Fire Technology, 51, 1279–1284, 2015

Manufactured in The United States
DOI: 10.1007/s10694-015-0497-7

Letter to the Editor

Tall Timber Buildings: What's Next in Fire Safety ?

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1. Introduction

The built environment is constantly changing. Interest has been growing around the world in the design and construction of taller timber buildings. The demand is not only due to the availability of new innovative materials like cross-laminated timber (CLT), but predominantly based upon the need for green and sustainable architecture, driven by building owners, managers and designers who see timber as a positive solution given the sustainable credentials it offers.

The construction industry has started to recognize that timber can offer an economically favorable construction method for mid and high-rise buildings [1], with architecturally modern and innovative solutions. Timber also provides lighter construction that results in substantial savings in foundation works when compared to other materials, leading to development opportunities in areas with poor soils. Another advantage of timber construction is the amount of offsite prefabrication that provides for highly accurate production, leading to faster overall construction times, which reduces building costs and weather protection costs, while increasing returns on investment. Timber also has other benefits in construction, such as significantly reduced crane costs, ease of alteration on site, reduced noise to neighboring areas and also reduced site traffic, especially when compared to concrete construction.

Despite the many positive attributes, timber is often viewed negatively, due to the perception of an increased fire hazard, which continues to be reinforced by some model building codes. In turn, codes have limited the use of timber to low-rise buildings only. The resurgence in timber construction has also led to questions over the use of timber in a role that many in the construction industry are not familiar with—a combustible structural material being utilized to heights of ten stories or more. The lack of familiarity with the material, limited project examples and the small number of skilled and experienced engineers within the construction industry has resulted in calls for additional fire research and testing. It is understood that new innovative products like post-tensioned CLT systems [2] will need more fire testing, as would any new innovative product. However, researchers, academics and engineers around the world have worked for decades to establish the collective knowledge on the performance of wooden structures under fire conditions [3–7] and this existing library of information needs to be better utilized. Therefore, the timber industry itself also needs to

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determine how best to provide answers and promote the existing knowledge, such that timber is chosen based on sustainability and economics.

So where to next for the timber industry—more research? More testing? more innovative products? In my opinion, the fundamentals for the future of timber as a fire safe building material require two areas of emphasis—education and targeted research.

2. Education

It is apparent that one of the key fundamental problems facing the timber industry in the use of timber as a high-rise building material is education. By education, this is not just raising awareness, but elevating the skills and knowledge of fire safety/protection engineers in the design of timber high-rise buildings. Fire departments, authorities having jurisdiction and especially fire safety/fire protection engineers, all need to have a greater understanding of how high-rise timber buildings can be constructed in a fire safe manner [8]. The timber industry has focused on education on low-rise buildings and has lagged in developing education on medium and high-rise buildings, which has been understandable, given the market demand, which has been driven by codes. Industry groups representing timber manufacturers and suppliers have roles to play, but more importantly, universities also need to provide equal lecture hours among concrete, steel and timber and offer more post-graduate opportunities in timber research.

I have also unfortunately seen and been exposed to numerous questions from very experienced and knowledgeable fire safety professionals that show they have a lack of familiarity with timber construction and associated research studies. Some examples include: confusion on the difference between combustibility and fire resistance ratings; the differences between light timber construction and mass-timber construction; and not understanding how a timber column or beam can achieve a 2 h fire resistance rating (Fig. 1). All of these questions have been extensively studied, typically since the 1970s by NRC (Canada), Forest Products Laboratory (USA), CSIRO (Australia), BRANZ (New Zealand), SP (Sweden), VTT (Finland), ETH (Zurich) and numerous other research agencies. Taken together, the resultant research has clearly shown the reliability of correlations for predicting the fire performance of timber.

3. Targeted Research

As more timber buildings are planned and constructed, it is evident that the two key construction products being utilized are glulam and CLT, often in combination, as can be seen with the new tallest timber building under construction, the 'Treet' in Norway [9].

The first glulam buildings were constructed in the early 1900s in Europe [10] and glulam has had decades of fire testing since, but CLT is still a relative newcomer to the construction industry. CLT was first used about 20 years ago in Austria and whilst Europe continues to lead the way in CLT construction, other

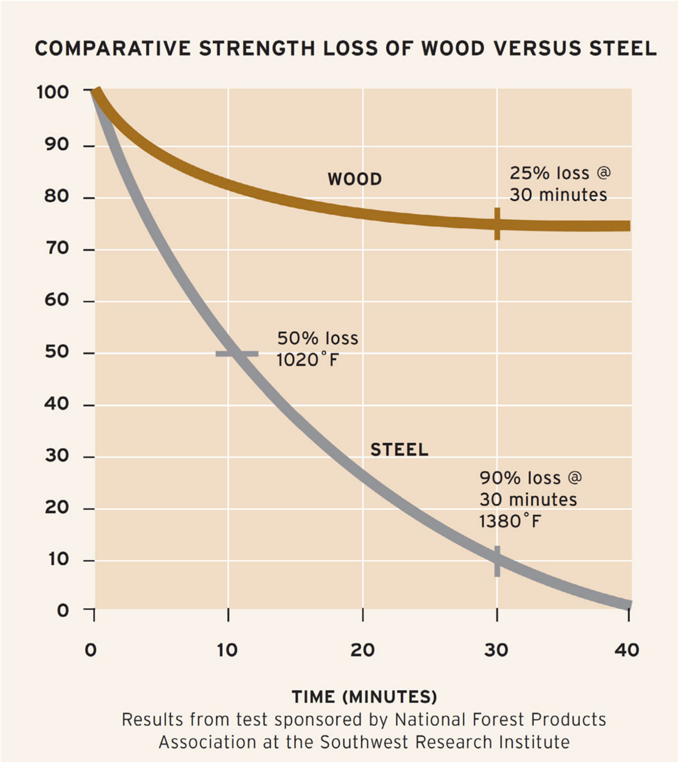

Figure 1. Comparison of strength for a W16 × 40 steel beam and a 7″ × 21″ glulam beam, with full loading within an ASTM E119 fire test. The steel beam collapsed after 30 min while the glulam beam remained in place, charring on 3 of the 4 faces (American Institute of Timber Construction).

countries are starting to see demand for CLT construction increase [11]. But does CLT have the test based evidence to support its use as a high-rise construction element, where it is used as load-bearing floors and walls? This is where the targeted research is required, to prioritize understanding of the knowledge gaps with CLT.

Fire testing of CLT has occurred mainly in Europe and Canada [12]. Tests have provided ample data on fire resistance for fully loaded CLT wall and floor panels, up to 3 h. However, much more test data is unavailable for use as it is proprietary documentation owned by the CLT manufacturers. Recently, CLT has been tested as a load-bearing element in both furnace and natural fires through the Canadian consortiums of FPInnovations [13] and NewBuildS [14], resulting in significant standard and natural fire test information (Fig. 2). Building on the European work, the collation and derivation of simplified correlations for determining how CLT chars and achieves an FRR is now available within the "CLT Handbook". The Handbook

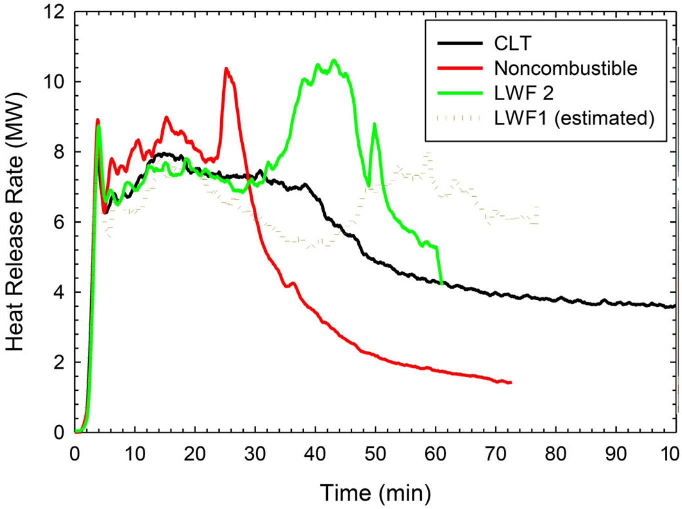

Figure 2. Comparison of identical room fire tests with differing wall and ceiling assemblies, showing that there is relatively insignificant differences in peak HRR of fire development, for the different assemblies of non-combustible, light-weight wood frame and encapsulated CLT [19].

summarizes the results of numerous fire tests from both Europe and Canada, and is a significant resource for understanding the fire performance of CLT.

But not all questions about CLT are answered. It is evident that two remaining topics still require additional research, testing and understanding:

(1) The contribution of exposed timber within a compartment, particularly in a residential setting, where the timber may be desired by architects to be exposed on the ceiling and walls, potentially representing 50 % to 75 % of the surface finishes, continues to need research [15, 16]. Recent work by FPInnovations and NewBuildS, has shown that a compartment with all surfaces of exposed CLT will result in an increased peak heat release rate [17]. More testing with natural fires is required to accurately determine the increase in HRR to ensure fire resistances are provided to resist full compartment burn-out, where CLT is exposed through architectural design;

(2) A second and directly connected issue is that of self-extinguishment of exposed CLT, where a design requires ceilings and walls to be mostly exposed. Limited research to date has shown that self-extinguishment will likely occur, but long-duration fire testing with natural fires has not occurred [7]. Again, once further testing in realistic compartment situations has taken place, the issue of self-extinguishment can be accounted for and assessed appropriately.

From a constructability point of view, fire safety/fire protection engineers need to understand the specific aspects of compartment fires with a majority of the walls and ceilings as exposed CLT. This requires the highest priority research, as architects desire more CLT to be exposed within their buildings. Where CLT is concealed behind fire grade gypsum plasterboard, there is adequate fire testing to show that CLT has little if any impact on the compartment fire properties [5, 11, 18].

I also find it interesting that AHJ's are asking that buildings with exposed CLT and glulam with code compliant fire resistance ratings are required to prove the structure and fire barriers can withstand a full-burn out of a compartment. Yet that question is rarely if ever asked when a structure is constructed from concrete or protected steel.

4. Summary

The desire to build sustainable buildings has led many to consider timber as part of the primary load-bearing frame. However, timber buildings are currently limited by prescriptive code legislation and in many jurisdictions, a reluctance to allow evidence based performance solutions. Model building codes that limit the use of materials based on type, rather than fire performance, are the greatest barrier to the use of timber. Model building codes therefore need to reflect the science and engineering capabilities of a construction product.

As knowledge and understanding of the fire performance of new timber products such as CLT develops, the potential for change in building codes becomes increasingly possible. Through increased education to improve the understanding of how timber performs in fire and targeted research to assist with the implementation of innovative timber elements, we should expect to see more tall timber buildings being safely constructed.

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