Newsletter 61

Collaborative Reporting for Safer Structures (CROSS) UK

This month we highlight a report raising concerns about the fire safety of multistorey buildings comprising cross-laminated timber structures and the risk of collapse in the event of an uncontrolled fire.

966: The risk of collapse of multistorey CLT buildings during a fire

Full report

This report highlights a growing trend in the industry regarding fire safety of buildings comprising cross-laminated timber (CLT) structures. The concern particularly relates to multistorey sleeping risk buildings in the UK. The design intent typically is to achieve 60 minutes' fire resistance for structural loadbearing elements based on tables in Approved Document Part B (Part B).

Building Regulations and Approved Document B

Compliance with this guidance does not automatically confer compliance with the Building Regulations, which are the functionally based legislative requirements all new buildings must meet. Clause B3 (1) of Schedule 1 in the Building Regulations requires that a building's *'stability will be maintained for a reasonable period'* in the event of a fire.

This, in the view of the reporter, is generally understood to mean that a structure should maintain its loadbearing capacity for as long as a fire could burn given available fuel sources; a fire should be able to develop, grow, naturally decay, and self-extinguish without intervention by the fire and rescue services, and without causing undue risk of collapse.

This is also the original basis for the longer fire resistance standards specified in Part B for multistorey buildings and is referred to as design for burnout. Design for burnout is usually demonstrated by ensuring the structure meets a predefined period in a standardised fire test, e.g. 60 or 90 minutes. However, the aim of the regulations for longer fire resistance durations is not to merely ensure that a test has been passed, but rather to ensure that a building's design is suitable to withstand burnout without collapse.

Is CLT self-extinguishing?

In buildings of non-combustible construction, such as steel and concrete, meeting the prescribed fire resistance in Part B is generally sufficient to ensure design for burnout. However, for combustible construction it is also necessary to demonstrate that the structure itself would self-extinguish as the fire decays, continues the reporter. They go on to say that there is considerable academic research indicating that CLT does not reliably self-extinguish.

Rather than benefiting from the build-up of insulating char, as would be expected from other types of structural timber, delamination (sometimes referred to as char fall-off) often occurs. This delamination process causes underlying CLT layers to become exposed and reignite during a fire. The result can be repeated episodes of charring, delamination, and reignition of underlayers; cyclical burning.

The reporter believes that as CLT does not reliably self-extinguish, one of the following methods should be used:

- →| Demonstration of self-extinguishing behaviour should be provided for the particular CLT construction used.
- →| The CLT should be fully encapsulated in fire-resistant plasterboard (or similar material) to limit the risk of it becoming involved in fire in the first place.

Fuel load from CLT

Part B guidance is based largely on risk associated with the anticipated fuel loading, i.e. the combustible content expected in the building based on its use. However, this is for the building contents only. There is no consideration to additional fuel load contributed by the structure itself.

Therefore, Part B guidance should only be applied in buildings where the structure is not anticipated to burn and contribute additional fuel, i.e. either non-combustible construction or fully encapsulated CLT as noted above.

Fire performance of CLT

A 60-minute design fire resistance period in accordance with the Eurocode (BS EN 1995 Parts 1-2) would assume a char layer will build up over time along the external surfaces of exposed timber structure during a fire. This char layer is then understood to insulate the inner portions of the structure to ensure continued structural stability. The

KEY LEARNING OUTCOMES

FOR DESIGNERS

- →| Designs that propose the use of CLT as structural elements in multistorey 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.
- →| Carrying out a systematic risk assessment for accidental loads, including fire, when using CLT in multistorey buildings can also help to identify and remove risks.
- →| The 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 Building Regulations.

FOR FIREFIGHTERS

- →| Be aware of the consequences of fire involving a multistorey building constructed using CLT.

phenomenon also leads to eventual self-extinguishment of the timber.

However, as CLT burns unpredictably and has a tendency to undergo cyclical burning rather than build up char, the application of the Eurocode method may not be suitable for demonstrating the fire performance of CLT.

Achieving design intent

Although the CLT structure meets Eurocode recommendations, application of Eurocode principles is not suitable, in the opinion of the reporter, to confirm the fire performance of CLT based on its unpredictable charring behaviour.

Furthermore, the design objective of 60 minutes' fire resistance may not be consistent with a full review of fuel loading as the periods in Part B do not account for fuel within an exposed combustible structure.

Lastly, even if the 60-minute fire resistance period was reasonable to withstand burnout, it is also necessary to ensure self-extinguishment of the structure as a fire decays. This cannot be assumed in general for CLT given, among other factors, its tendency to undergo cyclical burning.

Risk of collapse in fire

These concerns suggest to the reporter an unacceptable risk of collapse in the event of fire. What is most concerning is that these types of practices are becoming increasingly common in the industry. Guidance of both Part B and the Eurocode is easy to apply incorrectly. There are likely many other buildings, says the reporter, with exposed CLT structure which pose undue risk of collapse in fire.

In consideration of the above, the reporter recommends that the Eurocode and/or Part B guidance be explicitly changed to identify and mitigate specific fire safety risks of using exposed CLT in structural construction.

Expert Panel comments

In the drive to meet the commitment to achieve net-zero carbon by 2050, the use of CLT and other modern methods of construction will lead to changes to traditional construction. This report questions whether the Building Regulations guidance has kept up with some of these changes.

This could potentially lead to the construction of buildings that may not satisfy the functional requirements of the regulations or the expectations of the owners and their insurers. Some of these buildings might allow fire development that could endanger the occupants, neighbours and firefighters.

Identifying the risks of alternative materials

The use of alternative, reduced-carbon components and methods of construction should be encouraged but only when those involved in the design, construction, approval and management of the building are fully aware of the risks and relevant protective measures.

Designers have to take responsibility for their designs, which means understanding the limitations of codes, and the reporter's case study demonstrates the importance of abiding by this principle.

The recommended fire resistance periods given in Part B are not simply about evacuation times, but also firefighter safety and the safety of people in and around the building. Designers should also consider the preservation of the building itself, and its contents, and prevention of adverse environmental consequences from an uncontrolled fire.

While the Approved Documents are not explicit about the assumptions that sit behind the guidance, there is a wealth of industry and academic literature that details the principles of design for burnout.

Duty of care

For engineers who are using innovative construction materials, their professional duty of care requires particular diligence in checking that commonly applied design assumptions have not been invalidated by their chosen materials or systems. CLT can be used if it has been designed in a thoughtful and correct way with guidance from specialists if necessary.

In response to comments by the Fire Sector Federation via the Building Control Alliance, the Structural Timber Association (STA) has recently published *Structural timber buildings fire safety in use guidance* (Volume 6), which provides guidance on how designers ought to deal with these matters. This sets out credible pathways to demonstrating compliance with the requirements of the Building Regulations that go over and above the prescriptive fire resistance requirements stated in the Approved Documents.

Accidental loading conditions

Chartered structural engineers working on building designs of all types (including multistorey mass timber buildings) will be aware of the requirements for accidental loading conditions, including fire, as detailed in Approved Document A. Clause A3 of Schedule 1 in the Building Regulations states that *'the building shall be constructed so that in the event of an accident the building will not suffer collapse disproportionate to the cause'*. In this context, an accident would include fire.

CROSS is very aware of the importance of CLT and fire, and wishes to engage with all parties to improve knowledge and ensure the safety of occupants and firefighters. More reports and feedback are welcome.

FURTHER READING

CROSS encourages all interested readers to view the following additional resources:

Law A. and Bisby L. (2020) 'The rise and rise of fire resistance', *Fire Safe. J.,* 116, 103188; doi: https://doi.org/10.1016/j.firesaf.2020.103188

Law A. (2019) *Fire safety design: we need to talk about timber* [Online] Available at: www.istructe.org/resources/training/fire-safety-design-we-need-to-talk-about-timber/ (Accessed: April 2021)

Bisby L. (2019) *Adequacy in structural fire engineering* [Online] Available at: www.istructe.org/resources/training/adequacy-in-structural-fire-engineering/ (Accessed: April 2021)

Law A. and Hadden R. (2020) 'We need to talk about timber: fire safety design in tall buildings', *The Structural Engineer*, 98 (3), pp. 10–15

Deeny S., Lane B., Hadden R. and Lawrence A. (2018) 'Fire safety design in modern timber buildings', *The Structural Engineer,* 96 (1) pp. 48–53

HM Government (2020) *Manual to the Building Regulations: A code of practice for use in England* [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/901517/Manual_to_building_regs_-_July_2020.pdf (Accessed: April 2021)

WHAT IS CROSS-UK?

Collaborative Reporting for Safer Structures UK (CROSS-UK) helps professionals to make structures safer by publishing safety information based on the reports it receives and information in the public domain.

Find out more, including how to submit a safety report, at www.cross-safety.org/uk/about-cross-uk.