RiskTopic

Cross Laminated Timber Panels in Construction

With a continual increase in the use of Cross Laminated Timber (CLT) panels as the structural load bearing material in the formation of multi-storey properties, this Risk Topic looks to summarise what a CLT panel is, and to highlight key risks for construction projects and beyond.

Introduction

In the current climate of environmental awareness and the need to reduce carbon footprints in the construction process whilst producing 'green' properties; timber is the preferred choice for many to 'tick the box' of a number of planning constraints, requirements and/or initiatives.

The risk from fire of traditional timber 'stick' frame properties (usually small residential units) is well known. However; as Cross Laminated Timber (CLT) panels are becoming increasingly popular in the UK as a load-bearing factory produced construction material, the risk must be considered. Zurich has seen proposals of CLT construction up to 18 storeys tall. Taller properties are widely discussed in the media.

There is a popular belief that the condensed nature of timber in the panel results in a product that will not burn. However, a CLT fire in 2015 saw a 70% complete university building project suffer a total loss in a matter of hours.

Discussion

What is a CLT panel

CLT panels are factory formed using small sections of timber bonded together with permanent adhesives. In this way, imperfections in the original timber, such as knots, can be removed to reduce variability and enhance structural performance. The layers of timber (lamellas) are bonded perpendicularly to one another, resulting in structural strength across two dimensions, and improving structural integrity and dimensional stability.

CLT panels normally form the structural floor and wall elements of buildings. They are typically delivered to site for erection via crane. As an engineered timber product, with the cross-grain movement controlled by the cross-lamination, it is broadly dimensionally stable and shrinks less than standard solid timber construction. While it is usable on small projects, it is more often used on larger schemes where offsite manufacture and speed of construction can reduce costs.

Factory-manufactured panels can be formed in almost any size, restrictions being as much about delivery to site on the road network as manufacturing. Practical limits tend to result in heights and widths of about 3 m and overall lengths of up to 13.5 m.

The timber used in CLT is kiln dried with a moisture content of around 12%, low enough to prevent pest or fungal attack. It will typically be formed into three, five or seven layers depending on the structural requirements and desired thickness, with a practical maximum thickness of around 350–400 mm.

Figure 1 – CLT Panels as delivered to site.

Positive Points

The use of CLT panel construction has a number of positives for developers, contractors, and the end user:

- As a renewable material, it stores carbon throughout its usable lifespan;
- Avoids thermal bridging (in parapet walls or flat roof solutions);
- Good delivery of airtight envelope;
- Greater load distribution can reduce thickness of transfer slabs;
- Light weight reduces load on foundations so less need for materials with high embodied energy (e.g. concrete);
- Need for robust upfront design may improve overall design and efficiency;
- Robust finished wall will take sundry fixings;
- Simple and fast onsite construction process;

- Suitable for non-visible as well as exposed finishes;
- Vapour-permeable wall construction.

Figure 2 – CLT Panels in situ.

Risks

Documentation refers to CLT panels charring in the event of a fire rather than fully combusting, stating that the initial char acts as a barrier, preventing further combustion of the panel. However, further research has shown conflicting information indicating that charring continues whereby some 85mm thickness of panel may be lost in one hour.

Additionally, further documentation states that 'if the charred layers immediately fall off after charring, the fire protective function is lost' and 'after the charred layer has fallen off, an increased charring rate is expected due to the increased fire temperature.'

Further information states that during exposure to fire, and the resulting effect of temperature on the CLT cross-section, the adhesives between layers can soften. A possible consequence may be that sections of the char layer fall off.'

Zurich considers that CLT panels must be considered combustible whilst untreated / unprotected, as the surface layers will contribute to fire spread. Zurich acknowledges that fire would not commence as readily, nor spread as swiftly as that in traditional (light) timber construction; however, there is still a considerable risk to consider and mitigate.

On agreeing that fire is a risk, Zurich considered the following points:

- Extent of Damage – direct fire damage could be considerable with no effective fire breaks at an early stage e.g. door openings, service ducts etc. would allow surface spread / charring on both sides of a CLT wall, ceilings and floors simultaneously.

- Fire Brigade – Zurich has discussed with London Fire Brigade over their thoughts and potential response to fire at a multi-storey CLT structure. Whilst LFB recognise that a CLT structure may react differently to a light weight timber structure in that it would remain stable for a longer period in the event of a fire commencement; without further testing and experience, the LFB would undertake a dynamic risk assessment on an individual fire basis, and it is highly likely that if there is no danger to life, they would not enter a property to fight a fire and concentrate on protecting surrounding properties.

- Repairs – In the event of charred CLT panels, Zurich queried how damaged panels would be replaced. Discussions at a site survey suggested that charred panels could be easily cut-out and replaced (with temporary propping if required), without the need to remove adjacent undamaged panels.

- Smoke Damage – Tests indicate that CLT panels provide as much smoke as traditional light timber; as such, smoke would damage large proportions of CLT panels above heat damaged panels. Zurich are unclear as to how easy CLT panels are to clean in the event of smoke damage? Would the smell be removed, or would all affected panels require systematic replacement?

- Staircases – We assume that staircases would be timber construction: the staircases would vulnerable to fire commencement and exposure from underneath. Staircases would also allow a fast fire spread between storeys.

- Steel Connections – Any steel connections used to form joints between CLT will be vulnerable to fire damage, even if the CLT boards do only char and remain stable. This will lead to structural issues: how would steel members be tested throughout the structure to confirm suitability; and how are damaged sections replaced?

- Water Damage – Zurich acknowledges that CLT boards are not adversely affected by rain showers, and the laminated structure resists any distortion, allowing the members to dry appropriately to meet the required design specifications. However, during firefighting, large volumes of water will be pumped into the structure. What is the effect on the CLT boards under deluge from firefighting? Is there any issues for the glue between laminations? Will heaters be required to dry members, introducing a potential fire risk?

- 'Bare' Timber – if any bare timber is to be left as a feature i.e. not protected with plasterboard, Zurich understands that an intumescent varnish must be applied. This should consist of three layers, at least one of which is usually solvent-based, brush applied or sprayed. Again, this would introduce a fire risk and bring in conflict between keeping temperature high to enable varnish to set, whilst allowing adequate ventilation.

Guidance

From the above, there are many potential issues and unknowns in the event of any fire within a CLT structure in terms of property retention, including risk from collapse if a large section was lost.

Prevention of fire is the main criteria to enabling Zurich to provide cover. The site must be thought of by all operatives and management as a ‘high-risk large timber construction’ and it must not be assumed that CLT will not burn.

To reduce the risk from fire, The Joint Code of Practice on the Protection from Fire of Construction Sites (JCoP) must be strictly adhered to and improved on where possible: Note Section 23 of the JCoP re large timber frame structures, and the accompanying Checklist.

Additionally to the JCoP and compliance with all appropriate regulatory requirements, the following should be implemented at site as a minimum:

- A wired fire detection system should be fitted throughout the works as they progress, and be linked to temporary accommodation and security office.
- Waste must be removed from the construction works areas daily, with no waste left overnight.
- There must be no storage of combustible materials/ packaging within the buildings under construction.
- Hot works must be removed from site where practicable.
- All sources of ignition must be removed or reduced e.g. lighting, electrics, drying etc.
- The site must be non-smoking bar designated smoking areas located at least 20 metres away from the buildings under construction.
- In addition to other security measures, the site should be hoarded with minimum 3.0 metre high security hoarding.

Conclusion

Whilst the use of CLT panels for construction is relatively new, its use is on the increase, especially for high rise construction.

There is not currently enough history or data to enable positive analysis of the risk profile. As such, Zurich should work with our Clients to understand the projects, the risks involved and how these risk are being managed. It has been seen that a CLT structure will combust.

We are currently comfortable with CLT structures up to 3-4 stories being constructed by well-known competent contractors.

Zurich should attend CLT sites, especially during initial set up and commencement of CLT construction, to ensure adherence to the JCoP and offer an alternative viewpoint for potential problematic areas.

References

Reference 1: BRE Information Paper; Cross Laminated Timber, An introduction to low-impact building materials.

Reference 2: Construction with Cross-Laminated Timber in Multi-Storey Buildings Focus on Building Physics: Holzforschung Austria

Reference 3: Fire Behavior of Cross-Laminated Solid Timber Panels; ANDREA FRANGI, MARIO FONTANA, MARKUS KNOBLOCH and GIOVANNA BOCHICCHIO1; Institute of Structural Engineering, ETH Zurich

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