STA | STRUCTURAL TIMBER ASSOCIATION

Structural timber buildings fire safety in use guidance

Volume 6 - Mass timber structures; Building Regulation compliance B3(1)

STA fire safety research and guidance project | Version 2.1 | May 2023

Publication context

This guidance provides clarification of the routes for structural fire design compliance, applicable to mass timber buildings. It is intended for use by design professionals; to support competent fire safety strategy decisions, specifically relating to the structural stability of a building in the event of a fire within an enclosure. The content only focuses on English Building Regulation B3(1) "Internal fire spread - structure", with other Building Regulation requirements to be considered separately.

Who should read this?

Principal designers, architects, engineers, project design co-ordinators, fire engineers, building control bodies and the fire and rescue service. This guidance is for use by competent persons from the construction industry, who understand the sector they work in and have relevant experience.

Acknowledgements

This guidance has been drafted through members of the STA special interest group (SIG) on fire behaviour of mass timber. The STA would like to acknowledge the contributions of: Dr. Danny Hopkin (OFR), Dr. Michael Spearpoint (OFR), Dr. Carmen Gorska (Stora Enso), Martin Milner (STA) and members of the stakeholder review group.

Thanks are expressed to the research project funders: Stora Enso, Binderholz and KLH, and also to the work of OFR for preparing information in support of the production of this guidance. v2.1 review group: Dr Danny Hopkin (OFR), Dr. Michael Spearpoint (OFR), Clive Fussell (Engenuiti) and Martin Milner (STA).

STA Assure

STA member companies work under the audited STA Assure quality scheme where its structural timber building performance declarations only apply to members. They do not apply to non-member companies.

Document revision history

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v1.1 October 2020
Minor text adjustments.

v2.0 April 2023
Updated, clarified text across the document, OFR report removed from appendix and appendix examples added.

v2.1 May 2023
P20, Note 3 simplified.

Contents

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1. Introduction

This document details Building Regulation compliance routes for structural stability in the event of fire for mass timber buildings in England as part of the STA's library of fire-in-use best practice guidance. As in all building projects, on a case by case basis, additional measures to the compliance in this guidance may be required in order to address insurance requirements. The STA library of documentation provides guidance, information and recommendations on system specifications and good practice principles when using structural timber building methods.

The information may require updates and additional documents as regulations change and knowledge develops. Readers are to be aware of the need to check for updates and use the current issue of guidance from the STA website: www.structuraltimber.co.uk

The work includes key outputs from a mass timber research project, called 'STA Special Interest Group (SIG) - CLT compartment fire behaviour' under the chair of Matthew Linegar of Stora Enso.

The STA website www.structuraltimber.co.uk has additional information HERE

1.1 Scope

1.1.1 Regulatory scope

This guidance is focused on Building Regulation compliance routes for structural stability in the event of fire of mass timber buildings of differing uses and sizes.

The guidance is concerned with the life safety requirements for buildings constructed in England, as currently defined by the Regulations (Part B of the Building Regulations 2010, as amended). The scope is Regulation B3 - internal fire spread (structure), specifically, Regulation B3(1) which concerns the performance of the structural system in the event of fire.

The principles in this guidance are relevant to counterpart regulations in Scotland, Wales and Northern Ireland. However, agreement on the application of this guidance should be sought on a case-by-case basis with the relevant authority having jurisdiction.

Whilst the scope of this document is structural fire performance, mass timber can introduce hazards impacting all parts of a building's fire strategy, in particular flame spread across internal surfaces, external fire spread and space separation. The implications of building with mass timber and allowing it to contribute as a source of fuel should be fully understood by the design team and considered as at the outset of a project through a fire strategy review or for complex and medium rise projects a qualitative design review (QDR) process, as discussed in Section 3.1.

1.1.2 Timber construction scope

Mass timber is part of the family of material types that are in the structural timber building systems suite of options. As a building method, mass timber offers low carbon benefits and forms part of the offsite construction solution for speed, quality and cost-efficiency.

This guidance concerns large planar panels made from layers of timber, of which the following products are available:

- Cross laminated timber (CLT);
- Glued laminated timber (glulam) in large wall/floor panel form;
- Laminated veneer lumber (LVL) panels;
- Nail/dowelled laminated timber panels; and
- Engineered wood boards in large wall/floor panel form and of minimum 40mm thick.

1.1.3 Designer responsibility scope

This document conveys general guidance. It should be ensured on a case-by-case basis that its application is relevant and that the structural fire safety objectives for the project will be satisfied if this guidance is applied, noting that the purview of this guidance is life safety only.

The document assumes a requisite level of understanding/competence in its application, as discussed further in Section 1.4.

1.1.4 Scope of application of this guidance

The guidance is focussed on new buildings made either primarily from mass timber or in hybrid format. Where a project is an extension, the principles may not be directly applicable. For existing buildings the designer is to consider, on a case by case basis and in dialogue with relevant stakeholders, any potential change in risk and the appropriate route to demonstrating compliance with Regulation B3(1).

Early consultation with the project building control body is recommended to agree the structural fire safety objective and the route to compliance.

Images courtesy of Stora Enso

1.2 Why is this guidance needed and intent of guidance

Timber structures are resurgent due to environmental drivers, with an increasing number of tall and complex buildings being conceived that incorporate mass timber, either for the entirety of the structural frame or parts thereof in hybrid structures (often incorporating steel and/or concrete components). Timber is a combustible material. Where it forms large parts of a fire compartment's surface area and can contribute as a source of fuel (either because it is exposed by design or may become exposed prematurely during a fire), it can change the fire dynamics. Compared to using non-combustible materials this may lead to: higher heat release rates (HRRs), increased compartment gas temperatures, higher incident heat fluxes to structural elements, prolonged fire duration (**see Figure 1**), more combustion outside of openings causing more severe external flaming etc. A more exhaustive discussion related to fire hazards and mass timber buildings can be found in refs [1] and [2].

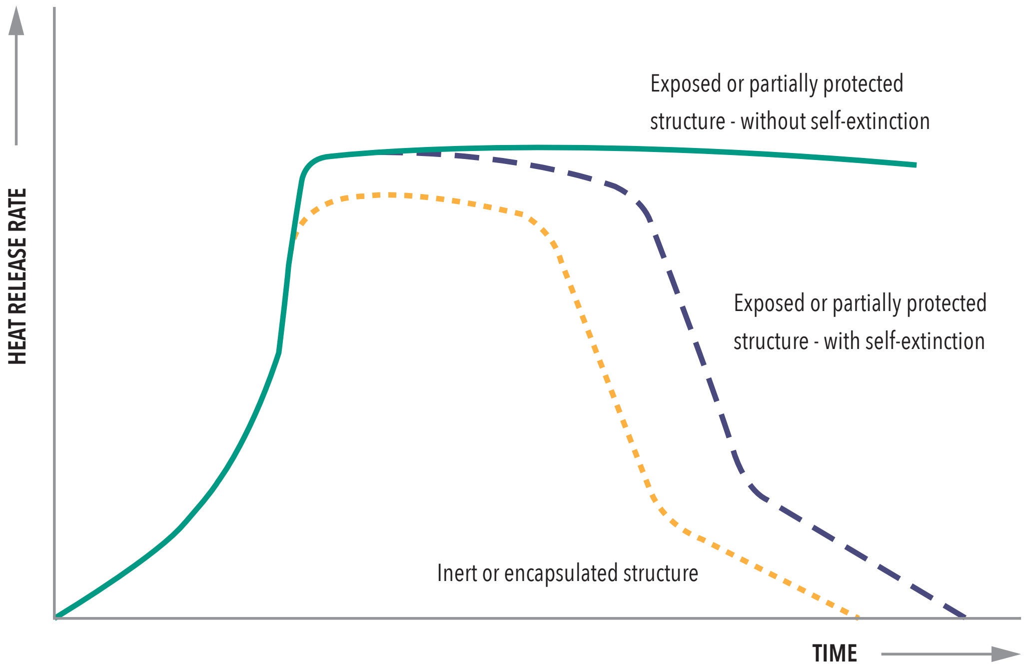

Figure 1: Conceptual illustration of heat release rate vs. time in inert or combustible enclosures, with or without self-extinction

Concerning the performance expected of the structure in the event of fire, the Building Regulations in England set out the minimum expectations under a life safety purview (as discussed in Section 2.1).

For the more common and straightforward building situations, guidance [3], [4] or codes [5], [6] are often applied to satisfy the requirements of the Building Regulations (see Section 2.3). These guidance documents and codes address structural performance in the event of fire through the provision of fire resistance to load-bearing elements of structure. Implicitly, the fire resistance paradigm and the guidance documents/codes that reference fire resistance periods include limitations, which are outlined in the OFR background report [20]. Discussions which elaborate on fire resistance, its origin and objectives can be found elsewhere, e.g. refs [7]-[9]

For higher consequence buildings, the affording of fire resistance to elements of structure is a proxy for an objective of the structure having a reasonable likelihood of surviving the full duration of a fire (burn-out), as discussed in more detail in Section 2.2. Where structural elements contribute as a source of fuel, the affordance of fire resistance to structural elements does not assure that the structural system will have a reasonable likelihood of surviving burn-out. By extension, the application of guidance or codes (which include fire resistance recommendations) does not always assure compliance with the relevant parts of the Building Regulations, with alternative routes to compliance required where a structure burns but must ultimately survive burn-out (see Section 2.4).

This document serves to guide designers towards the most appropriate route for compliance with Building Regulation B3(1) depending upon a project's specific circumstances, considering parameters that include:

- The structural fire safety objectives;
- The consequences associated with a fire induced structural failure; and
- The ability of the mass timber elements to contribute as a source of fuel.

1.3 STA special interest group and stakeholder review

This document is an output from the 'STA Special Interest Group (SIG) - CLT compartment fire behaviour'. Outputs are independently reviewed by a stakeholder review group. The project team structure and members are as shown in Figure 2.

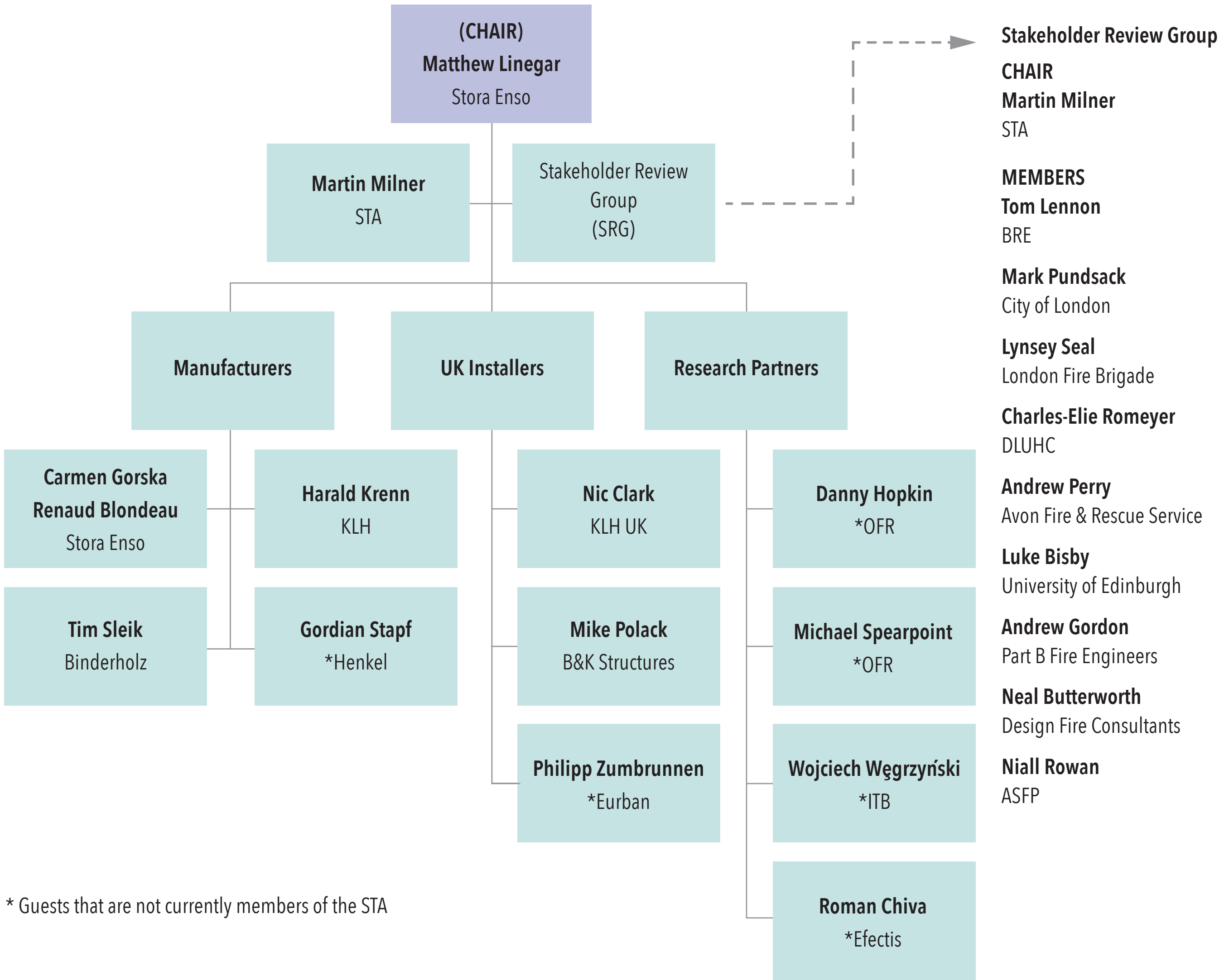

Figure 2: Structure of the STA SIG and stakeholder review group

1.4 Competency

STA Advice Note 7.3 sets out roles, responsibilities and scope of duties for those charged with the delivery of structural timber buildings. The design team must understand the limits of their competency and experience when delivering a timber building and recognise where the engagement of specialist input is needed to deliver a project that meets stakeholder goals and statutory requirements.

The structural fire engineering design of mass timber buildings is a specialised discipline within fire engineering competency. It requires specific knowledge and relevant experience in the fields of, for example, combustion, fire dynamics, heat transfer and structural response. Such expertise is not widely held by many fire safety professionals. Where it is established that a more complex fire safety engineering solution is required (e.g. see Section 2.4), only those individuals with demonstrable competence and relevant experience should be engaged to provide support to the project.

Similarly, the competence of the designer should be mirrored in the Building Regulations approvals process to ensure designs are adequately scrutinised and understood by the building control body; building control would, if lacking the required competence matched to the consequence of the risk, appoint external third-party reviewers to support the compliance process.

For buildings of higher consequence of failure, an independent third-party reviewer should be appointed to evaluate designs in addition to the building control body assessment, where a performance-based route to compliance is adopted (see Section 2.4). As per those charged with undertaking design responsibility, this peer review role should be undertaken by those individuals with recognised competence and demonstrable experience in the field of fire safety and mass timber structures.

This section introduces the statutory Building Regulation requirements in England with respect to structural performance in the event of fire, structural fire safety objectives and how they differ depending upon fire induced failure consequences, and the corresponding implications for the route to Building Regulations compliance for mass timber buildings.

2.1 Fire safety regulatory requirements and intentions

Building Regulation B3(1) in England states that:

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

The Secretary of State goes on to clarify the intention of the above functional requirement in Approved Document B as:

"For defined periods, loadbearing elements of structure withstand the effects of fire without loss of stability."

2.2 Structural fire performance objectives

Whilst speaking of periods of time, neither the wording of Regulation B3(1) nor the Secretary of State's clarified intention in ADB explicitly define the duration of structural stability required in the event of fire. With reference to the supporting OFR research [20] and parallel research developments in ref [8], the structural fire safety performance objectives for a building is influenced by the consequence of fire induced collapse. For buildings where the failure consequences are less significant, Regulation B3(1) can be interpreted as likely being satisfied subject to the structure remaining stable for an adequate period to facilitate occupant escape and limited internal fire and rescue service commitment to facilitate intervention. For buildings where the failure consequences are more significant (e.g. due to what is considered to be prolonged evacuation or a large commitment of fire service resources deep inside or at height within the building), Regulation B3(1) is likely satisfied subject to the structure having a reasonable likelihood of surviving the full duration of a fire (burn-out). The distinction of objectives is illustrated schematically in Figure 3 which goes on to indicate the implications for the compliance route (Section 2.5) and design solutions (Section 2.6).

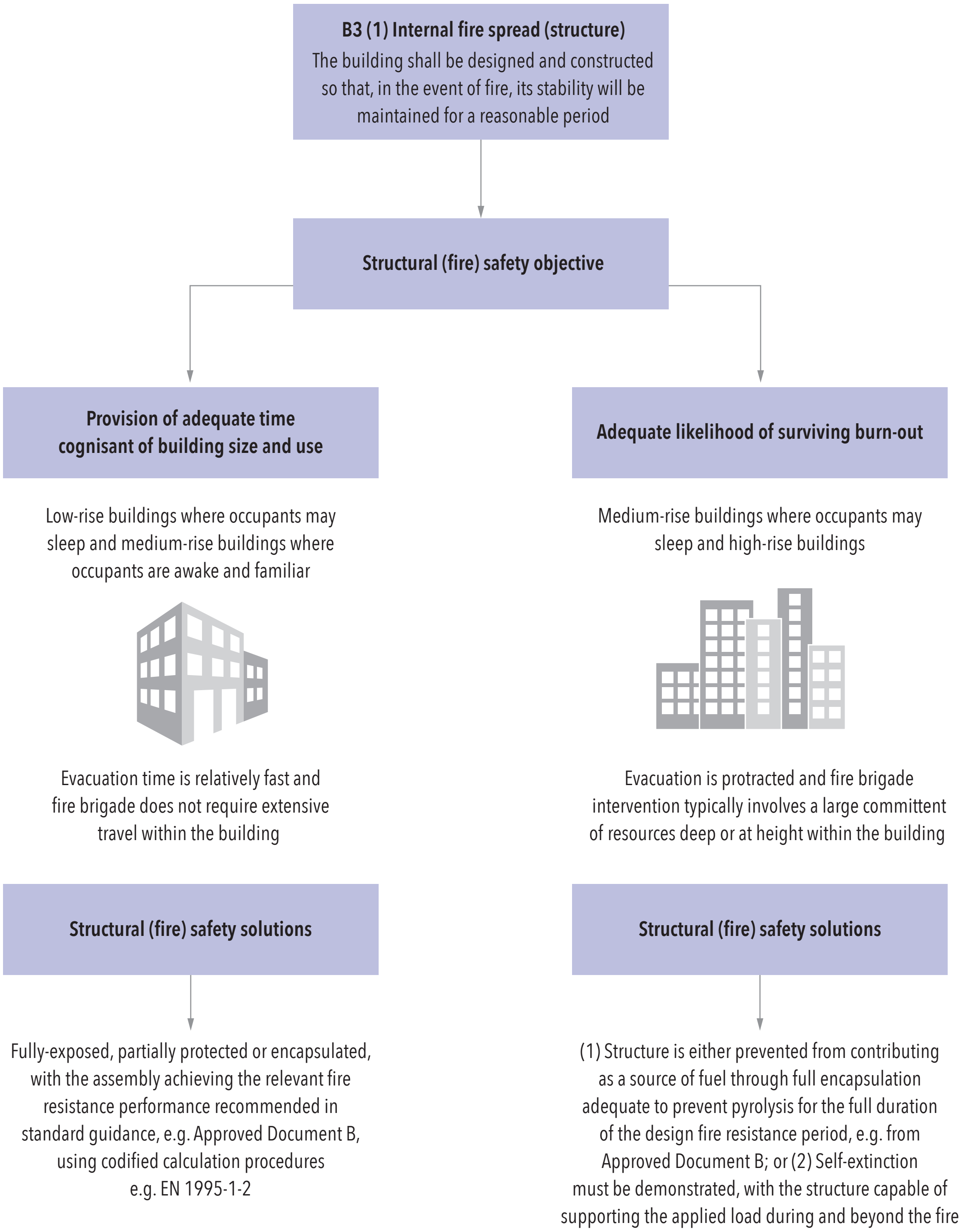

Figure 3: Illustration of the relationship between structural fire safety objectives, compliance routes and design solutions

2.3 Guidance-based routes to compliance

In most instances Regulation B3(1) is addressed through the adoption of the statutory guidance in Approved Document B [3], [4], or similar guidance such as BS 9991 [5] and BS 9999 [6]. Early agreement with the project building control body is recommended to agree the structural fire safety objective and the route to compliance. Therein, fire resistance ratings are recommended for elements of structure in function of building size and use. Subsequently, elements are either designed to inherently achieve or are protected to achieve the recommended fire resistance rating. In the case of mass timber elements, the fire resistance rating would commonly be demonstrated through the calculation methods in BS EN 1995-1-2 [10] or through appropriate test evidence. Once these 'fire resisting' elements are formed into a structural system, that structural system can be said to satisfy Regulation B3(1).

Whilst adopted as a common metric of performance, Section 2.2 highlights that structural elements can be afforded fire resistance to satisfy different structural fire safety objectives. With reference to the OFR report [20] and the literature cited therein, fire resistance guidance can likely only serve as an adequate proxy for the objective of a structure having a reasonable likelihood of surviving burn-out where the structure is prevented from contributing as a source of fuel.

2.4 Performance-based routes to compliance

Following statutory guidance (ADB) or similar codes (BS 9991, BS 9999) is not the only means of satisfying the requirements of Part B of the Building Regulations. Alternative routes exist and these are discussed in greater detail in BS 7974 [11] and the associated suite of Published Documents (with PD 7974-3 [12] being the most relevant in this case). For some more complex situations, such as those falling outside of the scope of guidance or codes, alternative fire engineering approaches/solutions may be the only means of demonstrating compliance with the Building Regulations and this is recognised in ADB.

BS 7974 notes a performance-based approach to design to constitute consideration of the specific fire hazards and their consequences such that fire safety measures can be introduced, as necessary, to ensure that the functional objectives for the design are met. BS 7974 encourages the inclusion of a qualitative design review (QDR) process, which is discussed further in Section 3.1.

2.5 Mass timber and the impact on route to compliance

It is discussed in Section 1 that combustible structures may increase the severity of fires within building enclosures if they are allowed to contribute as a source of fuel. This has implications for a structure's stability, affecting failure time and/or its likelihood of surviving burn-out.

The applicability/relevance of a guidance-based route to compliance, therefore, depends upon the structural fire performance objectives (as discussed in Section 2.2):

- Provision of adequate time: the structure having a reasonable likelihood of surviving the full duration of a fire is not a prerequisite for compliance with Regulation B3(1). Therefore, following the fire resistance guidance in ADB, for example, can likely result in an adequate level of safety and compliance with Regulation B3(1) subject to elements being designed appropriately for the recommended fire resistance rating (e.g. through application of BS EN 1995-1-2 [10]). The design solutions could involve the structure being fully exposed, partially protected or encapsulated (see Section 2.6);
- An adequate likelihood of surviving burn-out: unless the structure is prevented from contributing as a source of fuel, applying the fire resistance guidance in, for example, ADB cannot be said to result in a structure that can resist burn out and given this objective will not satisfy Regulation B3(1). Preventing the structure from contributing as a source of fuel will require encapsulation (see Section 2.6.2). Where the structure is permitted to become involved as a source of fuel, a performance-based route to compliance is likely the only means of demonstrating compliance with Regulation B3(1). Therein, it will often need to be demonstrated that the structure can undergo self-extinction and support the applied load both during and beyond the fire (see Section 2.6.3).

2.6 Mass timber and the impact on route to compliance

2.6.1 Partial protection

Partial protection implies that the fire resistance classification from BS EN 13501-2 [13] is achieved through a combination ofcontributions from the lining (often protection) material and substrate (e.g. sheathing or structural element). In a real fire and where this substrate is combustible, e.g. a mass timber structural element, this would infer that additional fuel will contribute to the fire beyond that of contents of the fire compartment at some point (ahead of burn-out). This will alter the fire dynamics within the compartment and will have implications for the structure's ability to potentially withstand the full duration (burn-out) of a fire.

2.6.2 Encapsulation

Encapsulation implies that sufficient protection is provided to the underlying structure/substrate to mitigate the onset of pyrolysis for the full duration of the relevant fire resistance period. This is commonly addressed through the specification of linings achieving demonstrated k_2 classifications per BS EN 13501-2 [13]. Where a lining is specified for the purposes of encapsulation, it should be shown that the interface temperature between the combustible substrate and lining (and away from fixings) remains below 200°C [14] (indicating the decomposition of hemicellulose) for the duration of the relevant fire resistance period. For mechanically fixed lining solutions, this is likely demonstrated through lining systems achieving a k_2 class but should be subject to review of the specific product test data and associated thermocouple readings.

Where encapsulation is adopted as the design solution, further consideration needs to be given to the overall fire strategy's 'defence-in-depth' to assure that premature failure of any protective lining does not lead to disproportionate damage/collapse of the overall structure. This is particularly relevant when considering Regulation A3, which is discussed further in Section 2.7.

2.6.3 Exposed structures and self-extinction

Self-extinction concerns the cessation of flaming combustion (in this case) of the structural elements either because they have been exposed to a fire from the outset, or have become exposed throughout the duration of a fire due to a partial protection solution. The demonstration of self-extinction would often form part of a performance-based route to compliance - as discussed in Section 2.4 - and is likely to be an expectation for all buildings where the fire induced failure consequences are more significant, regardless of the inclusion of active fire safety systems, such as sprinklers.

2.6.4 Structural backstop

Irrespective of the solution outlined in Sections 2.6.1 to 2.6.3, the (residual) structural elements must be capable of supporting the load either for the duration of the fire resistance period or for the full duration of a fire, as relevant to the route of compliance. This will typically involve a demonstration that the structure can support the loads for an accidental loading combination, as set out in BS EN 1990 [15] and BS EN 1991-1-2 [16] (including national application documents, e.g. [17], [18]).

2.7 Differentiating failure consequences

Failure consequences caused by fire drive the structural performance objectives discussed in Section 2.2.

Failure consequences are differentiated in guidance addressing general structural design (Approved Document A - ADA [19]) and fire safety design (Approved Document B - ADB).

With respect to disproportionate collapse, Regulation A3 (England) places an obligation to ensure: "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".

ADA provides guidance for designers by grouping buildings into consequence classes, as reflected in **Table 1**. When allowing designers to specify fire resistance to elements of structure, ADB adopts a combination of trigger heights and purpose groups to impose a reducing failure likelihood with increasing failure consequences. Whilst the two Approved Documents (ADA and ADB) can appear unrelated, it is considered appropriate in the context of this guidance that the ADA consequence class system serves as a boundary on the application for fire resistance guidance. This is clearly reflected in the high consequence buildings, with ADA calling for all consequence class 3 structures to be subject to a systematic risk assessment, considering all the normal hazards that may be reasonably foreseen, together with any abnormal hazards.

It is seen later in Section 3.2 that a guidance-based route to compliance is not advocated for consequence class 3 structures. For lesser consequence classes, i.e. 1, 2A and 2B, it is shown in Section 3.2 that a guidance-based route to compliance can be applicable, depending upon the structural fire safety objectives and subject to the limiting trigger heights referenced in Table 2a and 2b.

CONSEQUENCE CLASS	CONSEQUENCES OF FAILURE	TYPICAL BUILDING TYPE AND OCCUPANCY[2] - RELEVANT TO MASS TIMBER
CLASS 1[1]	Low	• Single occupancy houses not exceeding 4 storeys
CLASS 2A[1]	Low to medium	• 5 storey single occupancy houses • Hotels not exceeding 4 storeys • Flats, apartments and other residential buildings not exceeding 4 storeys • Offices not exceeding 4 storeys • Industrial buildings not exceeding 3 storeys • Retail premises not exceeding 3 storeys of less than 1000 m² floor area in each storey • Single storey educational buildings • All buildings not exceeding two storeys to which the public are admitted and which contain floor areas not exceeding 2000 m² at each storey
CLASS 2B	Upper risk group (medium)[2]	• Hotels, flats, apartments and other residential buildings greater than 4 storeys but not exceeding 15 storeys • Educational buildings greater than single storey but not exceeding 15 storeys • Retail premises greater than 3 storeys but not exceeding 15 storeys • Hospitals not exceeding 3 storeys • Offices greater than 4 storeys but not exceeding 15 storeys • All buildings to which the public are admitted, and which contain floor areas exceeding 2000 m² but not exceeding 5000 m² at each storey
CLASS 3	High	• All buildings defined above as Class 2 lower and upper consequences class that exceed the limits on area and number of storeys • All buildings to which members of the public are admitted in significant numbers • Stadia accommodating more than 5000 spectators

Table 1: Consequence class table extracted from Table 11 of Approved Document A (England) and in Annex A of BS EN 1991-1-71

NOTE [1]: *Users of the consequence classes in Table 1, in combination with the guidance presented in Section 3 shall consider buildings on a case-by-case basis. Due regard to the structural fire performance objectives for a given building are to be considered using the factors introduced in Section 2.2 which inform whether or not the structure needs be expected to withstand burn-out to comply with Regulation B3(1). In any review due consideration to the type of users/residents of a building is to be included in a decision process, for example a building where there is a high proportion of occupants who cannot self-evacuate shall have a medium to high consequence of failure (fire) regardless of the storey height or the number of storeys.*

NOTE [2]: *Consequence classes are further augmented with limiting trigger heights in function of the purpose groups as discussed in Section 3.2 and presented in* ***Table 2.1 and 2.2****.*

3. Guidance on routes to compliance

The following sections discuss general recommendations in support of ascertaining the most appropriate route to compliance with Regulation B3(1) for mass timber projects of varying scale and use. It should be applied noting the caveats discussed in Section 1.

3.1 The fire strategy and the QDR

The most appropriate route to compliance for a mass timber building project should be reviewed and agreed at the inception stage of a project. A fire safety strategy should be developed for all projects where factors such as the provision of automatic suppression systems, compartmentation, the evacuation strategy and fire brigade intervention strategy inform the structural fire performance objectives. STA Advice Note 7.3 [21] provides some guidance that the design team may wish to consider when developing a fire strategy for medium and low rise timber buildings.

Where a performance-based route to compliance is considered necessary/appropriate to meet the project goals and demonstrate compliance with B3(1), it is expected that any such solution will be developed following the guidance in BS 7974. This will include the completion of a qualitative design review (QDR) in consultation with all relevant stakeholders. BS 7974 provides a structured process for highlighting and determining fire hazards, fire risks, design actions and mitigation measures and will typically involve the following main stages [11], [21]:

a. Review architectural design and selection of materials, including their suitability and fire properties, occupant characteristics and client requirements;

b. Establish functional objectives for fire;

c. Identify fire hazards and possible consequences;

d. Establish trial fire safety engineering designs;

e. Set acceptance criteria for the designs;

f. Identify the method of analysis;

g. Where identified establish fire scenarios for analysis; and

h. Document outputs of the QDR

3.2 A consequence-based design tool for compliance

Section 3.1 highlights a need to consider the project objectives, technical design factors, material selection factors and possible fire-induced consequences. Adopting these as a foundation and in cognisance of the underpinning research set out in [20], a general consequence-based design tool to assist in identifying the most appropriate route to compliance for a mass timber building project has been developed and is summarised in **Table 2.1 and 2.2**. The adoption of this tool should be considered and agreed on a case-by-case basis with all stakeholders, with it noted that generalising guidance is never truly possible when faced with the myriad of building forms and functions that can exist in practice.

The guidance may be overly conservative in some specific instances and not sufficiently conservative in others (see **Table 1**, note 1). It also does not explicitly consider features of a fire strategy that may be beneficial in mitigating uncontrolled fires, such as automatic suppression systems. Users are therefore encouraged to consider what structural fire performance objectives are appropriate/relevant to the case in hand, in cognisance of the underlying drivers that dictate whether nor not it is necessary for the structure to survive burn-out when seeking to demonstrate compliance with B3(1). This can, where appropriate to do so, involve some consideration of the probability of a structurally significant fire occurring when active fire safety systems are installed - and the contribution of such systems to the likelihood of the structure surviving the full duration of a fire.

Section 2.7 discusses the differences in how structural failure consequences are differentiated with respect to Part A and Part B of the Building Regulations (and the associated statutory guidance). As a primary reference point, building consequence classes inform the route to compliance in **Table 2.1 and 2.2**. Building consequence classes speak in terms of the number of storeys (ground inclusive).

Depending upon the floor to floor/roof height, this can create a range of building heights of nominally the same number of storeys. The background research reported in OFR report [20] has highlighted the historical role of trigger heights in differentiating changes in escape duration, operational firefighting practices, etc., and, thus, structural fire safety objectives. Considering the impact of height on such fire strategy considerations, maximum heights for guidance-based routes to compliance are imposed in **Table 2.1 and 2.2** (through Note 2) for consequence class 2a structures. Refer to the example applications given in Appendix A

Table 2.1: Permissible compliance route to consequence class

CONSEQUENCE CLASS	CONSEQUENCES (risk of fire to multiple persons)	PERMISSIBLE COMPLIANCE ROUTE	
		GUIDANCE-BASED[1]	PERFORMANCE-BASED[4]
1	Low	Yes	Yes
2A	Low to medium	Yes[2]	Yes
2B	Medium	Yes[3]	Yes
3	High	No[5]	Yes

NOTE [1]: *For England the guidance-based approach is documented in, for example, Approved Document B which specifies the recommended fire resistance rating for elements of structure. Elements are then demonstrated as having adequate fire resistance through appropriate testing and/or calculation methods, e.g. BS EN 1995-1-2, supplier ETAs, etc.*

NOTE [2]: *Subject to the purpose group specific height limitations set out in table 2.2, otherwise Note 3 applies.*

NOTE [3]: *Applicable to mass timber afforded encapsulation with the lining capable of averting pyrolysis for the full duration of the fire resistance period.*

NOTE [4]: *Demonstration by a competent structural/fire engineer with relevant experience (Section 1.4) that the structure has a reasonable likelihood of surviving burn-out with due consideration of the ability of automatic suppression systems to mitigate fire growth, the impact of the combusting structure on fire development, the ability of the structure to undergo self-extinction; and the ability of the structure to support the applied loads during and beyond the fire event. A performance-based assessment may be augmented by project specific testing in support of demonstrating that the structure has an adequate likelihood of surviving burn-out. A summary of available test data is provided in reference document [22].*

NOTE [5]: *Consequence class 3 structures should be subject to a project-specific systematic risk assessment considering fire as an accident, per Approved Document A and in satisfaction of Regulation A3. This necessitates a performance-based assessment in all cases.*

Table 2.2: Upper floor height limits for suitability of a guidance-based approach, in the absence of a case-by-case assessment by a structural/fire engineer

BUILDING TYPE AND OCCUPANCY	LIMIT ON UPPER FLOOR LEVEL ABOVE LOWEST GROUND LEVEL
Residential	11m
Hotels and other residential	11m
Offices and mercantile	18m
Assembly and recreation	7.5m
Education/schools	7.5m

References

[1] Document available on the STA website http://www.structuraltimber.co.uk/sectors/clt-special-interest-group

[2] A. Law and R. M. Hadden, 'Burnout Means Burnout - SFPE'. https://www.sfpe.org/page/Issue5Feature1

[3] HM Government, 'The Building Regulations 2010, Approved Document B (Fire Safety) Volume 1 (2019 edition)', 2019.

[4] HM Government, 'The Building Regulations 2010, Approved Document B (Fire Safety) Volume 2 (2019 edition, as amended May 2020)', 2020.

[5] BSI, 'BS 9991:2015 Fire safety in the design, management and use of residential buildings. Code of practice', BSI, London, 2015.

[6] BSI, 'BS 9999:2017 Fire safety in the design, management and use of buildings. Code of practice', BSI, London, 2017.

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[8] A. Law and L. Bisby, 'The rise and rise of fire resistance', Fire Saf. J., p. 103188, Jul. 2020, doi: 10.1016/j.firesaf.2020.103188.

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[17] BSI, 'NA to BS EN 1991-1-2:2002 UK National Annex to Eurocode 1. Actions on structures. General actions. Actions on structures exposed to fire', BSI, London, 2007.

[18] BSI, 'PD 6688-1-2:2007 Background paper to the UK National Annex to BS EN 1991-1-2', BSI, London, 2007.

[19] HM Government, 'The Building Regulations 2010, Approved Document A (Structure)', London, 2004.

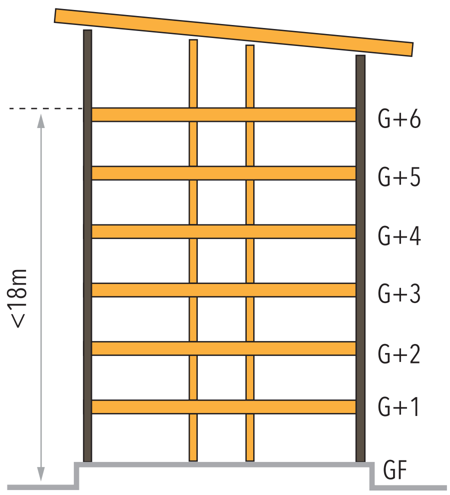
[20] OFR WP1 Report , Hopkin, D., Compliance roadmap for mass timber projects in England, Regulation B3(1), OFR, Manchester, 2020. (download HERE)

[21] STA Advice Note 7.3 Fire Safety Strategy (FSS) for structural timber buildings

[22] G. Ronquillo, D. Hopkin and M. Spearpoint, 'Review of large-scale fire tests on cross-laminated timber', Journal of Fire Sciences, 2021, doi: 10.1177/07349041211034460

Example 1 - residential

7 storey apartment building >18m from top floor to lowest ground level



CONSEQUENCE CLASS	CONSEQUENCES OF FAILURE	TYPICAL BUILDING TYPE AND OCCUPANCY[2] - RELEVANT TO MASS TIMBER
CLASS 1[1]	Low	• Single occupancy houses not exceeding 4 storeys
CLASS 2A[1]	Low to medium	• 5 storey single occupancy houses • Hotels not exceeding 4 storeys • Flats, apartments and other residential buildings not exceeding 4 storeys • Offices not exceeding 4 storeys • Industrial buildings not exceeding 3 storeys • Retail premises not exceeding 3 storeys of less than 1000 m^2 floor area in each storey • Single storey educational buildings • All buildings not exceeding two storeys to which the public are admitted and which contain floor areas not exceeding 2000 m^2 at each storey
CLASS 2B	Upper risk group (medium)[2]	• Hotels, flats, apartments and other residential buildings greater than 4 storeys but not exceeding 15 storeys • Educational buildings greater than single storey but not exceeding 15 storeys • Retail premises greater than 3 storeys but not exceeding 15 storeys • Hospitals not exceeding 3 storeys • Offices greater than 4 storeys but not exceeding 15 storeys • All buildings to which the public are admitted, and which contain floor areas exceeding 2000 m^2 but not exceeding 5000 m^2 at each storey
CLASS 3	High	• All buildings defined above as Class 2 lower and upper consequences class that exceed the limits on area and number of storeys • All buildings to which members of the public are admitted in significant numbers • Stadia accommodating more than 5000 spectators

Table 1 from P17 of this document (please refer to notes)

CONSEQUENCE CLASS	CONSEQUENCES (risk of fire to multiple persons)	PERMISSIBLE COMPLIANCE ROUTE	
		GUIDANCE-BASED[1]	PERFORMANCE-BASED[4]
1	Low	Yes	Yes
2A	Low to medium	Yes[2]	Yes
2B	Medium	Yes[3]	Yes
3	High	No[5]	Yes

Table 2.1 from P20 of this document

Guidance-based solution

Mass timber afforded encapsulation with the lining capable of averting pyrolysis for the full duration of the fire resistance period set out in Approved Document B Volume 1, e.g., k_2,90.

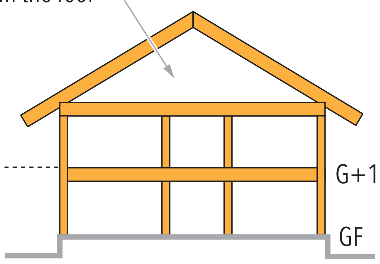
Performance-based solution

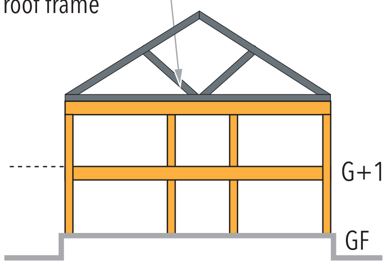
Mass timber can be exposed but requires demonstration by a competent fire engineer with relevant experience that the structure has a reasonable likelihood of surviving burn-out.

External wall zone must satisfy Regulation 7, with mass timber not permissible in the external wall zone.

Example 2 - residential

2 storey house





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2A	Low to medium	Yes[2]	Yes
2B	Medium	Yes[3]	Yes
3	High	No[5]	Yes

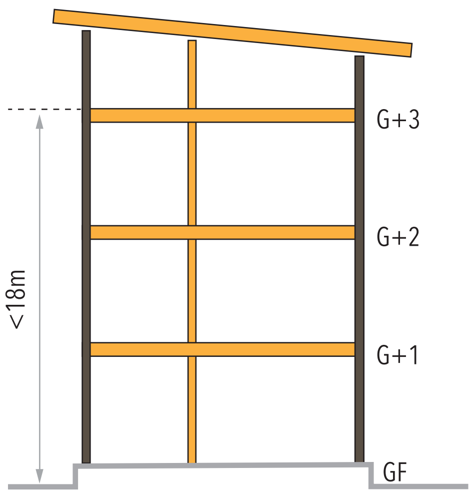
Table 2.1 from P20 of this document

Guidance-based solution

Mass timber can be exposed. Adopt fire resistance recommendation from Approved Document B, Volume 1. Elements are then demonstrated as having adequate fire resistance through appropriate testing and/or calculation methods, e.g., BS EN 1995-1-2.

Example 3 - commercial

4 storey office <18 m from top floor to lowest ground level



CONSEQUENCE CLASS	CONSEQUENCES OF FAILURE	TYPICAL BUILDING TYPE AND OCCUPANCY[2] - RELEVANT TO MASS TIMBER
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2B	Medium	Yes[3]	Yes
3	High	No[5]	Yes

Table 2.1 from P20 of this document

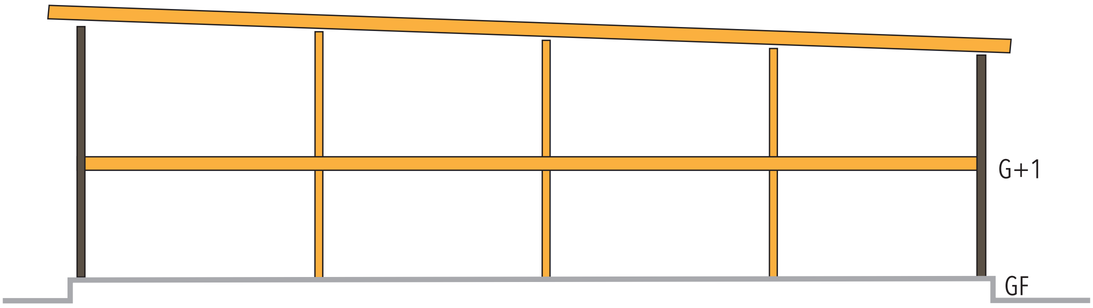
Guidance-based solution

Mass timber can be exposed. Adopt fire resistance recommendation from Approved Document B, Volume 2. Elements are then demonstrated as having adequate fire resistance through appropriate testing and/or calculation methods, e.g., BS EN 1995-1-2.

Example 4 - education

2 storey school, with compliance route agreed on a case specific basis through dialogue with key stakeholders

NOTE: *This example demonstrates that the designer is required to think about the compliance route matched to the structural fire safety objectives. This example shows that table 2.1 requires consideration of the building users and consequence of a fire induced collapse.*



B3 (1) Internal fire spread (structure)

The building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period

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Structural (fire) safety objective

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Provision of adequate time cognisant of building size and use

Low-rise buildings where occupants may sleep and medium-rise buildings where occupants are awake and familiar

Evacuation time is relatively fast and fire brigade does not require extensive travel within the building

Structural (fire) safety solutions

↓

Fully-exposed, partially protected or encapsulated, with the assembly achieving the relevant fire resistance performance recommended in standard guidance, e.g. Approved Document B, using codified calculation procedures e.g. EN 1995-1-2

Structural fire performance objectives and compliance route

The building's fire strategy is premised upon simultaneous evacuation, supported by the inclusion of an automatic detection and alarm system. Fire and rescue service access is to be provided by way of the building perimeter. In dialogue with key stakeholders, including the client, building control body and local fire and rescue service, it is agreed that the structure need not withstand burn-out, but must remain stable for long enough to facilitate occupant evacuation and the envisaged fire and rescue service activities. The adoption of the guidance in Approved Document B is agreed with stakeholders as being appropriate for this objective.

Guidance-based solution

Adopt fire resistance recommendation from Approved Document B, Volume 2. Elements are then demonstrated as having adequate fire resistance through appropriate testing and/or calculation methods, e.g., BS EN 1995-1-2.

Elements of mass timber can be exposed where fire resistance can be demonstrated.

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