
Design of building structures for fire

Compliance approach and the role of the Structural Engineer

1.0 Background to this guide

Developments in buildings have led to questions of both the correct approach to take in designing the structure of a building to resist fire exposure, and the role of the structural engineer in the process. The main drivers are:

- the increasing complexity of buildings
- the use of new materials
- the evolution of fire engineering and
- the focus on fire safety following fire incidents, in particular the Grenfell Tower tragedy.

In response, industry is questioning its existing approaches to fire safety and the roles, interactions and competences of those involved. These questions were acutely put in the Grenfell Tower Phase 2 Inquiry report ¹⁾. This questioned the applicability of prescriptive approaches, the lack of clarity around the roles and competencies of designers, particularly the Fire Engineer, and the confusion around responsibility for the design of structural elements and frames to resist fire exposure.

2.0 Aims of this guide

Two of the recommendations of the Grenfell Tower Phase 2 Inquiry report¹⁾ were that: designers should be able to clearly understand the applicability of prescriptive methods or statutory guidance to their designs; and that they should also be clear of their responsibilities regarding fire engineering. These two issues were identified by professionals from the Institution's volunteer panels and it was decided that guidance was needed in this area. This guide aims to:

1. Outline the methods available to demonstrate compliance with the Functional Requirements of Parts A and B of the Building Regulations with regards to fire safety of the structure;
2. Provide a framework to support designers in their selection of appropriate methods for demonstrating compliance with Building Regulations;
3. Define the role of the Structural Engineer regarding the performance of the structure to meet Parts A and B of the Building Regulations in relation to fire safety;
4. Lay down criteria for when a Fire Engineer and/or Structural Fire Engineer¹ are recommended due to the nature of the structure; and
5. Advise on how the Structural Engineer and other parties should interact.

¹ The term "Structural Fire Engineer" is not formally recognised but is used to describe an engineer with specialist skills in the complex analysis of structures subject to fire actions, including the derivation of fire loading and understanding of material and frame performance in fire."

This guidance is intended to support demonstration of compliance in England and Wales with Parts A and B of the Building Regulations in relation to fire safety of the structure, however the principles may be relevant in other jurisdictions.

This guide is not intended to provide advice on technical concepts, such as what fire resistance is, what fire resistance design approach may be used and the key structural and fire assumptions behind them, for which reference to other literature should be made. Its scope is limited to buildings.

3.0 Design objectives

3.1 Compliance with Building Regulations

The Building Act 1984 is primary legislation that enables the appropriate national authority the ability to make regulations (secondary legislation) “... for ... the purposes of—

(a)securing the health, safety, welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings...”²⁾

The Building Regulations are secondary legislation enacted under the Building Act. The primary objective of Part B of the Building Regulations *Fire Safety* is protection of life safety.

For the most part, the Building Regulations are set out as functional requirements and contain a series of outcomes that must be achieved. The Building Regulations were amended by The Building Safety Act 2022 to more clearly set out requirements on competency across key project Stakeholders.

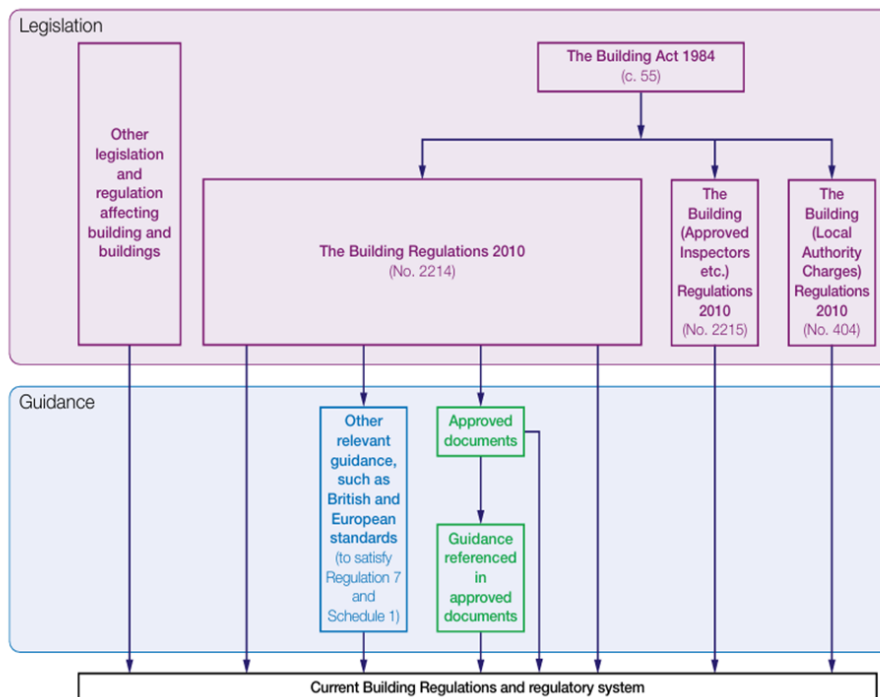


Figure 1: Building Development Regulatory Framework (Manual to the Building Regulations, July 2020, HM Government)

The structural design must comply with Part A Structure AND relevant parts of Part B of the Building Regulations ²⁾, extracts of which are reproduced below:

SCHEDULE 1: Regulations 4 and 6

Part A STRUCTURE

Disproportionate collapse

A3. The building shall be constructed so that in the event of an accident the building will not suffer collapse to an extent disproportionate to the cause.

PART B FIRE SAFETY

B2.—(1) To inhibit the spread of fire within the building, the internal linings shall—

- (a) adequately resist the spread of flame over their surfaces; and*
- (b) have, if ignited, either a rate of heat release or a rate of fire growth, which is reasonable in the circumstances.*

(2) In this paragraph “internal linings” means the materials or products used in lining any partition, wall, ceiling or other internal structure.

B3.—(1) The building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period.

(2) A wall common to two or more 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.

(3) Where reasonably necessary to inhibit the spread of fire within the building, measures shall be taken, to an extent appropriate to the size and intended use of the building, comprising either or both of the following—

- (a) sub-division of the building with fire-resisting construction;*
- (b) installation of suitable automatic fire suppression systems.*

(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.

Under Part A3, fire should be treated as an accidental case. Designers should be aware of Part 2 when selecting biogenic materials such as timber. The structure, walls or slabs, may form part of the compartmentation to meet Part 3. The structure may also restrain or support compartmentation and therefore have appropriate fire resistance.

3.2 Use of Approved Documents

Approved Documents are approved by the Secretary of State and give practical guidance on common building situations, about how to meet the requirements of the Building Regulations. However, these documents may not always be suitable for addressing the unique challenges presented by large, complex or otherwise unconventional buildings, which often stray from arrangements, designs and uses that have been widely experienced over time.

The Approved Documents do not contain detailed guidance about the definition of a common building situation, however they include indicators of uncommon buildings. Uncommon buildings are those that do not fit the typical scope of building regulations due to their distinctive design, setting, use, scale, or technology. Examples of non-standard fire related conditions found in uncommon buildings include:

1. Buildings with uncommon occupancies,
2. Buildings with high levels of complexity,
3. Very large or tall structures,
4. Large timber buildings, and
5. Buildings that integrate modern construction methods.

This document is intended to help structural engineers identify when they should seek additional expertise to ensure that the structure is able to deliver adequate performance during a fire due to the nature of the building or structure being uncommon, or complex. Features adding to complexity are further described in section 6.0. In these cases, the prescriptive guidance provided in Approved Documents may not be sufficient to ensure the necessary levels of safety, necessitating a more sophisticated approach to fire safety and/or structural assessment.

In addition to the specific needs of unconventional buildings, there are instances where common constructions might also fall outside the applicability of prescriptive fire solutions outlined in Approved Documents, a key point raised in the Grenfell Inquiry. It is important to understand the limits of the methods and the testing that sits behind the equations in standards referenced in Approved Documents. For example, Eurocode 1 Part 1-2 “Actions on structures exposed to fire” sets out limitations for the application of the parametric time-temperature curve and the Eurocode Time Equivalent method. Such scenarios include situations where the compartment area exceeds 500 m² or the maximum compartment height exceeds four meters.³⁾ Such cases may not be appropriate for the application of the Eurocode methods to demonstrate compliance with the Building Regulations.

A summary of the regulatory framework for England and Wales is included in Appendix A. We note that post the Grenfell Tower Inquiry Phase 2 report, Building Regulations may change in response to its recommendations.

3.3 Fire resistance

Common to all of the provisions of Part B of the Building Regulations is the property of fire resistance. Understanding it is therefore central to compliance. Fire resistance is a measure of one or more of the following.

- a. Resistance to collapse (**loadbearing capacity**), which applies to loadbearing elements only, denoted **R** in the European classification of the resistance to fire performance.
- b. Resistance to fire penetration (**integrity**), denoted **E** in the European classification of the resistance to fire performance.
- c. Resistance to the transfer of excessive heat (**insulation**), denoted **I** in the European classification of the resistance to fire performance.

Fire resistance is measured in minutes. This relates to time elapsed in a standard test and should not be confused with real time exposure to an accidental fire. Fire resistance design represents a simplified model and compliance does not necessarily equal performance. Testing to determine fire resistance is based on idealised, short-span, simply supported beams and columns exposed to a standard fire load that does not represent potential fire loading.

It is the responsibility of the structural engineer to ensure that the Fire Limit State (FLS) is designed for as part of the accidental load case to comply with Part A3 and that Fire Resistance period is achieved at the FLS as defined in the Fire Strategy and by Approved Document B. Fire resistance and fire protection should be considered an integral part of the structural engineering design.

3.4 Protection of property

The Building Regulations are intended to ensure a reasonable standard of life safety in a fire. The protection of property, including the building itself, often requires additional measures. Insurers usually set higher standards before accepting the insurance risk.

Many insurers use the RICS Authority Design Guide for the Fire Protection of Buildings by the Fire Protection Association (FPA) as a basis for providing guidance to the building designer on what they require. Further information on the protection of property can be obtained from the FPA website: www.thefpa.co.uk.

4.0 Selecting a design approach

It is important to consider that the selection of the method of analysis, and the level of detail required for analysis, depend on the requirements of the local authority and jurisdiction where the design is taking place. This guidance document considers England and Wales only.

4.1 Design approach

In the process of designing a structure to withstand fire conditions to provide adequate safety, it is common to employ relevant sections of Eurocodes. Eurocode EN 1991-1-2³⁾ provides designers with a variety of design options, as depicted in Figure 2.

Design approaches can be generally categorised into prescriptive and performance-based settings, as shown in Figure 2. The prescriptive approach utilises nominal fires to generate thermal actions, while the performance-based approach, employing fire safety engineering, takes into account thermal actions based on physical and chemical parameters. Such an analysis might lead to a situation where a structural engineer can undertake their structural design in accordance with the prescriptive rules.

Within these approaches, the fire resistance design of structures can be evaluated using one of three analysis methods:

- **Member:** involves evaluating each individual member of the structure which is assessed by considering it fully separated from other members, with the connection condition with other members replaced by appropriate boundary conditions.
- **Part structure:** involves assessment of multiple elements of the structure and uses appropriate boundary conditions to reflect their links with other parts of the structure.
- **Global structure:** assesses the whole structure in the assessment.

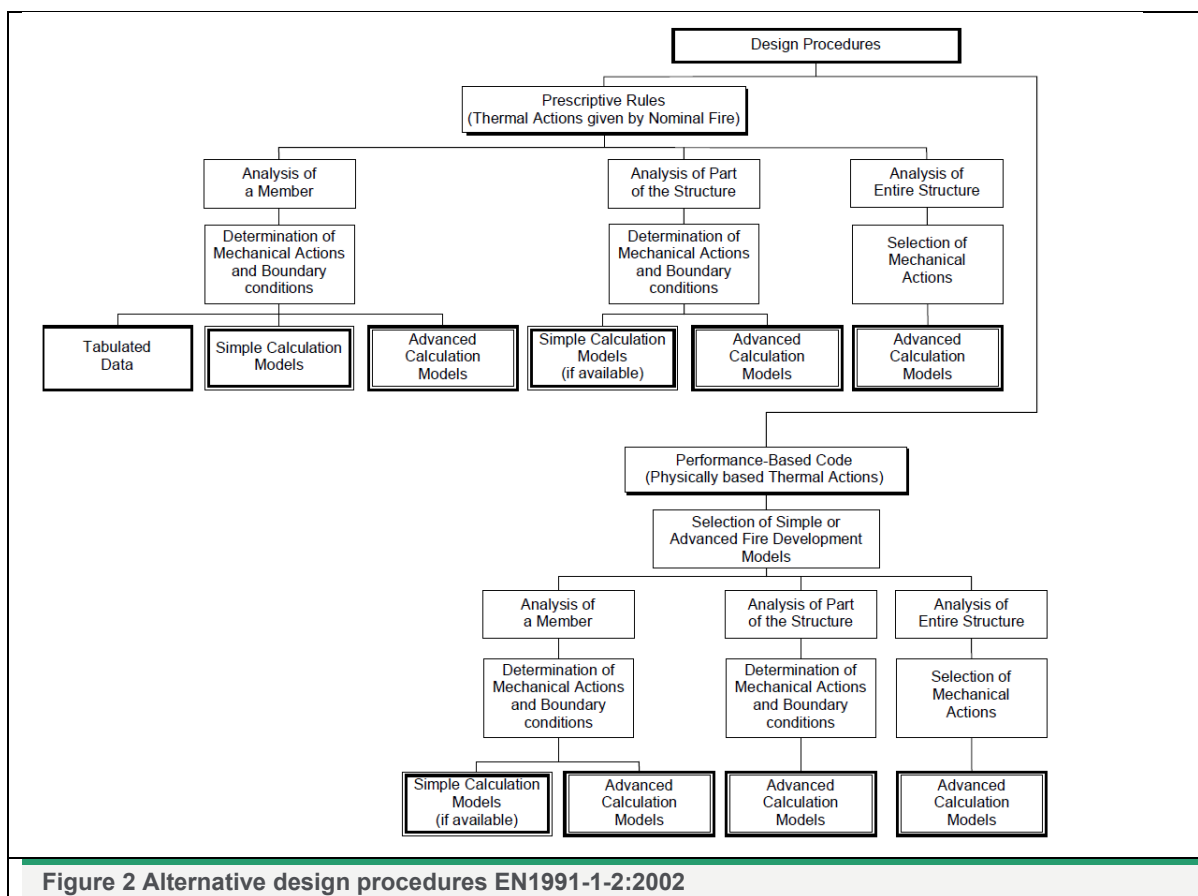


Figure 2 Alternative design procedures EN1991-1-2:2002

In the context of assessing the mechanical response of structures in a fire (development of stress, strain and deformation caused by degradation of material properties and restrained thermal expansion), the following remarks may be made:

- Single member analysis is suitable for isolated structural elements and is commonly used with simplified calculation methods, particularly under nominal fire conditions.
- The analysis of multiple structural components, or the overall structure, will encompass multiple structural members together, allowing for direct consideration of their interactions. This approach more accurately accounts for heating and cooling: reduction in strength, reduction in stiffness, and complex geometrical change, resulting in load redistribution from heated (weakened) parts within the fire compartment to cooler (stronger) parts outside it. By analysing the global behaviour of structures, a more realistic understanding of their mechanical response to fire conditions is achieved.

4.2 Elemental calculation methods

Where elemental design is adopted, it is important that a holistic approach is still considered. It is often global, cumulative and less predictable effects that govern the structural response in fire, so they should be considered where relevant.

For a particular design, the limiting temperature² may not be exceeded in any one element, but the deformations due to thermal expansion and destabilising effects of multiple components in the structure could still lead to localised or even progressive collapse.

The limiting temperatures commonly achievable by fire protection systems can often still lead to significant deformations at FLS, beyond normal serviceability acceptance criteria. These limiting temperatures can be

² The temperature at which the element can no longer support the applied loading

high enough for structures to lose significant stiffness and strength and therefore deform significantly even with applied fire protection. For structures governed by elastic buckling this could result in a considerable lack of performance in a fire and, potentially, an unconservative design if this is not properly considered in the calculation of the limiting temperature.

Project-specific scenarios should therefore be considered to identify critical elements whose response in a fire could compromise fire safety.

Consider where fire protection is not normally required by prescriptive methods. For example, where failure could result in toppling effects that could damage adjacent structures or fire escape / access routes. Roof beams, or secondary structure might be restraining compartment walls or external walls that need to achieve a fire resistance performance. Such elements may require fire protection to enable them to adequately support other fire resisting elements in the building.

It is also important to consider how connections are detailed and protected. Where fire protection is being optimised, for example by omitting or reducing protection to floor beams. it is important to ensure that principal vertical supports remain fully tied into the floor diaphragms and stability system. Thus, columns and ties should often remain protected following the optimisation process.

To prevent localized heat conduction from adjacent unprotected to protected structural members, fireproofing should be extended from a protected member onto an attached, unprotected member (coat-back) for a specified length

Other such examples to consider include:

- **non-linearity** caused by large deformations, for example inclined columns, curved beams leading to dramatic increases in load
- **Load reversal** in connections due to heating and cooling cycles and uneven/asymmetrical thermal loading, thermal expansion of floor plates
- **Local instabilities**, for example beams with web openings and slender web components.
- Stability of **transfer structures** e.g. loss of lateral restraint
- Excessive **deflections** of beams supporting compartment walls.
- **Lateral movement of edge beams** causing excessive axial forces on beam to slab fixings (particularly in timber-steel hybrid structures where ductility of connections is greatly reduced)
- **Ductility of connections** to allow for the large deformations that occur as a result of heating

4.3 Advanced calculation methods

Advanced calculation methods are often essential for accurately evaluating the fire safety of unconventional buildings. These methods are suited to complex or non-standard structures with unique geometries, unusual materials, or atypical load distributions where simplified methods may be considered inadequate or overly conservative. For performance-based designs, advanced calculation methods enable more precise modelling of specific fire scenarios and their effects on the structure, surpassing the limitations of prescriptive methods

Large or tall buildings also benefit from advanced calculation methods, as simplified methods or standard fire resistance tests may not accurately reflect the actual fire behaviour in these structures, particularly in large compartments or tall buildings. Critical infrastructure where the consequences of failure are severe, such as hospitals, power plants, or high-rise buildings, may require advanced analysis methods to be used to ensure that the proposed fire safety measures provide robust protection against the specific hazards in the building. Detailed risk assessments, which take into account various design fire scenarios and their potential impacts on the structure, rely on these advanced approaches.

Comprehensive analysis can optimise fire protection measures, potentially reducing materials and costs while maintaining high safety levels. When assessing the fire resistance of existing buildings, specifically those that may not meet current code requirements or are undergoing renovations, advanced calculation methods offer valuable insights where compliance with current code requirements does not exist, or cannot be proven.

Advanced calculation methods are also used to explore new materials, structural systems, or fire protection strategies, advancing current knowledge and practice. They are also utilised when dealing with complex fire scenarios that may not be adequately represented by standard time-temperature curves, such as localised fires or traveling fires in large spaces, including global structural analysis.

Global structural analysis examines the behaviour of the entire structure under fire conditions, including load redistribution and potential progressive collapse. These advanced methods typically involve finite element analysis, detailed fire models to predict temperature development in compartments, heat transfer analysis to determine temperature distribution within structural elements, and structural analysis to assess load-bearing capacity and deformation throughout the fire duration.

This comprehensive approach allows for an accurate representation of a structure's behaviour under fire conditions, considering factors like thermal expansion and restraint, material degradation at elevated temperatures, and the interaction between different structural elements. However, such analyses demand specialised expertise and significant computational resources.

Most commonly used non-specialist structural analysis software has limited capability when considering large deformations. Specialist software is capable of carrying out this computational analysis, but is often highly bespoke. The user must understand the limitations of the analysis methodology, in terms of the input and constraints, and must also consider the complex and unpredictable interactions between structural and non-structural elements which may require a more intuitive and qualitative assessment.

Extensive sensitivity and statistical analysis is often necessary to determine the overall risk profile of the potential collapse mechanisms and the various consequences of collapse. This includes parameters in the 'structural domain'; e.g. pattern loading, connection stiffness, boundary conditions and non-linear material properties; and in the 'fire domain'; e.g. variable design fires and heat transfer, single-sided heating of an element, heating and cooling cycles. Sensitivity studies should include for potential future changes, e.g. if partitions are introduced on office floorplates, openings are introduced between floors as part of a fit out, or the building use changes etc.

The appropriate approach to compliance should be established through a qualitative design review (QDR) to BS 7974 "Application of fire safety engineering principles to the design of buildings" 2019 at stage 1 of the project for larger or more complex schemes.

5.0 Roles and responsibilities

The scope of the structural engineer, architect, fire engineer and structural fire engineer, where appointed, should be identified on all projects in relation to fire safety, at the start of the project and should be reviewed throughout. Whilst this paper does not aim to define project roles, typical roles based on standard industry guidance are set out below.

5.1 The architect's role

The role of the architect generally is defined in the RIBA Plan of Work⁴, which includes a Fire Safety Strategy component. The architect's role in relation to fire will generally be to:

General:

- Undertake site / existing building appraisals
- Prepare architectural concept incorporating strategic engineering requirements
- Agree route to Building Regulations compliance
- Spatially coordinate architectural and engineering information
- Review design against Building Regulations
- Prepare and coordinate design team building systems information
- Prepare and integrate specialist subcontractor buildings systems information
- Submit Building Regulations application
- Prepare Inspection Reports digital record
- Hand over building in line with Plan for Use Strategy

Contribution or advice on:

- Fire safety strategy
- Fire safety coordination
- Fire safety specification

5.2 The Principal Designer: (BSA)

The Building Safety Act 2022⁵⁾ amended the Building Regulations in England and Wales, adding requirements for a Principal Designer to be appointed to lead the compliance of design work with Building Regulations. The Principal Designer is a Designer appointed to be in control of all the design work, who will:

- Plan, manage and monitor the design work, ensuring that the design, if built, would comply with building regulations
- Ensure that designers; cooperate, communicate and coordinate their work with the Client, the Principal Contractor, and other designers
- Liaise with the Principal Contractor, and share information
- On HRB's, manage the Golden Thread during design

Because of the similarity of roles, the architect will also normally be the Principal Designer

5.3 Structural Engineer's scope:

The scope of the structural engineer in relation to the fire performance of the structure is dependent on the nature of the structure and whether:

- The fire resistance is inherent to the structure (masonry, concrete) or applied.
- The structure can add to the fire load (i.e. mass timber).
- Part of the structure is designed by a specialist sub-contractor.

Proposed minimum Duties are set out below. These are based on the IStructE Structural Plan of Work 2020⁶⁾, an extract of which is contained in Appendix B. A detailed scope, by RIBA Plan of Work stage is included in Appendix D.

Additional requirements for Higher-risk buildings (HRBs) are also noted. Appendix C contains an extract of UK SPEC-HRB fire related recommended competences for structural engineers ⁷⁾, from which the requirements related to HRBs have been defined.

The structural engineer's actual role should be agreed with the client and made aware to the Principal Designer to ensure that no scope gaps exist on a project by project basis.

General

- Clearly define Scope and Responsibility for all matters relating to structural fire resistance including contractor design portions (CDPs).
- Advise the Client on the need to appoint a competent fire engineer or structural fire engineer, due to the nature or complexity of the structure or its design. (This may be due to the proposed design extending beyond the limits of prescriptive structural fire design or the structural engineer's competence)
- Incorporate architect's/ fire engineer's structural fire resistance requirements into the structural design and ensure the design meets the prescribed structural fire rating.
- Define design standards for fire resistance, compartmentation and spread in the context of the structure
- Carry out appraisals of structures
- Establish the form of fire resistance for the structure
- Identify any key vulnerabilities of the structure in a fire, including consideration of progressive and disproportionate collapse
- Identify any key boundary conditions of the building and vulnerable interfaces / adjacencies
- Document structural fire performance requirements in design report and specifications
- Check FLS (Eurocode) load combinations and document the calculations accordingly.

Collaborate/ advise on:

- Identify where structural members are supporting / restraining compartment walls / fire separation, to define which members require fire resistance.
- Interface in developing critical fire system details (e.g. penetration fire stopping, smoke duct coordination, fire resisting construction-structure joints, fire protection of exposed elements).
- Advise on structural movements and tolerances.
- Highlight any potential construction stage fire issues in CDM documentation

Construction

- Review structural passive fire protection design submissions
- Specify requirements for and review contractor site inspections, surveys and tests
- Carry out site inspections to report on general progress and compliance of the structure
- Provide final construction drawings that incorporate changes into As Built Drawings
- Provide CDM & fire safety information.

For HRBs

- Provide Golden Thread information
- Input into structural section of Safety Case Report

A key consideration is design against disproportionate collapse in the event of a fire. For simple buildings and where prescriptive approaches to compliance are followed, this may not always be explicitly checked, with an implicit assumption that following requirements for compartmentation and fire resistance provide protection. However, it is recommended that the disproportionate collapse as a result of fire is considered. Where a structural fire engineer is appointed, this should still remain within the structural engineer's scope.

5.4 The fire engineer's Scope in relation to the structure

Where a fire engineer is appointed, their scope will be agreed between them and the client. The structural engineer should ensure that scopes are coordinated. The fire engineer's current typical scope in relation to the structure is summarised below, based on: "Fire Industry Association; Fire Engineer Scope of Works" ⁸⁾. extracts of which are contained in Appendix E.

Design

- Confirm the relevant fire safety design objectives.
- Define the required fire resistance, and clarify the basis of this decision, i.e. applicable regulations, guidance, approach
- Identify relevant fire legislation and any additional design requirements such as insurance or additional client requirements.
- For existing buildings, support the structural engineer in devising survey scope
- Carry out a compliance check and identify any aspects of the design where changes would be required, or fire engineering analyses are needed.
- Produce fire strategy report, outlining key fire safety principles and systems and circulate to the client and design team.
- Review the design documentation to ensure that it complies with the fire strategy.
- Consult with all relevant approving authorities: building control/approved inspector, fire brigade, insurer and stakeholders as appropriate.
- Where relevant, carry out detailed fire engineering analyses, document the results in a report and coordinate relevant requirements with other consultants.
- EITHER: Produce fire drawings and circulate to the client and the design team OR: Assist others in preparation of those fire drawings.

Construction

- As reasonably requested by the client, visit the construction site and report to the client on compliance of the works with the design and, on completion of the works, comment on whether the works comply with the approved Fire Strategy.
- As reasonably requested by the client, visit the construction site and report to the client on compliance of the works with the design and, on completion of the works, comment on whether the works comply with the approved Fire Strategy.
- Update fire strategy report in line with as-built design.
- EITHER: Update fire drawings in line with as-built design, OR:
- Assist in the update of fire drawings in line with as-built design.
- Provide CDM and fire safety information

In December 2025 the government published the “Fire Engineers Advisory Panel: Authoritative Statement”⁹⁾ (The Authoritative Statement), in response to one of the recommendations of the Grenfell Inquiry Phase 2 report. The Authoritative statement proposes the definition of a fire engineer and their restricted function; preparation of the Fire Strategy Report, for which recommendations on contents are also given. These recommendations are proposed to be adopted into law.

5.5 The structural fire engineer’s Scope in relation to the structure

The reviews carried out by the fire engineer (FE) and structural engineer (SE) described above may identify gaps in design competence between them in relation to the structural design where the structure, building or route to demonstrate compliance are complex. This may necessitate the appointment of a structural fire engineer (SFE) to carry out detailed analysis and design of the structure and/or the fire protection strategy under the fire limit state load case. Should this be the case, appointing the SFE as a subconsultant to the SE would ensure that the overall responsibility for the structural design resides with one party. Should the SFE be separately appointed the SE’s scope would need to be adjusted. Contractually this can normally only occur with the express consent of the client. The SFE’s scope may encompass advice on the entire structure or elements of it. The SFE’s scope of services will vary by project, but a basic scope is given below:

Design

- Review fire performance criteria, including fire performance above statutory requirements and requirements for performance of structure post-fire.
- Review/ Advise on the structural frame design/ assessment of existing structure to meet building regulation and client requirements
- Peer review of fire performance design of structure (also termed the fire protection strategy).
- Carry out design checks on elements of the structure for relevant fire cases
- Establish critical fire system details fire protection of exposed elements, potential difficult interfaces between protected member and surrounding elements such as insulation, cladding, brackets and MEP equipment.
- provide outline performance specification for contractor designed fire related elements

Construction

- Highlight any construction fire issues
- Review the design of specialist packages for incorporation into overall structural/fire design
- Review specialist structural/fire design items
- Statutory consultation with fire authorities (where required for structure)
- Carry out Site Inspections of fire protection.
- Input into Fire section of CDM file and fire safety information

For HRBs

- Input into Safety Case (HRBs)
- Into Golden Thread fire information (HRBs)

A detailed potential scope for SFE services, by RIBA Plan of Work stage, is included in Appendix D.

5.6 Interface with other parties

5.6.1 General

The responsibility for the performance of structural elements is typically split between several parties, from designers to specialist suppliers. The Grenfell Phase 2 Inquiry report highlighted a lack of understanding of parties' roles. It is therefore recommended that a responsibility matrix is developed to clarify these. The aim is to deliver a warranted fire protection system based on the details and performance requirements provided for all structural members, including connections. A template is provided in Appendix F. The Hackitt report also commented on the need to consider buildings as systems and to understand how disciplines interface. The UKSPEC-HRB competencies state that designers should be aware of the performance of the structure affects the fire safety systems and vice versa. Parties therefore need to collaborate in the design of the building for fire.

5.6.2 Interface with specialist contractors and manufacturers.

In splitting design responsibility, structural engineers should clearly identify:

- The design responsibility for contractor designed portions (CPDs).
- The responsibility for the performance of products, such as fire protection.
- The design responsibility for the structural design of secondary elements that could compromise fire safety such as escape corridor walls and ceilings.
- The responsibility of the structural engineer for assessing compliance of the above.

6.1 The complexity of the structural performance in fire

In determining the complexity of the structural performance in fire, and therefore the appropriate compliance approach and in turn the need for a structural fire engineer, the performance of the structure in fire relation to code assumptions needs to be understood. The performance of structural elements and systems in fire is evaluated by considering three components:

- I. Characterising the fire.
- II. Heat transfer from the fire into structural members; and
- III. Response of the structural members to the heating, in terms of changes in shape, loss of material (i.e. spalling of concrete or combustion of timber) and loss of strength and stiffness

The four main assumptions underlying Codes are:

- 1) A cellulosic fire,
- 2) Compartment characteristics within certain bounds,
- 3) Conventional steel and concrete construction; and
- 4) Building response characterised by single-element response

Structural engineers therefore need to seek expert advice when:

- Fire hazards due to use are complex, (e.g storage of flammable materials).
- The structural form results in unusual compartmentation strategy (e.g modular construction).
- Non-conventional materials or section shapes are utilised (e.g exposed mass timber);
- Highly rigid structures, or structures relying on global-frame load paths are adopted (e.g modular construction)

Examples of complexity parameters are summarised in the swim-lane diagram below. Other parameters or design conditions may also arise, and their impact should be assessed against the above assumptions.

Recommendations for when a fire engineer is appointed on a timber building are given by the Structural Timber Association in "STA Advice Note 7 Robustness against fire, Part 3 - Fire Safety Strategy (FSS) for structural timber buildings ⁹⁾.

Parameters	Single use office	Atrium building	Multi-use industrial	Bridge
Use	Single use office	Atrium building	Multi-use industrial	Bridge
Design fire	Standard Fire	Parametric Fire	Hydrocarbon fire	EUREKA RWS
Enclosure geometry/size	Rectangular <50m ²		Irregular/multi-storey and/or >1000m ²	Hospital/care home
Occupancy	Awake/familiar	Public spaces		
External wall	Concrete Masonry	Unitised	Rainscreen	Combustible
Power systems	Multi-substation	electric Generator	Combined heat/power	Battery storage
Age	New build	Existing		Historic
Material/Form	Steel Concrete Masonry	Light timber	Composite	Mass timber Modular
Design basis	Eurocode tables	Eurocode equations		First principles SFE
Floor geometry	Rectilinear regular		Irregular	
Stability structure	Columns	Transfer structure	Inclined vertical elements	Mega frames
Restraint	Single core	Multi-core		
Failure consequence	Local/single member failure	Multi-member failure		Global collapse

Less conventional



More conventional

Figure 4: When structural engineers should seek fire safety specialist advice

6.2 The compliance approach

The Hackitt Report and Grenfell Tower Inquiry Phase 2 report both questioned the inappropriate adoption of statutory guidance in the Approved Documents to demonstrate the *functional* compliance with Building Regulations. Both the veracity of the Approved Documents and the judgment of designers in selecting their use have come under scrutiny. In particular, the ability of prescriptive approaches to keep pace with technological developments, such as MMC, has been challenged. In response the Approved Documents, particularly in reaction to fire, are under review. Additionally, the Building Safety Regulator, that oversees Building Control functions in England and Wales, has stipulated that a risk-based approach to Building Regulation compliance be adopted, where designers assure themselves of the applicability of statutory and non-statutory guidance. Advice on applicability of Approved Documents is given in section 3.0. This implies a need for all designers to understand the basis of statutory guidance and the boundaries of its applicability. Complex methods of demonstration may be required, as described above, due to complexity of the structural design in fire, or due to common structure's characteristics being outside of the scope of applicability of statutory guidance. Where more complex methods of justification are required, a fire engineer and possibly a structural fire engineer may be required.

6.3 The competency test

The need to employ a fire engineer to assist in the design of the structure will be determined by:

- i) The complexity of the structural performance in fire;
- ii) The compliance approach; and
- iii) The competency of the structural engineer relevant to the structural design for fire.

Designers should not work outside of their area of competence. This has long been a provision of the Institution's Code of Conduct, is typically a contractual requirement, and is now enshrined in the secondary legislation paved by the Building Safety Act 2022, SI 911 2023 ⁵⁾:

“11F.—(1) Any person carrying out any building work or any design work must have—

- a) where the person is an individual, the skills, knowledge, experience and behaviours necessary,*
- b) where the person is not an individual, the organisational capability,*
to carry out—
 - i) the building work in accordance with all relevant requirements;*
 - ii) the design work so that the building work to which the design relates, if built, would be in accordance with all relevant requirements.*

There is no general statutory guidance on the necessary competence level; however, standards for designers of non-HRB's are described in the Core Objectives of the Institution of Structural Engineers. Following the Grenfell Tower fire and passing of the Building Safety Act 2022, additional competences are required for those working on Higher-risk buildings (HRBs). Recommendations are given in the Engineering Council's UK-SPEC HRB Structural Annex ⁷⁾, extracts of which are included in Appendix C. The Authoritative Statement ⁹⁾ also recommends competences for fire engineers for adoption by government.

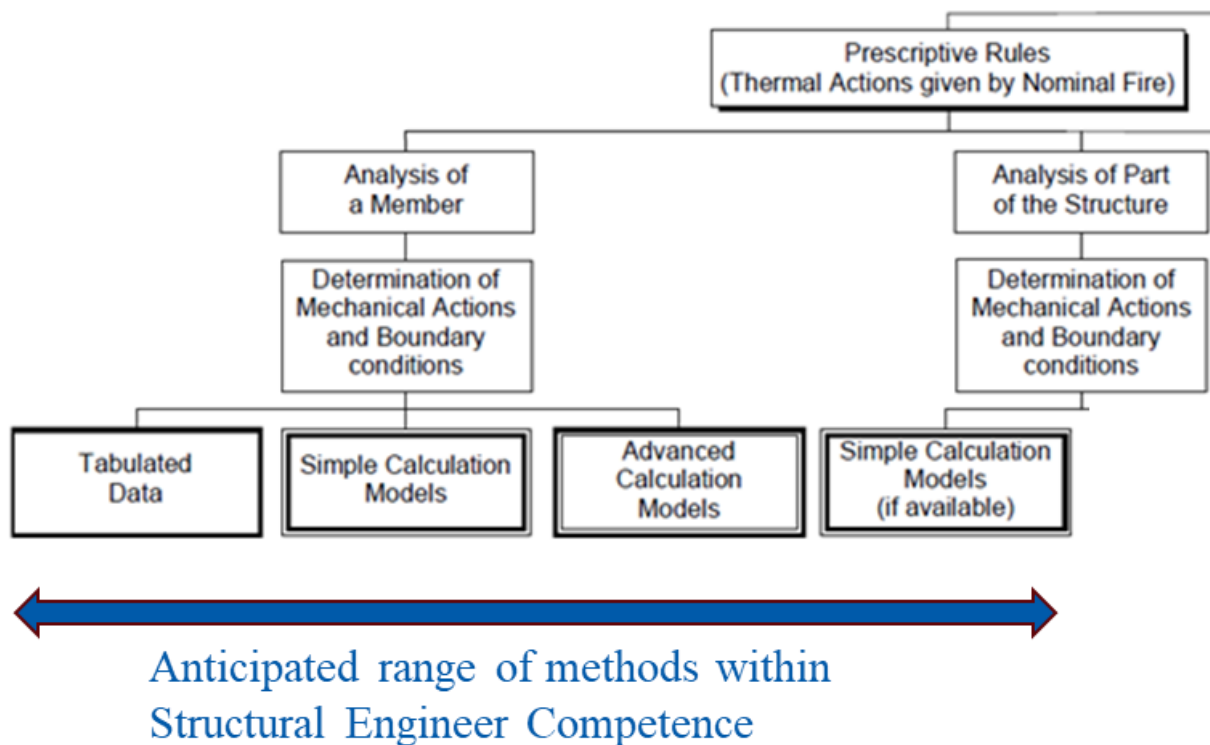


Figure 4: Anticipated range of methods within structural engineer competence (Excerpt from Figure 2)

It is envisaged that typical structural engineer's competence would cover the application of prescriptive rules, from the use of tabulated data to assessment via simple calculation models of part of the structure.

For those working on HRBs, the competence of the structural engineer may extend to assessment via whole building models. Refer UK SPEC-HRB Structural Discipline Annexe, ⁷⁾, extracts of which are contained in Appendix C.

As noted above, where the compliance approach for the structure is not within the structural engineer's competence a "structural fire engineer" may also be required to assist in the design of the structure in the fire load case.

This section has addressed the competencies required for structural engineers and fire engineers, as well as the importance of involving a structural fire engineer in complex projects. This discussion is also relevant for Building Control Officers, who must review these solutions. It is essential for them to possess the necessary expertise to understand and evaluate the proposed approaches. If they lack this competency, the review should be conducted by a qualified structural fire engineer. Any failure of the approving authority in assessing compliance with Building Regulations does not absolve the structural engineer from ensuring that their design complies with all relevant parts of the Building Regulations.

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BSI Acknowledgement (for Figures 2 and 4)

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Appendix A: Overview of the Regulatory Framework

The primary objective of the design of the structure for fire is protection of life safety through functional compliance with the Building Regulations. We note that post the Grenfell Tower Inquiry Phase 2 report, Building Regulations may change in response to its recommendations.

A.1 The Building Act and Building Regulations

The Building Act 1984 is primary legislation that enables the appropriate national authority the ability to make regulations (secondary legislation) in support of: (a) the design and construction of buildings; (b) the demolition of buildings; and (c) services, fittings and equipment provided in or in connection with buildings. The Building Regulations are secondary legislation enacted under the Building Act.

These Building Regulations serve several purposes but of most relevance to this topic is “*securing the health, safety, welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings*”, as stated in the Building Act.

For the most part, the Building Regulations are set out functional requirements and contain a series of outcomes that must be achieved. In relation to structural engineering, these are Regulations A1(1), A1(2), A2 and A3 in Schedule 1. For the purposes of demonstrating the format of a performance-based regulation, Regulation A3 is reproduced verbatim below:

“A3. The building shall be constructed so that in the event of an accident the building will not suffer collapse to an extent disproportionate to the cause.”

With respect to fire safety, the relevant Regulations are B1, B2(1), B2(2), B3(1), B3(2), B3(3), B3(4), B4(1), B4(2), B5(1) and B5(2) of Schedule 1. Regulation B3(1) is produced verbatim below due to its relevance to the topic:

“B3. (1) The building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period.”

Alongside performance-based regulations, post-Grenfell amendments have introduced prescriptive elements that principally relate to the external wall zone. These are set out in Regulation 7 – materials and workmanship, specifically, 7(1), 7(1A), 7(2), 7(3) and 7(4).

A.2 Approved Documents

The Building Act 1984 not only enables the appropriate national authority the ability to make Building Regulations, but they also may issue and approve documents for the purpose of providing practical guidance with respect to satisfying the requirements of the Building Regulations.

Documents prepared by the appropriate national authority are known as Approved Documents (ADs), with ADA providing practical guidance relating to structural engineering and ADB on matters of fire safety. Whilst following an AD is not mandatory, were civil or criminal proceedings to materialise, the Building Act notes that: (a) “*a failure to comply with a relevant Approved Document may be relied upon as tending to establish liability*”, whilst (b) “*proof of compliance with such a document may be relied on as tending to negative liability*”.

The ADs, whilst intended to provide practical guidance for the purpose of Building Regulations compliance, are not a panacea and their scope is limited by their introduction as purporting to address “*common building situations*”.

The ADs do not define what constitutes a common building situation, but they do provide a warning that “*they may not provide appropriate guidance if the case is unusual in terms of its design, setting, use, scale or technology*”. The introduction goes on to cite some examples that might be uncommon building situations, which include:

- (i) difficult ground conditions,
- (ii) buildings with unusual occupancies or high levels of complexity,
- (iii) very large or very tall buildings,
- (iv) large timber buildings and
- (v) some buildings that incorporate modern construction methods.

In the case of fire safety matters, ADB identifies that should uncommon building situations arise, fire safety engineering may be the only practical way to achieve a satisfactory standard of fire safety in some complex buildings and in buildings that contain different uses.

This statement in relation to the scope of ADB has an important implication. That is, given ADB’s scope, designers will only tend towards negative liability when applying the documents to the intended common building situations. Consequently, the designer will tend to establish liability when faced with an uncommon building situation, regardless of whether the ADs are followed or some other route to compliance, i.e. fire safety engineering, is adopted.

A.3 Other guidance documents and codes of practice

Alongside formal Approved Documents enabled by the Building Act, other guidance documents are issued by Government departments for specific cases, for example Hospitals in the form of HTM-05-02 and BB100 for schools. Codes of practice are also published by the British Standards Institution (BSI), for example, BS 9991 and BS 9999.

Whilst such documents are not facilitated by the Building Act and, thus, positions on circumstances under which a designer may either establish liability or tend towards negative liability cannot be expressed, all note caution on limits of applicability. That is, there is no panacea when it comes to fire safety guidance as a means of supporting compliance with the Building Regulations and there will always be cases where reliance on such guidance may be insufficient to evidence compliance.

For example, in the case of BS 9999, the code of practice draws attention to “*tall and very tall buildings*”, with it noted that there can be increased demands on elements of a fire strategy arising from height and that a qualitative design review (QDR) can be necessary to: “*determine whether the recommendations in BS 9999 are appropriate, or whether a full fire engineered solution is required*”.

Factors that may render a building situation uncommon and/or where reliance on guidance might be inappropriate and this is considered in the next section.

A.4 Requirements Relating to Higher-risk buildings (HRBs)

Under the Building Safety Act 2022 additional statutory requirements apply to Higher-risk buildings (HRBs), that is residential buildings, care homes or hospitals of at least 18m height or 7 storeys and containing at least 2 residential units (both new and existing). A safety case must be prepared for such residential buildings and this should consider the fire (and structural) safety based on ALARP principles. A risk assessment is required, and provisions may go beyond statutory Building Regulation compliance.

Appendix B: Structural Plan of Work Overlay

	0 Strategic Definition	1 Preparation and Brief	2 Concept Design ¹	3 Spatial Coordination ¹	4 Technical Design ¹	4.5 Production Information	5 Manufacturing and Construction ¹	6 Handover ¹	7 Use ¹	
	Briefing			Design			Delivery		Evaluation	
Overview²	Client's key requirements defined	Project health confirmed and initial Project Brief defined. Revised information provided to clients to enable project to progress	Architectural and engineering concept information prepared and developed to meet the Project Brief	Architectural and engineering information available. Coordinated between discipline teams and coordinated to the Project Brief, Cost Plan and Project Strategy	Architectural and engineering technical design fully coordinated and completed to satisfy the project	Engineering information including specialist sub-contractor technical information, assembly and construction to be provided	Manufacturing, assembly and construction completed	Project handed over. Client notified and initial As-Built completed	Finalise and assess performance. Final Occupancy Evaluation of Building performance is undertaken	
Continuity Assessment	Contributes to preparation of Client Requirements	Contributes to preparation of Project Brief	Contributes to the Brief information	Contributes to the Brief information	Contributes to the Brief information	Contributes to the Brief information	Contributes to the Brief information	Contributes to the Brief information	Contributes to the Brief information	
Design	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints	Identify structural constraints Identify structural constraints Identify structural constraints Identify structural constraints
Interface	Contributes to the development of the Responsibility Matrix	Contributes to the development of the Responsibility Matrix	Contributes to the development of the Responsibility Matrix	Contributes to the development of the Responsibility Matrix	Contributes to the development of the Responsibility Matrix	Contributes to the development of the Responsibility Matrix	Contributes to the development of the Responsibility Matrix	Contributes to the development of the Responsibility Matrix	Contributes to the development of the Responsibility Matrix	
Construction	Identify adjoining 'involvement' issues	Identify adjoining 'involvement' issues	Identify adjoining 'involvement' issues	Identify adjoining 'involvement' issues	Identify adjoining 'involvement' issues	Identify adjoining 'involvement' issues	Identify adjoining 'involvement' issues	Identify adjoining 'involvement' issues	Identify adjoining 'involvement' issues	
Management	Provide information for and contribute to Project Execution Plan as required	Provide information for and contribute to Project Execution Plan as required	Provide information for and contribute to Project Execution Plan as required	Provide information for and contribute to Project Execution Plan as required	Provide information for and contribute to Project Execution Plan as required	Provide information for and contribute to Project Execution Plan as required	Provide information for and contribute to Project Execution Plan as required	Provide information for and contribute to Project Execution Plan as required	Provide information for and contribute to Project Execution Plan as required	
Sustainability	Support the strategic definition of the project Identify potential Climate Change impact on the project Identify potential Climate Change impact on the project	Support the client in developing a brief Contribute positively towards mitigating Climate Change Identify potential Climate Change impact on the project	Evaluate options to lower the embodied carbon in the building Agree embodied-carbon trading terms and targets Consider design for deconstruction and reuse	Agree with the establishment of a method of embodied carbon calculation across the whole design team This embodied carbon in structural components is agreed and agreed targets agreed at Stage 2	Develop and contribute to 1+0-006 for risk mitigation Agree with the implementation of Change Control Procedures Agree with the implementation of Change Control Procedures	Develop and contribute to 1+0-006 for risk mitigation Agree with the implementation of Change Control Procedures Agree with the implementation of Change Control Procedures	Develop and contribute to 1+0-006 for risk mitigation Agree with the implementation of Change Control Procedures Agree with the implementation of Change Control Procedures	Develop and contribute to 1+0-006 for risk mitigation Agree with the implementation of Change Control Procedures Agree with the implementation of Change Control Procedures	Develop and contribute to 1+0-006 for risk mitigation Agree with the implementation of Change Control Procedures Agree with the implementation of Change Control Procedures	Develop and contribute to 1+0-006 for risk mitigation Agree with the implementation of Change Control Procedures Agree with the implementation of Change Control Procedures
Statutory Requirements³	CDM requirements including appointment of Principal Designer	CDM requirements including appointment of Principal Designer	CDM requirements including appointment of Principal Designer	CDM requirements including appointment of Principal Designer	CDM requirements including appointment of Principal Designer	CDM requirements including appointment of Principal Designer	CDM requirements including appointment of Principal Designer	CDM requirements including appointment of Principal Designer	CDM requirements including appointment of Principal Designer	
Stage Outputs	Deliverables at end of stage	Deliverables at end of stage	Deliverables at end of stage	Deliverables at end of stage	Deliverables at end of stage	Deliverables at end of stage	Deliverables at end of stage	Deliverables at end of stage	Deliverables at end of stage	
Information Exchanges	Propose Exchange Information Requirements (ER)	Propose Exchange Information Requirements (ER)	Propose Exchange Information Requirements (ER)	Propose Exchange Information Requirements (ER)	Propose Exchange Information Requirements (ER)	Propose Exchange Information Requirements (ER)	Propose Exchange Information Requirements (ER)	Propose Exchange Information Requirements (ER)	Propose Exchange Information Requirements (ER)	
Collaboration Requirements	Initial review of key structural engineering information including structural analysis of project	Initial review of key structural engineering information including structural analysis of project	Initial review of key structural engineering information including structural analysis of project	Initial review of key structural engineering information including structural analysis of project	Initial review of key structural engineering information including structural analysis of project	Initial review of key structural engineering information including structural analysis of project	Initial review of key structural engineering information including structural analysis of project	Initial review of key structural engineering information including structural analysis of project	Initial review of key structural engineering information including structural analysis of project	
Design Assurance	Review of manufacturing and construction specifications	Review of manufacturing and construction specifications	Review of manufacturing and construction specifications	Review of manufacturing and construction specifications	Review of manufacturing and construction specifications	Review of manufacturing and construction specifications	Review of manufacturing and construction specifications	Review of manufacturing and construction specifications	Review of manufacturing and construction specifications	

Appendix C: UK SPEC HRB Extracts

Structural Discipline Annex; HRB specific criteria

AA. Knowledge and understanding

- Identify the root causes of hazards which might significantly affect the structural or fire safety of the building.
- Evaluate the consequential risks which might significantly affect the structural or fire safety of the building, should the hazards materialise.
- Identify the barriers in place that reduce or prevent hazards affecting the structural or fire safety of the building from materialising, or limit their consequences should they do so, and demonstrate an ability to evaluate the effectiveness of those barriers.
- Identify the basic characteristics of a structural material or form of construction and its behaviour under major accident fire and structural safety hazards.
- Assess the impact of major accident fire and structural safety hazards on the performance of the structure, recognising that the necessary action may require mitigation beyond that set out in codes of practice.
- Understand of the difference between performance-based (“engineering,” or first principles) approaches and compliance-based approaches in demonstrating design against structural (including disproportionate) collapse and against fire-related hazards.
- Select an appropriate design solution that addresses the identified major accident fire and structural safety hazards in a manner consistent with ALARP principles.
- Understand the expected change in the behaviour of the structure if a structural or fire-related action were to be larger than anticipated, or the strength or stiffness were to be lower than anticipated or were to undergo a larger-than-expected change following an event.
- Understand the different means of protecting the structure against fire, their relationship to applicable regulations and contemporary practice.
- Understand the information needs to be passed to other designers, the Principal Contractor, CDM Principal Designer, Principal Designer, and the client regarding their design, maintenance, inspection and repair and decommissioning implications.
- Understand the difference between direct protection of structural elements against fire and the fire engineering design of the structural frame, and the effect on the behaviour of the structure under fire conditions.
- Understand the ways in which the structural design may affect the fire safety of the building, and how the fire engineering design might impact on the structural safety of the building.

BB. Design, development and solving engineering problems

- Ensure the application of the design is inclusive of all products, components and systems to implement the fire safety strategy and safety in design, construction and operation for the building.
- Identify the constraints of the building, develop and implement fire safety design solutions that consider safety and wellbeing of occupants, sustainability, resilience and future proof in operation, decommissioning and disposal.

Appendix D: Detailed Scope of the structural engineer and structural fire engineer

The scope of the structural engineer, fire engineer and structural fire engineer, where appointed, should be identified on all projects. The structural engineer's typical scope should cover the following. Additional requirements for Higher-risk buildings (HRBs) are also noted. Appendix C contains an extract of UK SPEC-HRB fire related recommended competences for structural engineers ⁷⁾, from which the requirements related to HRBs have been defined: Where a structural fire engineer (SFE) is appointed, duties marked * may be carried out by the SFE.

D1.0 Structural Engineer's scope:

Stage 1: Preparation & Brief

- **Design:** Identify client's fire performance criteria, including fire performance above statutory requirements and requirements for performance of structure post-fire.
- **Interface:**
 - Advise on the need for the appointment of a fire engineer or structural fire engineer due to structural characteristics.
 - Establish any boundary issues affecting structural design (prevention of collapse over boundary).
- **Management:** include structure/ fire issues in risk register.
- **Statutory requirements:**
 - Identify statutory fire related requirements for structure.
 - Establish BSA fire related compliance requirements.
- **Stage outputs:** Definition of fire related structural performance requirements.
- **Information exchanges:** appointment fire design scope agreed, with fire engineer, architect, Principal Designer, client.
- **Design Assurance:** Review of whether minimum statutory fire resistance periods should be exceeded to protect property. (e.g car parks).

Stage 2: Concept

- **Design:**
 - Integrate fire considerations into concept studies.
 - Identify key vulnerabilities and work within the design team to address these.
 - Define fire design standards; resistance, compartmentation, spread*.
 - Select the structural frame to meet building regulation and client requirements.
 - Develop options for the appropriate method of fire protection of the structure*.
 - Assess the feasibility of the structure to meet compartmentation requirements, where required to do so*.
- **Interface:** Agree fire design responsibilities in Responsibility Matrix, including specialist design items.
- **Construction:** Identify contractor responsibility for fire performance of structural items (design, product supply, detailing).
- **Statutory requirements::**
 - Review and agree structural aspects of fire strategy.
 - Agree method of demonstrating compliance of structure with fire requirements*.
- **Stage outputs:** Report on means of achieving fire performance of structure*.
- **Information exchanges:**
 - In: review Fire Strategy Report.
 - Out; Structural zones, including protective finishes.

- **Collaboration requirements:** Agree; compartmentation requirements for structure, where finishes provide fire protection, minimum structural thickness requirements for fire performance.
- **Design Assurance:** Review if structure contributes to fire load or poses additional risk; i.e untried technology or is a known risk to stakeholders.

Stage 3: Developed Design

- **Design:**
 - Establish form of fire resistance*.
 - Check structural compartmentation*.
 - Check Minimum structural thickness requirements for fire*.
 - Design checks on elements in fire limit state (FLS) case³.
- **Interface:** Establish critical fire system details (e.g. penetration fire stopping, smoke duct coordination, fire resisting construction-structure joints, fire protection of exposed elements). *
- **Construction:**
 - Prepare outline performance specification for contractor designed elements related to fire*..
 - Highlight any construction stage fire issues*.
- **Management:** Prepare Risk Matrix section describing protection of structure from fire in use and during construction*.
- **Statutory requirements:** Initial discussions with Building Regulation Advisor/ Principal Designer.
- **Stage outputs:** Fire design section of Structural RIBA Stage 3 Design report*.
- **Information exchanges:** Review interaction of structure with fire systems..
- **Collaboration requirements:**
 - Method of fire protecting penetrations through structure*
 - Impact of structural performance on fire systems*
- **Design Assurance:** Advice on compliance of fire design principles and approach with Building Regulations advisor.

Stage 4: Technical Design

- **Design:**
 - Define utilisation at the FLS to allow the limiting temperatures to be defined, (whether by the SE or by others)
 - Fire design of structure completed
 - Specification of the fire performance of structural products such as balcony thermal breaks*.
 - Design of specialist packages incorporated into overall fire design
 - Review specialist design items*
- **Interface:** Liaison with specialist contractors.
- **Construction:** Performance and detailed specification for fire items*.
- **Management:** Risk Matrix updated to include contractor design items.
- **Statutory requirements:** Submission of Building Regulation application for Part B compliance*.
- **Stage outputs:** "Construction" information.
 - Fire protection drawings
 - Performance and detailed specification for contractor design items
 - Fire section of RIBA Stage 4 design report*
 - Structure-Fire information of Golden Thread (HRBs)
- **Information exchanges:** structural model.
- **Collaboration requirements:**
 - Detailed coordination of specialist proposals
 - Advice on the approximate deflection of the structure in serviceability and standard fire situations*

³ Design of a structure to BS EN 1990:2002 to fulfil the required performance in case of fire

- **Design Assurance;**
 - Statutory consultation fire authorities*
 - Fire Testing of structural elements where appropriate*

Stage 4.5: Production Information

- Design:-
- Interface: Review of specialist contractor's submissions *
- Construction: -
- Management: -
- Statutory requirements; -
 - Building Control approval of fire design
 - Submission of compliance evidence for Building Control Approval
- Stage outputs: -
- Information exchanges: -
- Collaboration requirements: -
- Design Assurance; submission of contractor's QA & Inspection plan

Stage 5: Construction

- Design: -Compile "As built" information
- Interface: - Review of contractor site inspections, surveys and tests
- Construction: Site inspections
- Management: -
- Statutory requirements; Building Control approval of installation of fire related issues
- Stage outputs:
 - "As built" drawings
 - Structure-Fire information of Golden Thread (HRBs)
- Information exchanges: Fire protection inspection records
- Collaboration requirements: Site "As built" information
- Design Assurance: Site Inspections of fire protection

Stage 6: Handover & Closeout

- Design: -
- Interface: Facilities Management team - to understand fire performance
- Construction:-
- Management: Assembly structural- fire section of CDM (O&M) manual
- Statutory requirements. Handover structure/ fire section of CDM file
- Stage outputs:
 - fire section of CDM file
 - Fire-structure section of Residual Risk Assessment
 - Structure-Fire information of Golden Thread (HRBs)
- Information exchanges:
- CDM file.
- Fire safety information ⁴.
- Collaboration requirements.
- Design Assurance:
 - Fire section of CDM file
 - Safety case (HRBs)

⁴ As required by Regulation 38 of the Building Regulations 2010 ⁹⁾ "fire safety information" means information relating to the design and construction which will assist the responsible person to operate and maintain the building with reasonable safety.

- Golden Thread fire information (HRBs)

D2.0 The structural fire engineer's Scope in relation to the structure

The reviews carried out by the fire engineer (FE) and structural engineer (SE) may necessitate a structural fire engineer (SFE) being employed to carry out detailed analysis and design of the structure for the fire load case. Should this be the case it is recommended that the SFE is a subconsultant to the SE to ensure that the overall responsibility for the structural design resides with one party. Should the SFE be separately appointed the SE's scope would need to be adjusted. Contractually this can normally only occur with the express consent of the client. The SFE's scope may encompass advice on the entire structure or elements of it. The SFE's scope of services will vary by project, but a range of common scope items is given below:

Stage 1: Preparation & Brief

- Design: Review client's fire performance criteria, including fire performance above statutory requirements and requirements for performance of structure post-fire.
- Stage outputs: structural fire engineer's scope.
- Information exchanges: Agree appointment scope with fire engineer, architect, Principal Designer and client.
- Collaboration requirements: Agree split of responsibilities with structural engineer & fire engineer.
- Design Assurance: Include fire issues in Risk Matrix.

Stage 2: Concept

- Design:
 - Supporting the SE in the definition of any survey specifications
 - Review fire design standards; structural fire resistance, compartmentation, spread of flame
 - Advise on fire load case scenarios
 - Review/ Advise on the structural frame design to meet building regulation and client requirements
 - Review the selection of the appropriate method of fire protection of the structure
 - Review the assessment of the ability of the structure to meet compartmentation requirements, where required to do so.
- Interface: Agree fire responsibilities in Responsibility Matrix, including specialist design.
- Construction: Identify contractor responsibility for fire performance.
- Management: -
- Statutory requirements;
 - Review structural aspects of fire strategy
 - Determine method of demonstrating compliance of structure with fire requirements
- Stage outputs: Peer review of fire performance design of structure.
- Information exchanges:
 - In: Fire strategy, structural information
 - Out: Peer review
- Collaboration requirements: Selection of structural frame solution, fire requirements and method of demonstrating compliance.
- Design Assurance: Confirmation that fire characteristics of the structure can meet statutory and third party requirements.

Stage 3: Developed Design

- Design:
 - Review and advise on form of fire resistance

- Review adequacy of structural compartmentation
 - Review minimum structural thickness requirements
 - Carry out design checks on elements or the structure for relevant fire cases
- Interface: Establish critical fire system details (e.g penetration fire stopping, smoke duct coordination, fire resisting construction-structure joints, fire protection of exposed elements)
- Construction;
 - provide outline performance specification for contractor designed fire related elements
 - Highlight any construction fire issues
- Management: Prepare section of Risk Matrix describing protection of structure from fire in use and during construction.
- Statutory requirements; Agree method of demonstrating compliance.
- Stage outputs: Fire design section of structural RIBA Stage 3 report.
- Information exchanges:
 - In: structural model
 - Out: Fire load case analysis and design
- Collaboration requirements:
 - Incorporation of structural fire design into overall structural design
 - Method of fire protecting penetrations through structure
 - Impact of structural performance on fire systems
- Design Assurance:
 - Review of overall structural performance in fire
 - Assessment of whether structure contributes to the propagation of fire and development of mitigation strategies

Stage 4: Technical Design

- Design:
 - Review the design of specialist packages for incorporation into overall structural/fire design
 - Review the specification of the fire performance of structural products such as balcony thermal breaks.
 - Support the SE on specifying and undertaking physical testing of structural fire re-protection arrangements
 - Review specialist structural/fire design items
- Interface: Liaison with specialist contractors and structural engineer.
- Construction; Input into performance and detailed specification for structural/fire items.
- Management: -Update Structural/ Fire section of Risk Matrix.
- Statutory requirements;
 - Structure/fire Input into structural Building Regulation submission
 - Structure/fire Input into safety case & Risk Assessment (HRBs)
- Stage outputs: "Construction" information.
 - Analysis and design report of structure in fire condition
 - Performance and detailed specification
 - Fire section of Structural RIBA Stage 4 design report
- Information exchanges:
 - In: Structural Model
 - Out: Analysis and design report of structure in fire condition
- Collaboration requirements:
 - Detailed coordination of structural/fire details with structural design
 - Detailed coordination of specialist proposals
 - Advice on the approximate deflection of the structure in serviceability and standard fire situations
- Design Assurance;

- Statutory consultation with fire authorities (where required for structure)
- Fire Testing Report to demonstrate statutory compliance (where required in relation to structure)

Stage 4.5 Production Information

- Design: -
- Interface: Review of specialist contractor's structure/fire submissions
- Construction: -
- Management: -
- Statutory requirements;
 - Building Control approval of fire design
 - Submission of compliance evidence for Building Control Approval
- Stage outputs:
- Information exchanges:
- Collaboration requirements:
- Design Assurance; Contractor's QA & Inspection plan approved.

Stage 5: Construction

- Design: -
- Interface: - Review of contractor site inspections, surveys and tests
- Construction: Site inspections
- Management: -
- Statutory requirements; Building Control approval of installation of fire related issues
- Stage outputs:
 - Review of "As built" drawings
 - Review Structure-Fire information of Golden Thread (HRBs)
- Information exchanges: Fire protection inspection records
- Collaboration requirements: -
- Design Assurance: Site Inspections of fire protection.

Stage 6: Handover & Closeout

- Design: -
- Interface: -
- Construction:-
- Management: Review Assembly structural- fire section of CDM (O&M) manual
- Statutory requirements.
 - Review structure/ fire section of CDM file
 - Review Fire safety information
- Stage outputs: -
- Information exchanges: -
- Collaboration requirements: -
- Design Assurance:
 - Fire section of CDM file
 - Safety case (HRBs)
 - Golden Thread fire information (HRBs)

Appendix E: Fire Industry Association; Fire Engineer Scope of Works Extracts ⁸⁾

The fire engineer's overall role will be to provide advice in relation to the fire safety aspects of the design in order to provide reasonable confidence that the design that is developed, as well as the completed building, should achieve an acceptable standard of fire safety, comply with the client's objectives and meet all relevant legal fire safety requirements.

The fire engineer should co-ordinate with the design team to ensure that the other members of the team are aware of any fire safety design issues relevant to their responsibilities within the project.

The primary aspects of responsibility for the fire engineer are as follows.

- Identify the fire safety design objectives for the project such as, but not limited to, identification of relevant statutory controls, confirmation of any client fire safety requirements, confirmation of any insurance requirements.
- Work with the design team to develop the design to meet the fire safety design objectives.
- Document the fire safety design in a fire strategy report.
- EITHER: Produce relevant fire drawings OR: Assist the design team in producing relevant fire drawings.
- Review design documentation produced by others within the design team such as architectural design, M&E designs and tender documentation, to ensure that it complies with the objectives of the fire strategy.

The fire strategy should cover all relevant fire safety design issues, in particular:

- Design, location and protection of escape routes.
- Identification and specification of all fire safety systems that are required.
- Surface spread of flame requirements for surface materials.
- Structural fire resistance requirements.
- Fire compartmentation requirements including fire-stopping and cavity barriers.
- External fire spread.
- Access and facilities for fire services.

The detailed design of the fire safety systems and precautions that are identified in the fire strategy should then be carried out by others in the design team, eg escape routes designed by the architect, fire alarm systems designed by the M&E engineer.

Throughout the design, the fire engineer should identify any detailed fire engineering analyses that are required. At an appropriate stage of the design, the fire engineer should:

- Discuss the analyses with the relevant approving parties, eg client, building control/approved inspector, fire brigade, insurers and agree the acceptance criteria of the analyses.
- Ensure that the analyses is carried out in accordance with the relevant acceptance criteria.
- When the analysis is complete, circulate the conclusions and document the results in a report which should be submitted to the relevant approving authorities.
- Co-ordinate with approving authorities to seek acceptance or, should changes be required, ensure that those changes are carried out and re-submit as appropriate.

In relation to fire compartmentation, including fire stopping and cavity barriers, the fire engineer should specify the fire compartmentation requirements and ensure that those are detailed in relevant fire compartmentation drawings.

Appendix F: Structural Fire Performance Responsibility Matrix

It is recommended that a responsibility matrix is developed on each project. A sample is shown below.

Party/ Task	Structural Engineer	Client	Architect/ PD	Fire Engineer	Structural Fire Engineer	Specialist Contractor
Define the required fire resistance and clarify the basis of this decision	I		I ⁴⁾	R ⁴⁾	I	I
Additional fire performance requirements (above statutory)		R				
Advise on uses giving rise to extraordinary fire loading		R		I		
QDR	I		R	I	I	
Structural Fire Engineer Scope	R		I	I	I	
Fire Strategy	I		I	R	I	
Fire Protection drawings			R	I	I	
Requirements for structural fire protection	R			I	I	
Method of demonstrating compliance of structure with Part B of the building regulations	I		I	I	R*	
Overall Design of Structure	R				I	
Fire load case analysis and design	I			I	R*	
Advise on structural movements in fire	I		I	I	R*	
Lead discussions with Building Control and third parties	I		I	R		
Performance specification for specialist design items and products	R				I	
Design of specialist items and products	I				I	R
Inspection of structural/ fire items	I		I	I	I	R
General Inspection of structural/ fire items	R		I	I	I	
As Built information	I					R
CDM File	R		I	I	I	I
Safety case; general	R				I	
Specialist fire analysis	I			I	R	

Notes

- 1) The above relates to structural/fire items
- 2) * Where appointed, otherwise the responsibility of the structural engineer
- 3) Abbreviations:
 - a. R: Responsible
 - b. I: Interface
- 4) By architect where no fire engineer appointed