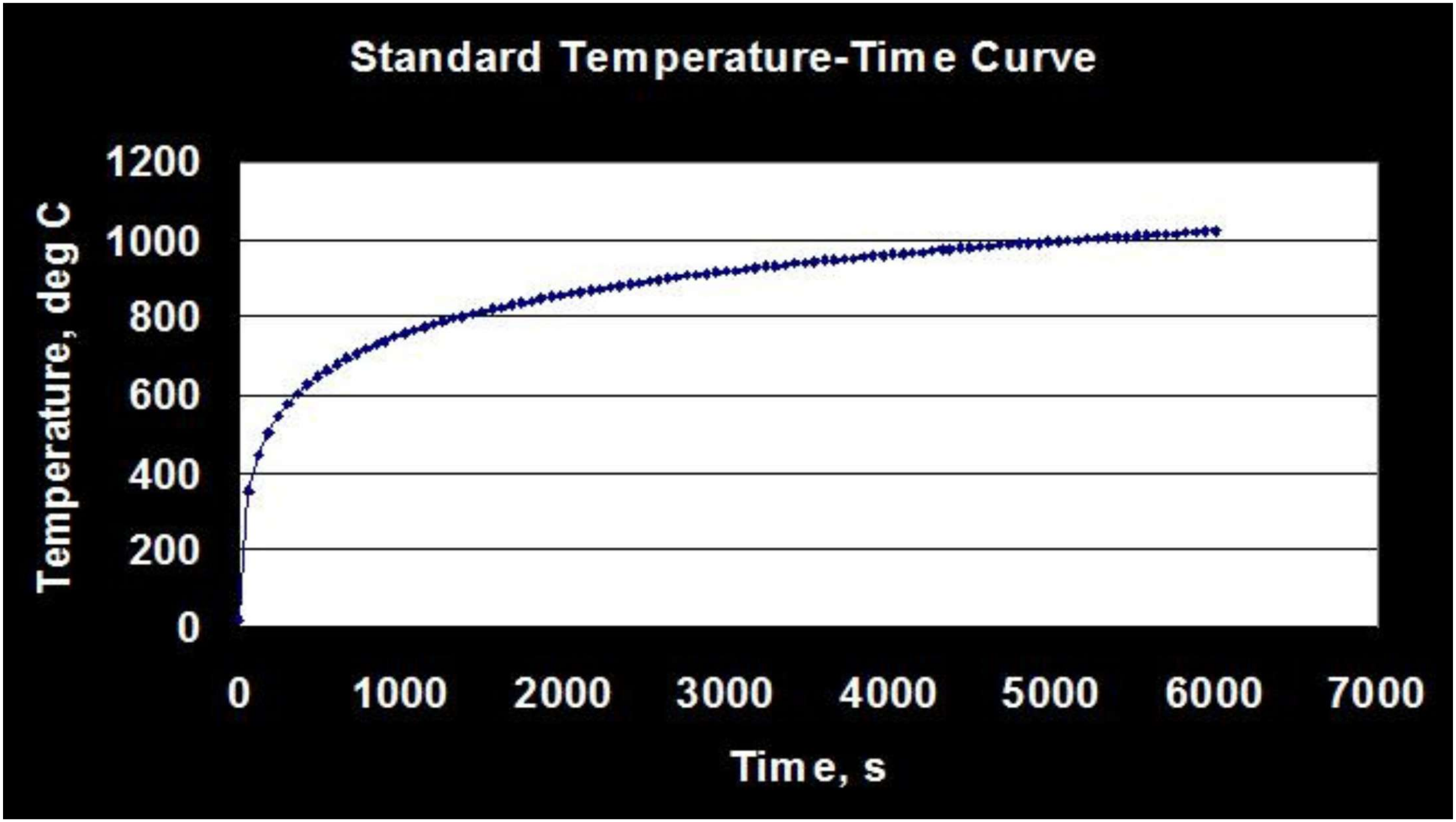
Method evaluates fire characteristics of a surface product in a room fire scenario

- Basis for Euro-classification System
  - Large scale Room-Corner Test
- Surface linings to Euroclass A-E
- Field of application:
  - building products
  - thermoplastic materials,
  - joint systems, irregular
  - pipe insulation
  - upholstered furniture
- The method measures the following:
  - heat release rate (kW), total heat release (MJ) and smoke production rate (m2/s).
  - flashover phenomenon is also registered
  - toxic gases can also be measured using FTIR analysis
- Also used in marine applications
  - for classification of “fire-restricting materials”



Standard Temp, T vs. time, t

- Curve is based on an unrestrained column (i.e pinned joints)
- Curve does not take into account the interactions brought about by whole building behaviour
- Determined by controlling the gas phase temperature in the furnace
- Unnatural fire situation as no limiting factor such as exhaustion of fuel or lack of ventilation
- Does not create a realistic model
- Temperature as defined by the curve continues to increase with time hence no cooling takes place
- Not suitable for modelling the cooling of a structure after a fire



Standard Temperature-Time Curve
1200
1000
800
600
400
200
0
0
1000
2000
3000
4000
5000
6000
7000
Temperature, deg C
Time, s

Standard Temp, T vs. time, t

- Standard Fire Curves
  - suitable for making comparisons
- Do not provide us with a true indication of how structural components and assemblies will behave in an actual fire
- Collapse is the only physical limit state performance as a failure criteria for both the ISO 834 and ASTM E199 tests
- Their increasing temperatures do not reflect the fact that natural fires (i.e. compartment fires) decrease in fire intensity
  - once the fuel in the compartment has been expended
  - Do not account for material decomposition within the compartment, the boundary construction of the compartment, or ventilation effects on the fire.

Standard fire curve equation

- $T = 345 \log_{10}(8t + 1) + T_0$
- Temperature values, T (°C), for the ISO 834 fire follow the equation above where t (minutes) is the time and To (ºC) is the ambient temperature.
  - Failure criteria for the ISO 834 fire are (Malhotra 1982):
- (1) Collapse or the downward deformation of flexural members exceeding L/30 where L is the span,
- (2) Ignition of a cotton pad held close to an opening for 10 seconds, and
- (3) Temperature of the unexposed face rising more than 140ºC as an average or by more than 180ºC at any point.

Understanding Structures

- Time-Temperature Curves at Various Points

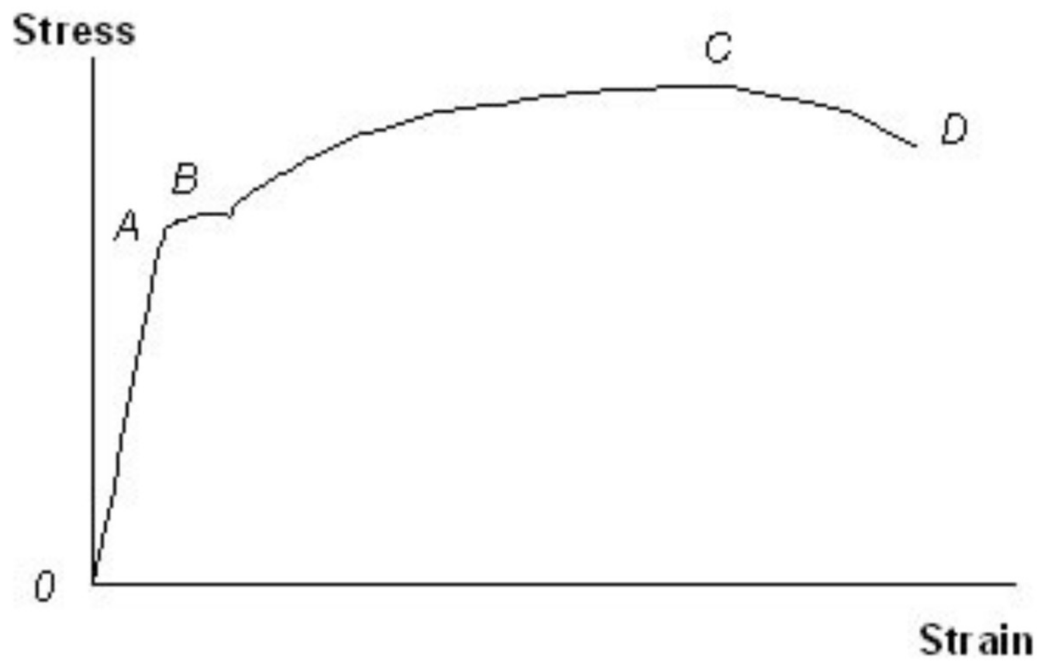
Time (minutes)	ASTM E119 Temperature (ºC)	ISO 834 Temperature (ºC)
0	20	20
5	538	576
10	704	678
30	843	842
60	927	945
120	1010	1049
240	1093	1153
480	1260	1257

Stress-strain curve

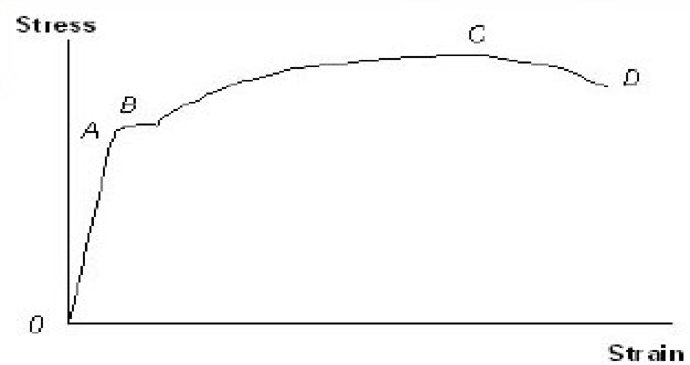
Mechanical properties depend on the loading and on the rate of heating of the members.

- When a load is applied to a material, deformation will occur and these relationships linking load and deformation are identified through testing and are expressed in terms of ‘stress’ [force/area] and ‘strain’ [change in size/original size].
- The stress-strain relationship can be used to establish (a) the compressive yielding strength, (b) the tensile yielding strength, (c) the modulus of elasticity and (d) the ultimate strength of the material.
- Figure 2.1.1 presents a typical stress/strain curve for a structural mild steel specimen subjected to tensile test under normal conditions.
- The specimen elongation is plotted along the horizontal axis and the corresponding stresses are indicated by the ordinates of the curve 0ABCD.
- This diagram will be used to explain some of the following nomenclature.

Typical stress-strain curve for mild steel



Proportional Limit:	**In the region 0A, in Figure 2.1.1, the stress and the strain are proportional and the stress at *A* is the proportional limit. If upon removal of the stress (load), the strain in the specimen returns to zero as the stress goes to zero, the material is said to remain perfectly elastic.**
***Modulus of Elasticity*:**	The constant of proportionality in the straight-line region 0A is called the modulus of elasticity or **Young's Modulus**. Geometrically, it is equal to the slope of the stress-strain relationship in the region 0A.
Yield Strength:	Upon loading beyond the proportional limit, the elongation increases more rapidly and the diagram becomes curved. At point *B*, a sudden elongation of the specimen takes place without significant increase in the applied load and the material has yielded. The value of stress at point *B* is called **yield stress** or **yield strength**. The deformation of the material prior to reaching the yield point creates only elastic strains, which are fully recovered if the applied load is removed. However, once the stress in the material exceeds the yield stress, permanent (plastic) deformation begins to occur. The strains associated with this permanent deformation are called **plastic strains**.
***Ultimate Strength*:**	When the material has passed through the yielding point, stress continues to increase with strain, but at a slower rate than in the elastic range, until a maximum value is reached which is termed the **ultimate strength** (point *C* in Figure 2.1.1). The increase in stress upon yield stress is due to material strain hardening. Beyond point *C*, the stress decreases until the specimen **ruptures** at point *D*.



Fire performance rating

Materials/ structure/doorsets satisfies the performance criteria prescribed in

Appendices A and B of Technical Guidance Document B - 2006.

- (a) Where a fire resistance rating for elements of structure and for other forms of construction is specified it should mean that the item satisfies the performance criteria prescribed in Table A1 of Technical Guidance Document B (i.e. loadbearing capacity, integrity and insulation as appropriate)
- As determined by reference to EITHER THE HARMONISED European Standard I.S. EN 1350 1-2: 2003 in terms of the fire resistance to be met by elements of structure, doors and other forms of construction
- Or by reference to BS476: Parts 20-24: 1987 (or to BS476 : Part 8 : 1972 in respect of elements tested or assessed prior to 1 January 1988).

Fire performance rating

Materials/ structure/doorsets satisfies the performance criteria prescribed in Appendices A and B of Technical Guidance Document B - 2006.

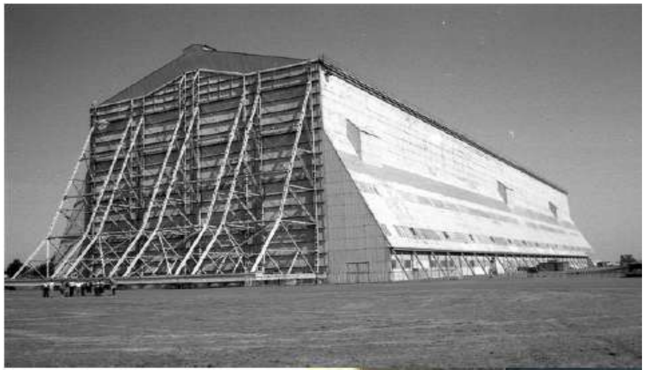
- (b) Doorsets are to be elements of construction which are certified by fire test to either the harmonized European fire test to I.S. EN 1634 as Ex or to BS476 as FDx.
- Such doorsets, which are designated as Ex or FDx are to achieve “x” minutes integrity rating to I.S. EN 1634 or to BS476-22:1987 respectively (or BS 476-8:1972 for doors tested or assessed prior to 1 January 1988) [FD20 or FD30 or FD60 or FD90 or FD120] or [E20 or E30 or E60 or E90 or E120].
- (c) Where the doors are additionally prescribed as having an “ExSa / FDxS ” rating in this Report or in the Council’s (Building Control Authority) Certificate the doors shall have fitted smoke seals which limit the leakage past the head and jambs.
- (i) Unless pressurisation techniques complying with I.S. EN 21 01-6 are used, FDx doors should have a leakage rate not exceeding 3 m2/hour (head and jambs only) when tested at 25 Pa under BS 476:Section 31.1, or
- (ii) Unless pressurisation techniques complying with I.S. EN2101-6 are used, Ex doors should also meet the additional classification requirement of Sa when tested in accordance with I.S. EN1634-3: 2004.

Fire performance rating

materials/ structure/doorsets satisfies the performance criteria prescribed in Appendices A and B of Technical Guidance Document B - 2006.

- Fire resistance in the European classification can be given as REI 30 / REI 60 where;
  - R is the European classification of the resistance to fire performance in respect of loadbearing capacity
  - E is the European classification of the resistance to fire performance in respect of integrity, and
  - I is the European classification of the resistance to fire performance in respect of insulation.

Cardington Test Facility



The Behaviour of Multi- Storey Steel Framed Building

– British Steel / European Coal and Steel Community (ECSC)

- 1995 – 1997 testing to understand and develop numerical calculation procedures

– 4 major fire tests being examined

– structural behaviour studied

– full scale demonstration fire

– Built within the BRE large scale test facility

Concrete Testing Program

- European Concrete Building Project, Cardington
  - (supported by a consortium led by the British Cement Association)
- Constructed as a 7 storey column slab construction
- Designed to the limits of EN 1992-1-2, with a fire resistance of 60 minutes, representing a typical office building in a medium-sized town.
- Behaviour of the frame investigated under accurately simulated applied static loads in a realistic compartment fire

Concrete Framed Building

Fire Compartment before

Fire Compartment after

Timber Frame 2000 UK

- Investigating the performance and economic prospects of medium-rise timber frame buildings
- A two-phase investigation.

  – Phase I provided the background study and justification to recommend and approve core and non-core programmes of work for Phase II along with the detailed design of a full-scale medium-rise building to be used as a test-bed.

  – Phase II comprised the construction and testing of the building and the preparation of authoritative guidance for the design of medium-rise timber frame structures.

TF 2000

2.2 SM at elevated temperatures

- Concrete
- Plasterboard
- Timber
- Masonry
- Cast Iron
- Steel
- Gypsum
- Glass
- Fibreglass

SM at elevated temperatures

At temperatures over 450°C

- Reduction of material strength and stiffness, Displays a significant creep phenomenon.
  - Creep results in an increase of deformation (strain) with time, even if the temperature and applied stress remain unchanged (Twilt 1988)
- Thermal properties of steel at elevated temperatures are found to be dependent on temperature and are less influenced by the stress level and heating rate.
- Hot finished carbon steel

  loses strength above 300°C

  reduces in strength at steady rate up to 800°C.
- cold worked steels

  including reinforcement,

  there is a more rapid decrease of strength after 300°C (Lawson & Newman 1990).

SM at elevated temperatures

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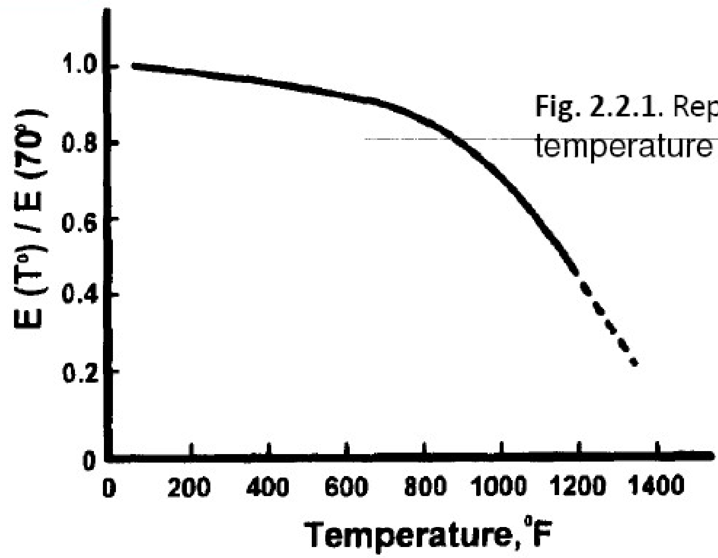
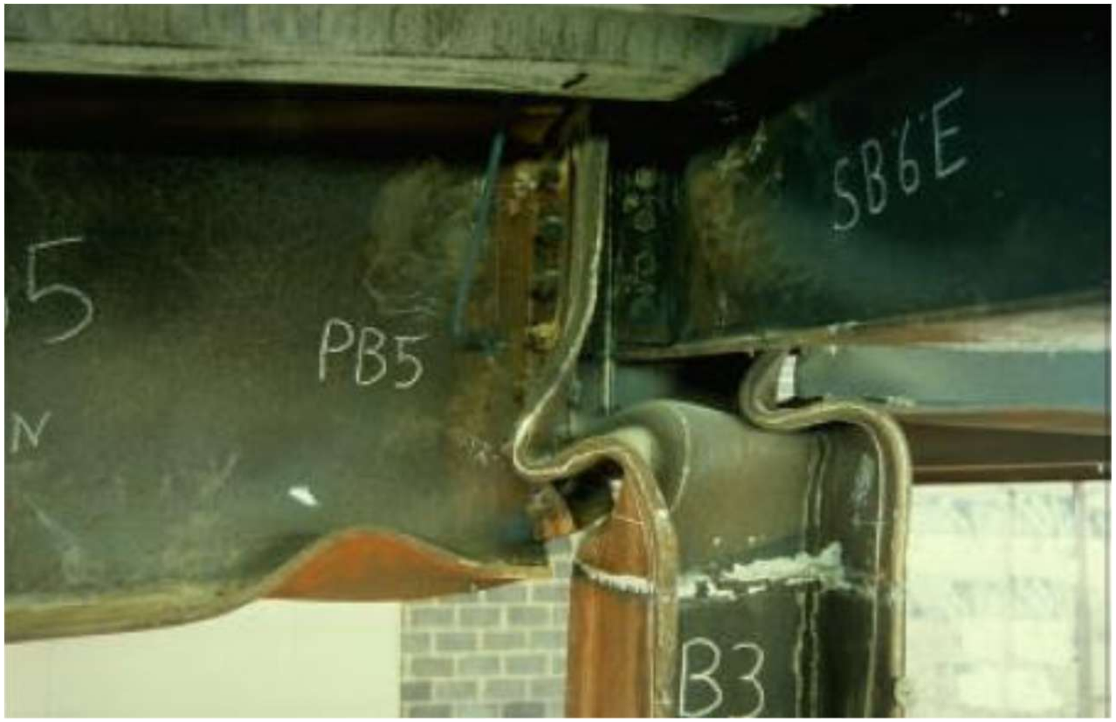


Fig. 2.2.1. Representative modulus of elasticity—temperature diagram for structural steel

Ste

• As the temperature of the steel increases, an unrestrained member will elongate according to: ΔL = άLΔT

Structural Steel Deformation



Structural Steel

- Carbon Steel (Hot Rolled) – extensive small-scale tensile test programme in the 1980s on BS4360 steels [Grades 43A and 50B] provided elevated temperature data
- Stainless Steels
  – corrosion and heat-resistant iron-based materials
  – contains at least 10% of chromium (increasing the percentage of chromium will increase the resistance)
- Fire Resistant Steels (Japan)
  – building regulations limit conventional steelwork to 350°C
  – have higher yield strength at elevated temperatures
  – successfully reduces the amount of fire protection
  – structural members may even be unprotected up to 600°C
- Light Gauge Steel (also known as cold-formed steel) formed by cold rolling thin steel sheet into sections
- "C" or "Z" sections used as roof purlins / rails for cladding
- little fire resistance
- Performance in fire is only briefly described in Eurocodes and BSI Codes

Spalling

Spalling of cover of a R.C. beam – reaction to fire

- Direct exposure to fire
- Indicates reinforcement buckled

Masonry

Minimal damage from exposure to heat and the effects of fire

- Primary concern is deterioration of the mortar
- Thermal Bowing occurs both transversely and longitudinally
- Differential thermal expansion causing thermal bowing will have a detrimental effect on the stability of the walls, in particular for tall walls not fixed at the top.
- Fire resistance, ranging from 30 minutes up to 6 hours

– Tabulated data for fire resistance of masonry walls are found in (a) BS5628- 3:2001 and in (b) I.S. EN1996-1-1-2:2005 as well as in (c) BRE Report BR128 (1988). Note: tabulated data in BR128 have been based on BS5628-3 (1985), but presented in a different manner.

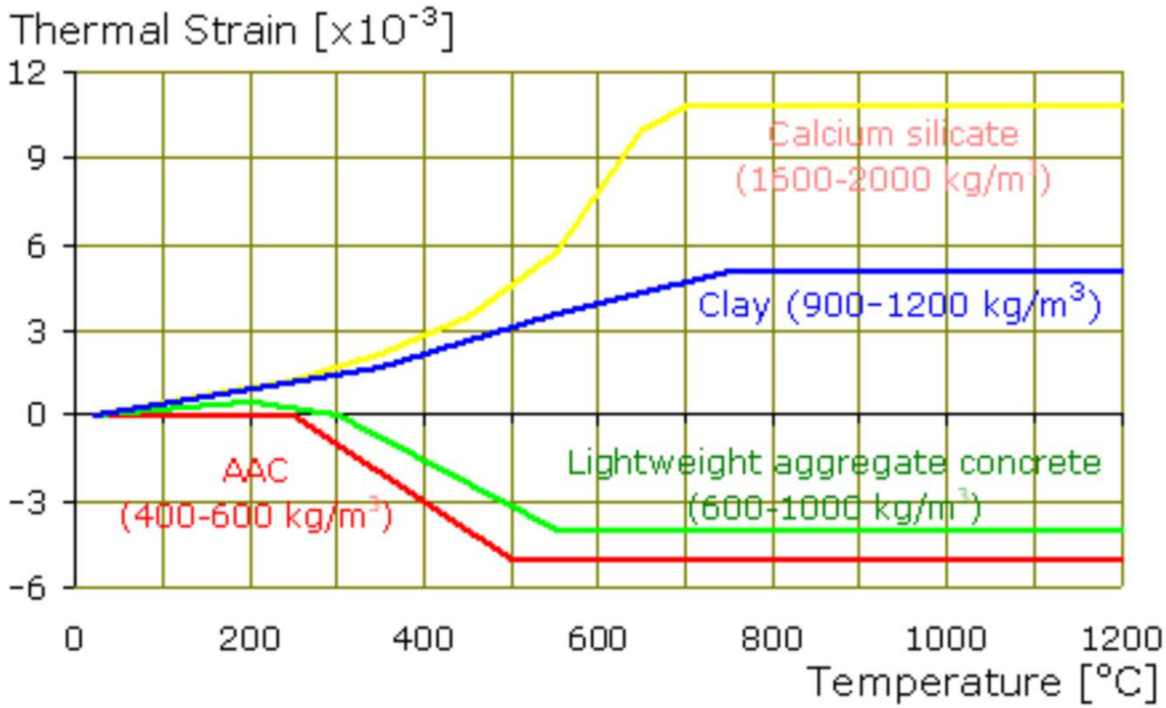
- The most significant material property characterising the fire performance of masonry is the density

– density is a measure of the porosity of the brick which will govern the thermal properties of masonry at elevated temperatures (Purkiss 1996)

Variation of thermal strains

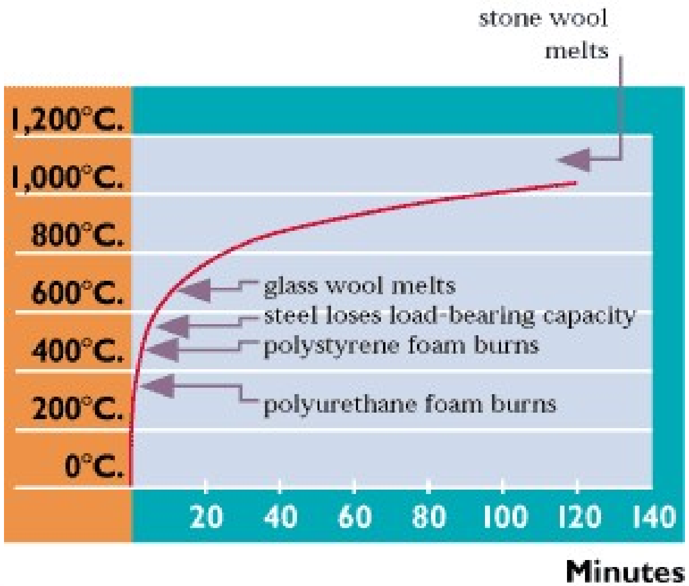
- Figure 2.2.1 (taken from EC6) compares the for various types of masonry unit at elevated temperatures included in Annex D (informative) of EN1996-1-2. The design data shows that not all masonry units will expand under heating. The Autoclaved Aerated Concrete) AAC and lightweight aggregate concrete units shrink at elevated temperatures.

Variation of thermal strains



Rockwool stone wool

- The major difference between stone wool and other types of insulation materials is that Rockwool stone wool withstands temperatures of more



Glass wool insulation will melt at a lower temperature (600°C).
Most foamed plastics will decompose, burn and/or disappear at temperatures below 300°C.

heat that material can withstand	
Material	Temperature
Glass wool	230 - 250 °C
Stone wool	700 - 850 °C
Ceramic fibre wool	1200 °C

Cast Iron

- Older/heritage structures on the exterior surfaces fastened to masonry
- Resists heat and fire
- May crack or shatter when cooled.
- Greatest hazard
  – weakening of bolts connecting these CI sheets to masonry walls
- Very heavy;
- Poses a collapse zone risk

Cast Iron buildings
– Green Street, SoHo, NYC

1852 Suir bridge, Caherabbey, Cahir, Co. Tipperary Railway viaduct - wrought-iron box girders on limestone masonry piers

2.3 Design of structures exposed to fire

- The design(er) of structures is to achieve fire safety engineering objectives
  - – interpret various code requirements for fire safety
  - – understand the concepts of fire severity and fire resistance
  - – utilise time-temperature curves for fully developed compartment fires
  - – understand the behaviour of structural elements and buildings exposed to fires
  - – able to design steel, concrete and timber structures to resist fire exposure, and
  - – assess the fire performance of existing structures
- Fire Safety in Buildings
  - – Fire Safety Objectives for the building
  - – Set design framework for Fire Safety compliance, for Fire Resistance
  - – Building construction seeks to control Fire Spread.
- Fire Safety Engineering

  – Design in FS Engineering is concerned with controlling ignition, flammability, fire growth, management for ensuring safe and effective means of escape.

  – fire detection systems, smoke control and fire fighting systems.

  – Compartmentation

  – Regulatory control
  - limiting structural collapse
  - Limiting fire spread between structures

2.3 Design of structures exposed to fire

- **Fire and Heat**
- The following areas require scientific knowledge on the part of the designer:
  - Fuels, Combustion, Fire Initiation, Burning Objects, fire growth (t-squared fires),
  - Pre-flashover Design Fires and Heat Transfer
- **Room Fires**
- building blocks of buildings for understanding fire spread:
  - Localised (plumes-Pre-flashover) fires,
  - Flashover,
  - Post-flashover Fires and Design Fires.
- Natural fires
  - decay/cooling phase
  - parametric equations are recognized in the Eurocodes
- **Fire Severity**
- Designers needs to have Fire Severity measured
  - in order to establish the minimum required levels of Fire Resistance
  - Normally measured against a Standard Fire
  - A means of establishing an Equivalent Fire Severity to the standard

2.3 Design of structures exposed to fire

- **Fire Resistance**
- Codified levels of Fire Resistance
- Components are measured in Fire-resistance Tests
- **Materials at elevated temperatures**
- Thermal data on materials used need to be understood by the structural designer.
- Designing for the exposure to fire requires a knowledge of the forms of construction, of fire Behaviours, of Fire-resistance Ratings, the properties of materials, Temperatures within Assemblies, of Structural Behaviour and the design of Structures in Fire, of Construction Details and of connections.
- **Steel Structures**
- **Concrete Structures**
- **Timber Structures**
- **Light Frame Construction**

Structural Design in Ireland / EU

- Transitional phase -introduction / use of EU-wide Eurocodes
- Nationally Determined Parameter allow for differences in NATIONAL regulatory control (NAD)
- Structural I.S. ENs integrate fire with the structural provisions
- Various levels of design allowed
  - Traditional prescriptive approach (conventional)
  - Advanced, performance based (first principles)
  - Practice of FSE /structural design growing
  - More engineered approaches to fire protection

Structural Fire engineering Design

- Prescriptive approach (deemed-to-satisfy rules) (BS5588-1)
- Partial Performance based approach
  – to address a particular part of the design with the rest of the design following a prescriptive based approach
  – TGD-B allowing B1 / B3 solutions
- Full performance based approach
  – BS7974:2001 (following on from DD240) - fire safety engineering solution only
  – Published documents PD7974:0-7 support the BS7974 framework
  – for fire safety engineering design a system of sub-systems has been adopted to organize the design approach.

Structural Fire engineering Design

- Performance based approach
- assessment of 3 basic components - (a) the likely fire behaviour, (b) heat transfer to the structure, and

  (c) the structural response

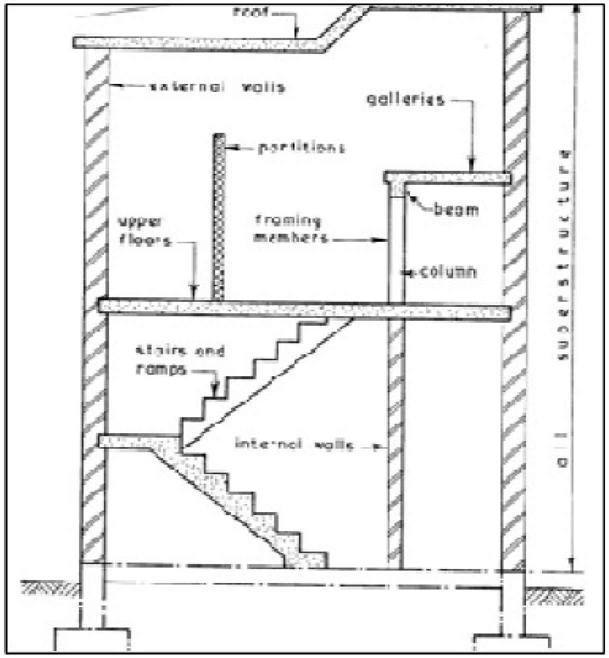
  – Overall complexity depends on assumptions and methods adopted to predict each of these design components.
- (an Advanced Design) generally allows more economical designs
  – maintains acceptable levels of life safety,
  – allows more innovative and complex buildings,
  – a better understanding of the actual structural behaviour during fire,
  – allows identification / strengthening of 'weak' links within the structure.
- Advocates claim
  – increase in the levels of safety (vis a vis simple design approaches)
  – additional protection to the building contents, the building superstructure, heritage, business continuity, corporate image of the occupants or owner, and/or the environmental impact

Structural Stability

- The performance and period of stability of a structure or element is directly related to the material involved.
  - Stability prevents structural collapse.
- Indicators for building collapse include:
  - loose masonry products and mortar joints
  - Walls leaning in or out; distorted, warped, or buckled members
  - prolonged fire exposure or excessive heat
  - unusual creaks and cracking sounds
  - deformations in excess of design parameters
  - structural members pulling away from walls
  - firefighting water adding additional weight and alterations to structural members

What requires protection ?

- At the time of a Fire
- – Floors
- – Walls
- – Steps
- – Landings
- – Support structure



Fire Protection

- **Steelwork protection**
  - *Spray protection*
    - *Intumescent coatings*
    - *cementitious/gypsum based mineral coatings*
    - *Sprayed mineral wool coating*
  - *Board protection*
  - *Concrete encasement*
  - *Intumescent treatment*
- **Concrete protection**
  - resists the transmission of heat
  - confines high temperatures to a shallow zone

Masonry & Fire

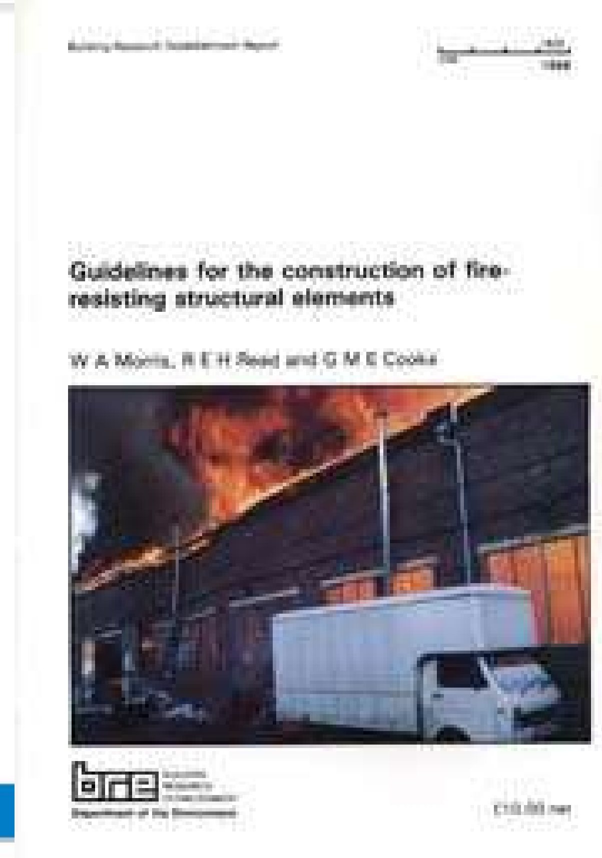
Empirically, utilised as fire break walls because they perform extremely well

- Collapses generally caused by
  (a) the surrounding structure placing eccentric or lateral loads on the walls,
  (b) the large thermal bowing of some tall walls not fixed at the top, and
  (c) large vertical deflection or collapse of supporting members to the walls.

- **Tabulated fire resistance data in codes**
  - based on wall test results from standard fire resistance tests carried out over 50 years
  - wall construction require satisfying the performance criteria in accordance with BS476
  - minimum wall thickness for a specified period of fire resistance, ranging ½ hour up to 6 hours
  - Tabulated data for fire resistance of masonry walls are found in (a) BS5628-3:2001 and in (b) I.S. EN1996-1-1-2:2005 as well as in (c) BRE Report BR128 (1988)
  - Note: tabulated data in BR128 have been based on BS5628-3 (1985), but presented in a different manner.

Traditional Approach – TGD-B

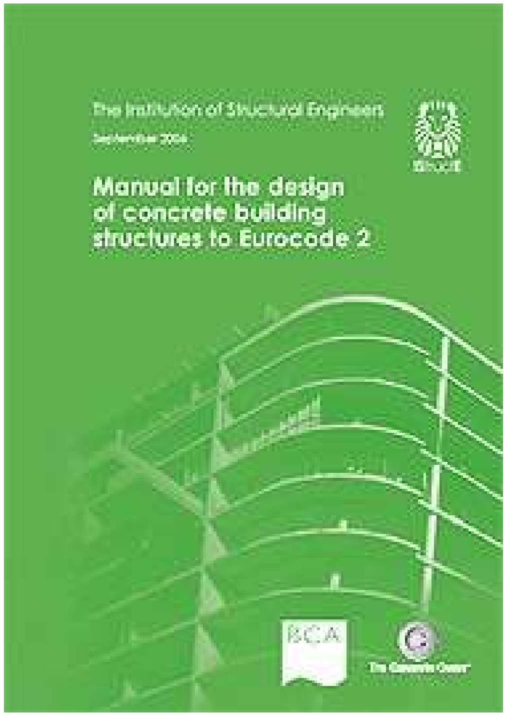
Fire protection
– using concrete, blockwork and plasterboard,
• information on material thickness
– for specific fire resistance times
• Guidelines for the Construction of Fire Resisting Structural Elements

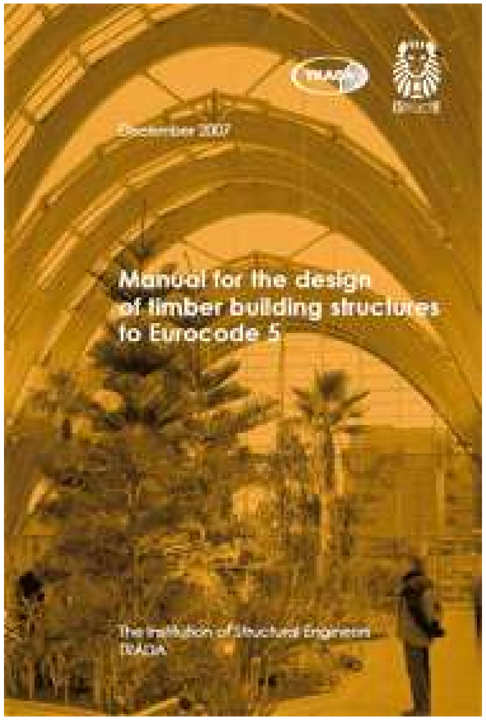


IStructE - Design Manuals

- IStructE published design manuals to support the ECs 2, 5 & 6 for construction in the UK
  - – utilizing the UK NDPs.
- Manual for the design of concrete building structures to Eurocode 2 (2006)
- Manual for the design of timber building structures to Eurocode 5 (2007)
  - – TRADA – Wood Information Sheet for designing to EC5
- Manual for the design of plain masonry in building structures to Eurocode 6

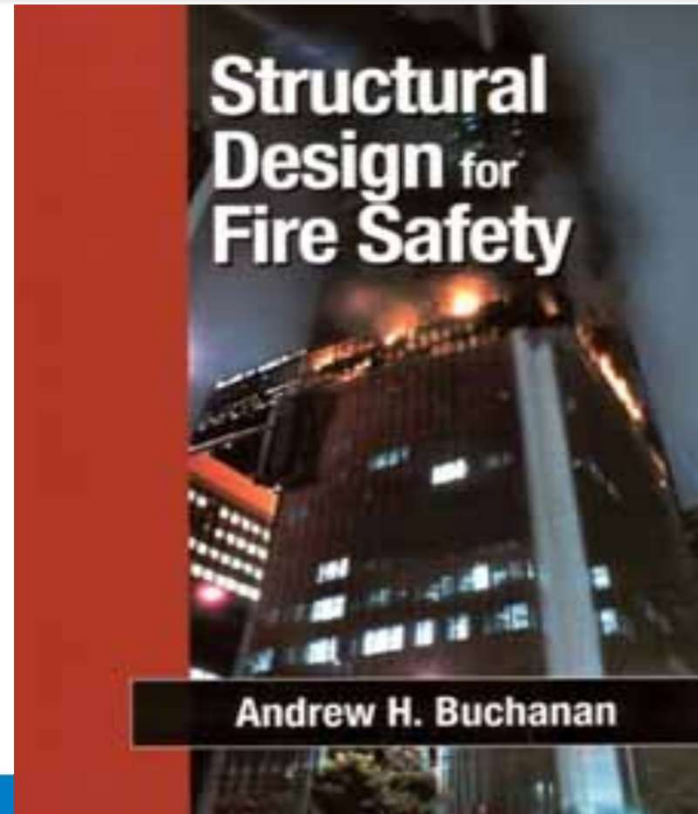
IStructE - Design Manuals





Structural Design for Fire Safety

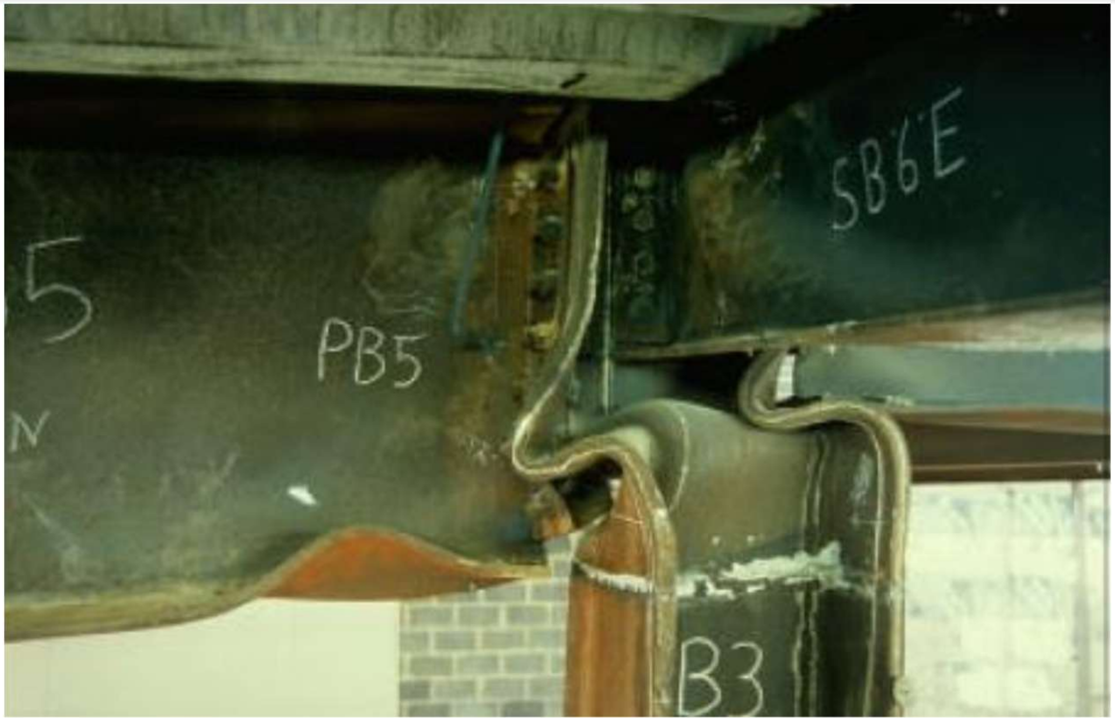
- by Andrew H. Buchanan
- comprehensive overview of the fire resistance of building structures
- concepts of fire severity and fire resistance
- Estimating time-temperature curves for fully developed compartment fires
- behavior of structural elements and buildings exposed to fires
- Designing steel, concrete and timber structures to resist fire exposure
- Assessing the fire performance of existing structures.



Fire Safety Engineering Design of Structures

• design concerns and philosophies, regulatory control, the behaviour characteristics of natural fires , Properties of different materials at Elevated temperatures
• Focusing on the fire sections of the Structural Eurocodes
• It includes design methods based on the fire sections of the new Structural Eurocodes.
• worked calculations and examples
• by J.A. Purkiss
• Format: Hardback 424 pages
• Date of publish: 24/11/2006
Publisher: Butterworth-Heinemann Ltd
• ISBN 0471889938

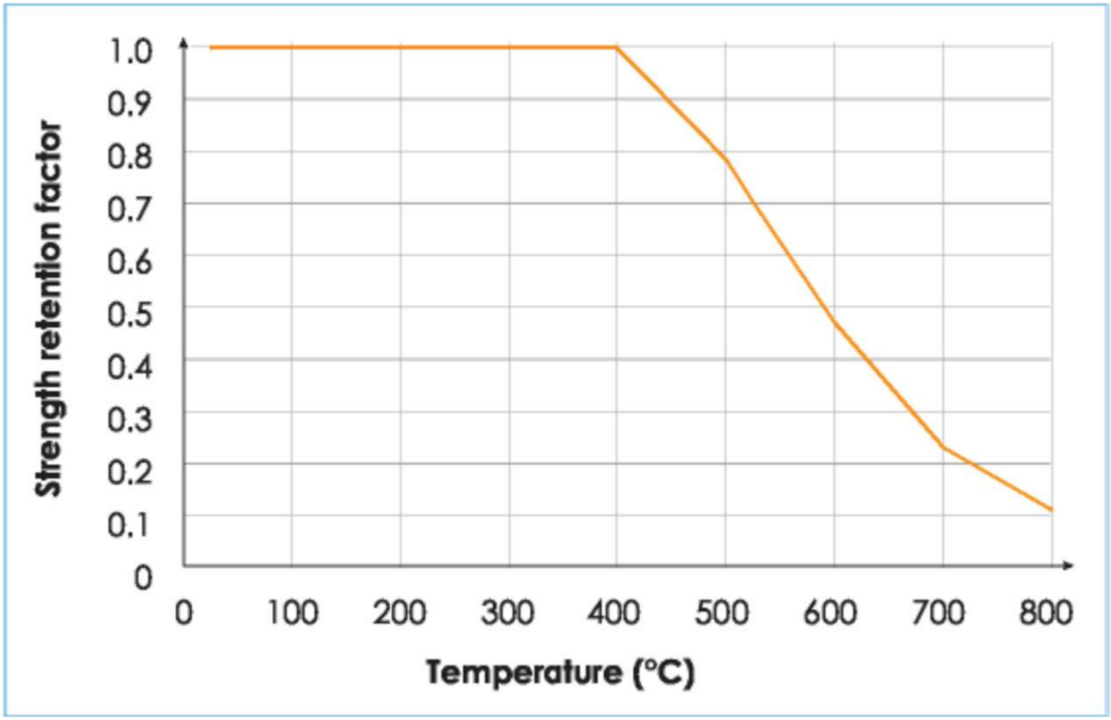
2.4 Steel structures



Structural Steel Deformation

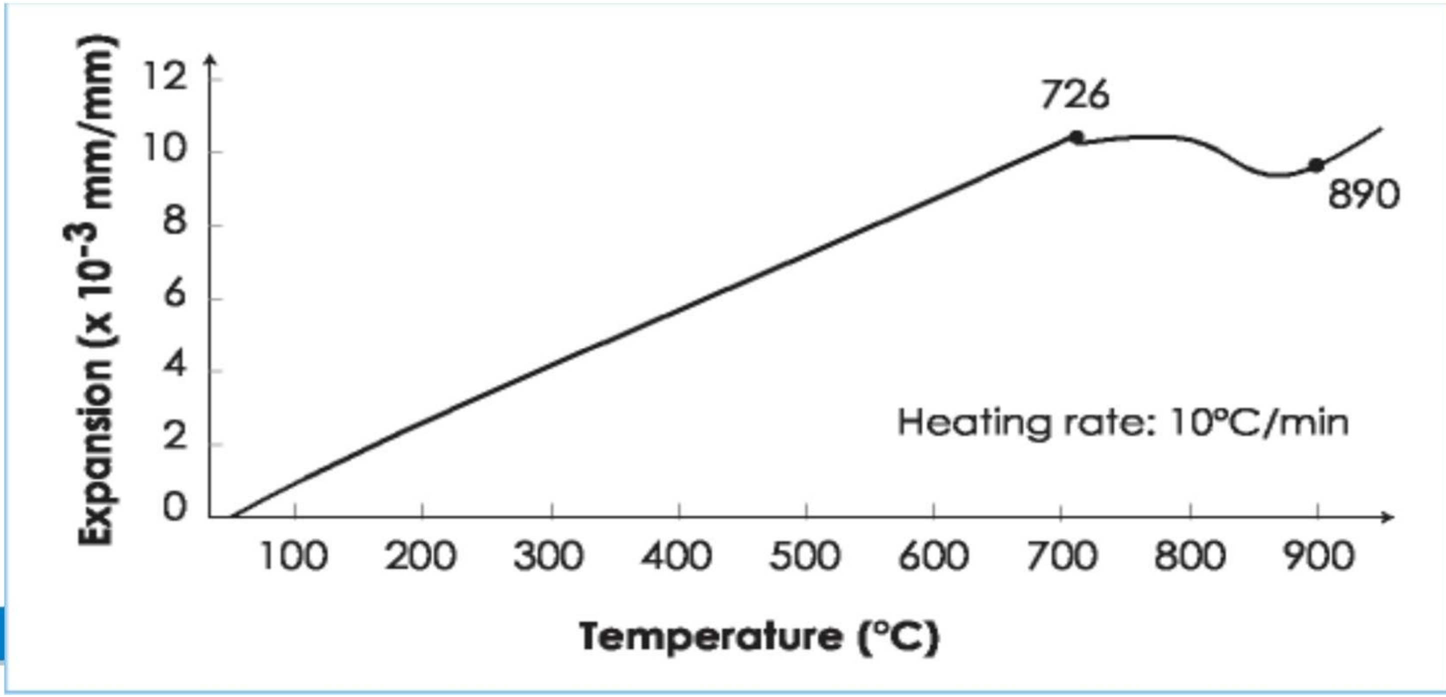
Variation of effective steel strength with temperature

- High temperatures (500oC+) causes steel to expand
- Thermal bowing
- Dimensional size will determine the rate of failure
- Webbed trusses fail sooner than heavy I- beams
- Heavy loads and composition will also affect rate of failure
- plastic deformation
- Structural strength decreases by as much as half at 600°C



Thermal expansion of steel with increasing temp.

- The rate of thermal expansion remains constant up to 700°C when there is a temporary sudden change in behaviour.

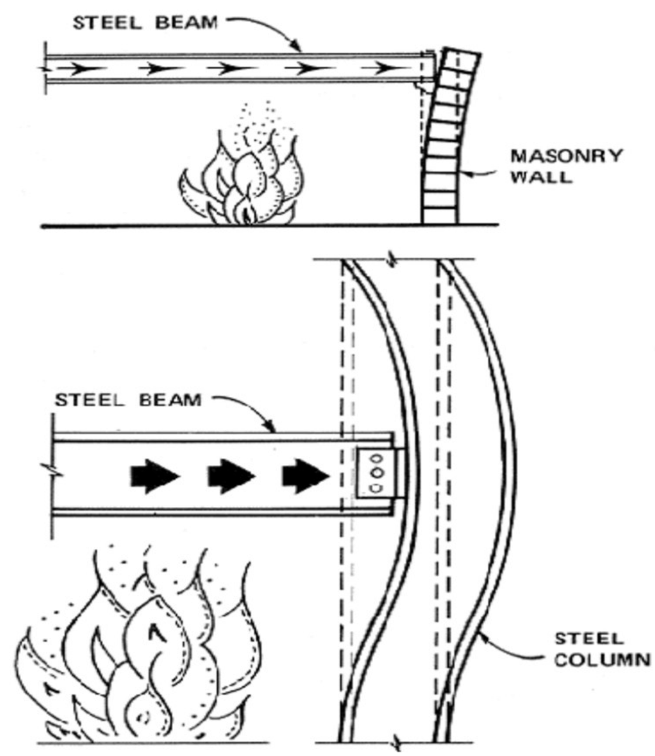


Steel - Primary commercial building material

- Several factors affect the integrity of steel in fire conditions
- High temperatures (1000°F) causes steel to expand.
  - This expansion may push exterior walls out (bowing) causing a roof to collapse.
- The dimensional size of steel members will also determine the rate of failure.
  - Webbed trusses fail sooner than heavy I- beams.
- Heavy loads and composition will also affect rate of failure
- Material properties damaged when exposed to excessive heat exposure
  - causing considerable plastic deformation.
- Structural strength decreases by as much as 50% at temperatures of 600 °C (degrees Celsius)
  - members require fire protection through the use of fire insulating materials/methods.
  - enables the continued ability to resist collapse,
  - INHIBITS flame penetration through partitioning walls, slabs and ceilings

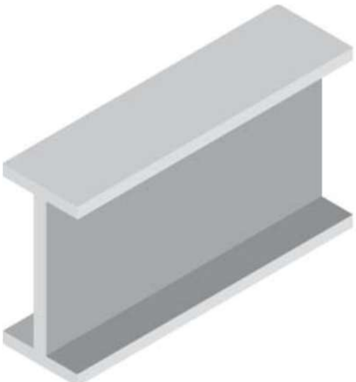
Steel

- Significant coefficient of linear expansion , ά, under thermal loads.
- For T<1000 °C ά= (0.004T + 12) x 10 -6 Celsius -1
  T = temperature in degrees Celsius
- If axially restrained against displacement
  – (as a column is), the expansion due to heat will be translated into thermal stresses
  – will increase the overall stress level in the member and cause an earlier collapse
- Without axial restraint
  – a steel member will expand and could set up eccentric loading of adjacent structural members by displacing one of their ends
  – E.g. a beam displacing the top of a column or of a load bearing masonry wall, as illustrated over
  – Good fire protection engineering dictates that either, thermal expansion be prevented by limiting steel temperatures, or its effects on the structure be accommodated in the design



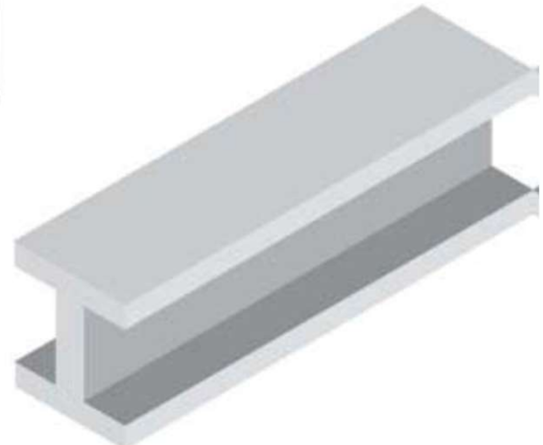
Section Factor

- Effect of section dimensions Hp/A concept



High Hp/Low A
= Fast heating

Low Hp/High A
= Slow heating



• Fire Resistance – Time
– contributory factor – HEATING RATE of the member
– time to failure (or limiting) temperature
– 'Massivity' quantified in 'Section Factor' (Hp/A) Concept
• Section Factor = Heat Perimeter exposed to flames - Hp(m) / Cross Sectional Area - A(m2)

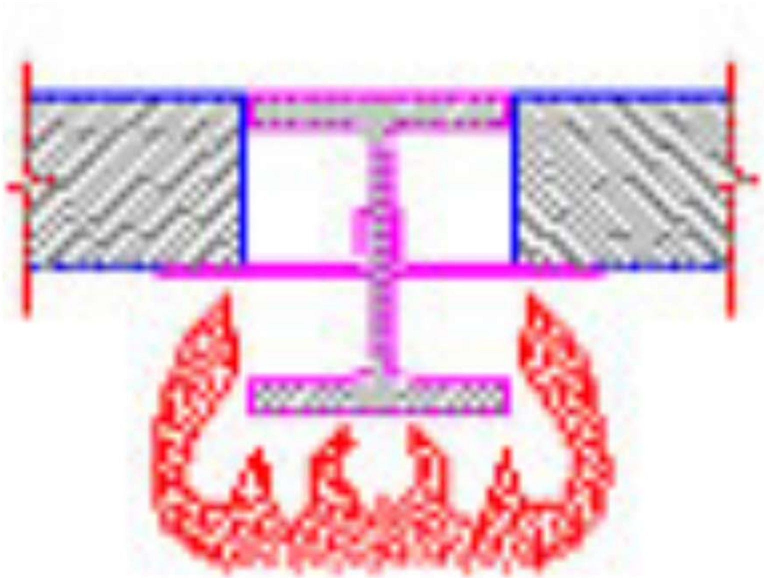
Insulation protects Steel

- Type and Thickness of Insulation
  - required fire resistance period
  - Section factor (which can be described as the heated perimeter/cross-sectional area) of the steel member concerned.
- Insulation thickness selected so that critical temperature value not exceeded
  - during the required fire protection time.
- Building's fire resistance periods differ
  - in the range ., 1, 2 or 4 hours
  - various jurisdictions
  - design code, type of building and the possible consequences of a structural failure
- fire protection system either an active or a passive protection method
- Water sprinkler systems and water-filled structural member systems
  - active fire protection systems
- Integrated structural members, insulating boards, sprayed coatings, intumescent coatings, suspended ceilings, concrete covers and composite member protections
  - passive fire protection systems.

Structural Steel

- Basic idea – Keep steel element below its critical temperature, which is between 500 and 560°C,
- depending on which standard and which country one regards
  - Retard exposure time and
  - Degrade the fire's severity on the structural members
- At elevated temperatures
  - steel first expands.
  - After critical temperature
  - softens and ceases to render any structural support
  - Strength and Stiffness lost at high temperature levels
- Instead, its collapse is actually a drain on that, which it was meant to uphold
- Section factor Hp/A in Ireland, now changed to Eurocode A/V
- High Hp & Low A: Fast Heating Low Hp & High A: Slow Heating
- Convenient parameter to measure the thermal response
- Heating Rate proportional to the surface area (A) of steel exposed to the fire and inversely proportional to the mass or volume (V) of the section.
- Low section factor heated at slower rate
  - Terms A/V and Hp/A have exactly the same meaning

Structural Steel Design



Structural Steel Design

- BSI steel design code
- BS5950-8:2003– provides information on how to calculate the section factor
- or the 'Yellow Book'
  - [Fire Protection for Structural Steel in Buildings (The Yellow Book) Third Edition (Revised June 2004) by ASFP, 2004]
- Effective Yield Stress
  - Generally taken as zero at 1200 0C
  - In actuality the yield value does not fall to zero unless 1550 ^{0}C reached by steel
  - 1550 ^{0}C rarely reached in building fires
- Non-combustible but has a high heat conducting value
  - High conducting value adversely affects steel's structural performance during fire exposure and makes it important to create a fire design for steel framed buildings.

Structural Steel

- Generic and proprietary materials in passive fire protection
- Categories:
  - Generic Materials,
  - sprays (cementitious or gypsum based coatings),
  - boards and blankets, and
  - intumescent coatings.
- Materials and Systems need to be subjected to and certified to fire tests in accordance with BS476
  - Testing assesses potential fissuring, cracking or detachment of a protection system
  - Testing determines the insulating performance of fire protection materials through checking the steel temperature for different section factors, orientations and protection thicknesses

Application of protection Systems

Guidance

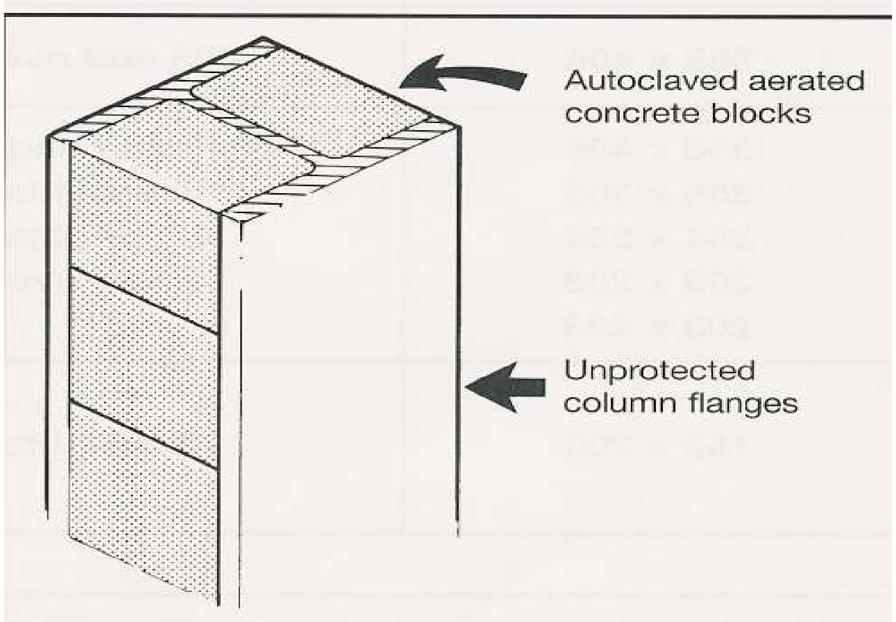
- "Fire protection for structural steel in buildings, the Yellow Book" (ASFP Publication),
- "Guidelines for the construction of fire-resisting structural elements" (BRE Publication), in BS8202-1 (1995), in BS8202-2 (1992),
- "Building design using cold formed steel sections: fire protection" (SCI-P-129),
- "On-site measurement of intumescent coatings" (ASFP TGN 003: P1),
- "Structural fire design: Off-site applied thin film intumescent coatings" (SCI-P- 160).
- Design guidance is available in EN 1993-1-2 Eurocode 3 - Design of Steel Structures - Structural Fire Design;
- EN 1994-1-2 Design of Composite Structures - Structural Fire Design and the IISI (International Iron and Steel Institute – now (2008) known as the World Steel Association) Publication, "International Fire Engineering Design for Steel Structures", 1993.

Is Passive protection effective ?

- Fendolite (Mandoval) after 90 minute fire

Block-filled Columns

30 minutes for unprotected steelwork
Thermal bowing if walled on one side



Protecting steel structures

Practical examples of passive fire protection

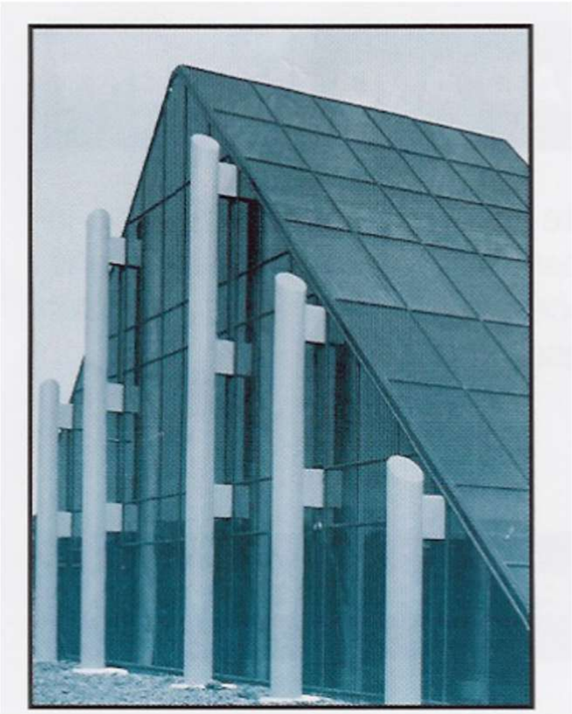
Shelf Angle floor beams

30 minutes for unprotected steelwork

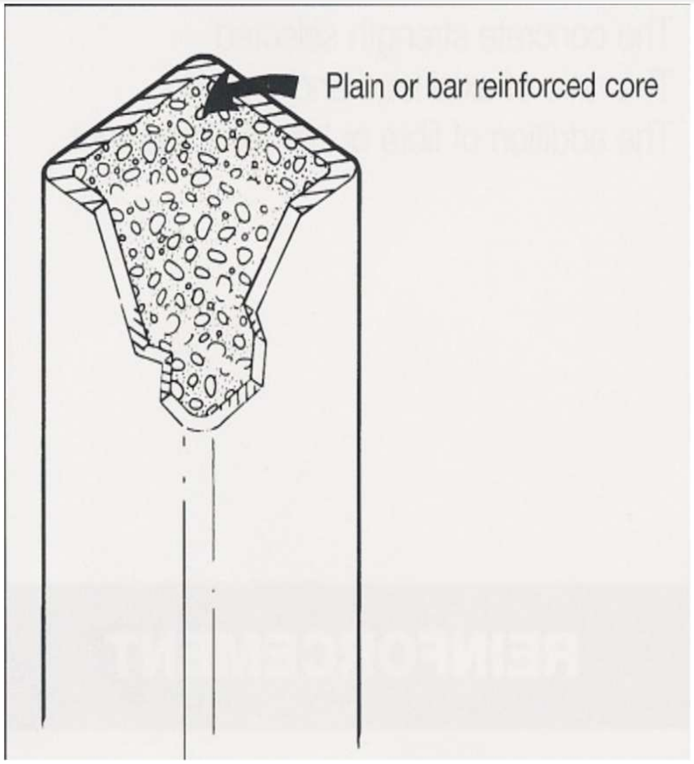
Firebatt mineral wool

– Flexible
– Light
– Follows shape
– Insulation

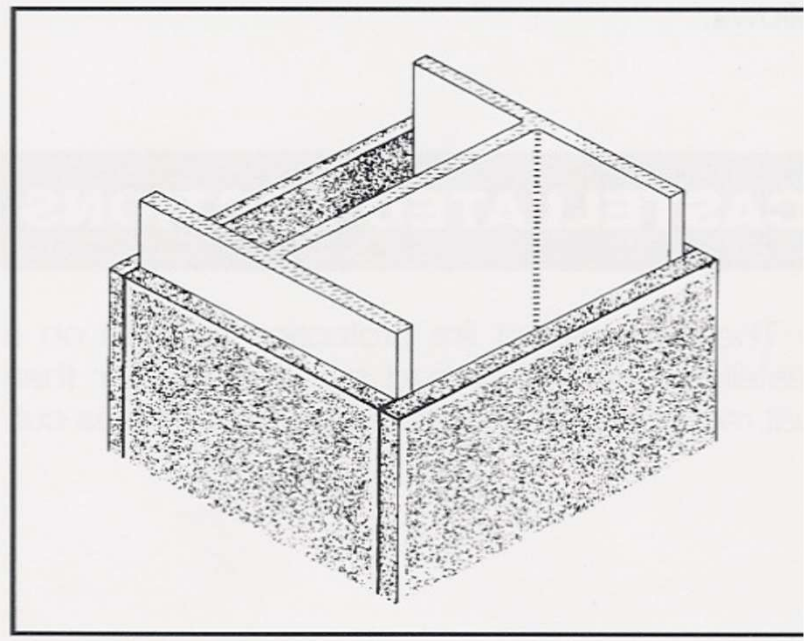
Concrete filled Hollow Columns



Permanent shuttering prevents spalling giving up to 2 Hours F.R.
Heat to concrete slowly – load to concrete as steel weakens

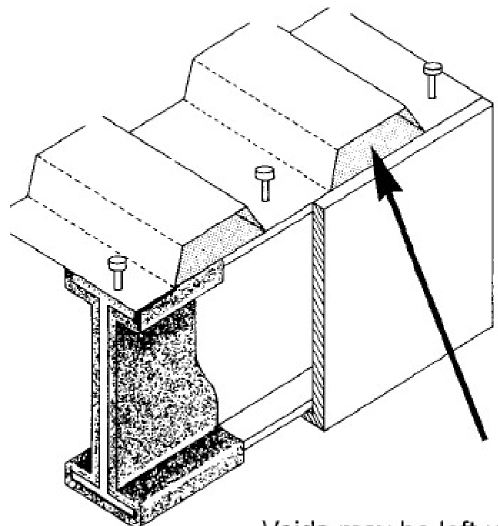


Board protection

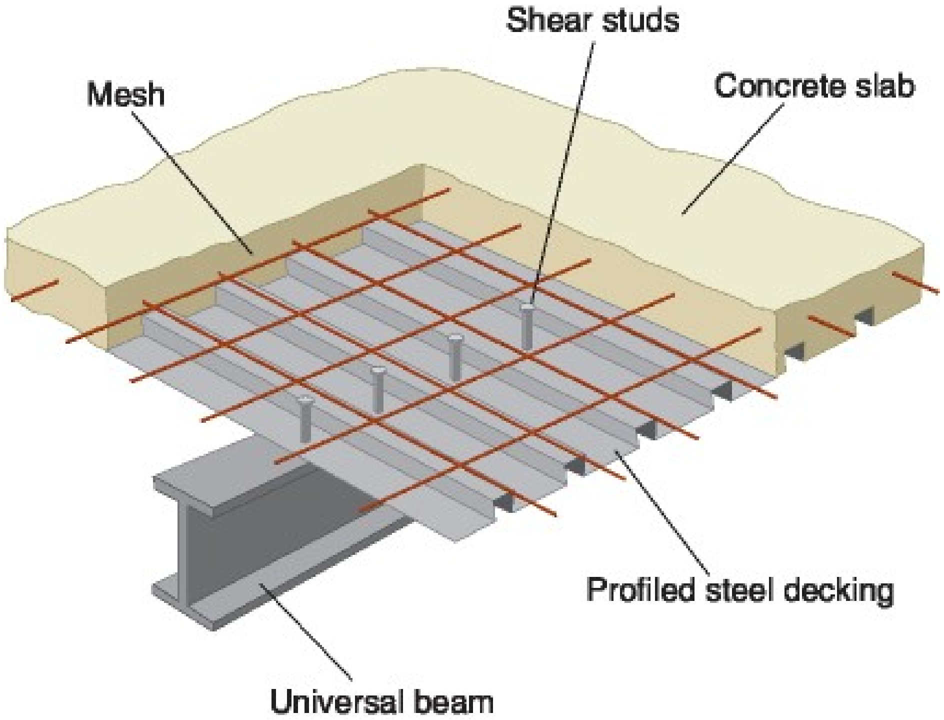


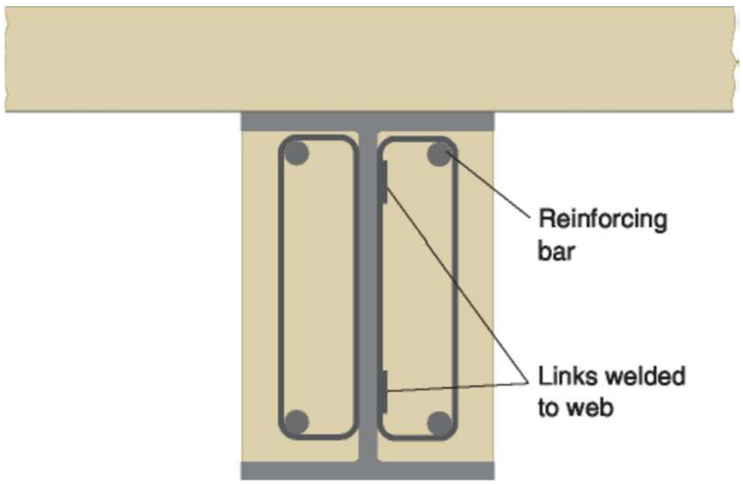
Up to 4 Hours for Non-primed steelwork

Composite Slabs – profiled metal decking



Mesh Reinforced Concrete screed placed as floor finish on metal decking

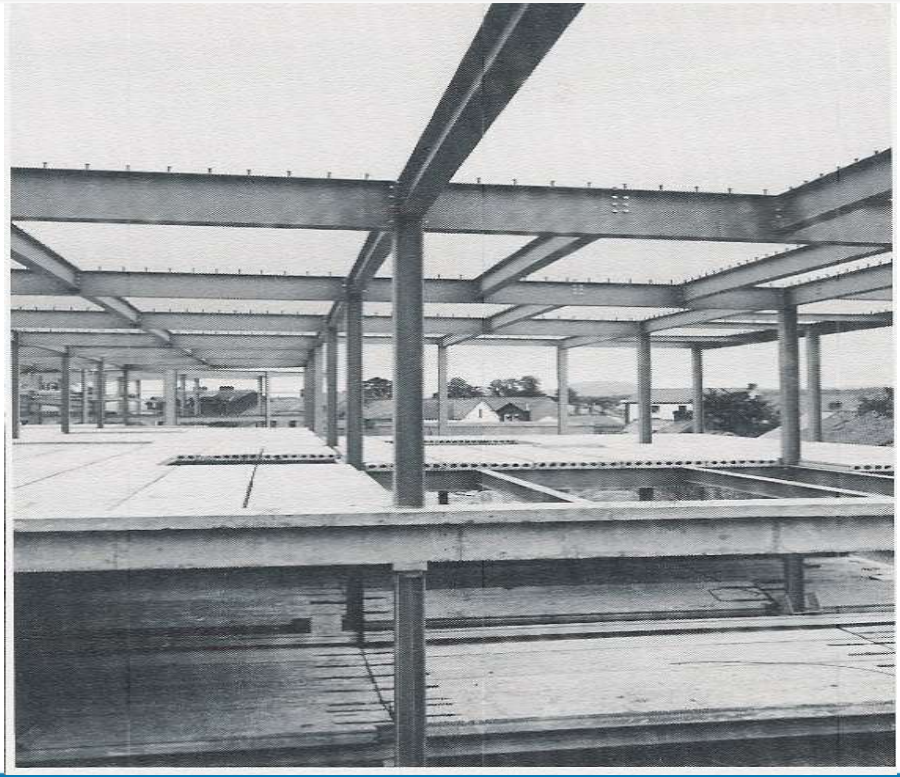




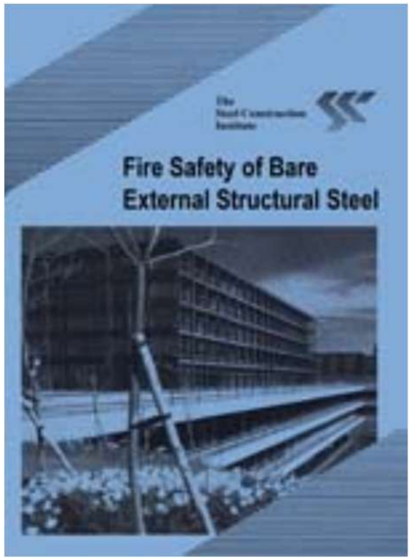
Reinforced Web
Composite Beam Slimfloor

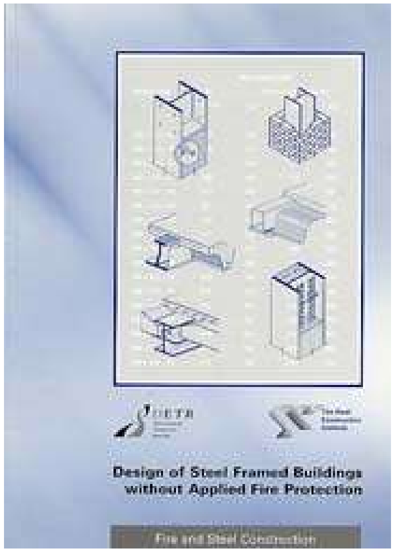
Hollowcore construction

- Hollowcore precast floors
- Steel frame
- Trimmer beams



• SCI publication No 186 – Design of Steel framed Buildings without Applied Fire Protection
• The Steel Construction Institute (SCI) publication Fire Safety of Bare External Structural Steel
• Eurocode 3





2.5 Concrete structures

- Indicates reinforcement buckled
- Direct exposure to fire
- Early spalling of cover concrete

High Temperatures – a deterioration in properties

• Of particular importance are
– loss in compressive strength
– loss of elastic modulus
– cracking and spalling of the concrete
– reduced yield strength, ductility and tensile strength of the reinforcement steel.

• And the loss of bond between the steel and concrete.
• As part of this process to ascertain whether a structure can be repaired rather than demolished (after a fire) it is necessary to assess the extent of deterioration of the concrete itself.

fire damaged concrete

- Above 300oC, the colour of siliceous aggregate concrete is said to change from normal to:
- pink or red (300-600°C),
- whitish grey (600-900°C), and buff (900-1000°C).
- colour change = loss of concrete strength
- regarded as being suspect of deterioration

fire damaged concrete

Fig 2.5.1 Arris of beam exposed by fire

Fig 2.5.2 Soffit of slab exposed

Concrete (reinforced)

- Steel rods or mesh give tensile strength
- inherent compression strength
- limits fire spread, but vulnerable under very high heat conditions
- Spalling and cracking - indicators of loss of integrity
  - Do not assume adequacy because of concrete
- Non-combustible - very slow rate of heat transfer
- minimum size and depth of cover to all reinforcement
  - limiting the acquired temperature of reinforcement BS8110-1:1997
  - as well as by the use of BS8110-2:1985
- lightweight concrete and retro-checking fire resistance
  - Eurocode I.S. EN1991-1-2 in transition
- tabulated data of EN1991-1-2 more extensive than that of BS8110-2

Steel reinforcement

Table 2.5.2 Properties of steel reinforcement at High Temperatures	
Strength	Yield stress begins to reduce at 300-500^{0}C, depending on the type of steel. At 550-600^{0}C, yield stress is reduced to about 50% of normal. If temperature does not exceed 600^{0}C then recovery is 90-100%. Cold-worked steel loses its recovery potential rapidly after 600^{0}C, hot-rolled high yield steel less rapidly and mild steel tend to recover well.
Thermal expansion	Co-efficient of TE is a measure of how much a material will change in length and shape with rise in temperature. Co-efficient remains almost unchanged up to 600^{0}C (i.e. almost linear). 11.7x10^{-6}/^{0}C (at room temp)
Modulus of elasticity	A measure of the movement or deformation that occurs due to stress. [E = stress/strain]. E-value decreases (strain increases) as temperature rises. At 600^{0}C it may be less than 50% of normal value.
Thermal conductivity	K, is a measure of the ease with which heat will flow through a material. It decreases (linearly) with rise in temperature.

Aggregates and fire

Table 2.5.3 Effect of aggregates		
Above 100⁰C	Water is released from concrete	Strength is not affected but Young's Modulus is decreased by 10-20%
Above 300⁰C	Silicate Hydrates decompose	Compressive strength deteriorates slowly below 450⁰C
Above 500⁰C	Portlandite will be dehydrated	Compressive strength deteriorates rapidly
Above 600⁰C	Some aggregates begin to convert or to decompose	Relative expansion of different materials also creates a web of microcracks.

Table 2.5.3
CIB W14 Report: "Repairability of fire damaged structures"

Material Properties of Structural Concrete (Portland Cement, Quartzitic Gravel Aggregate) after Fire Exposure in relation to Values before the Fire

	Temperature (^{0}C)						
	200	300	400	500	600	800	1000
Strength (%)	80	70	60	40	20	10	0
Elastic Modulus (%)	60	50	40	30	10	5	0

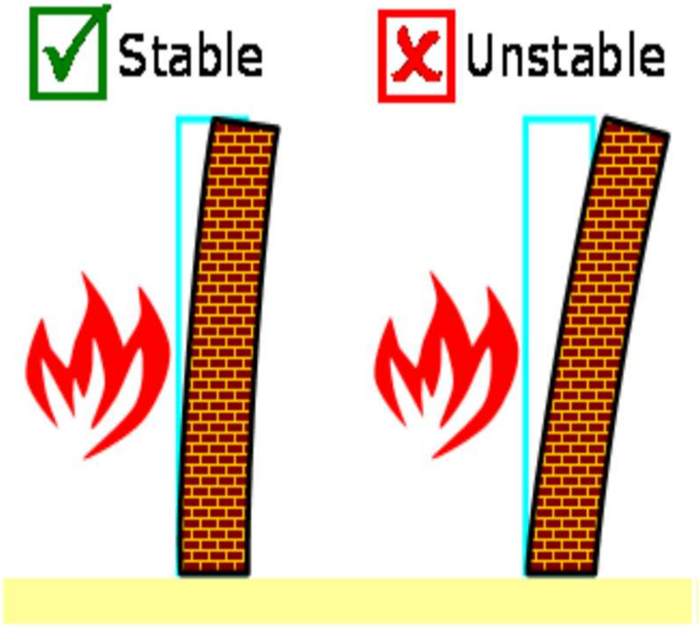
Masonry

- Minimal damage from exposure to heat and the effects of fire
- Brick, stone, block, and concrete castings are typical masonry products.
  - Block used for load-bearing walls, but brick and stone are better suited for fire and veneer walls.
  - May spall or crack if rapidly cooled with firefighting waterstreams

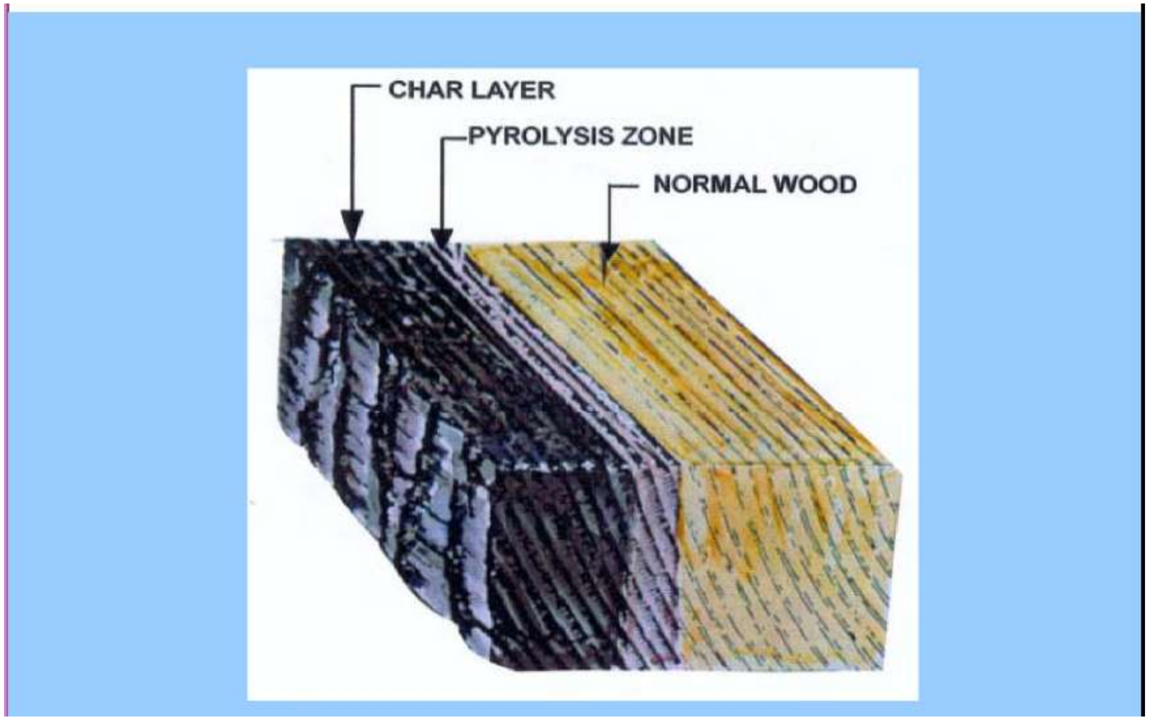
    (structurally sound ?)
- Primary concern - deterioration of the mortar

Masonry

- Thermal Bowing
- transversely and longitudinally
- Low thermal conductivity with single
  side heating
- Sharp temperature gradient across the section
- Differential thermal expansion causing thermal
- bowing
- Detrimental effect on wall stability
- Particularly tall walls not fixed at the top



2.6 Timber structures

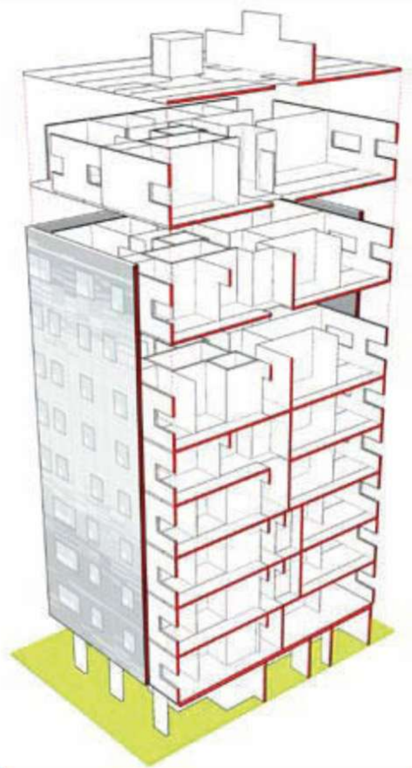


Structural Timber

- Used in several structural areas in different types of construction.
- Plywood, composite sheets, solid dimensional timber (lumber), and laminate beams are used in floors, walls, partitions, ceilings and roofs.
  - The reaction of wood to heat and to fire depends on moisture content and section size.
- The larger the dimensions, the longer wood can retain structural integrity.
- The higher the moisture content also limits the rate of burning.
- Composite sheets contain wood chips or fibres glued and pressed into sheets.
  - This material can produce toxic gases and rapidly deteriorate in fire conditions.

Irish Standard I.S. 440 specifies requirements for materials, design, manufacture, construction details, site work and quality control relating to timber frame dwellings.

Cross laminate (CL)

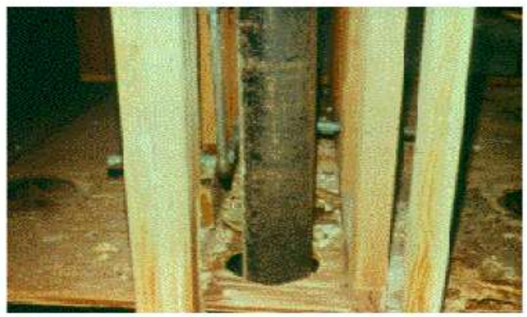


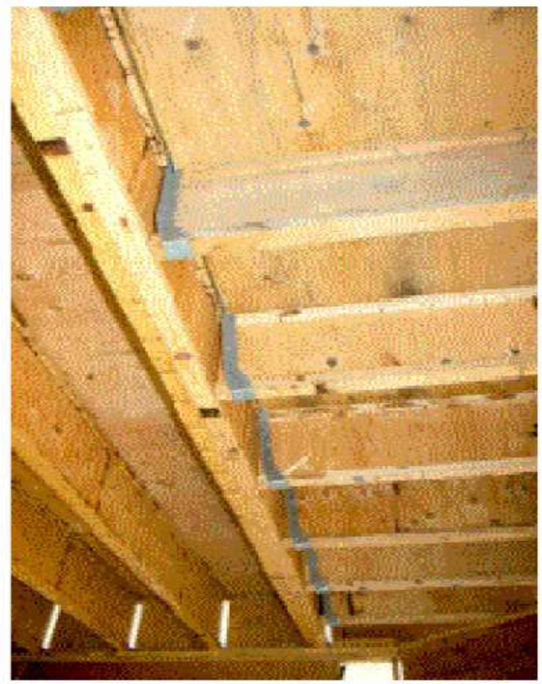
- Apartments with 8-storey CL structure at 24 Murray Grove, London
- TRADA
- Cross-laminate up to 40m and span of 7m
- Platform timber up to 20m and span of 5.5m

Wälludden, Svenska (An tSualainn) 1996 Flats

Lotsen, Svenska (An tSualainn) 1996 offices

Timber Structural Details





Design of Timber Structures

- Prescriptive rules in BRE's report BR128 (1988) extensively used for timber floors.
- BS5268-4.1 & BS5268-4.2 are used for members & stud walls and joisted floors
  - I.S. EN1995-1-2 is in transition use for all general timber structures
- Concept for structural design in use
  - calculate timber member strengths on a residual non-charred section
  - the charred portion is considered as having no structural strength
- The rules for determining the charring depths are based on the standard fire tests
  - a large number of the standard fire tests carried out to determine the rates of charring have been conducted on panels subjected to a single face heating in a small furnace, rather than on full-scale timber elements subjected to multi-face heating in a normal size furnace (Purkiss 1996).
- Actual charring conditions of beam and column members in real fires may/will differ
  - members' geometry and the heat flux on the members are quite different

Design of Timber Structures

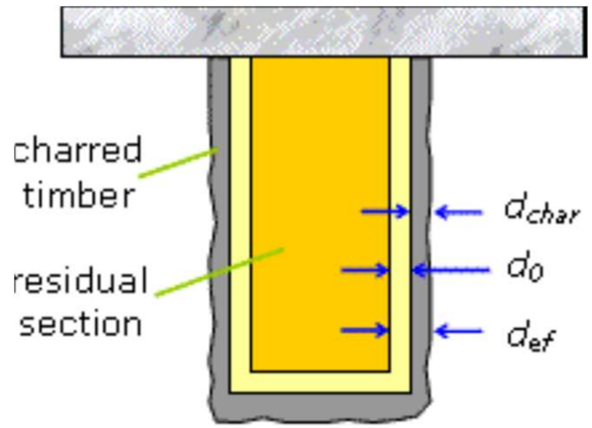
- The use of charring depths is suitable for large section timber which will perform well in a fire.
  - Smaller section timber require protection from linings
- EN1995-1-2
  - for walls and floors, timber frame members < 38mm protected by claddings throughout the required fire resistance time
  - Fixings of the protecting lining to the supporting timber on site is crucial
  - Fixings must be of equivalent quality as the fixings used in the standard fire tests
  - Tabular values were obtained from the standard tests
- BS5268-4.2
  - Tabulated data for various fire resistance periods in stability, integrity and insulation for floors and walls
  - e.g. internal / external single or double leaf walls, timber floors with concealed or exposed joists, up to a limit of one hour's fire resistance of 1 hour or less, using different joist sizes, floor boarding and ceiling protection.
- Localised charring and loss of anchorage will occur to any nail, screw or bolt exposed to heating during fire due to rapid heat conduction (red spots)
  - BS5268-4.1 requires fastener to be fire protected if fastener loss could result in loss of fire resistance
  - EN1995-1-2 takes the inherent fire resistance of various connections as the minimum fire resistance

• EN1995-1-2 introduces the concept of effective charring depth d_{ef}

– as shown in figure T2 over

– In addition to the charring depth d_{char} obtained from the standard fire tests, the constant d0 = 7mm is calibrated from the tests

– coefficient k_0 (= 1.0) depends on factors such as the surface protection and the required fire resistance duration



$$d_{ef} = d_{char} + k_0 d_0$$

Effective Charring Depth according to EN1995-1-2

2.7 Light frame construction

Plasterboard

- Gypsum plasterboard or Gypsum board
- Rigid sheets of building material - gypsum plaster and other materials
  - – Can contain sand, perlite or vermiculite
  - – Gypsum is a crystalline mineral
  - – de-hydrated gypsum is referred to as 'plaster of paris'
- Quality of the Board critically affects fire performance of an assembly
- Most boards are a sandwich of plaster between sheets of paper chemically and mechanically bound
- 'Sheetrock' in North America

– used to create light-frame construction with fire resistance (dry-walling)

- Fibrous board has no paper

– relies on glass fibre or sisal reinforcing within the plaster for strength

– silicone additives are used for moisture resistance

- Specifications denote dimensional tolerances, minimum flexural strength, hardness and nail-pull resistance under normal temp conditions, as well as fire resistance

– GF glass-fibre reinforcing board in EU and Type X board in the USA

Objectives in Building Construction

- Designing for fire safety
- In the event of an outbreak of fire
  - life safety
  - continuity of vital operations
  - property protection
  - Fire Safety Certificate
- Designing for Building behaviour

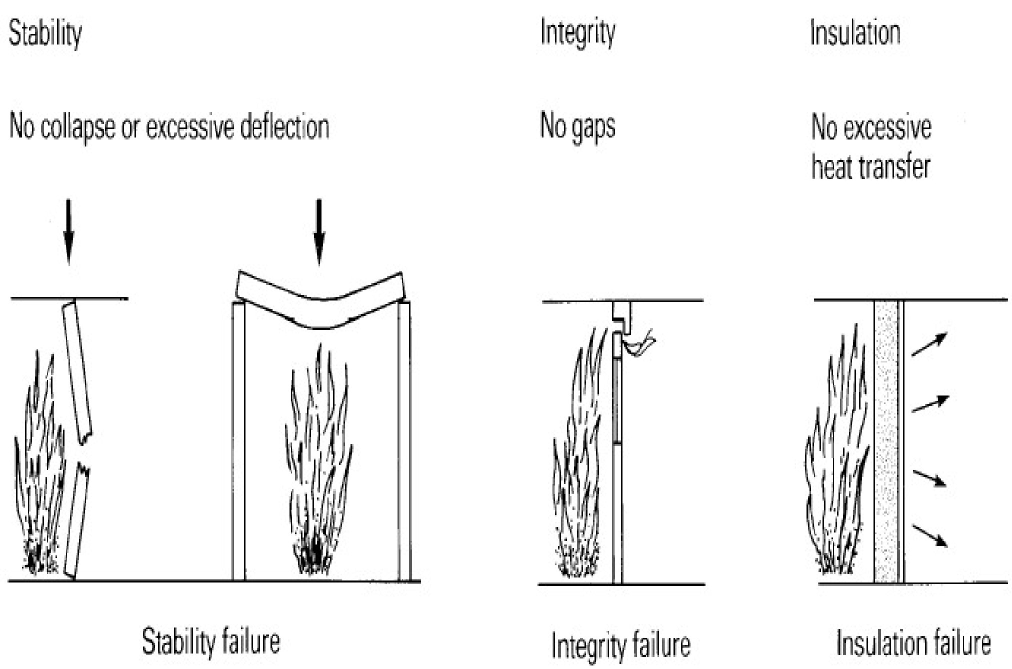
Heat Transfer in Buildings

- Conduction
  – direct transfer i.e. by touch
  – e.g. door handle on the off-fire side

- Convection
  – transfer through movement of gases or fluids
  – e.g. hot air above a fire

- Radiation
  – transfer through waves of heat through air
  – e.g. blistered paint on a fire tender facing a fire

Building Construction- Fire Resistance



Fire Resistance

- ability to withstand the effects of fire for a period of time
- British Standard BS476
- Referred to in terms of time (30 minutes)
- Stability, Integrity & Insulation
- *Loadbearing & Non-loadbearing capacity* (formerly only stability prior to 1987)
  – resistance to collapse or excessive deflection
  – *Integrity*
- resistance to penetration of sustained flame or hot gases
  – *Insulation*
- resistance to excessive temperature rise on the unexposed face

2.8 Construction Fire Technology

- Building Construction

Building Construction - Materials

- Wood……………. – Charring - (residual section)
- Concrete………. – Spalling – (steel bars)
- Steel……………..– Failure – (thermal expansion)
- Masonry………..– Density – (expansion)
- Plastics…………. – Melting – (thermoplastic)
- Glass……………. – Cracking
- Aluminium……..– Softening at 660 ˚C - 600 ˚C

Doors and protection from fire

The Envirograf® guide to fire door protection.

Introduction

The role of the fire door is one of the most important elements of fire protection in a building. It's effectiveness resisting flames and smoke helps stop a fire from spreading, saving property and allowing time for occupants to escape, thereby saving lives. **This is particularly important in multiple occupancy housing, retirement homes, maisonettes, flats etc.**

The fitting of a fire door is more complex than it seems. For example a fire door must have intumescent around either the door edge or the frame. And, as smoke is the main killer in any fire, smoke seals should be fitted. Door furniture must also provide fire protection.

Despite new British Standards which clearly state the required specifications for a fire door set, Fire Officers are constantly finding doors with items fitted that have no fire protection qualities, completely removing the doors fire integrity, e.g. Letter boxes, hinges, locks, and more recently cat and dog flaps.

If a fire was to occur these doors would be ineffective, and could lead to the loss of life.

Environmental Seals Limited have produced a range of products designed to maintain the integrity of the fire door, particularly doors located in houses of multiple occupancy.

They have all been produced with cost effectiveness and ease of installation in mind.

Envirograf fire door protection products - keeping fire doors effective!

A FIRE DOOR IS NOT A FIRE DOOR WITHOUT INTUMESCENT

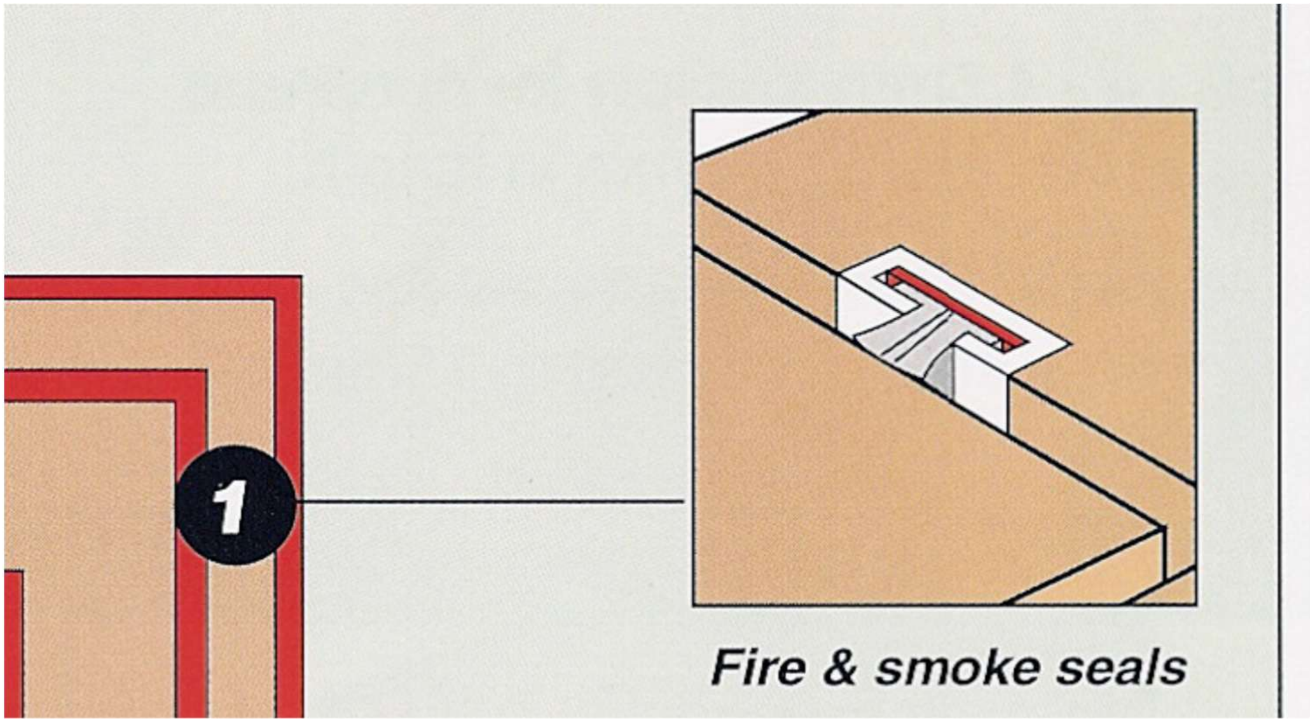
Envirograf Product Information

Tel: 01304 842555 Fax: 01304 842666

Parts of a typical fire doorset

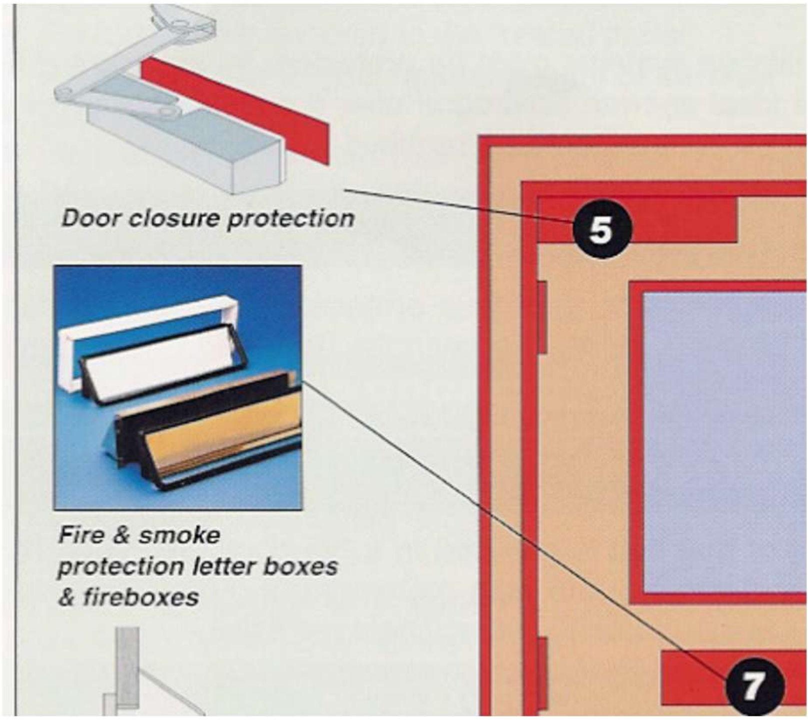
Hinges
&
Grilles

Potential Weaknesses in fire doorsets

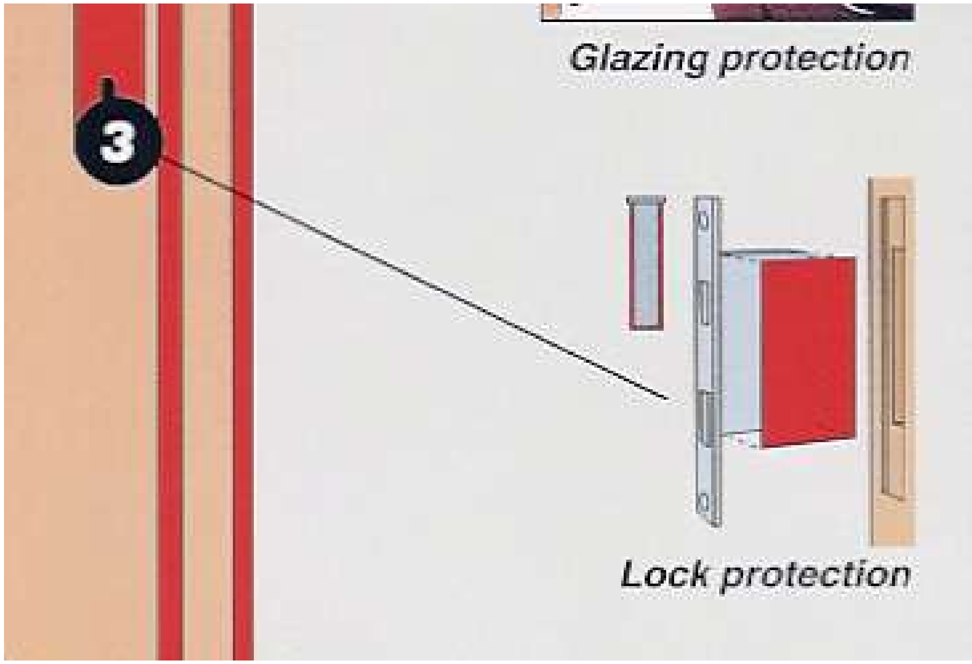


Potential Weaknesses in fire doorsets

Door closers
&
Letterbox opes



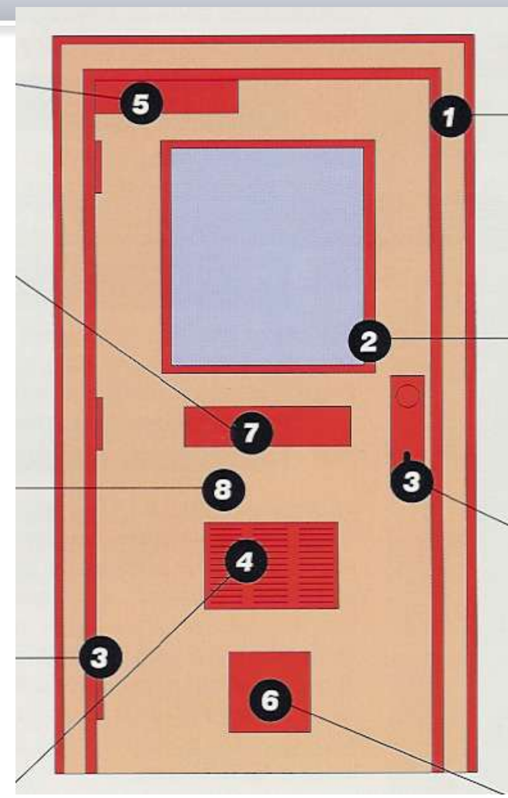
Potential Weaknesses in fire doorsets



Hot spots

Potential Weaknesses in fire doorsets

- Seals
- Glazing
- Locks
- Grilles
- Closer boxes
- Flaps
- Letter boxes

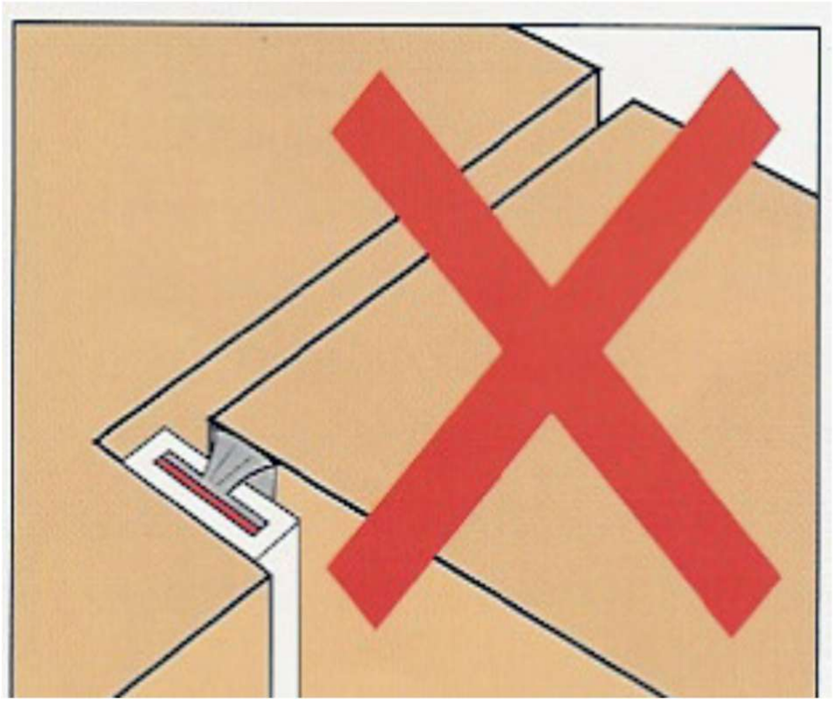


Sample Industry controls

Identification markers
- Period of fire resistance
- FD20
- FD30 & FD30S
- FD60 & FD60S
- FD90 & FD90S

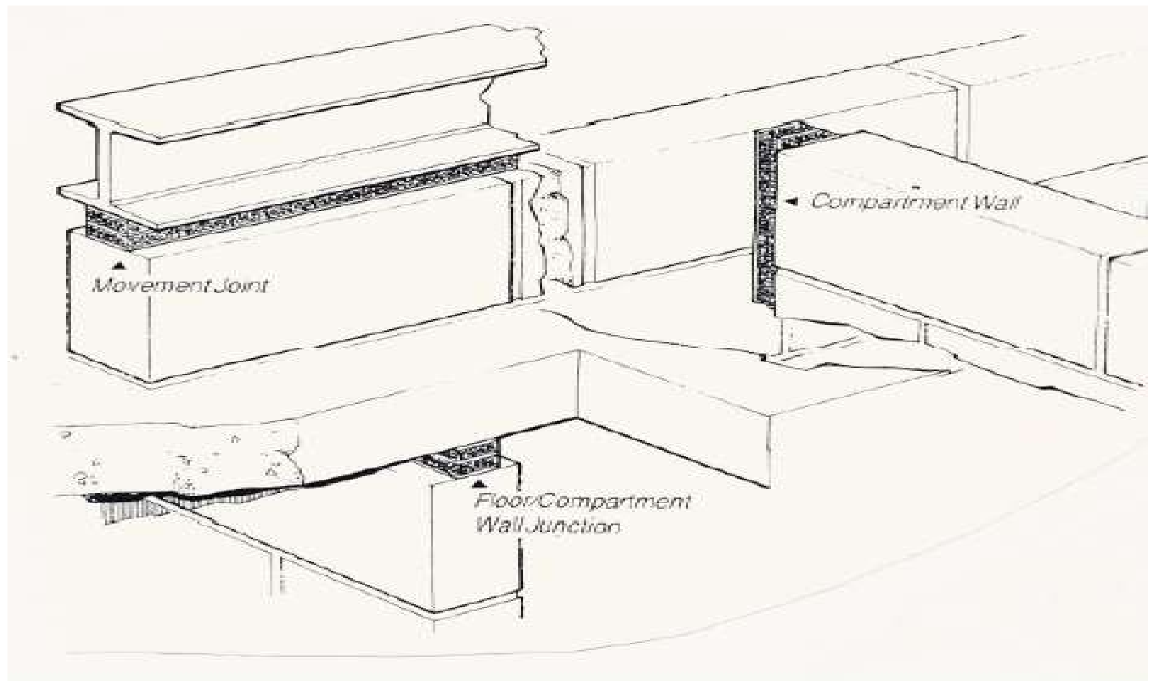
Fire doorsets and intumescence

- Intumescent Strip located against doorstop
- In a fire it will push the door open…



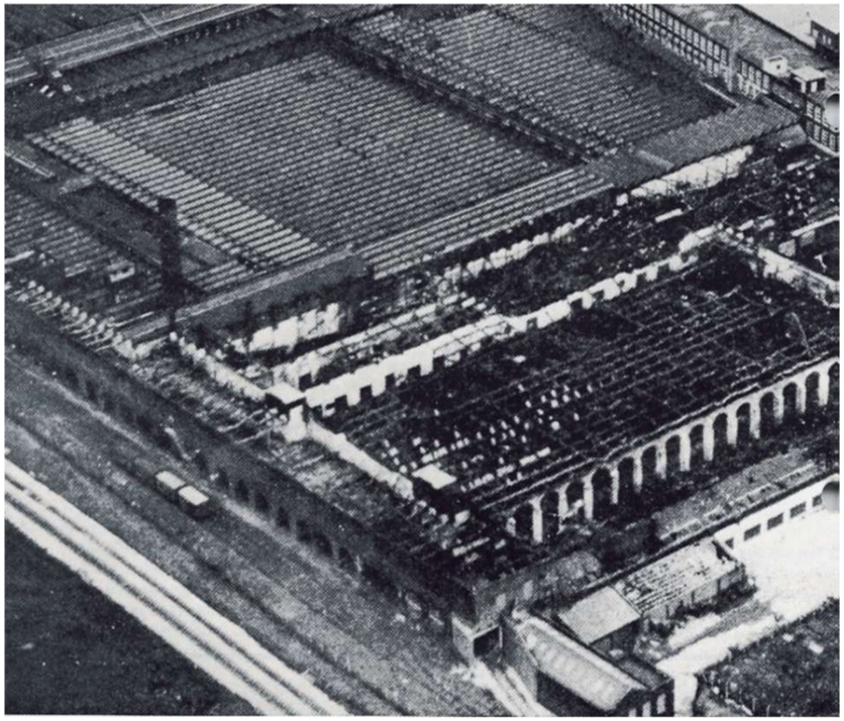
Compartment Joints

- Degree of movement
- Size of gap
- Location of gap



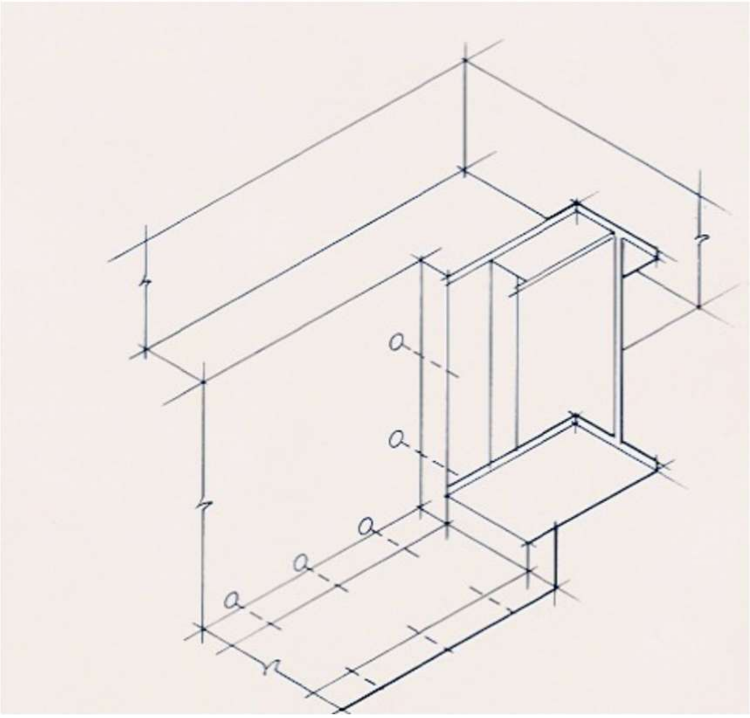
Division walls

- Merchandise warehouse in Lancaster, U.K., 1971
- Brick Division Wall assisted Fire Brigade

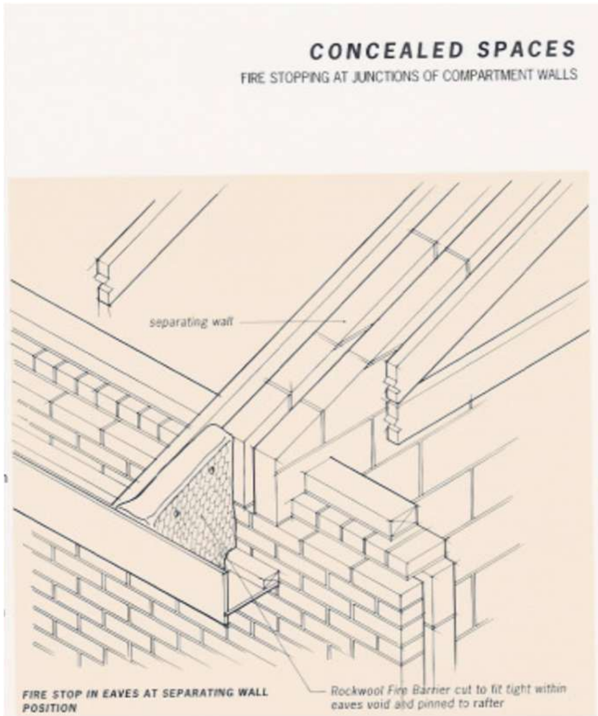


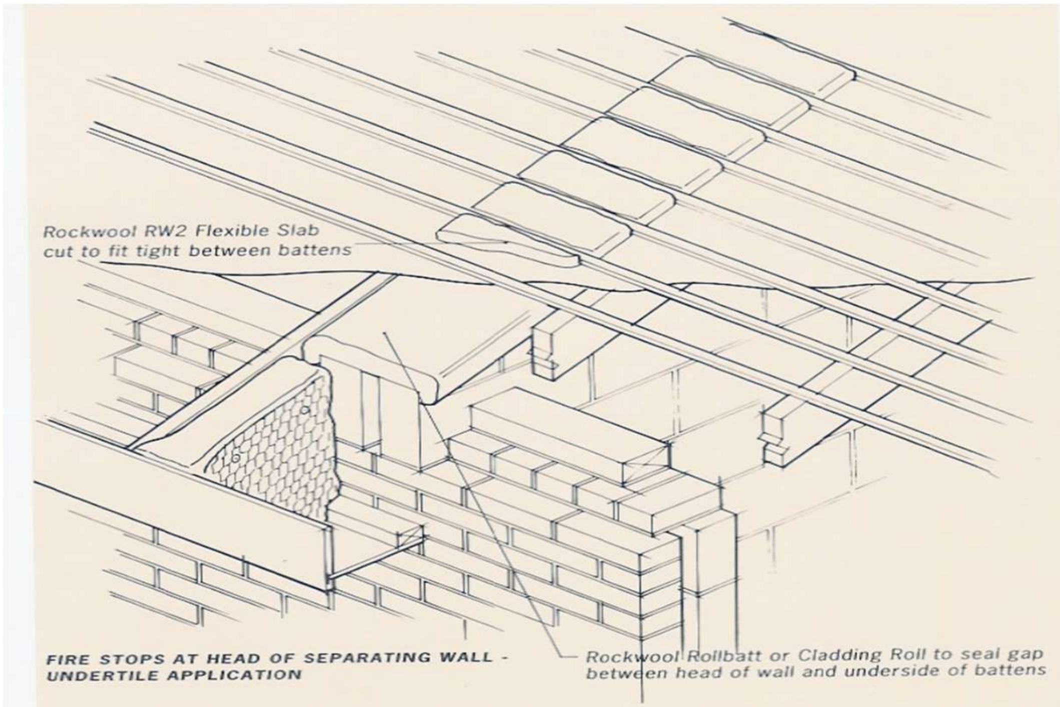
Proprietary board protection

- light systems
- encasing systems
- curved or variable geometry surfaces
- fixed by stud welded steel pins or noggings
- Rockwool ConlitR ,Gypsum fireline, Cape boards Supalux, Promat Vicuclad, Knauf encasement boards
- Various fire ratings
  - Fixings,
  - movement because of loading,
  - steel elements in walls,
  - joints,
  - noggings,
  - clips,
  - spacing of screw



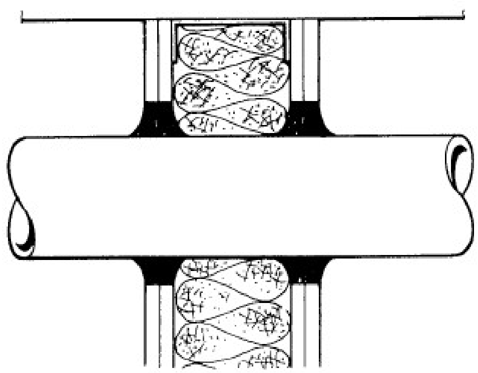
Wall / Roof junctions





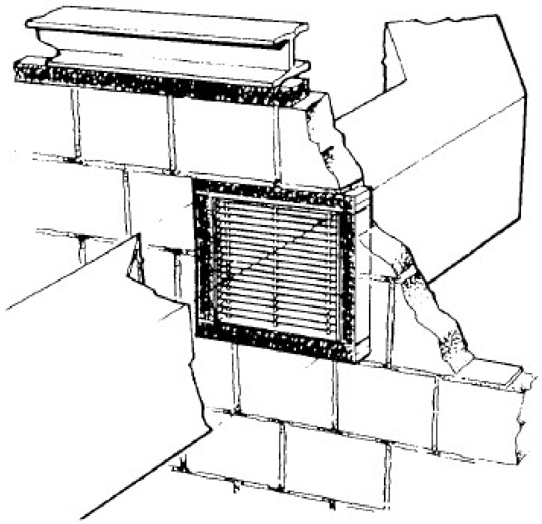
Firestopping services

Studded wall both sides collared

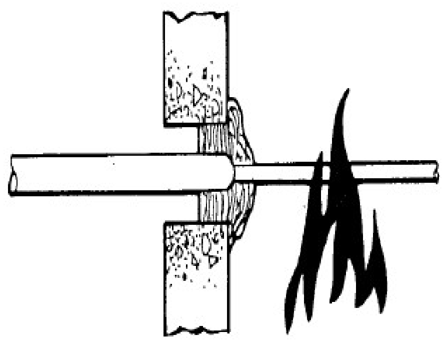


Exterior sealed

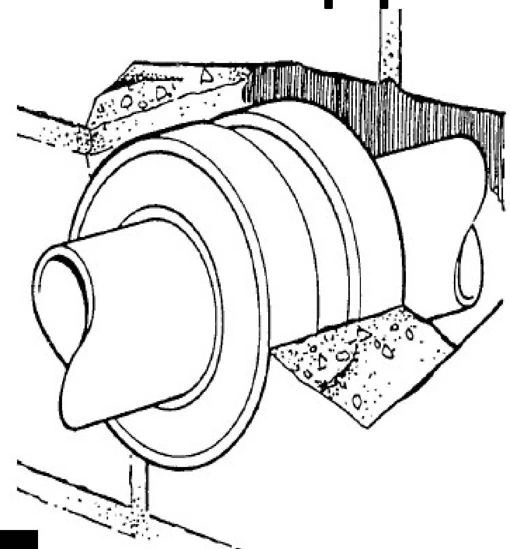
Interior grille



Cable / Pipe penetration fire stopping



- Cable mastic collar



- In-line intumescent sleeve collar

Fire dampers for ductwork

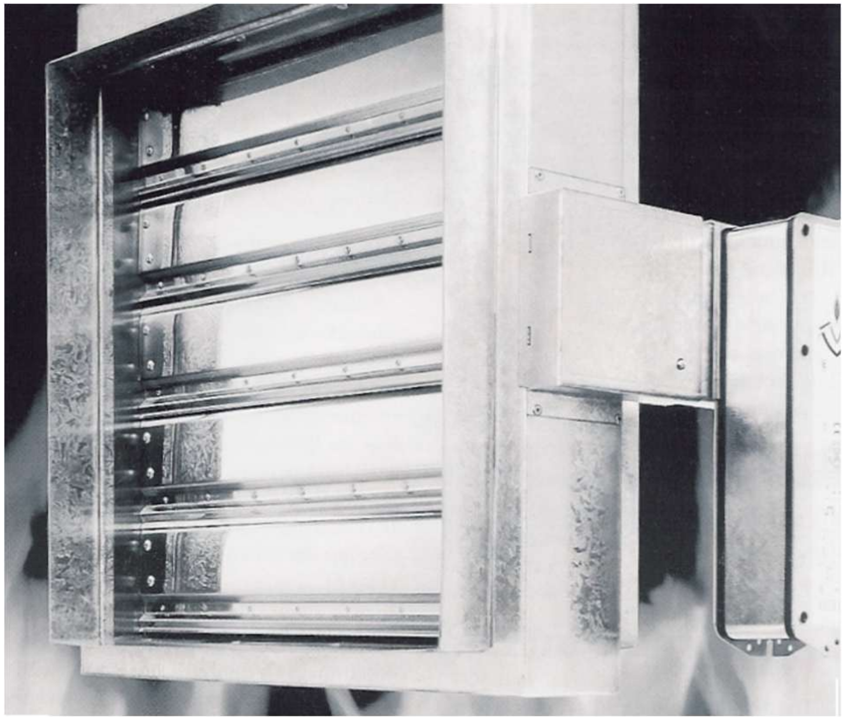
- Typical fire & smoke damper
- Louvred
- Powered actuator
- Fixity

– fixed in-line

– side hung (wall flush)

– off-set (spigot))

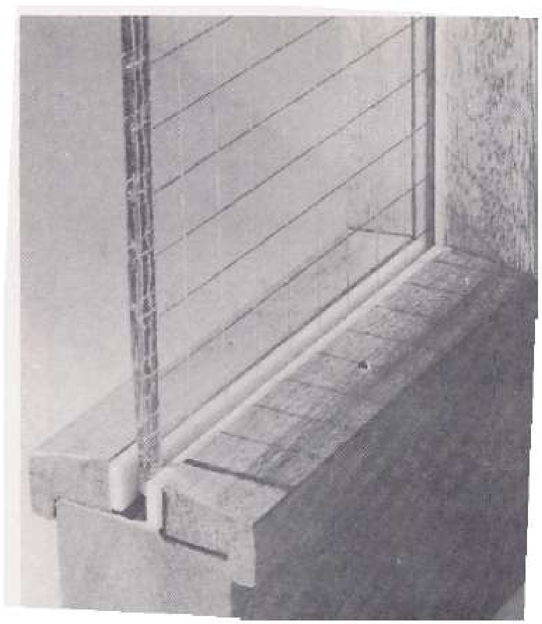
- fire rated or non-fire rated

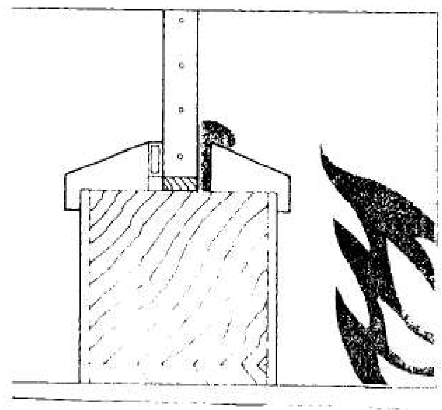


Criteria when assessing a particular product:

- Size of the ope
- Flexibility of services
- Smoke (or gas) tightness required
- Ambient conditions
- Design life
- Frequency of alterations to services
- Parent construction
- Compatibility with environment (e.g. rigid material in ‘dynamic’ situation)
- Large span and thermal expansion differentials
- Co-ordination with other contractors

Fire-resisting glazing



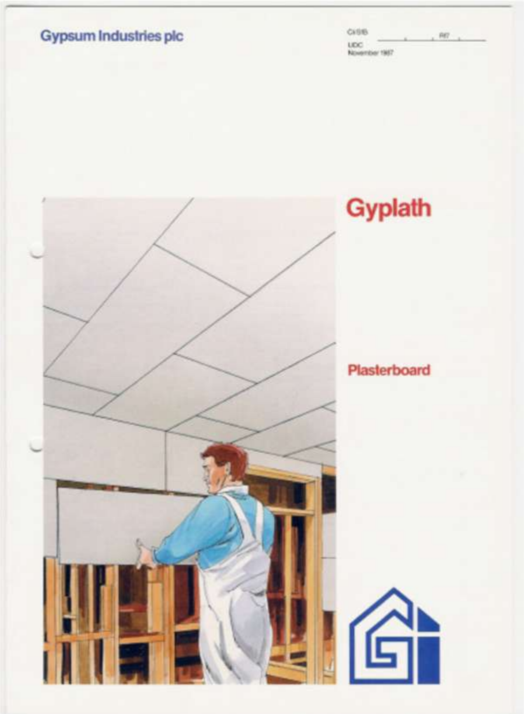


- Beading
- Depth of glass
- 150 C – 200 C
- Glazing pocket

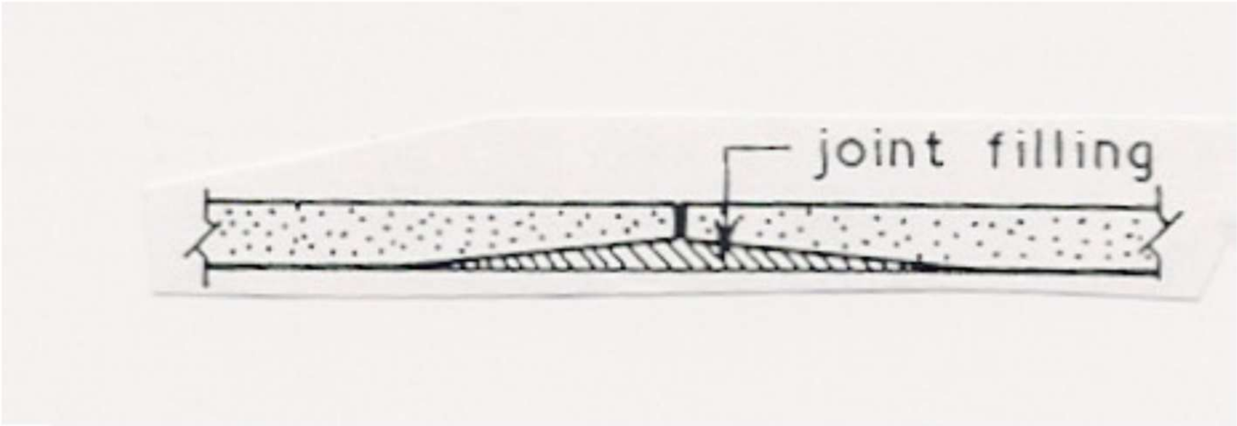
Gypsum products

- Fireline board
- Ceilings
- Studded walls
- Double slabbing

– Staggered joints

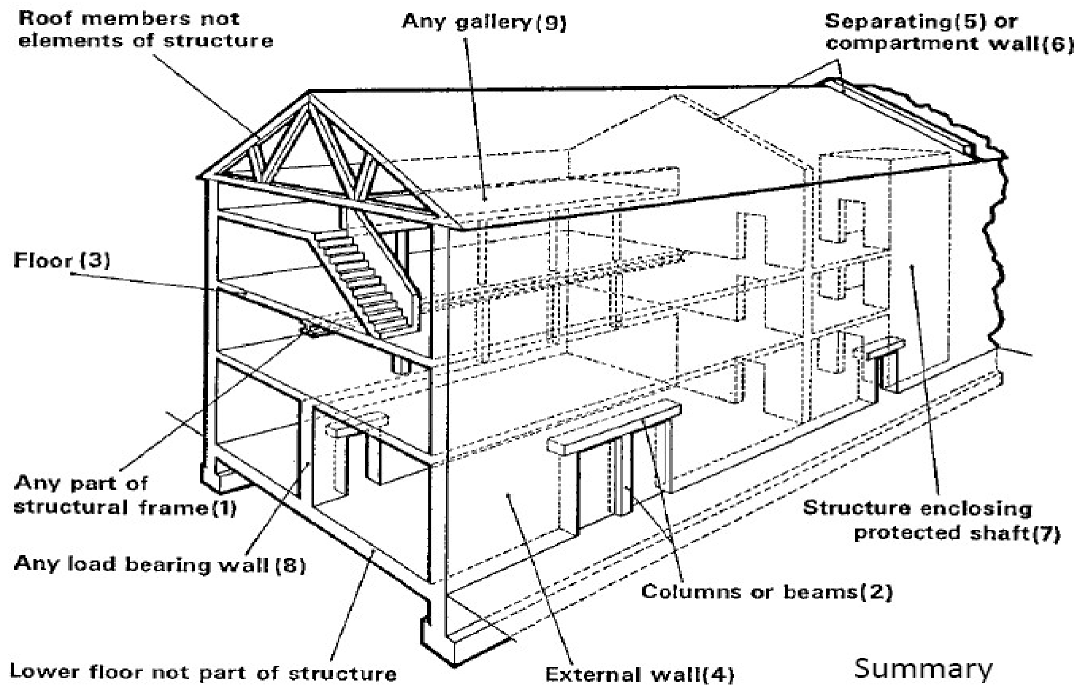


Detailing



- Omission
– Consequences for integrity and insulation
– Premature loss in structure

Compartmentation



Summary

Building collapse

- Reinstatement
- Heritage
- Collateral damage

COLLAPSE OF BURNING BUILDINGS

- “Ordinary masonry , assuming no explosion or
- internal pressure, will fall within a distance from the
- wall equal to one third its height, but bricks may
- bounce or fall further”
- -Fire Protection Handbook (6th Edition, NFPA)
- i.e. H/3 + maybe BT

COLLAPSE OF BURNING BUILDINGS

- “Ordinary masonry, assuming no explosion or internal pressure, will
- fall within a distance from the wall equal to its full height, but
- bricksmay bounce or fall further;
- if there is pressure behind the collapse it will fall within a distance
- equal to twice its full height, but bricks may bounce or fall further ”
- - FIREFIGHTER A. RETIRED (H + BT)

San Andraus building

31 storeys

Concrete framed building

Forms of Construction

Prestressed floor beams

- Can achieve sixty minutes fire resistance
- Screeded

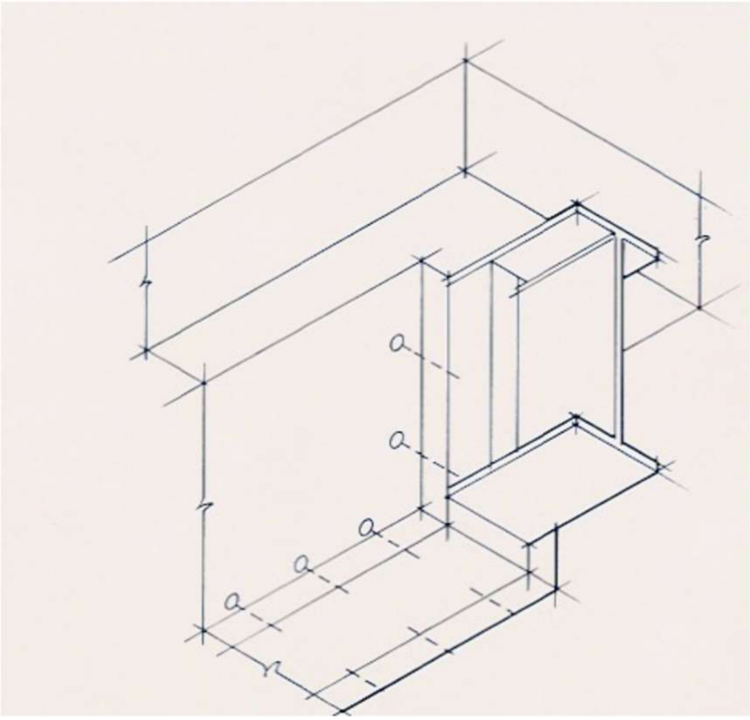
Typical means of protection from fire

Protection of structure

- Rockwool firebatts
- Encasement

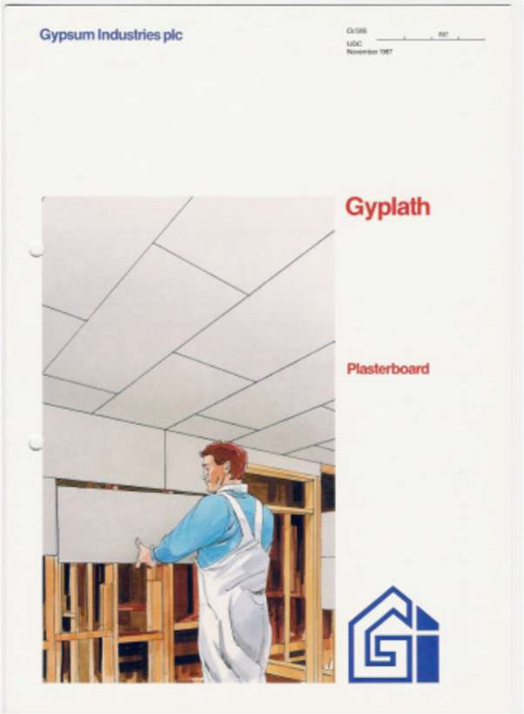
Protection of structure

- Proprietary boards
- Encasement



Studded walls – joisted floors

- Plasterboard protection
- Fireline Board



Surface Spread of Flame Rating

- QUALITIES:

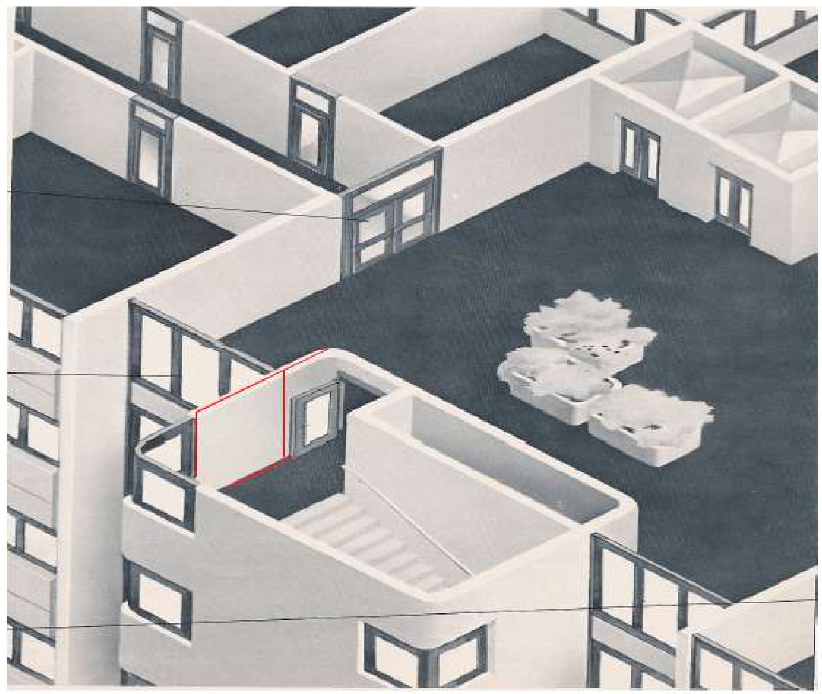
Be difficult to ignite ; Do not support flame

Glazing and Fire Safety

Glass block wall construction

- Non-loadbearing
- Steel lattice
- Insulation
- Expansion joints

Glazing and fire rated walls

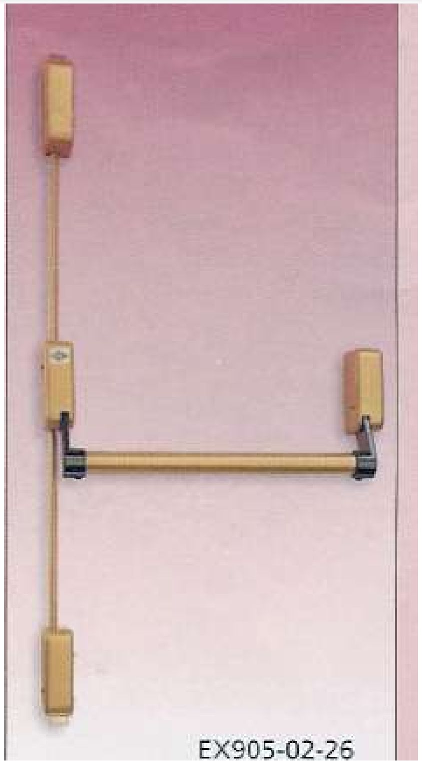


Doors in construction

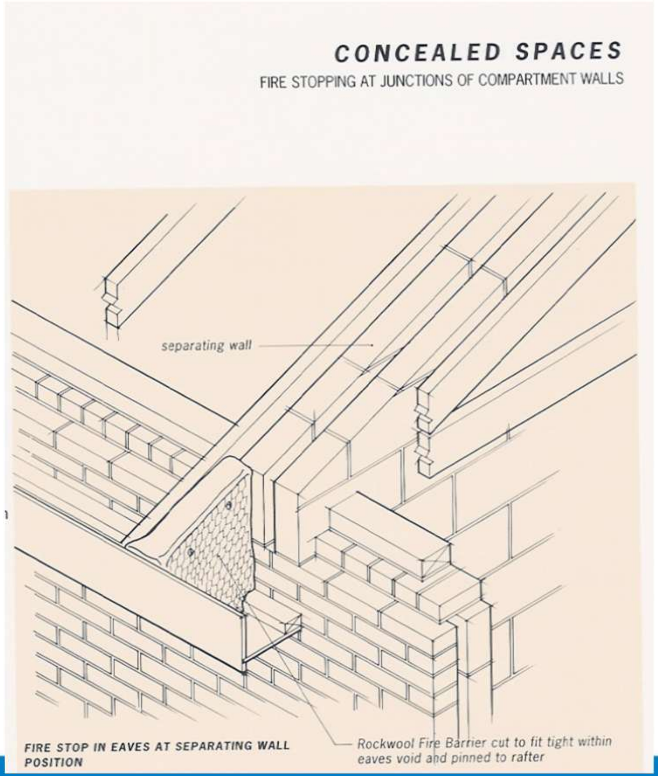
- Fire Doorsets V. Fire exit doors

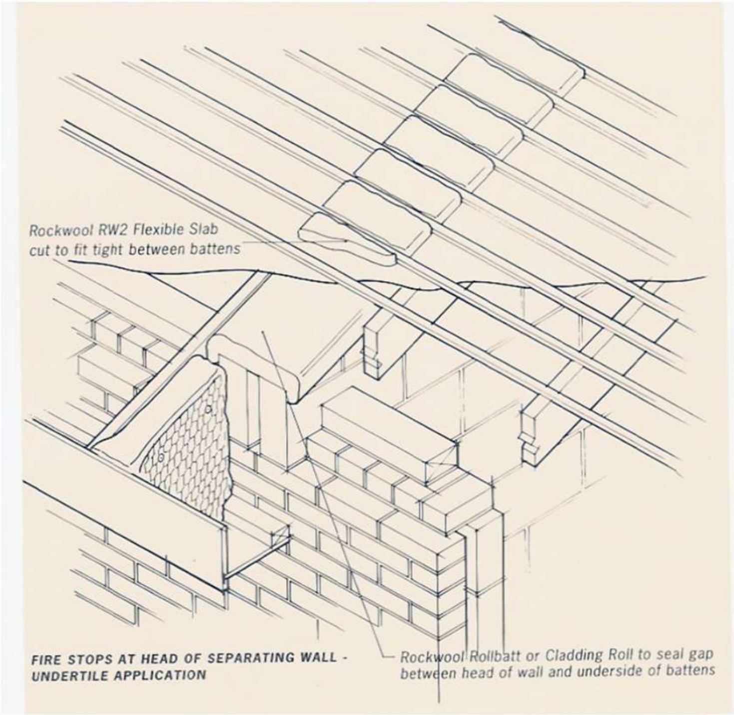
Fire doorset – Fire exit door

Exit Door fittings



Party Wall

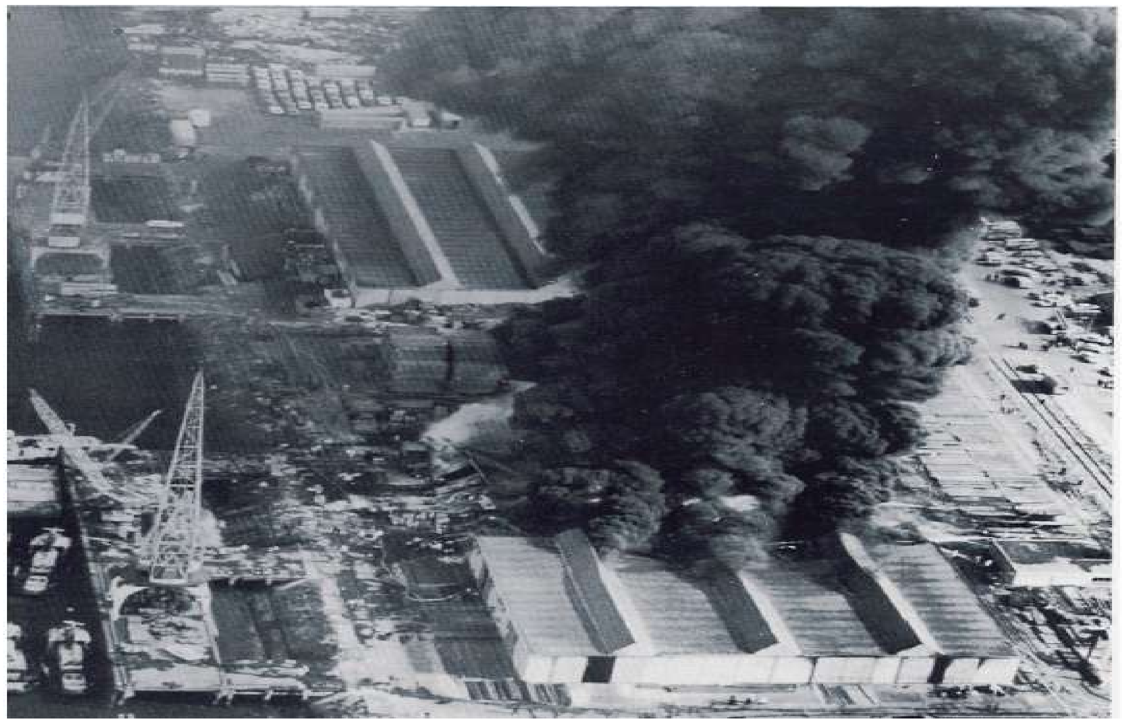

CONCEALED SPACES
FIRE STOPPING AT JUNCTIONS OF COMPARTMENT WALLS
separating wall
FIRE STOP IN EAVES AT SEPARATING WALL POSITION
Rockwool Fire Barrier cut to fit tight within eaves void and pinned to rafter


Rockwool RW2 Flexible Slab cut to fit tight between battens
FIRE STOPS AT HEAD OF SEPARATING WALL - UNDERTILE APPLICATION
Rockwool Rollbatt or Cladding Roll to seal gap between head of wall and underside of battens

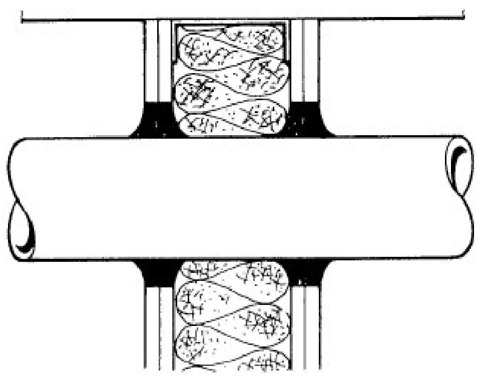
The Fire Brigade and Compartmentation

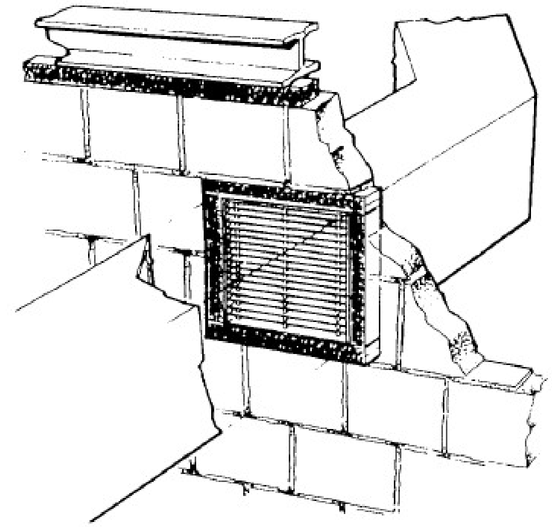
Warehouse fire in the Netherlands, 1965

Indicates the extent of loss in the absence of compartmentation and the difficulty of gaining control for the fire service



Fire stopping of fire barrier penetrations

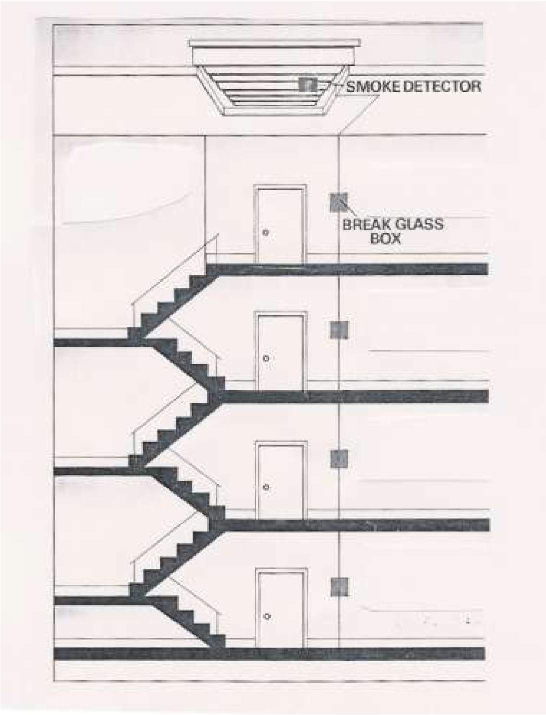




Smoke ventilator [AOV]

- Protected staircase
- Manual
- Automatic
- Fire detection system
- Maintenance
- Fire Brigade

1.0m2 Aerodynamic
Free Area



Assignment

The aim of the assignment is for you to apply the course material to a real-life situation by considering the issues relevant to the module.

Your written assignment should incorporate *all* of the following:

1. An executive summary explanation for the client, relevant to her/him as a lay person, of the challenges you have identified in your assignment.

   [*20 marks*]
2. A demonstration of your awareness of the factors involved in identification of the principal considerations. [*50 marks*]
3. Evidence of a good command of the subject. [20 marks]
4. Check for learning, summary and conclusions. [10 marks]

Assignment

- 3.1. Each student is required submit a 1,500 to 2,000 word assignment document following attendance at the course module.
- 3.2. Students will submit their module assignment to IT Carlow Blackboard.
- 3.3. Assignments must be uploaded by [03-02-2016].
- 3.4. Assignments should be submitted typed in double line spacing and should include a bibliography.
- 3.5. Each assignment must be presented on A4 size paper (white), font size 12**.**
- 3.6. Students must retain a hard copy and an electronic copy of their project.
- 3.7. All assignments should be accompanied by an Assignment Cover sheet and a personal declaration that the work is entirely the student's for the purpose of academic assessment.
- 3.8. Each student assignment should demonstrate an understanding of academic theory on the part of the student and should also relate to their work environment.

Assignment

- 3.9. Each student assignment should be structured in sections as follows:
- **The Assignment task (scope – what is the reader reading about ???).**
- **Introduction**: The introduction should consist of 2-300 words and should contain reference to the main areas to be explored in the assignment.
- **Main Body**: It should contain references to texts used in the research for the assignment academic theory, case studies and the student's work experience.
- **Conclusions**: The conclusions should refer to the information contained in the main body and should consist of perhaps 300-500 words. No new information should be introduced in this section. It should be used to draw the whole assignment together in a logical fashion and provide closure.
- 3.10. Each student assignment must have a bibliography. This should indicate the source material used and should include

Plagiarism

3.11 Plagiarism is regarded as either intentionally or unintentionally the '*passing off*' of others' work as one's own. This includes the using of others' ideas, information presented or accessed in either visual or audio formats and asking or paying another to produce work.

- *In short, do not;* Pass off another's work as your own
- Ask another to do work which you claim as your own
- Buy or copy work from electronic sources which you claim as your own or Use another's ideas as your own

3.12 Plagiarism can be either an intentional act whereby work is deliberately utilised and claimed as one's own, or it can occur unintentionally either through bad academic practice by the student or failure to inform yourself about the Institute's regulations. Plagiarism is not confined to written assignments, projects or theses; it incorporates all academic work, including practical workshops, demonstrations, three dimensional work and artistic practice.

3.13 It is imperative that students reference their own work and provide a bibliography to support their referencing within the assignment. Students must be aware that lecturers may use specialist plagiarism detection software and other appropriate measures where plagiarism is suspected.

Bachelor Degree in Business Studies
Fire Safety, Engineering & Design: 2025-2026
Stage 2: BSEMS_B_Y2 : DAY 2 of 5

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