Fire-safe use of timber

As the push for more timber construction continues because of its low carbon attributes, further research into the fire safety of timber products is important. Recent BRANZ projects added to the available knowledge.

BY GEORGE HARE, BRANZ FIRE RESEARCH ENGINEER

AS COUNTRIES around the world strive to achieve carbon emissions reduction targets, timber is increasingly being used in construction where historically concrete and steel would have been specified. However, unlike steel and concrete, timber is combustible and presents different fire safety challenges.

A BRANZ research project was established to address gaps in two particular aspects of fire engineering in timber construction – first, the spread of flame and associated fire growth with partially timber-lined compartments, and second, a look at the fire performance of mass timber in construction.

Fire growth with partial timber linings

The requirements of New Zealand Building Code clause C3.4(a) are that 'materials used as internal surface linings in the following areas of buildings must meet the performance criteria specified in Table 1'.

The method for determining a Material Group Number is given in C/VM2 Appendix A. Untreated, most timber can only achieve Group 3 when tested to ISO 9705:1993 and therefore cannot be used in some areas of buildings on walls and ceilings. However, Table 1 assumes that the entire surface in question is lined with a single material.

In many cases, partial linings of more-combustible materials such as timber may be desired. Other than the minor exceptions listed in C/AS2 4.17.6 and C/AS2 4.17.7, there is no currently accepted method of considering the fire safety implications of using partial linings of more-combustible material such as timber.

Fire spread performance of EWPs

The research looked at the fire spread performance of a variety of New Zealand-made *Pinus radiata* engineered wood products (EWPs) including medium-density fibreboard (MDF), plywood, cross-laminated timber (CLT) and laminated veneer lumber (LVL).

Small-scale samples were tested in a cone calorimeter to ISO 5660:2015 to determine the time to ignition and heat release rate (HRR). The results were subsequently run through a clustering analysis to see if the different products could be grouped based on performance in the cone calorimeter. The clustering analysis identified a thermally thick and thermally thin group.

A product was selected from each group for testing at room scale – nominally in accordance with ISO 9705:1993 – but with different quantities of wall and ceiling coverage. The products selected were a 9 mm thick and 18 mm thick MDF product from the same manufacturer to minimise any other experimental differences.

Results from the ISO 9705 room-scale testing were combined with data previously collected for 7 mm and 12 mm plywood. They were then analysed to see what limiting factor could be applied to timber materials to achieve the equivalent of at least a Group 2 performance – HRR exceeding 1 MW after a minimum of 10 minutes.

Results

The analysis indicated that the type and thickness of EWP was not a big contributor to performance. With a total coverage area of less than 37%, an equivalent to Group 2 or better could be achieved. However, these results are based only on results at ISO 9705 room scale, and further work would be required to validate the findings at a larger scale.

Area of *building*	Performance determined under conditions described in ISO 9705: 1993	
	***Buildings* not protected with an automatic *fire* sprinkler system**	***Buildings* protected with an automatic *fire* sprinkler system**
Wall/ceiling materials in sleeping areas where care or detention is provided	Material Group Number 1-S	Material Group Number 1 or 2
Wall/ceiling materials in exitways	Material Group Number 1-S	Material Group Number 1 or 2
Wall/ceiling materials in all *occupied spaces* in importance level 4 *buildings*	Material Group Number 1-S	Material Group Number 1 or 2
Internal surfaces of ducts for *HVAC systems*	Material Group Number 1-S	Material Group Number 1 or 2
Ceiling materials in crowd and sleeping uses except *household units* and where care or detention is provided	Material Group Number 1-S or 2-S	Material Group Number 1 or 2
Wall materials in crowd and sleeping uses except *household units* and where care or detention is provided	Material Group Number 1-S or 2-S	Material Group Number 1, 2, or 3
Wall/ceiling materials in occupied spaces in all other locations in *buildings*, including *household units*	Material Group Number 1, 2, or 3	Material Group Number 1, 2, or 3
External surfaces of ducts for *HVAC systems*	Material Group Number 1, 2, or 3	Material Group Number 1, 2, or 3
Acoustic treatment and pipe insulation within airhandling plenums in sleeping uses	Material Group Number 1, 2, or 3	Material Group Number 1, 2, or 3

Table 1: Material Group Number performance requirements from Building Code clause C3.4(a).

Study Report SR474 *Fire-safe use of timber construction II - partial timber linings* has more details (see www.branz.co.nz/pubs).

Fire performance of mass timber

The second part of the project was to look at the fire risk associated with mass timber use in construction, and it was split into three different work packages:

- Passive fire protection of CLT.
- A CLT pyrolysis submodel for B-RISK.
- Testing of mass timber connections in fire.

Passive fire protection of CLT

BRANZ contracted OFR Consultants in the UK to undertake a literature review of international practices and methods for passive fire protection of CLT construction. The study looked at exposed, partially protected and fully encapsulated or protected CLT along with options to achieve each level of protection.

For exposed CLT, fire-retardant strategies were investigated. Although fire-retardant treatments were shown to slow the spread of flame in the early stages of fire growth, once established, the fire-retardant treatments have been shown to have little effect.

Partial protection can be provided by the application of intumescent coatings or a variety of protective board products for encapsulation of the CLT to delay the onset of charring. As the duration of the fire increases, the intumescent or sacrificial board products ablate or fall away, exposing the CLT to the fire.

Fully encapsulated or protected systems generally require multiple layers of protective board products to enable the full burnout of the design fire in the compartment. Although one or more layers of protective boards may fall away, the remaining protection prevents the CLT from pyrolysing and becoming involved in the fire.

External Research Report ER68 *Passive fire protection of cross laminated timber* has more details (see www.branz.co.nz/pubs).

Delamination and B-RISK model

Thermal stability of adhesives was also identified as a problem in the OFR Consultants review.

The US and Canada require the thermal performance of the adhesives used in CLT to be evaluated to ensure that delamination will not occur. If delamination occurs, fire regrowth during decay has been observed as the layers fall off, exposing fresh timber/fuel to the fire.

The delamination phenomenon has been studied by Fire Research Group's Dr Colleen Wade who has added a new feature to the BRANZ B-RISK zone model software that enables modelling of CLT compartments with full or partial CLT wall and ceiling linings.

External Research Report ER67 *Pyrolysis model for mass timber: B-RISK theory* has more details (see www.branz.co.nz/pubs).

Testing mass timber joints in fire

University of Canterbury PhD student Paul Horne, in collaboration with BRANZ, undertook fire resistance testing of a variety of LVL mass timber beam-column joints looking at both shear and moment performance of post-tensioned connections.

Further experiments assessed the performance of similar joints during the decay phase of a fire. The full thesis will be released in due course, but early indications are that joints with exposed steel do not perform as well as expected.

For more information, see *Fire performance of mass timber joints* in *Build* 184.

More challenges to fire safety

This research has helped to address some of the questions around the use of more mass timber in construction and also highlights the fact that further work is required to understand all the challenges to fire safety.