Fire Research Update

CLT Special Interest Group

Dr Carmen Gorska

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Building offsite solutions in timber

SITE SAFE

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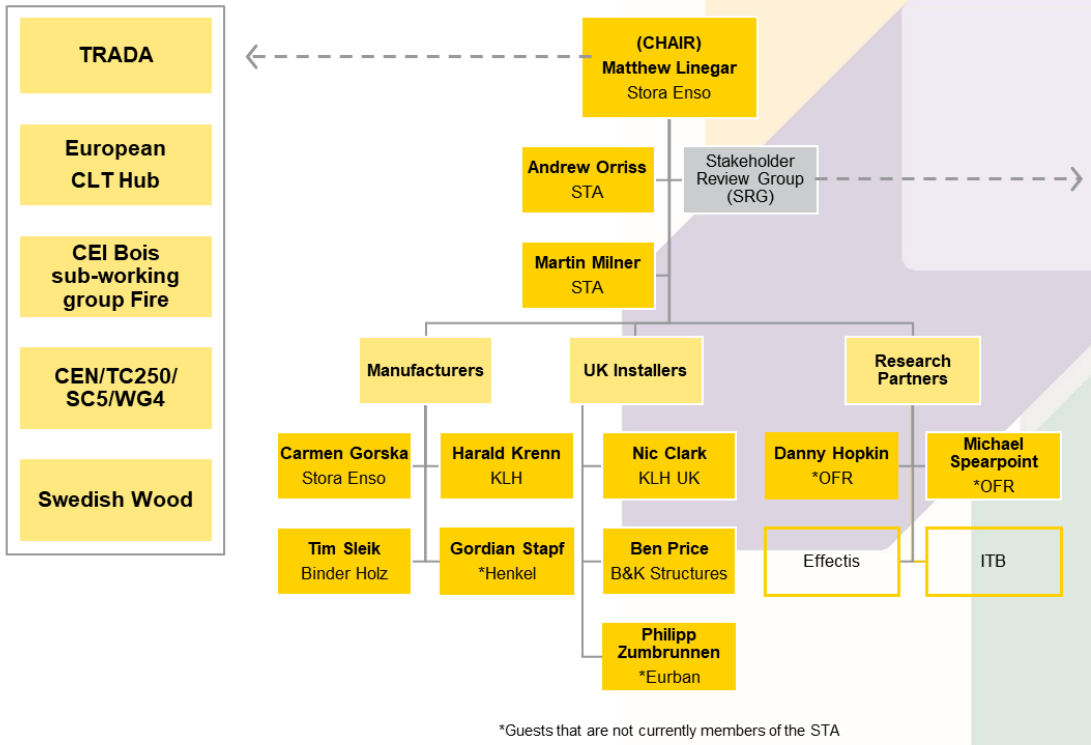
STA Special Interest Group (SIG) – CLT compartment fire behaviour



*Guests that are not currently members of the STA

Stakeholder Review Group

Chair: *Martin Milner, STA*

Members:

Tom Lennon, BRE
Mark Pundsack, City of London
Richard Bettis, HSE
Lynsey Seal, London Fire
Charles-Elie Romeyer, MHCLG
Andrew Perry, Avon Fire
David Poxon, The FPA
Neil Gibbins, Institute of Fire Engineers
Luke Bisby, University of Edinburgh
John Lewis, NHBC
Martin Taylor, LABC Warranty
Sarah Sheppard, MD Warranty Inspection services
Neal Butterworth, Design Fire Consultants
Niall Rowan, FPA

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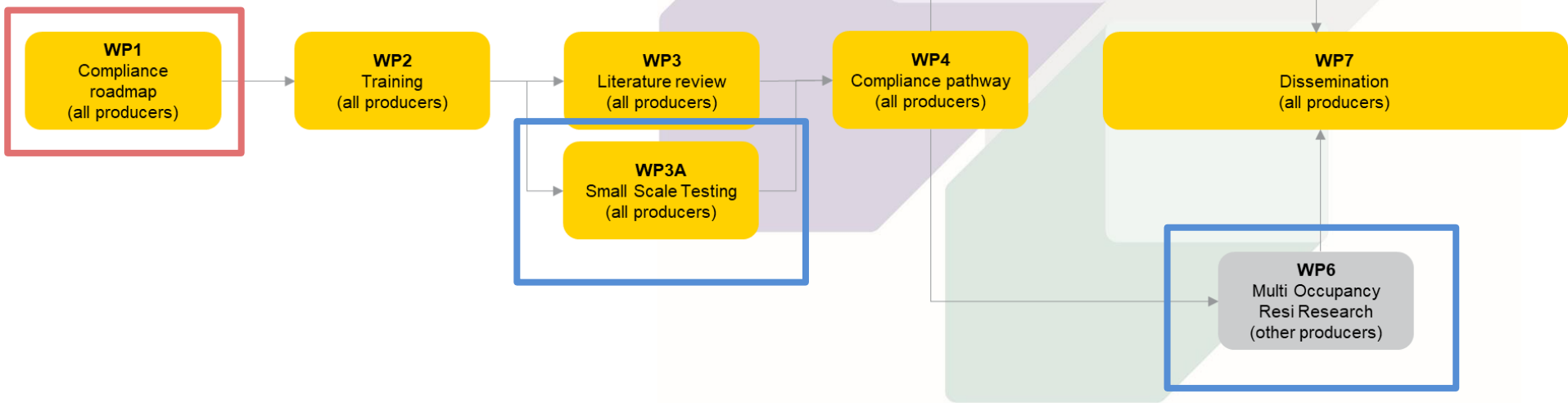
Work Packages

Dr Danny Hopkin



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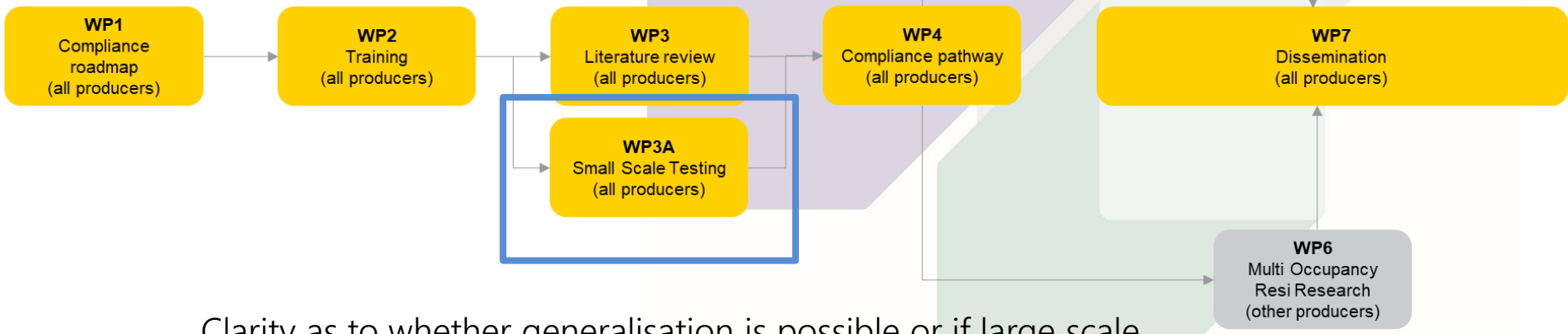
Work Packages



Clarity as to whether generalisation is possible or if large scale experiments must include a variety of supplier's panels

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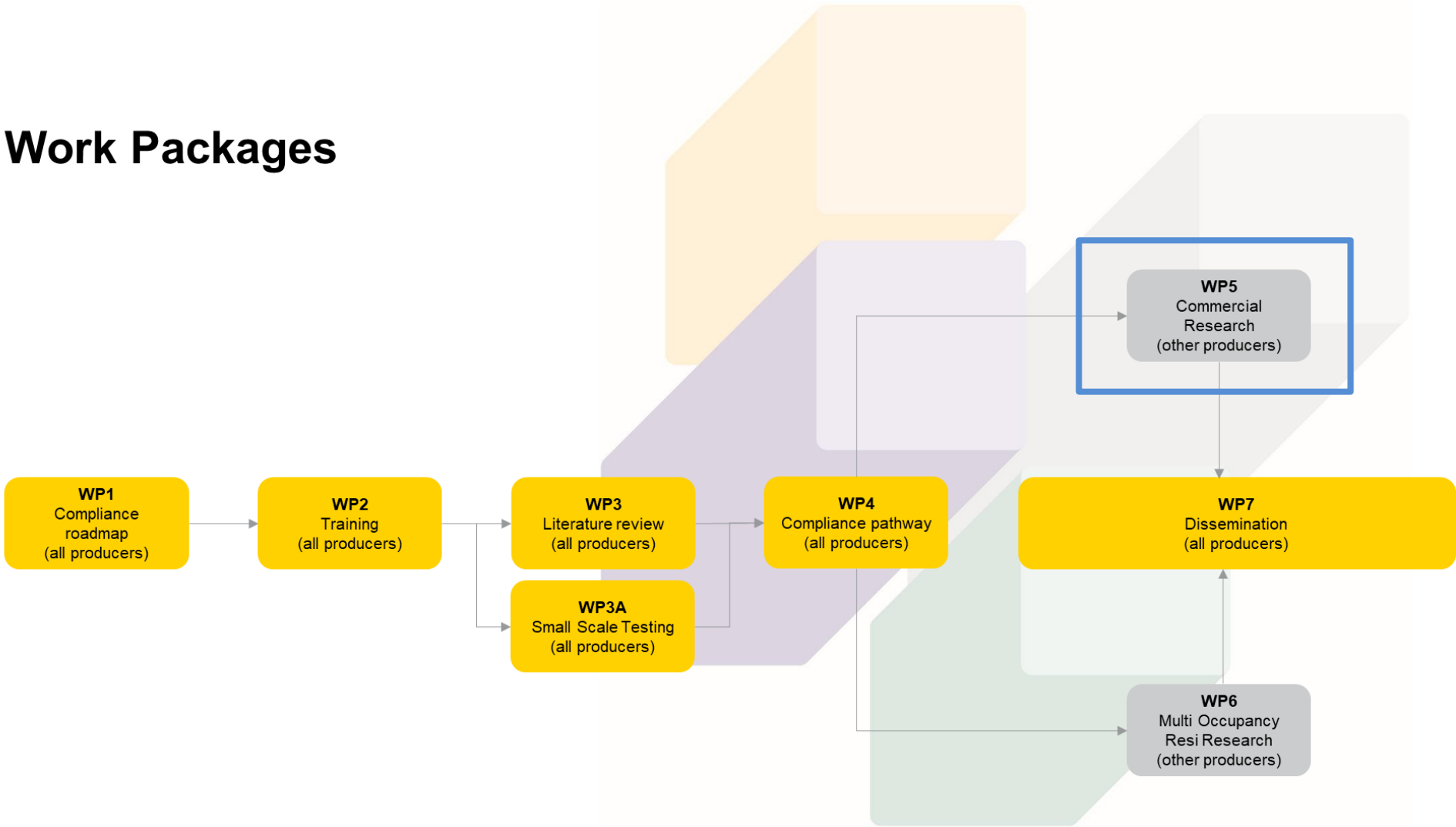
Comparative small-scale tests

Variables

- Manufacturer (Stora Enso, Binderholz, KLH)
- Edge joint (Glued vs non-edge-glued)
- Adhesive (HBS vs HBX)
- Lamella thickness (thin vs thick outer lamella)

Work Packages



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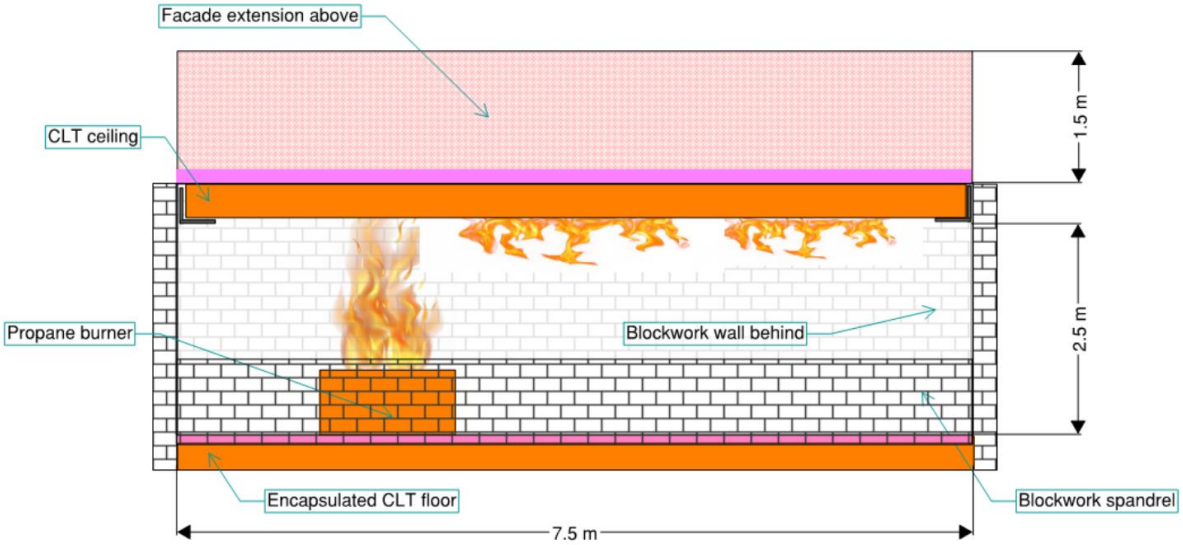
Commercial large-scale tests



Objectives:

- Changes in flame spread over the ceiling
- Effect of delamination on self-extinguishment
- HBX performance in a realistic fire scenario

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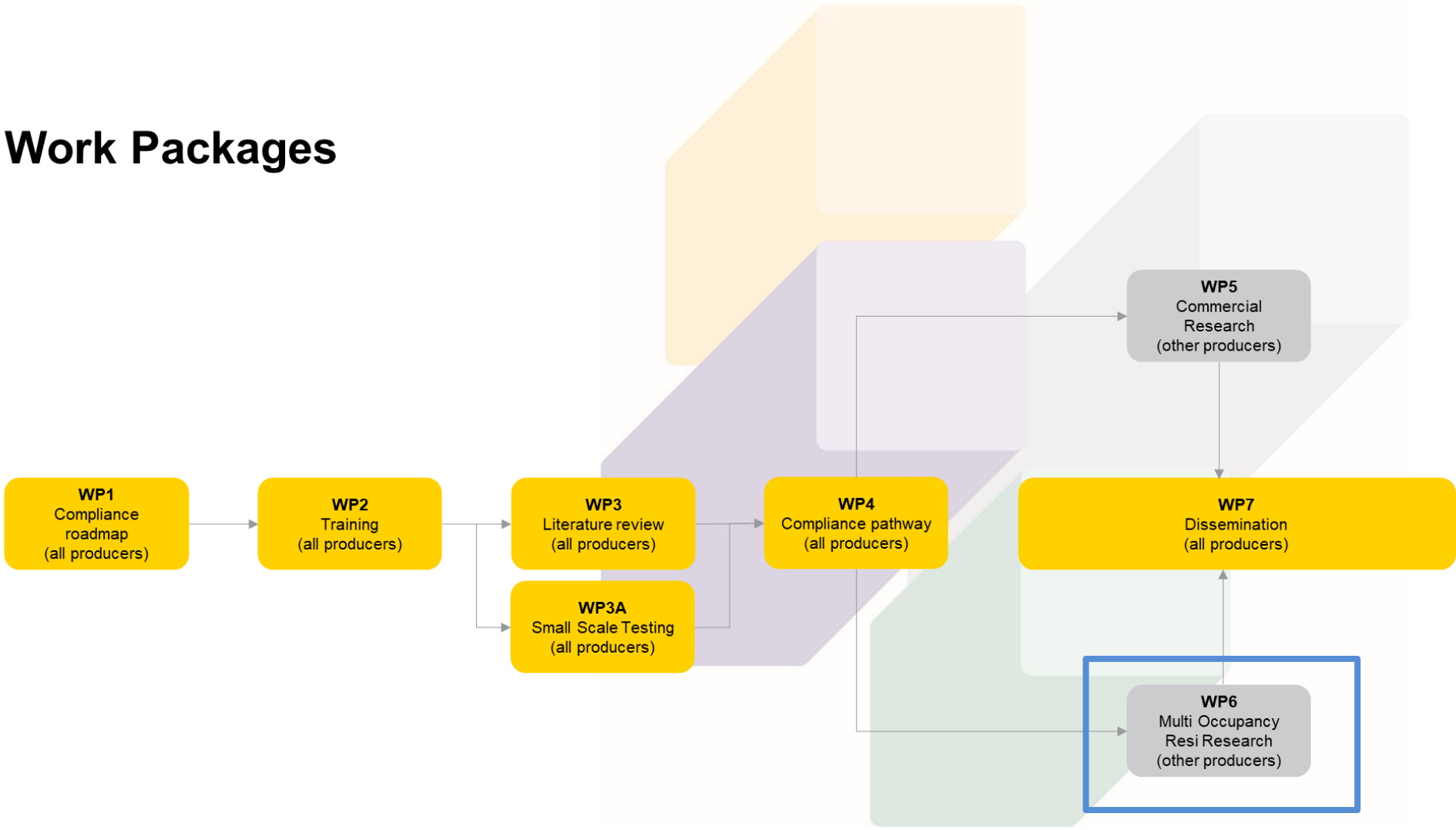
Work Packages



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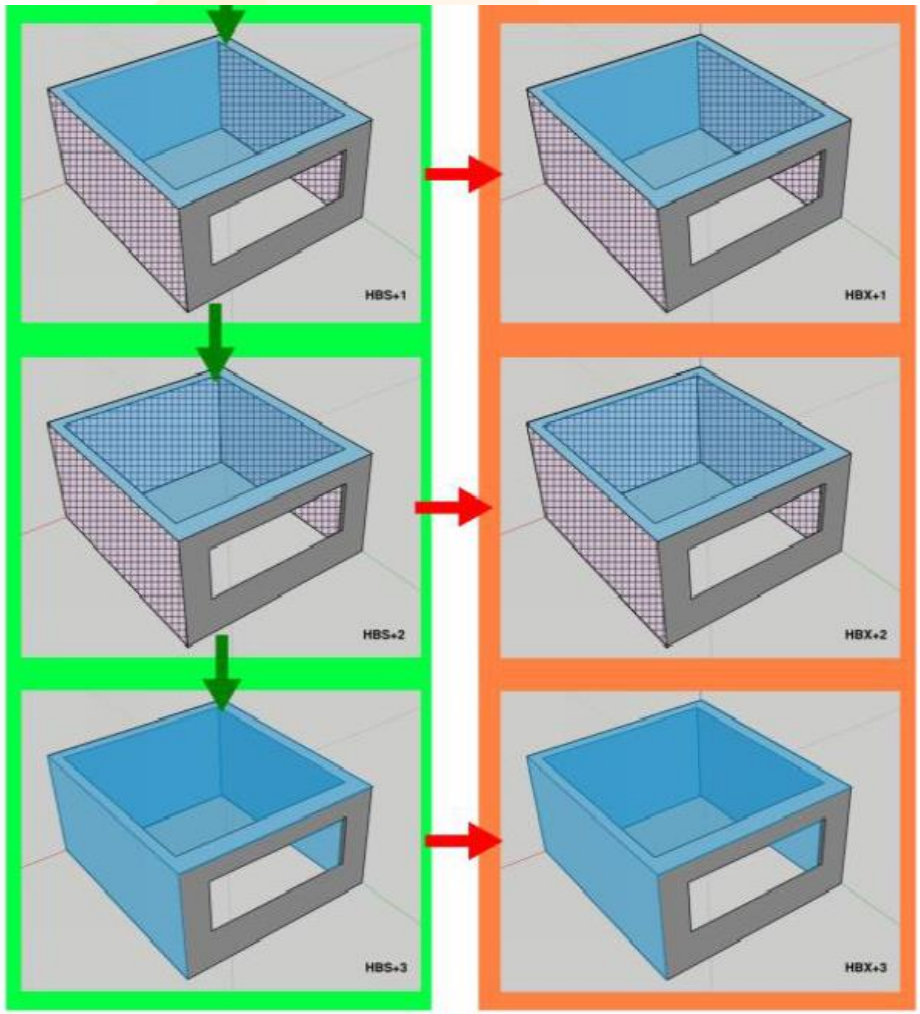
Residential large-scale tests

Objectives:

- Demonstrate that current solutions of encapsulation perform adequately.
- Optimize the level of encapsulation and still obtain adequate fire performance.



Thank you!

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STA Special Interest Group (SIG) - CLT compartment fire behaviour

Structural timber buildings: fire safety in use guidance – Vol. 6
Compliance road-map for B3(1)

Dr. Danny Hopkin CEng FIFireE FIMechE
OFR - Technical Director
Danny.Hopkin@OFRConsultants.com

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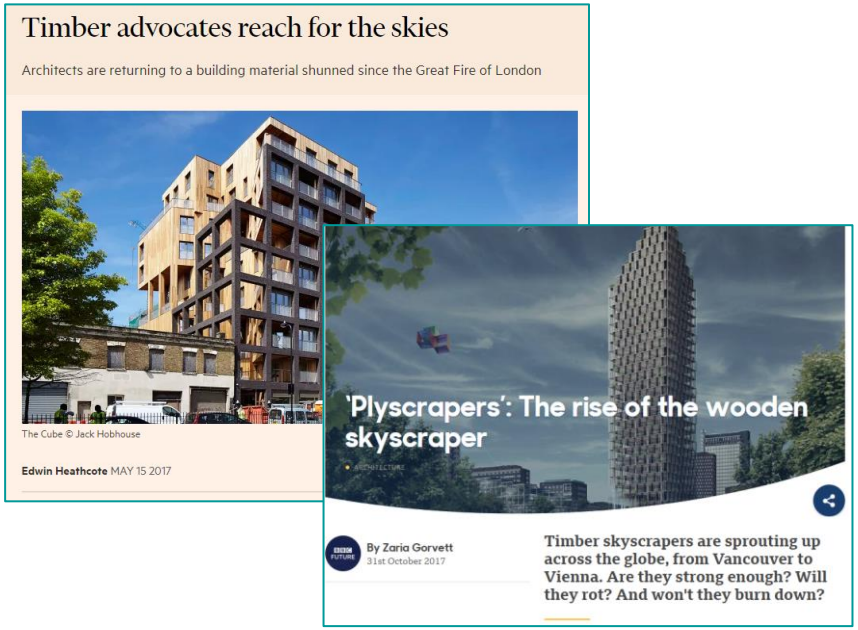
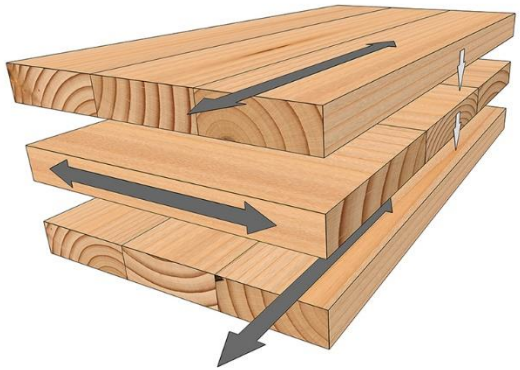
Mass Timber: Ambition & history



Timber – the answer to an environmental crisis?

Cross laminated timber (CLT)



Engineered wood products

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We're encapsulating CLT…even when that fails, the CLT behind it will continue to perform structurally and as a compartment…

Very big pieces of wood are hard to set on fire – they aren't kindling material…

The plasterboard gives 49 minutes of fire protection, after that the timber chars at 0.7mm per minute so we have to ensure we have enough timber remaining to carry the loads after 120 mins…

CLT is not only safe in fire, but safer than many other standard materials, such as steel

If you're making a fire, everyone knows you don't start with giant logs….

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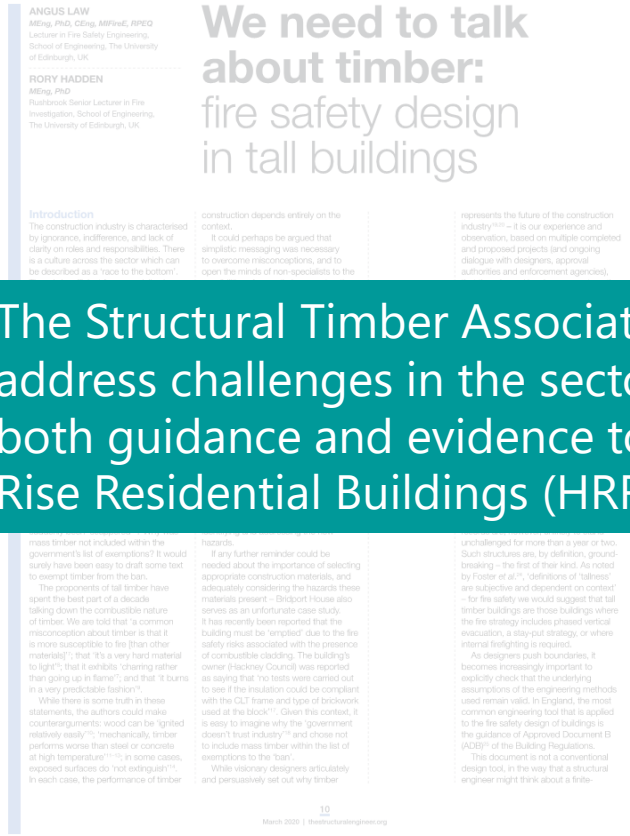
Mass timber – knowledge & competency



ANGUS LAW
MEng, PhD, CEng, MIFireE, RPEQ
Lecturer in Fire Safety Engineering, School of Engineering, The University of Edinburgh, UK

RORY HADDEN
MEng, PhD
Rushbrook Senior Lecturer in Fire Investigation, School of Engineering, The University of Edinburgh, UK

We need to talk about timber: fire safety design in tall buildings

Introduction

The construction industry is characterised by ignorance, indifference, and lack of clarity on roles and responsibilities. There is a culture across the sector which can be described as a 'race to the bottom'.

construction depends entirely on the context.

It could perhaps be argued that simplistic messaging was necessary to overcome misconceptions, and to open the minds of non-specialists to the

represents the future of the construction industry[1,2,3] – it is our experience and observation, based on multiple completed and proposed projects (and ongoing dialogue with designers, approval authorities and enforcement agencies),

mass timber not included within the government's list of exemptions? It would surely have been easy to draft some text to exempt timber from the ban.

The proponents of tall timber have spent the best part of a decade talking down the combustible nature of timber. We are told that 'a common misconception about timber is that it is more susceptible to fire (than other materials)'[4]; that 'it's a very hard material to light'[5]; that it exhibits 'charring rather than going up in flame'[6]; and that 'it burns in a very predictable fashion'[6].

While there is some truth in these statements, the authors could make counterarguments: wood can be 'ignited relatively easily'[7]; 'mechanically, timber performs worse than steel or concrete at high temperature'[8,9,10]; in some cases, exposed surfaces do 'not extinguish'[11]. In each case, the performance of timber

hazards.

If any further reminder could be needed about the importance of selecting appropriate construction materials, and adequately considering the hazards these materials present – Bridport House also serves as an unfortunate case study. It has recently been reported that the building must be 'emptied' due to the fire safety risks associated with the presence of combustible cladding. The building's owner (Hackney Council) was reported as saying that 'no tests were carried out to see if the insulation could be compliant with the CLT frame and type of brickwork used at the block'[12]. Given this context, it is easy to imagine why the 'government doesn't trust industry'[13] and chose not to include mass timber within the list of exemptions to the 'ban'.

While visionary designers articulately and persuasively set out why timber

unchallenged for more than a year or two. Such structures are, by definition, ground-breaking – the first of their kind. As noted by Foster et al.[14], 'definitions of "tallness" are subjective and dependent on context' – for fire safety we would suggest that tall timber buildings are those buildings where the fire strategy includes phased vertical evacuation, a stay-put strategy, or where internal firefighting is required.

As designers push boundaries, it becomes increasingly important to explicitly check that the underlying assumptions of the engineering methods used remain valid. In England, the most common engineering tool that is applied to the fire safety design of buildings is the guidance of Approved Document B (ADB)[15] of the Building Regulations.

This document is not a conventional design tool, in the way that a structural engineer might think about a finite-

10

March 2020 | thestructuralengineer.org

"It is our experience and observation, based on multiple

clarity about roles and responsibilities, or is simply a symptom of Hackitt's 'race to the bottom'"

Law & Hadden (2020)

The Structural Timber Association Special Interest Group has been formed to address challenges in the sector, through a series of work packages to provide both guidance and evidence to support the fire safe design of mass timber High Rise Residential Buildings (HRRB) and commercial buildings.

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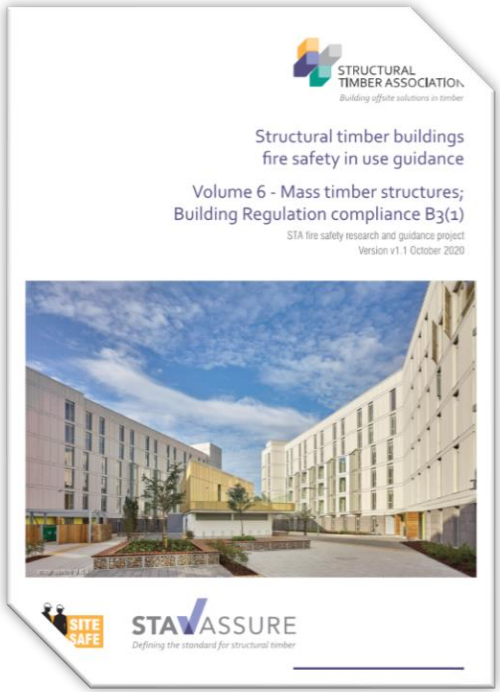
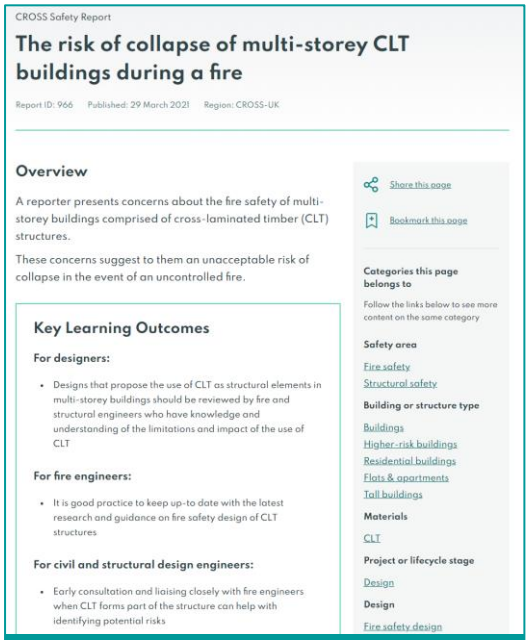
A critical need for compliance guidance

Work instigated by the Fire Sector Federation but never formally published – drafts in circulation not intended for adoption



www.structuraltimber.co.uk/sectors/clt-special-interest-group


CROSS Safety Report

The risk of collapse of multi-storey CLT buildings during a fire

Report ID: 966 Published: 29 March 2021 Region: CROSS-UK

Overview

A reporter presents concerns about the fire safety of multi-storey buildings comprised of cross-laminated timber (CLT) structures.

These concerns suggest to them an unacceptable risk of collapse in the event of an uncontrolled fire.

Key Learning Outcomes

For designers:

- Designs that propose the use of CLT as structural elements in multi-storey buildings should be reviewed by fire and structural engineers who have knowledge and understanding of the limitations and impact of the use of CLT

For fire engineers:

- It is good practice to keep up-to date with the latest research and guidance on fire safety design of CLT structures

For civil and structural design engineers:

- Early consultation and liaising closely with fire engineers when CLT forms part of the structure can help with identifying potential risks

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Safety area

Fire safety
Structural safety

Building or structure type

Buildings
Higher-risk buildings
Residential buildings
Flats & apartments
Tall buildings

Materials

CLT

Project or lifecycle stage

Design

Design

Fire safety design

"The Structural Timber Association (STA) has recently published Structural timber buildings fire safety in use guidance (Volume 6) which sets out credible pathways to demonstrating compliance with the requirements of the buildings regulations"

CROSS UK

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What does it mean to “comply”?

STATUTORY INSTRUMENTS

2010 No. 2214

BUILDING AND BUILDINGS, ENGLAND AND WALES

The Building Regulations 2010

Made	*6th September 2010*
Laid before Parliament	*9th September 2010*
Coming into force	*1st October 2010*

The Secretary of State is a Minister designated(**1**) for the purposes of section 2(2) of the European Communities Act 1972(**2**) in relation to matters relating to the environment.

In accordance with section 14(3) of the Building Act 1984(3) he has consulted the Building Regulations Advisory Committee and such other bodies as appeared to him to be representative of the interests concerned.

The Secretary of State makes the following Regulations in exercise of the powers conferred by section 2(2) of the European Communities Act 1972 and by sections 1(1), 2A, 3, 5, 8(2) and (6), 34, 35, 47(1) and 126 of, and paragraphs 1, 2, 3, 4, 4A, 7, 8, 9, 10 and 11 of Schedule 1 to, the Building Act 1984:

(**1**) S.I. 2008/301.

(**2**) 1972 c.68.

(**3**) 1984 c.55; section 126 is cited for the definition of “prescribed”. Section 1 was amended by section 1 of the Sustainable and Secure Buildings Act 2004 (c.22) and section 2A was inserted by section 4 of that Act; section 47(1) was amended by section 8 of that Act and S.I. 1996/1905; paragraph 4A of Schedule 1 was inserted by section 8 of that Act; paragraph 7 of Schedule 1 was amended by section 3 of that Act and by section 11 of the Climate Change and Sustainable Energy Act 2006 (c.19); paragraph 8 of Schedule 1 was amended by section 3 of the Sustainable and Secure Buildings Act 2004 and by section 40 of the Flood and Water Management Act 2010 (c.29); paragraph 11(1)(a) of Schedule 1 was amended by S.I. 1986/452. Certain functions of a Minister of the Crown under the Building Act 1984 were transferred to the National Assembly for Wales constituted by the Government of Wales Act 1998 (c.38) by article 2 of, and Schedule 1 to, the National Assembly for Wales (Transfer of Functions) Order 1999 (S.I. 1999/672) as varied by article 4 of, and Schedule 3 to, the National Assembly for Wales (Transfer of Functions) Order 2000 (S.I. 2000/253) and have been transferred to the Welsh Ministers by paragraph 30 of Schedule 11 to the Government of Wales Act 2006 (c.32). Subject to certain exceptions and reservations, the remaining functions conferred on the Secretary of State by the Building Act 1984 are transferred to the Welsh Ministers, as far as they are exercisable in relation to Wales, by the Welsh Ministers (Transfer of Functions) (No.2) Order 2009 (S.I. 2009/3019) with effect from 31st December 2011.

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

B4. (1) EXTERNAL FIRE SPREAD

The external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard to the height, use and position of the building.

Performance based framework…

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What does it mean to “comply”?

STATUTORY INSTRUMENTS

2018 No. 1230

BUILDING AND BUILDINGS, ENGLAND

The Building (Amendment) Regulations 2018

Made	*28th November 2018*
Laid before Parliament	*29th November 2018*
Coming into force	*21st December 2018*

The Secretary of State has consulted the Building Regulations Advisory Committee for England and such other bodies as appeared to him to be representative of the interests concerned in accordance with section 14(3) of the Building Act 1984(**1**).

The Secretary of State makes the following Regulations in exercise of the powers conferred by section 1 of, and paragraphs 7, 8 and 10 of Schedule 1 to, the Building Act 1984(**2**).

(**1**) 1984 c.55. Section 14(3) was amended by article 8(1) and (3) of S.I. 2009/3019.

(**2**) Section 1 was amended by section 1(1) to (3) of the Sustainable and Secure Buildings Act 2004 (c 22).

REGULATION 7

…building work shall be carried out so that materials which become part of an external wall, or specified attachment, of a relevant building are of European Classification A2-s1, do or A1, classified in accordance with BS EN 13501-1:2007+A1:2009…

…with a prescriptive anomaly

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Routes to compliance for life safety

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REGULATION 7

...building work shall be carried out so that materials which become part of an external wall, or specified attachment, of a relevant building are of European Classification A2-s1, d0 or A1, classified in accordance with BS EN 13501-1:2007+A1:2009...

Competent decision making

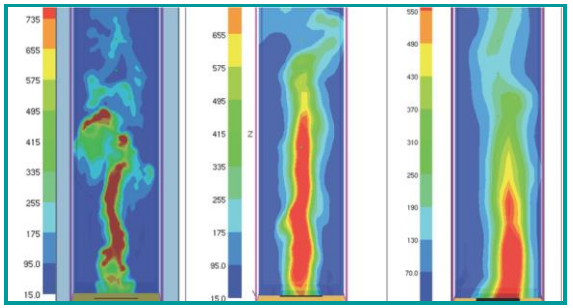
Path for relevant buildings

Path for the common

Path for the uncommon

Standard guidance

Alternative fire engineering solution



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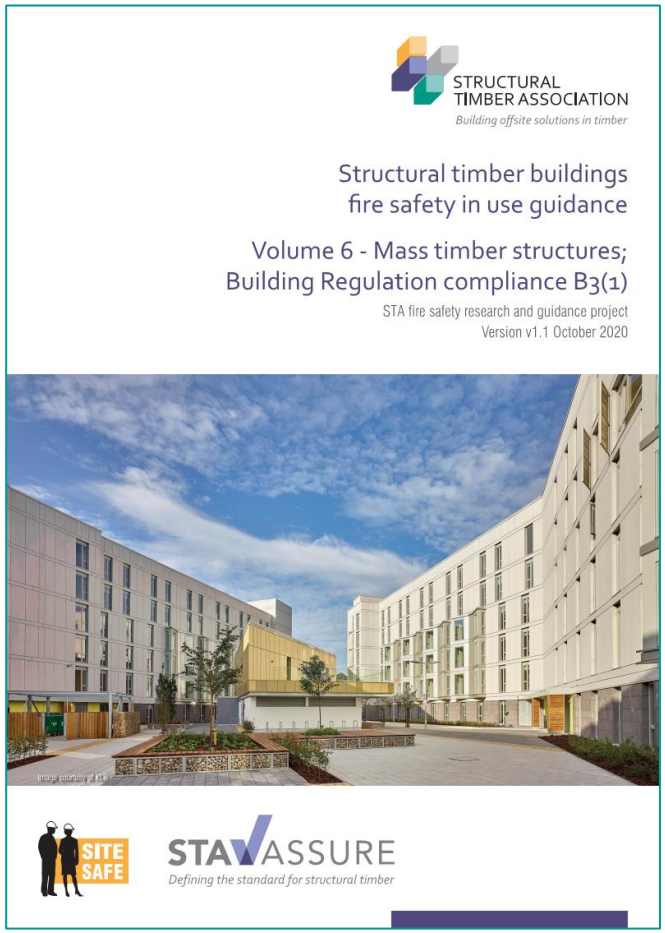
Guidance on the route to compliance (WP1)



- Focussed on structural performance in the event of fire
- Caters for new build only, i.e., no specific guidance for extensions
- Targeted at England, specifically Regulation B3(1)
- Part of a larger suite of fire safety in use guidance
- Underpinned by OFR research as lead consultant to the project

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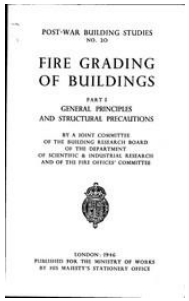
Clarity of objective



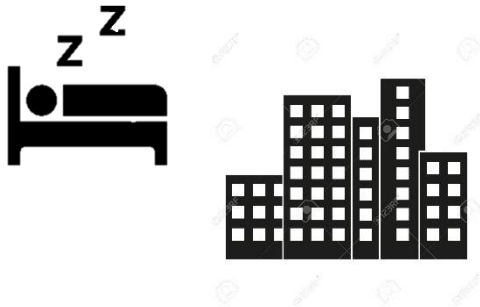
B3. (1) INTERNAL FIRE SPREAD (STRUCTURE)

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

Structural safety objective

Adequate time

Evacuation time is relatively fast
Fire brigade intervention is rapid
and does not require extensive travel
within the building



Adequate likelihood of surviving burnout

Evacuation is protracted
Fire brigade intervention involves extensive travel within the building

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Bifurcation of structural objectives and consequence differentiation

Approved Document A: Consequence Classes

CONSEQUENCE CLASS	CONSEQUENCES OF FAILURE	TYPICAL BUILDING TYPE AND OCCUPANCY - 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)	• 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

Approved Document B: Trigger Heights

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

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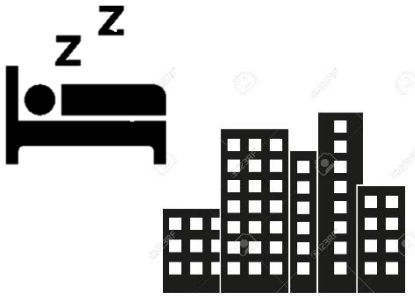
Clarity of solution & design evidence

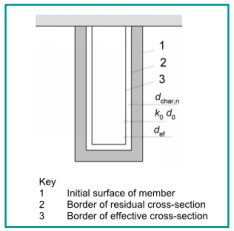
B3. (1) INTERNAL FIRE SPREAD (STRUCTURE)

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

Structural safety objective

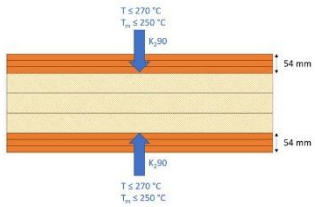


Adequate time



Adequate likelihood of surviving burnout

$$\dot{m}''_f = \frac{1}{\Delta H_p}\left[\dot{q}''_{ext} + \dot{q}''_{ch} - \dot{q}''_{loss} - \left(-k\frac{dT}{dx}\Big|_{x=x_{ch}}\right) - \frac{\partial(\delta q''')}{\partial t}\right]$$



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A consequence-based decision support tool

1. Establish the consequence class

2. Review permissible compliance routes

3. Note constraints on the compliance routes:

Performance-based - always an option

Guidance-based -

Limited to CC1 and CC2
For CC2b this is encapsulation only

CONSEQUENCE CLASS	CONSEQUENCES	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.*

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

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

NOTE 3: *Only 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 fire engineer with relevant experience (see Section 1.4) that the structure has a reasonable likelihood of surviving burn-out with due consideration of: 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 self-extinction is achieved and that the structure subsequently remains stable.*

NOTE 5: *Consequence class 3 structures should be subject to a project-specific system 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.*

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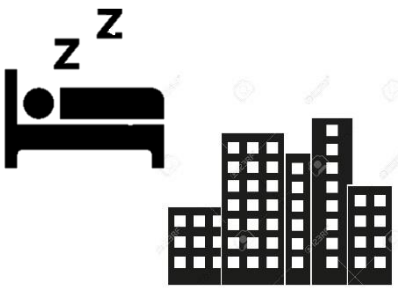
Example application 1

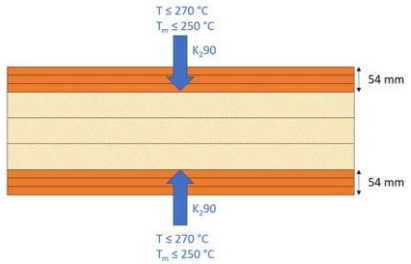


High rise residential building
8 storeys of CLT (CC2b)

A relevant building under Regulation 7 – No CLT can be present in the external wall zone

Structural safety objective

Adequate likelihood of surviving burnout



Fully encapsulated structure for 90 min fire resistance

Exposed or partially protected

$$\dot{m}_f'' = \frac{1}{\Delta H_p}\left[\dot{q}_{ext}'' + \dot{q}_{ch}'' - \dot{q}_{loss}'' - \left(-k\frac{dT}{dx}\Big|_{x=x_{ch}}\right) - \frac{\partial(\delta q''')}{\partial t}\right]$$

Demonstrate self-extinction

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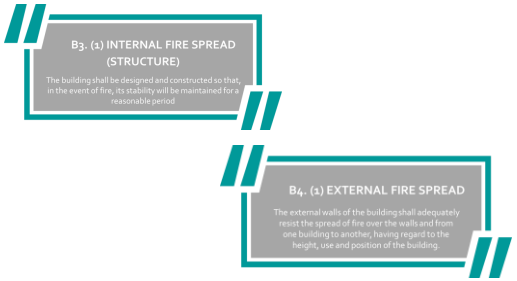
Example application 2

Ground plus two office (CC2a)

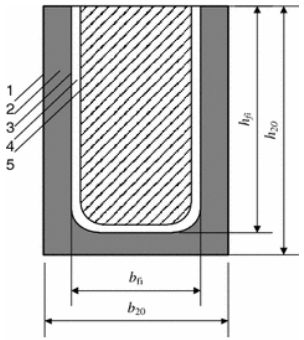


Functional requirements from Part B (note building not within the scope of Regulation 7)

Structural safety objective

Adequate time

Load-bearing structural elements to achieve 60 min fire resistance



Key:
1 Original cross-section
2 Char layer
3 Residual cross-section
4 Zero-strength layer
5 Effective cross-section

Exposed, partially protected or encapsulated

Demonstrate that elements achieve fire resistance

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Musings on extensions

- What to do in the case of an extension to an existing building using mass timber?
  - **It depends…..**
  - Does the extension change the consequence class and, therefore, the performance objective?
  - What are the consequences of the extension 'failing' and would this undermine the integrity of the global structural system?
  - Can the 'failure' of the extension be addressed / mitigated through some other measure, e.g., a strong floor?
  - **Ultimately a case by case discussion with the AHJ**
  - Synergy between the Part A and Part B solutions to the challenge of an extension

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Summary

- Mass timber buildings introduce hazards and challenges that are not present in non-combustible structures
- The first WP has delivered a compliance road-map for B3(1) which guides designers towards the right expertise, design solutions and evidence in function of the consequence class and height of the building
- The road-map supports status quo approaches for straightforward buildings, but promotes more rigorous performance-based assessments where the structure is / may become exposed and falls within a higher consequence class
- The guidance continues to gather traction as BCB, FRS and CROSS cite it as a credible means of demonstrating compliance with B3(1)
- The intention is to update the guidance to include an appendix of example applications
- The STA guidance **DOES NOT ADDRESS ALL THE FIRE HAZARDS OR IMPLICATIONS OF BUILDING WITH MASS TIMBER** – the guidance should be used as part of a holistic fire strategy, delivered by a **competent designer with relevant experience**, in dialogue with key stakeholders

Thanks for listening

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