Wood Products And Sustainable Construction

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SUMMARY

The remarkable growth of engineered wood products (EWP) in the last decade of the twentieth century constitutes one of the success stories of the wood products industry. The sector's success has been driven by technology which has broadened the range of usable raw materials, including plantation fibre and previously underutilized species such as aspen. The design, production and building process for North American residential construction has kept pace with the evolution in building materials. Wood platform-frame construction has evolved from a long tradition of conventional practices where housing materials are brought to the building site and assembled in sequence by various building trades and construction workers. Recent developments have been the incorporation of pre-engineered roof, floor and wall systems into the conventional on-site home building process and the rapid growth of manufactured, panelized and modular home construction. In addition to affordability and quality, wood platform-frame construction offers superior performance under earthquake conditions. Recent improvements in design and materials have made wood frame structures comparable to other building systems with respect to durability and fire performance. Finally, life cycle analysis of different building materials has demonstrated unequivocally the environmental advantages of wood construction.

Keywords: Engineered wood products, Platform-frame construction, Life cycle analysis

INTRODUCTION

Wood-frame construction has been the mainstay of the North American housing market for some 200 years. It has developed into what we now know as "platform-frame" construction, a building system that is gaining acceptance worldwide because of its: affordability; superior performance; beauty; and flexibility in design, construction and renovation. This flexibility has enabled the evolution of platform-frame construction through responses to the changing needs of both the construction industry and the homeowner [6, 3].

ENGINEERED WOOD PRODUCTS

In the last 15 to 20 years, we have seen significant changes in harvesting profiles across Canada as sources of larger timber less readily accessible, as closer utilisation standards (less sound wood left on the harvest site, and more complete usage of harvested wood) have been implemented, as utilisation of broadleaf species has increased, as environmental regulations have been developed and implemented, and as new fibre sources come on stream from plantation forests. This change in profile has resulted in a general decrease in piece (log) size, an increase in the number of trees and diversity of species harvested, and, in many instances, a decrease in wood quality. The emphasis in wood products manufacturing also has changed, with further breakdown of timber into strands, veneers and fibre constituents which have then been reconstituted into new lumber, panel, and other construction products. These engineered wood products (EWP) are of high uniformity and well-defined performance properties. These products have broadened the range of raw materials, such as trembling aspen and plantation hybrid poplars, that can be used in structural applications. As well as being able to use lower quality fibre, EWPs require less fibre to produce the same strength characteristics as dimensional lumber. Notable examples of EWPs used in structural applications include finger-joined lumber, laminated veneer lumber, glued-laminated lumber, parallel strand lumber, oriented strand lumber, plywood, and oriented strand board. In our quest to extend wood fibre and product performance, research efforts are leading to an array of new composite products, such as bark board, based on wood residues, and strawboard which is based on agricultural residues. As well, we are seeing the development of new high performance products made out of wood and non-wood materials such as plastic and cement. While many factors have contributed to the evolution of EWPs, customer demand, fibre supply and quality, environmental concerns, and new technologies have been the principal drivers from the global perspective. In turn, EWPs have provided additional flexibility and impetus to the evolution we have seen in design, production and building of wooden platform-frame structures in North America.

NEW CONSTRUCTION TECHNIQUES AND APPLICATIONS

Construction techniques have evolved to meet changing market needs. We are seeing less on-site housing construction and more factory pre-fabrication of components or complete structures. Shortage of skilled framers has driven this change. In North America, 95% of roof trusses in stick-built houses are manufactured off-site. We are also seeing similar trends with respect to wall and floor systems. The use of engineered wood I-beams has increased dramatically; I-beams are now found in 40% of all houses built. This growing integration of pre-engineered systems into conventional construction in North America fostered an explosion in the development of innovative roof, floor and wall construction systems. New technologies for other systems in the house, such as energy-efficient building-envelope and ventilation systems, were introduced at about the same time. Panelized and modular home construction techniques are gaining considerable popularity in Sweden and the US. They are fast becoming cost-effective methods of construction and result in a high quality end- product. As the quality and performance of conventional platform-frame construction systems became better understood and documented, designers increased their confidence in using wood platform-frame systems for complex, non-traditional end-uses such as engineered multi-family residential and non-residential construction. A recent development has been the growth of hybrid construction in which the wood frame system is used in combination with other systems. One example is condominiums that consist of a concrete garage and possibly a structural steel or concrete commercial first floor, upon which is built a multi-storey wood-frame structure. Considerable interest in such “hybrid” construction is being shown both inside and outside of North America (Europe, South America and Asia). There is also considerable potential for increasing wood product content (including EWPs) in non-residential construction, again both inside and outside of North America [5]. In the United States, for example, the amount invested in non-residential building construction (including schools, offices, stores, public buildings) is not that much less annually than the amount invested in new home construction, yet at present, these structures consume only a small fraction of wood products. While some of these non-residential buildings are precluded from using wood for code-related reasons, such as those over four storeys in height, it is estimated that fifty percent of the buildings constructed could be utilizing wood as the main structural material and remain within existing codes. Further research and development are essential in order to expand the development of EWPs and provide optimal building solutions for the non-residential market.

NORTH AMERICAN REGULATORY PROCESS FOR WOOD-FRAME CONSTRUCTION

There are two main ways for a builder to gain regulatory approval for construction of a house in North America: through either conventional or engineered construction provisions of the Building Code applicable to the site. The provisions for conventional housing construction found in North American Building Codes have evolved along with the platform-frame construction system. They are developed and maintained by a committee process that includes various stakeholders. The prescriptive provisions for conventional wood-frame construction are based on best available knowledge and 200 years of experience. They are deemed to comply with the design provisions of the applicable Building Code. Using conventional construction techniques, certain materials are pre-engineered (for example, span tables for lumber joists). The engineering design calculations for sub-assemblies (e.g. roof trusses) and engineered wood products (e.g. laminated veneer lumber) are performed by the manufacturers for use in conventional construction. Therefore, the use of such products also does not require the builders to have a design professional to design and approve their use. Alternatively, each Building Code in North America references a Design Standard for each material. A builder can also choose, for example, to use an engineered home design. In this case a design professional specifies the materials and certifies that the design conforms to the provision of the Building Code applicable to the site. All on-site, permanent home construction is subject to local Building Code regulations. However, in the United States there is one other mechanism for gaining regulatory approval. There is a category called “Manufactured Homes” (formerly “mobile homes”). These are homes that are assembled off-site, put on wheels and transported to the site. These homes are subject to provisions provided by the US Department of Housing and Urban Development.

PERFORMANCE OF PLATFORM-FRAME CONSTRUCTION SYSTEMS

Various surveys and focus groups, including architects, builders and homeowners, have suggested that there are about a dozen attributes that are deemed to be important in a home (Table 1). Wood-built structures score very high with most of these attributes. Nevertheless, there have been notable concerns expressed about the issues of strength, fire safety, durability and environmental merit of wood construction. These concerns pose serious obstacles to extending or even maintaining the use of wood. While some concerns are legitimate, others are not.

STRENGTH AND SAFETY

Timbers have been used as structural members in buildings for centuries and have proven to be an excellent material for structural applications due to their superior ratio of strength to weight. Tiemann [9], in his authoritative review of wood and other structural materials, concluded "weight for weight, dry wood without defect is stronger than steel." In early aviation, airplane fuselages were often constructed from wood, only to be later replaced by lightweight metals, such as aluminum alloys. Data on the specific load carrying capacities of wood, steel and concrete confirm the favourable strength–to-weight ratio of wood [1]. Extensive seismic testing, using the shaketable and cyclic racking, on wood systems and structures has demonstrated the superior performance of wood platform-frame construction. In addition, post-earthquake assessments at Northridge and Kobe showed that very few fatalities were associated with platform-frame wood buildings. A recent survey of the impacts of seven major earthquakes between 1964 and 1995 revealed that only 34 reported fatalities could be attributed to failure of platform-frame wood buildings [7]. The evidence strongly supports the conclusion that platform-frame wood structures achieve life safety objectives under severe earthquake conditions. The public generally has a negative perception about the fire safety of wood structures. In the past, fire codes were strongly biased against wood construction. Indeed, wood is a combustible material. However, the critical issue is one of public safety, namely, how long does a structure need to maintain its integrity and strength under fire loads in order to allow for the safe egress of its occupants. Forintek, working with an international consortium of fire scientists, has evaluated the fire performance of different construction materials and systems. The results [8] have led to significant revisions in the building codes, which, in turn, have resulted in fairer treatment of wood-frame construction systems. An ongoing effort is needed to ensure wood construction is fairly evaluated by code officials and the public.

DURABILITY

Rot from excessive moisture and damage from termites have been perennial issues with wood structures. We continue to have problems worldwide with building envelope failures because design and construction practices have not adequately protected wood in wall and roof assemblies from getting wet. If wood is wet for too long, it will rot, as we have seen with the 'leaky condo' problems in Vancouver, Canada, and elsewhere. When we examine the situation more closely, we see that the problem is invariably a question of poor design, poor construction, poor maintenance, or a combination thereof. When these issues are addressed, wood structures can last indefinitely. More research and better education of architects, specifiers, builders and homeowners are required. There is a need for further research around the moisture management of wood structures as well as more aggressive technology transfer and training programs for architects and the construction industry. Where the fault does lie with the material, new innovations and alternative materials should be sought. In the end, when it comes to the choice of building material, we have to recognize that there will be circumstances where wood should not be used. Termite damage in wood structures poses another major threat. The voracious formosan termite (C. formosanus) has become a major pest throughout the tropics as well as in California, the Southern US, Japan, China and Taiwan. Conventional control strategies are generally costly, can be hazardous, and have limited long-term effectiveness. Alternative strategies are needed. Borate treatment of wood products has proven to be a very effective control agent under conditions where it is not susceptible to leaching from excessive exposure to water. Borate is non-toxic to humans, environmentally benign, cost–effective, and comparable in efficacy to treatment with CCA. It is now widely used in Hawaii, and is rapidly gaining popularity in the Southern US and Japan where wood construction predominates.

ENVIRONMENTAL MERIT

It is hoped that in the future, when designers and users are deciding on building materials, greater consideration will be given to wood's superiority when it comes to its softer environmental footprint as compared to that of other materials. It is rather unfortunate that environmental sustainability has had such negative connotations for wood products when, in reality, of all the mainstream structural materials, wood is the only renewable resource. Public perception around timber harvesting and wood construction remains an area of major concern around the world. Globally, the building industry and interested publics have seen the issues around resource extraction and utilization as mutually exclusive, i.e. either build in wood or save the forest. Our challenge is to encourage people to look at these two issues on the basis of solid scientific information. In North America, the issues associated with harvesting trees are considerably more emotional and complex than those surrounding wood construction. In Canada, industry and government are attempting to address these issues on several fronts. Forest reserves and parks are being established to protect a diversity of ecosystems (e.g. over 12 % in British Columbia); forest management is continually improving; forest practice codes have been implemented across Canada; and third party certification of forest practices and products is being implemented. All of these actions are a statement of industry's and government's commitment to ensure an abundant and sustainable forest for future generations. We know, for example, that today there is more wood growing in North America than there was 30 years ago [4]. Indeed, in the global context, the supply of timber continues to outstrip demand (Table 2) and, with the rapidly growing plantations coming on stream, we anticipate that this trend will continue. Construction has a significant impact on the environment. It accounts for 10 % of all global activity: it utilises 40 % of the world's materials and energy production, 17 % of the fresh water consumption and 25 % of the global wood harvest. A few years ago, Forintek Canada Corp. initiated the development of life cycle methodologies to assess the environmental merit of different construction materials. This initiative eventually led to the creation of the Athena Sustainability Institute, which today is internationally accepted for the quality and credibility of its research. Life cycle comparison of various structures constructed in wood, steel and concrete have conclusively validated the environmental superiority of the wood-based design. The environmental performance of a typical single-family house constructed with three different materials is presented in Figure 1 [2]. The wood house has a concrete basement with a wood frame and a wood roof system; the steel house has a concrete basement, a steel frame and a wood roof system; and the concrete house has a concrete basement, a concrete frame and a wood roof system. The results show that for most environmental indices, wood strongly outperforms the competing materials. Material waste on-site is the only exception where steel exhibits an advantage. However, the trend is towards less wood waste on-site. This is due to the move to prefabricated components and EWPs, growing interest from architects for optimizing wood usage on site, and growing regulations to reduce wood waste in landfills. Also, it should not be forgotten that wood is the only mainstream structural material that is renewable. We are all aware of how important forests are for sequestering and storing carbon, and what an important role they can play in mitigating global warming. Wood products can also play a significant role in extending the length of time that this carbon remains stored. In addition, more recycling of these products will further enhance this attribute. Overall, wood usage has an impressive array of attributes when it comes to environmental merit, namely, it captures solar energy; it absorbs carbon dioxide during all phases of its life cycle, it sequesters carbon dioxide until the wood decays or is burned; it is renewable (harvested forests can be regenerated); it is minimally and cleanly processed into lumber and other building materials; it is recyclable and biodegradable; and it is a better insulator than either concrete or steel. It is expected that factual and effective communication will demonstrate, to the public and the construction industry, the environmental merits of wood construction using wood products from sustainably managed forests.

SUMMARY

Safe, affordable, healthy and environmentally friendly housing is a basic human necessity, and probably one of the most challenging social issues facing countries around the world. Wood usage will continue to grow, particularly in construction applications, as more people come to appreciate its environmental merit and superior structural performance. Indeed, we are seeing evidence of that in established markets such as North America, Japan and parts of Europe, and in emerging markets such as China, Taiwan, Korea and parts of South America. Platform-frame construction has been and will continue to be a building system of choice for many generations to come. It has the flexibility to evolve with changing societal needs and conditions.

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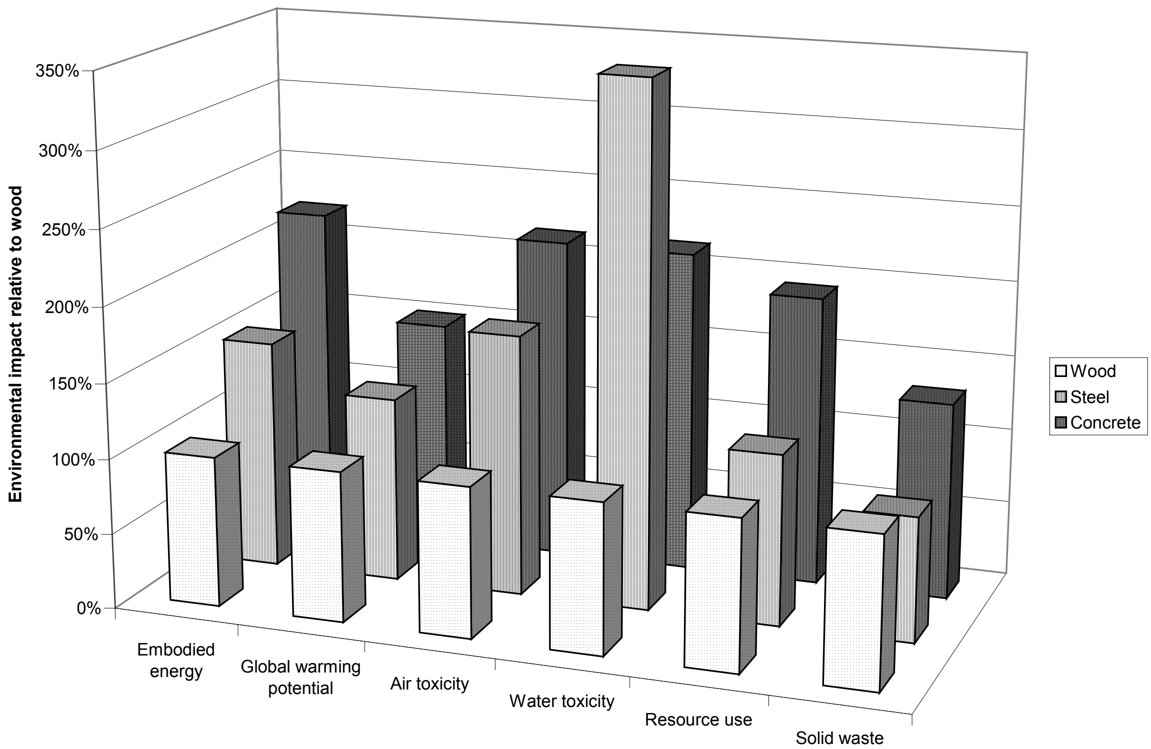
Table 1 Attributes of shelter systems deemed important by architects, builders and homeowners.

Attributes of Shelter Systems	
Natural	Affordable
Appearance and Style	Low Maintenance
Design Flexibility	Adaptable
Healthy	Multi-Functional
Guaranteed Durable	Comfortable
Safe	Energy Efficient
Environmental Merit	

Table 2 Timber harvest as a percentage of wood increment.

Region or country	%
Europe – 41 countries	59
EU – 15 countries	64
Nordic countries	72
Baltic countries	50
Central and Eastern Europe	56
Russia	16
North America	79



Source: Pepke, UN/ECE Timber Committee, pers. comm.

Figure 1. Environmental impact of wood, steel and concrete home.