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

Introduction to the STA SIG project and a compliance road-map for structural fire safety

Dr. Danny Hopkin
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OFR Fire + Risk Consultants

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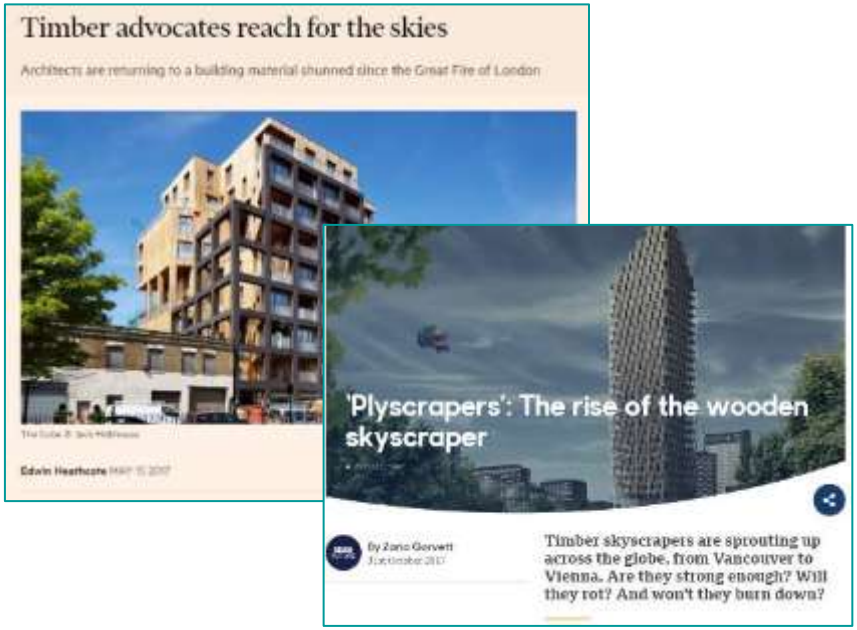
Mass Timber: Ambition & history



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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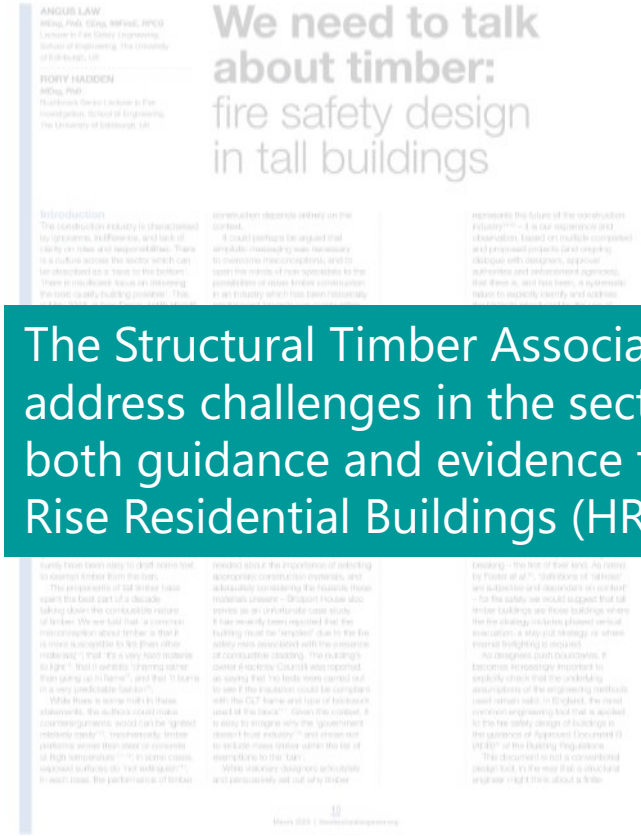
Mass timber – knowledge & competency



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

"It is our experience and observation, based on multiple completed and proposed projects (and ongoing dialogue with 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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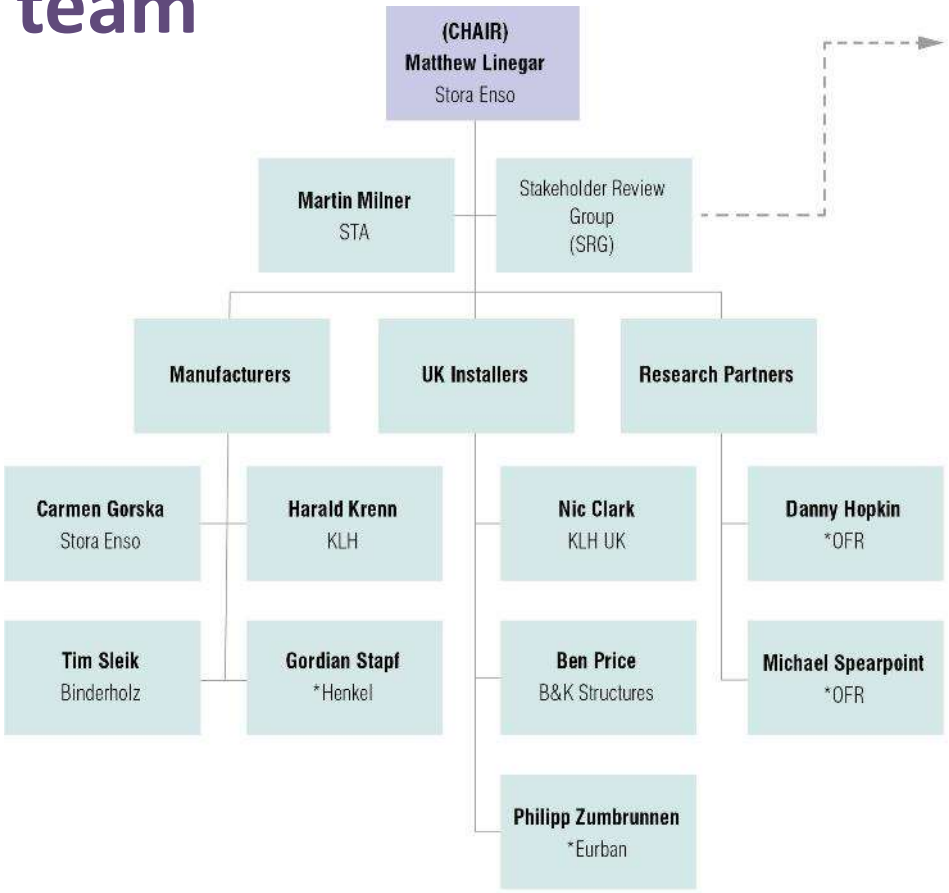
SIG Partners

Funding Partners

Supporting Partners

Project team



* 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

Lynsey Seal
London Fire Brigade

Charles-Elie Romeyer
Ministry of Housing, Communities & Local Government

Andrew Perry
Avon Fire & Rescue Service

Neil Gibbins
Institution of Fire Engineers

Luke Bisby
University of Edinburgh

John Lewis
NHBC

Sarah Sheppard
MD Warranty Inspection Services

Neal Butterworth
Design Fire Consultants

Niall Rowan
ASFP

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SIG project objectives and goals

To clarify routes to compliance and develop / promote a safe working design envelope for mass timber buildings in the UK

Education & promotion of good practice	Knowledge generation	Dissemination
WP1 & WP2	WP3a, WP5 & WP6	WP3 and 4

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Work Packages

Work Packages	Description	Deliverables
WP1 - Compliance framework	Development and demonstration of a compliance framework: The compliance framework will focus on the information that should be produced by the design team to demonstrate that an adequate level of safety is achieved.	- STA Guidance note - Compliance Framework
WP	bers and then the general public on how to apply the Compliance framework	- STA webinar (members) - STA webinar (public)
WP ex	nd horizontal orientation to characterise differences in behaviours of different HBX adhesives	- Test report and journal paper
WP	tests repo ng researc	
W C	ns can be achieved through the application of standard guidance (e.g. ADB). cture's involvement in a fire must be mitigated. This requires full at information is required to support an encapsulated route to compliance and he partner suppliers in an attempt to standardise common details.	- Compliance pathway for HRRB - Gap analysis for manufacturers
W	e to compliance for mass timber HRRB whereby some protection is provided e performance is achieved through the inherent resistance of the CLT. These Regulation 7(2), limiting the amount of combustible material forming the	- Compartment testing - Design report
C research	of calculation tools, design approaches and corresponding experimental / resentative of office construction.	- Compartment testing - Research report

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

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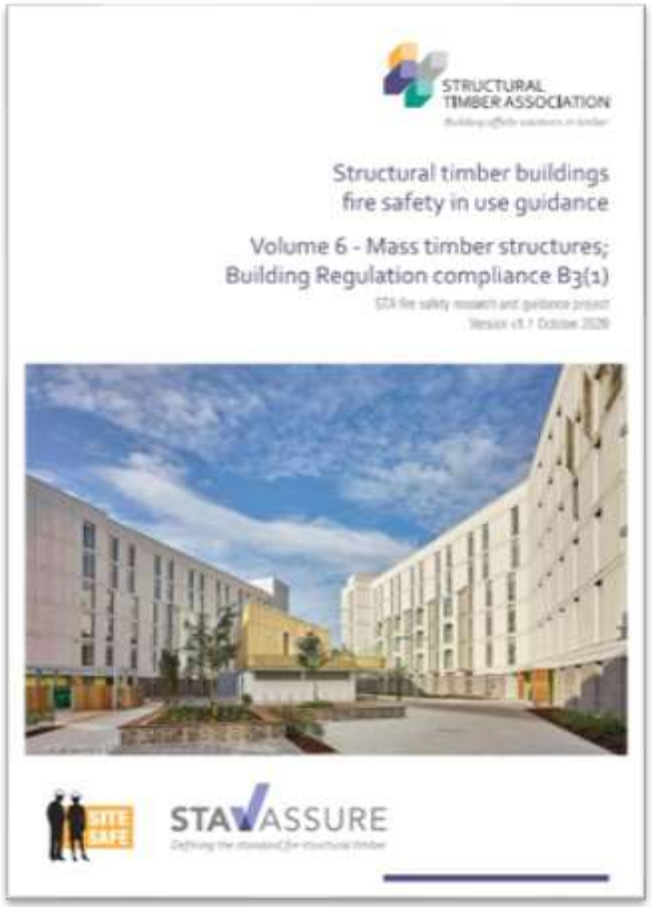
Guidance on the route to compliance (WP1)



- Focussed on structural performance in the event of fire
- Targeted at England, specifically Regulation B3(1)
- Part of a larger suite of fire safety in use guidance
- Underpinned by OFR research & research by others

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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 — 8th 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 1A(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.23) and section 2A was inserted by section 4 of that Act; section 47(1) was amended by section 6 of that Act and S.I. 1999/1999, paragraph 4A of Schedule 1 was inserted by section 6 of that Act; paragraph 7 of Schedule 1 was amended by section 3 of that Act and by section 71 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. 1999/452. 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, so 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 21st 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	28th 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).

...with a prescriptive anomaly

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Routes to compliance for life safety

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.

Path for relevant buildings

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...

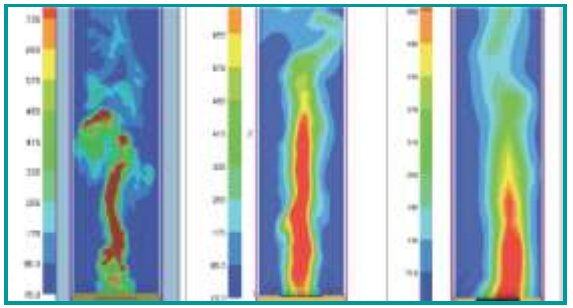
Competent decision making

Path for the common

Path for the uncommon

Standard guidance

Alternative fire engineering solution



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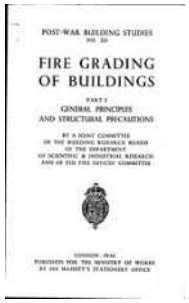
Clarity of objective



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 primarily from outside

Adequate likelihood of surviving burnout

Evacuation is protracted
Fire brigade intervention is internal

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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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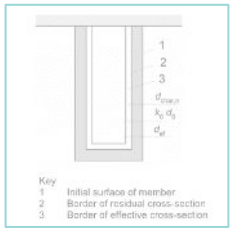
Clarity of solution & design evidence

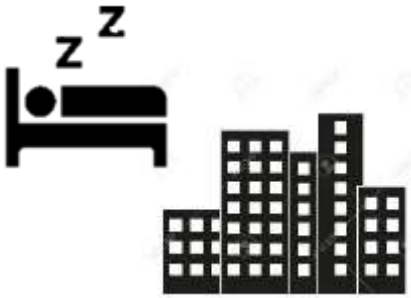
B3. (1) INTERNAL FIRE SPREAD (STRUCTURE)

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

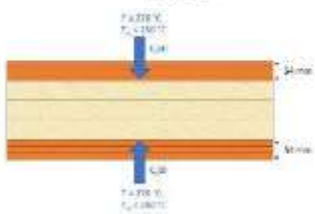
Adequate time





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 for compliance with Regulation B3(1)

Guidance-based – application of a FR from, e.g. ADB

Performance-based – appraisal of the structure relative to realistic fire conditions

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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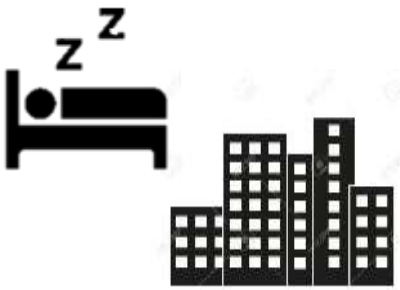
Example

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



High-rise residential building
8 storeys of CLT (CC2B)

Structural safety objective

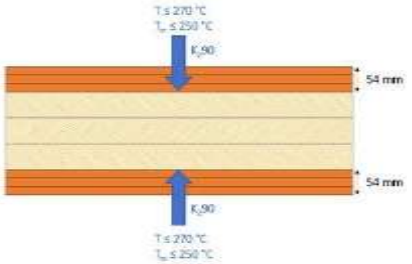
Adequate likelihood of surviving burnout

CONSEQUENCE CLASS	CONSEQUENCES	PERMISSIBLE COMPLIANCE ROUTE	
		GUIDANCE-BASED[1]	PERFORMANCE-BASED[1]
1	Low	Yes	Yes
2A	Low to medium	Yes[2]	Yes
2B	Medium	Yes[3]	Yes
3	High	No[3]	Yes

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



Fully encapsulated structure for 90 min fire resistance

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Summary

- Mass timber buildings introduce hazards and challenges that are not present in non-combustible structures
- These hazards are often not adequately addressed in common routes to compliance, such as through the application of Approved Document B (ADB)
- The STA SIG has been setup to deliver an applied research project that will provide clarity on matters of fire safety compliance and generate knowledge to support competent designers
- The first WP has delivered a compliance road-map 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 project continues to progress at pace and will move towards large scale experiments in early 2021, with a focus on commercial construction (WP6)

Thanks

As project outputs become available, they will be posted on:

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

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