Timber in Multi-storey Construction

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Timber in Multi-storey Construction

Timber is one of the oldest construction materials and, while it is widely used across the world, steel and concrete are often still the materials of choice for larger residential and commercial buildings. This is starting to change in response to global climate challenges as timber is seen as a sustainable alternative to other traditional construction materials because it is the only building material that can be grown and needs low energy to produce the final product.

Light timber construction systems, such as timber-frame, are well-established both in Ireland and abroad. However, recent developments in timber engineering have led to the development of high-performance engineered wood products with large dimensions, known as mass timber, which can replace steel or concrete in large-scale construction. These products include large glued laminated beams and columns, used in post-and-beam frames, and cross-laminated timber (CLT) panels. The introduction of CLT has led to the development of large commercial and residential timber buildings including multi-storey buildings across the globe.

It is important to be aware that mass timber construction, of which CLT is the most widely known, is different to light timber frame construction. CLT is used in large buildings and requires a specialist design and erection team with a high degree of control and inspection.

In this paper, CLT and its use in multi-storey timber buildings is described and measures to enable the increased use of this construction system in mid-rise (under 5 storeys) and high-rise (above 5 storeys) buildings in Ireland are discussed.

Cross-Laminated Timber (CLT) – The emergence of a modern construction material

- CLT is a **thick timber panel product** manufactured by gluing together several layers of timber boards, with successive layers glued at right angles to the previous one. These panels can have final dimensions up to 400 mm thick, 3 m wide and 18 m long and can be used for building floors, walls and roofs. Wider panels are available but transport restrictions usually determine the maximum width. The cross-laminated arrangement provides strength, rigidity, dimensional stability and high load-carrying capacity.

Five layer CLT panel

- **Offsite prefabrication** of CLT panels leads to high precision products with design flexibility, fast and accurate assembly, reduced construction times and minimal disruption to the neighbourhood.
- The **light weight** of the panels results in reduced foundation costs and ease of assembly. The largest commercial panels can be lifted with a standard mobile crane. The eight floors of CLT for the Murray Grove apartment building in London were erected by 4 men with a mobile crane in 27 working days.
- CLT provides opportunities to use timber products in a **wider range of applications** than was possible heretofore. The last 10 years have seen a significant move to using this technology in the mid- to high-rise construction sector.
- In the UK alone, over **100 educational buildings** in CLT were constructed between 2003 and 2011.
- To date, over **40 buildings between 5 and 14 stories tall** have been completed across the globe. The 14-storey TREET building in Norway is currently the tallest timber building in the world but this record will be broken in 2017 when the **18-storey Brock Commons student residence** is completed in Vancouver, Canada. The 17 timber storeys were **erected** over the concrete ground floor **in 9 weeks** using a single crane. The building is now due for completion 6 months ahead of schedule. Vancouver aims to be the greenest city in the world by 2020 and is the site for what will be the highest CLT building when it is completed in 2017.
- The **London Borough of Hackney** is the first local authority in England to promote timber construction. Since it introduced a **'Timber First' policy** in 2012, more than **18 multi-storey timber buildings** have been built in the region.
- Compared to **the UK**, where **over 600 CLT buildings** have been constructed, this form of construction is relatively **new to Ireland** and until recently has been limited to single family dwellings.

Brock Commons student residence, Vancouver

Image courtesy of Acton Ostry Architects Inc.
Photographer: Michael Elkan

Image courtesy of naturally:wood.com. Photographer: KK Law

- **Two recently completed commercial buildings in Dublin**, the Ballyogen Environmental Management Centre and the Samuel Beckett Civic Campus, have used CLT for walls, floors and roofs.

- Increased use of timber in building construction can positively contribute to **sustainable building** practices. Ease of disassembly allows for **reuse of the material** and a more resource-efficient product life cycle. An important consideration is the fact that the timber building elements **sequester carbon over their lifespan**. Using timber as a replacement for more carbon intensive construction materials has a significant benefit in **avoiding construction-based emissions** from these materials.

- Research and testing has been performed to characterise the **fire performance** of timber structures so that safe fire design can be conducted. Research has shown that CLT exhibits a **greatly improved fire performance compared to light timber**. The thick section size achieves an inherent **fire resistance** that protects the element due to the formation of a **charring layer**. **Additional fire resistance** is achieved with the addition of **gypsum boards** and the use of **sprinklers**.

- Since its introduction in the 1990s, CLT has been the subject of intensive research, which has enabled the development of product standards and design guidelines. The CEN standardisation committee, CEN/TC 250/SC5, has established a working group to draft **new design rules** for inclusion in the next revisions to **Eurocode 5**. Currently, use of CLT is regulated through national or **European Technical Approvals** and the harmonised European product Standard EN 16351:2015.

- About 90% of **CLT production** worldwide is located in Europe, with a total production volume of 560,000 m^3 in 2014. To respond to the rapid uptake of this technology across the globe, plants have recently opened or are planned in Canada, the US, Japan, China and New Zealand. With the demand for CLT growing rapidly, the global production in 2015 rose to 725,000 m^3 and it is estimated to grow to 3 million m^3 in the next 10 years.

Multi-storey timber construction in Ireland

The main constraint to the more widespread adoption of CLT in multi-storey construction, not only in Ireland but also in some other countries, relates to the national building regulations concerning fire safety.

The Irish Building Regulations, mainly through Technical Guidance Document (TGD) B (Fire Safety) currently have limits on the use of combustible materials, these include:

- Limiting the height of a building (currently <10m to the uppermost floor level, generally meaning a maximum of 3 storeys above ground floor level). This only applies in buildings that are required to have a fire resistance of 60 minutes or more.

- Construction of compartment floors in Residential Institutional Buildings shall be constructed using non-combustible materials.

- Construction of compartment walls using materials of limited combustibility in residential institutional buildings, and in all buildings requiring 60 minutes fire resistance, and having a floor higher than 10m over the lowest adjacent ground level.

- Separating walls shall be constructed using non-combustible materials. An exception to this requirement is in the case of 1 or 2 storey timber frame dwellings. (The draft TGD B Volume 2 – Dwellings, exempts timber frame dwellings up to 3 storeys from this requirement, and allows up to 4 storeys if sprinklered).

- The TGD B Volume 2 – Dwellings, also stipulates that the external envelope of a building should not provide a medium for fire spread. It also states that the use of combustible materials for cladding framework may present such a risk. In both cases, this is a requirement even though they may provide a lining classification of Class B s2, d3 (European).

While the TGDs allow alternative approaches to their guidance, in practice it is difficult to get around these limits.

TGD B is being revised and will have two parts; Volume 2 will be for single family housing while Volume 1 will be for other buildings. Volume 2 was recently published and Volume 1 has yet to go to public consultation. The inclusion of any limits on combustible material in Volume 1 could influence the perception on the use of timber in tall buildings. The TGDs permit alternative approaches for compliance with the building regulations and while a high-rise building could be shown to perform satisfactorily in relation to the Irish building regulations, the inclusion of limits on combustible materials could result in additional work for the design team in having a design approved and this may be a deterrent to the use of timber in such buildings.

Many countries are moving towards a performance-based design approach. In the case of fire design, this would mean that minimum national fire performance targets will be specified and the designers will be required to demonstrate that the building design meets those targets. In light of the speed of development of new construction products and technologies, this approach would allow the Irish construction sector to take advantage of these developments.

As the adoption of performance-based design is not likely in the short-term, and given the lack of experience with CLT construction among design professionals and the fire service in Ireland, a proactive approach to disseminating knowledge on fire-safe design of mid- and high-rise CLT buildings should be undertaken. Designers and fire officers from the UK with experience in delivering these types of buildings could provide very useful guidance for both Irish designers and fire officers in developing acceptable design solutions for Ireland.

Reference

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