Computational design of glued laminated timber trusses: a comparison of Australian Standard and Eurocode fire safety design implementations.

Gabrielle K. Hodge*[1], Cristian Maluk[2] and Joseph M. Gattas[3]

[1] Arup, Brisbane, Australia [1, 2, 3] School of Civil Engineering, University of Queensland, Australia
(E-mail: gabbi.hodge@arup.com, c.maluk@uq.edu.au, j.gattas@uq.edu.au)

ABSTRACT

There has been a sharp recent increase in utilisation of mass timber products in Australian mid-rise and tall building construction. Mass timber building structures are classified as Type A in the BCA, with corresponding design requirements that ensure an appropriate performance during and after fire. The continued improvements, increasing availability, and importance placed on the sustainability of structures have been critical in the increase demand of mass timber products (Buck, Wang, & Gustafsson 2015). Fire design has been identified as an important aspect of the design of mass timber structures (Law, 1983). A computational design tool to aid in the geometric and structural the design of glue laminated (glulam) trusses has been used to contrast two design approaches for delivering fire safe timber structures. This tool comprises geometry generation, member design, connection design, and generation of BIM model components.

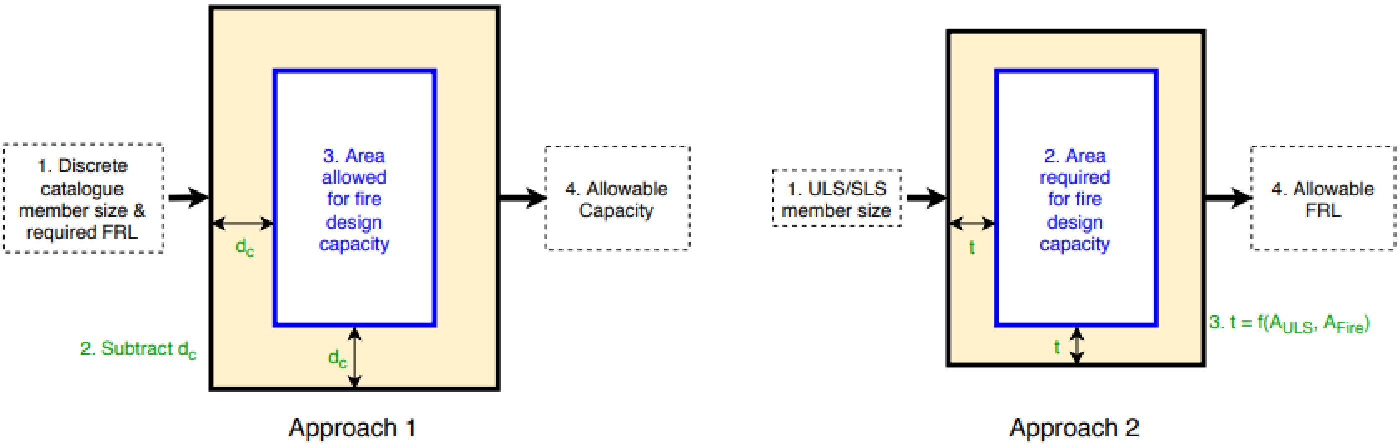

Figure 1. Schematic of the two design approaches to delivering a fire safe timber structure.

The first approach to fire design follows the method contained in the BCA, which involves using a constant charring rate (e.g. 0.56 mm/min for 700 kg/m^3 glulam, as per AS1720.4) for the required FRL (Fire Resistance Level) to calculate the total char depth. This approach offers minimal flexibility to designers, as a prescribed FRL is required, regardless the fire scenario that can be specific to the application being designed. Most times, this can result in members which are conservatively sized for fire conditions.

The second approach considers fire variables such as total amount of fuel, ventilation, geometry of the compartment, among others. This approach follows the Eurocode 1 provision which considers a Eurocode Parametric fire scenario (refer to Figure 2). A constant charring rate (e.g. 0.55 mm/min for 700 kg/m^3 glulam, as per Eurocode 5) is considered as occurring for the full duration of the fire. This method allows for the designer to gauge the effects (and sensitivity) of the type/size of fire to load bearing capacity of the timber structure during and after fire. Whilst this offers significant improvements compared to the first approach, the assumed constant charring rate remains to be a fundamental assumptions of both these approaches.

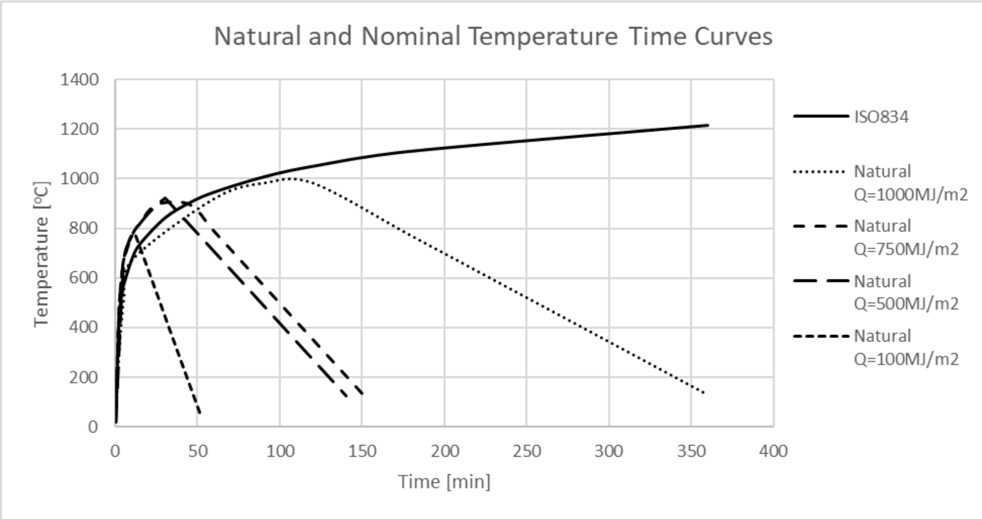

Figure 2. Natural and Nominal Temperature-Time Curve Progression.

Details of three as-built timber trusses, designed in accordance using the Australian Standards, or equivalent processes, were obtained. These trusses were redesigned using each of the fire safety design approaches independently. Applying the first approach, the tool was able to accurately size truss members and connections for three as-built case studies. Using the second approach, a reduction in member size of at least 35% was achieved for all case studies; with member sizes governed by typical ULS and SLS load combinations, rather than fire safety requirements. These findings provide a valuable benchmark of structural design outcomes achieved with contrasting fire design strategies. Findings also demonstrate how a computational design tool developed to support informed designers can result in a more economical and rational design outcome for timber structures.

Keywords: Fire Design, Glue Laminated Timber, Computational Design, Char Depth.

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Reference:

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