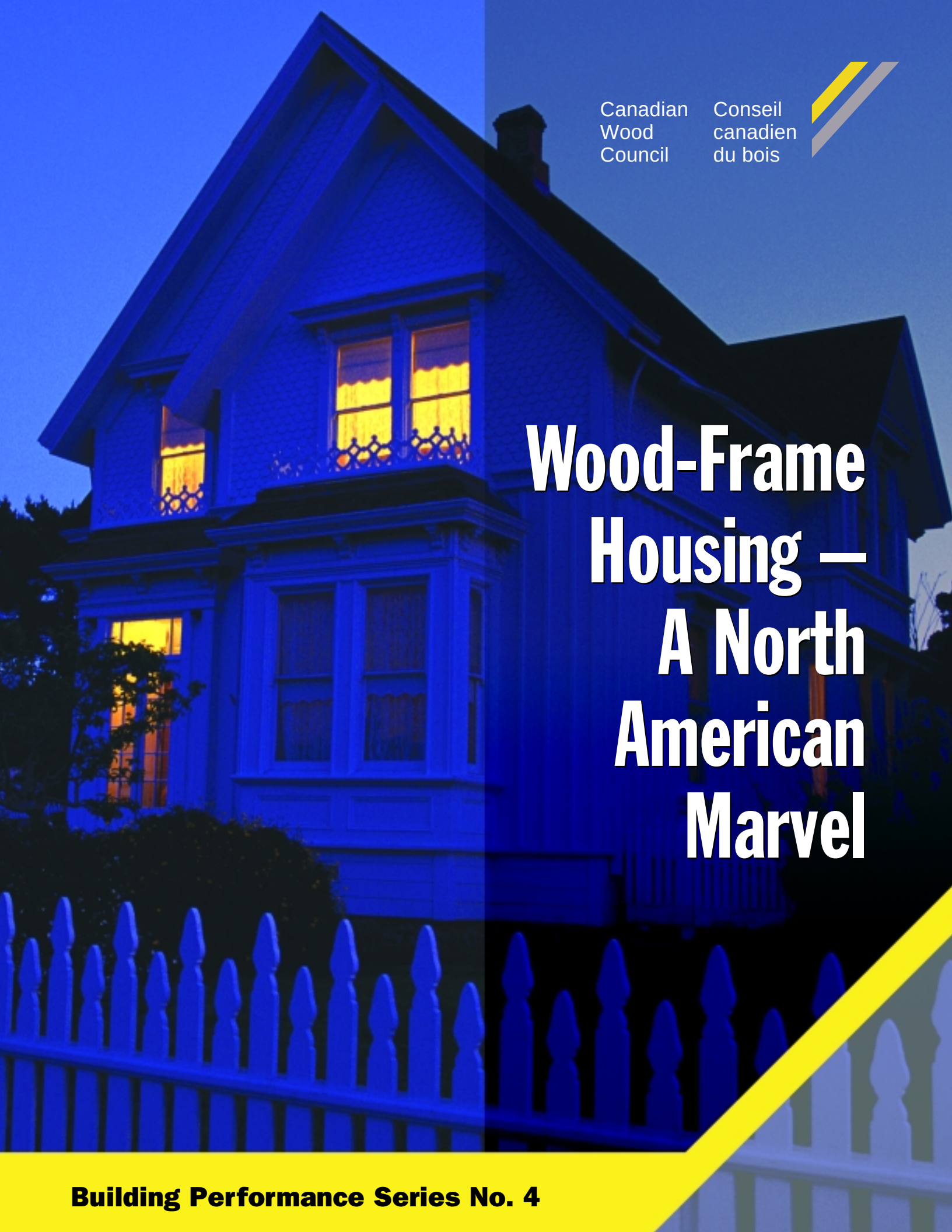

Canadian Wood Council

Conseil canadien du bois

Wood-Frame Housing — A North American Marvel

Building Performance Series No. 4

Wood – The Choice for Builders

North Americans enjoy the highest standard of safe and comfortable housing in the world. This is not by chance – wood-frame construction is the residential building system of choice and many countries wishing to improve the comfort and security of their citizens are adopting it.

North America is blessed with resources of all kinds. A continuing abundance of forest resources has, since the earliest settlers, encouraged using wood to build housing.

Today, as designers, builders and homeowners pursue safe, energy efficient housing that is easy on the environment and can perform in the face of major challenges like high winds and earthquakes, there are stronger reasons than ever to build with wood.

Wood-frame construction is strong, durable, easy to insulate, easy to renovate and delivers value. It is backed by two hundred years of proven performance and a wealth of research and new product development to make it better than ever. And it is the only major building material that is renewable.

Strong winds… heavy snow loads… high humidity… extreme temperatures – whatever your building challenges, wood-frame housing has proven technical solutions to overcome any problem.

Wood sells houses. In addition to the shelter, warmth and safety provided by the wood structure, buyers recognize and appreciate the aesthetic value of wood for exposed applications like cabinetry, flooring, furniture and moldings.

Not only is wood builder-friendly, it is also environmentally friendly. Wood products take less energy to manufacture, affect the environment less than other materials, and they come from North American forests that are abundant and increasing in size.

So Simple Yet So Effective

Wood-frame construction combines dimension lumber or engineered wood products and structural wood panel sheathing to make wall, floor and roof assemblies that are robust and fast to build. The assemblies are tough, easy to connect and easy to insulate. It is a building technology that has been applied millions of times. In fact, about a million new wood houses are built every year in North America.

Always Thinking Better

What other building material is so easy to work with? What other structural material can be engineered and glued to make strong, dependable beams and columns? What other major building material is renewable?

From the manufacturing of complete homes in factories, to the shipping of wall and floor assemblies in containers to Asia, to the prefabrication of wall units on site, the modularization of wood-frame construction delivers cost savings and quality for builders.

The wood industry in North America has developed several technologies that reduce building costs and speed construction. Made popular by the invention of the metal plate in the 1950's, there is simply nothing that challenges wood trusses for roofing applications. Designed and manufactured under exacting factory conditions, wood trusses offer quality, performance and flexibility. Virtually any roof shape or loading can be accommodated.

The search for better ways of doing things has resulted in the commercial successes of new products like wood I-joists and laminated veneer lumber (LVL). These products, the outcome of continual innovation and evolution, provide consistent engineering properties, dimensional stability, higher strength to weight ratio and reliability. Their long-span capabilities give new flexibility for open span layouts and make building faster.

Every innovation has brought features that help builders build it right the first time – machine stress-rating improves predicted strength; finger-joining produces straighter studs; and laminated beams including LVL, PSL, LSL provide higher strengths and larger dimensions. Innovations in floor systems like screwing and gluing reduce squeaks and increase strength. Engineered wood products are not only making better houses, their strength and long-span capabilities make them a cost-effective choice for commercial and industrial buildings.

So, whether you build on site, purchase manufactured wall and floor units, or a complete house, wood and engineered wood products offer all kinds of possibilities to suit your preferences and those of your customers.

Builder Know-how

There is a huge reservoir of designers, carpenters, supervisors and builders in North America who know how to use wood-frame construction to create strong and durable buildings.

In other parts of the world, there is keen interest in how North America builds. That's why expert crews from here have fanned out around the world to show those looking for economical, durable and safer housing solutions the wood-frame system that provides North Americans the best housing in the world. Whether at home or helping elsewhere, wood-frame construction is easily learned. The tools are basic, the techniques are proven, and years and years of experience have resulted in tricks of the trade that save time. The building materials are tough, light, and easy use.

Most builders appreciate wood-frame construction for its proven history of performance, its ease of use, its availability and its value in relation to its cost.

Easy Renovation – A Big Selling Feature

The National Association of Home Builders estimates homeowners spent $160 billion on remodelling in 2001. Whether remodelling involves increasing the size of a house or rearranging existing space, wood-frame construction is easier to modify.

This ease of modification is an important feature for buyers of both new homes and existing homes. It allows them to economically alter their houses to suit changing needs. When it comes to remodelling, wood is unmatched in how easily changes can be made. Thinking of adding a window to that concrete wall in the bedroom or moving the wall out three feet to enlarge the room?

Taking on All Challenges

North America has comprehensive building codes intended to provide high levels of health and safety – a material can be used as long as it provides the performance required by the codes.

No housing material comes close to matching the years of performance and technical foundation of wood-frame construction. Building codes have approved wood requirements based on proven performance that is supported by research institutions like the Forest Products Laboratory (FPL) in Madison, Wisconsin. FPL has served since 1910 as the nation's leading wood research institute, working with many universities, industries, and federal and state agencies. Today, more than 250 scientists and support staff are engaged in expanding knowledge in areas as diverse as building performance, new material development and developing environmentally friendly technology.

And this is only the tip of the iceberg. In addition to FPL, a multitude of companies and universities in the US and Canada are engaged in constantly improving the materials and techniques that make North American wood-frame construction an ongoing success story.

Keeping Energy Bills Down

Wood framing means comfort and economy when it comes to keeping you warm in winter and cool in summer. Wood is a good insulator because of its cellular structure – 400 times better than steel.

The real advantage comes from the better overall assembly performance of wood-frame construction. Heating and cooling costs are a significant portion of the cost of running a household, and low energy usage is a very important feature for homebuyers.

While wood has always had a good reputation for being easy to insulate to high standards, steel and concrete must overcome problems from thermal bridging, and the possible consequence of moisture condensation on cold surfaces.

Laboratory tests conducted at the National Research Council of Canada and the Oak Ridge National Laboratory show that light metal framing significantly

Light metal framing reduces the effective R-value of a wall assembly almost 50%.

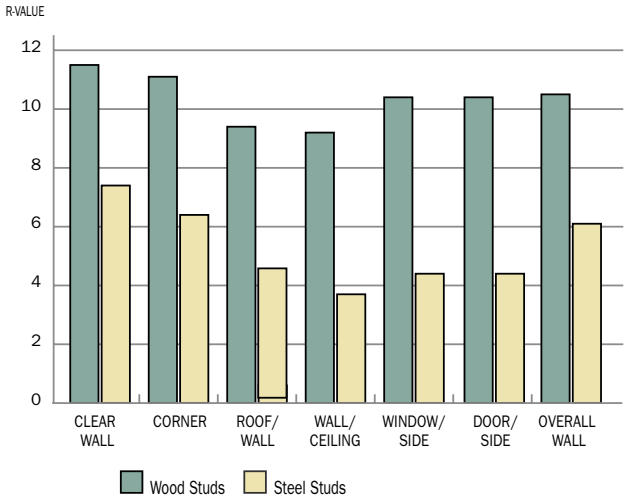

FIGURE 1 – Thermal Resistances of Wall Components with R-12 Insulation

reduces the effective thermal resistance, or R-value, of a wall assembly by almost 50% resulting in increased energy use (Figure 1).

Wood-frame construction is easy to insulate to high standards. Several jurisdictions have developed advanced wood-frame construction techniques (E Seal, Super E™ and R-2000) that exceed existing standards for R-value and air-tightness. Wood-frame assemblies are the common choice for the extreme cold of the far north.

Wood-frame construction can easily be adapted to any energy code requirement. This means wood-frame houses, offices, schools, and other commercial and industrial buildings can keep energy bills for heating and cooling low.

For more information about the insulating advantage of wood-frame construction, see:

1. E Seal: **http://www.eei.org/esg/e_seal/**
2. Thermal Performance of Light-Frame Assemblies: **http://www.cwc.ca/publications/tech_bulletins/**
3. Super E ™: **http://www.super-e.com/html/english/general/gen-what.html**

A Safe Bet in Earthquakes

Wood-frame construction has proven to be one of the safest building systems in an earthquake because it offers some key earthquake advantages compared to other materials:

1. Wood is strong and lightweight – less mass is an advantage because it means lower forces are exerted on a building.
2. Wood-framing has many members and many nailed connections – there are lots of back-up load paths to absorb the forces.
3. The nail connections typically used in wood-frame construction are effective in dissipating the energy of an earthquake.

A recent study examined the performance of wood-frame construction in seven major earthquakes over the past 40 years. The study concluded wood-frame buildings can resist severe shaking with a low risk of injury or structural damage. By contrast, 40,000 died in the 1999 Turkish earthquake, mainly in masonry and concrete buildings[1].

The 1995 Kobe, Japan earthquake killed 6,000 and caused $100 billion in damage. Houses built to modern standards using North American wood-frame construction were virtually unaffected.

In the Northridge earthquake in California in 1994, 30 people died and there was $35 billion in property damage. A recent report on the performance of wood-framing in earthquakes notes "Single family dwellings suffered minimal structural damage to elements that are critical to the safety of occupants[1]."

No building can be completely earthquake proof, but good seismic design will minimize damage. Wood-frame construction is strong, light-weight, and flexible – characteristics that make it an excellent design choice in earthquake regions.

Want to know more about how well wood performs in earthquakes?

1. Performance of Wood-frame Building Construction in Earthquakes, Forintek Canada Corp., 1999: **http://www.forintek.ca/**
2. The Anatomy of a Safe Building: **http://www.scecdc.scec.org/eqhazbuild.html**

Shelter from the Storm

"Wood systems performed well where there was strict adherence to the South Florida Building Code and construction provisions had been maintained."

Hurricane Andrew – Wood Building Performance and Analysis[1]

Solid attachment of wood sheathing panels to wood framing produces shearwalls and diaphragms that make a house strong and safe for those localized areas that face a risk from the high winds posed by hurricanes.

It is well documented that wood-frame construction can take the kind of pounding hurricanes deliver. In fact, many wood houses in the Caribbean and elsewhere have survived multiple severe storms. In 1992, hurricane Andrew brought winds in excess of 140 mph to South Florida, almost 50% more than the code design speed. An engineering report "Hurricane Andrew – Wood Building Performance and Analysis[1]" investigated the performance of building materials and systems and found that even though the winds were stronger than code expectations, wood-frame houses performed well.

As Mark Twain said "Everyone complains about the weather, but no one does anything about it." In reality, a lot has been done to better understand hurricane forces and how they affect buildings. Knowledge of the wind speeds and forces unleashed by hurricanes has increased significantly in the past two decades and in response, building codes have increased the design wind speed in many areas. Advances like hold-downs, bracing, and fastening systems together with the shearwall and diaphragm action of wood-frame construction result in a building system that can take the extreme forces of hurricanes.

There are many examples of wood buildings that have lasted a long time. And with good design and construction, that wood-frame house you started today will provide safety and comfort for many, many years.

Wood-frame construction is a strong, adaptable building system that is easy to design and build to resist the most severe wind loads.

For more information about the performance of wood-frame construction in high wind areas, see:

1. Hurricane Andrew – Wood Building Performance and Analysis, A Special Report of the National Forest Products Association, 1992
2. The Wood Frame Construction Manual (WFCM) for One- and Two-Family Dwellings, 2001 Edition, American Wood Council: **http://www.awc.org/Standards/wfcm.html**

Outlasting Lifetimes

Most buildings are replaced not because they wear out but because the type, style and size of a building is no longer suitable. The ease of renovating or enlarging a wood building means it can be adjusted to suit changing requirements better than most. This is but one reason why wood housing continues to outlast generations.

Often, the best examples become historic buildings for interpretive purposes. Visits to sites like colonial Williamsburg, Virginia demonstrate the early reliance on wood building and its enduring nature.

There are many examples of wood buildings that have lasted a long time. And with good design and construction, that wood-frame house you started today will provide safety and comfort for many, many years.

Surely, the primary functions of buildings are to keep us warm and dry. No matter what the type of building or the materials used, water needs to be kept out of the building envelope. For information about the four basic principles for dry and durable buildings – Deflection, Drainage, Drying and Durable materials – see references 1 and 2.

Developed by early settlers, wood-frame construction has since been subjected to the most intensive research and evaluation of any building system anywhere, resulting in building systems that can take the challenge of Alaska winters, Seattle rains, Texas summers and everything between.

Most areas of North America do not face a risk from termites. In areas that do face a risk, special construction and housekeeping techniques are necessary. Without proper vigilance, any structure in termite-prone areas is susceptible to termites. Borate treatment of lumber and panels, a recent innovation, is an effective way of repelling termites. The presence of moisture around a foundation can lead termites to access sheet-metal or concrete structures in search of food sources such as drywall paper. And they can damage non-edible materials like cable shields, plastic laminates and foam insulation.

Care and attention to detail will help any building perform better and longer.

For more information about the durability of wood-frame construction, see:

1. Durability: **http://www.durable-wood.com/**
2. Moisture and Wood-Frame Assemblies: **http://www.cwc.ca/publications/building_performance/**
3. Termite Control and Wood-Frame Buildings: **http://www.cwc.ca/publications/building_performance/**

Wood Can Take the Heat

Fire is a destructive force that has bedevilled humans through the ages. Even with modern construction technology and fire detection and suppression systems, building occupants' highest risk comes from heat and smoke inhalation.

Fire is a riddle. In a fire, steel doesn't burn, but loses its strength at high temperature, severely reducing the ability of sheet metal framed walls and roofs to stay in place and provide protection. Concrete also doesn't burn, but it is subject to explosive spalling from excessive heat and large amounts of smoke can be released from burning foam insulation used in insulated concrete form construction.

And wood is a material that does burn, but like steel and concrete, can meet and exceed the fire safety provisions of building codes for use in walls, floors and roofs. Wood can retain its strength during a fire because of the char that forms, providing protection to the unburned portion.

There is no well-defined method of assessing life safety from fire in buildings. Life safety is a concept, and no formula can identify or guarantee that a building is safe from fire."

Fire Protection Handbook, National Fire Protection Association

Studies examining causes for fatalities in residential buildings show that in the majority of fires, the combustible contents are the first items to be ignited and the smoke and heat generated by these burning contents cause about 90% of the deaths. Only 0.2% of deaths in homes were attributable to structural collapse[1].

Designing a building to ensure minimal risk or to meet a prescribed level of safety from fire is more complex than just the simple consideration of what materials will be used for construction. Many factors must be considered including the use of the building, the number of people in the building, the presence of fire detection and suppression systems, how easily people can exit the building in case of a fire and how a fire spread can be contained.

Fire safety requirements for single-family houses in Canadian and US building codes are the same regardless of the type of construction used. These requirements focus on ensuring that the people living in a house can evacuate quickly if there is a fire because research has shown that fire can grow rapidly from the burning contents of the house and that this poses the greatest fire risk.

Research into the performance of wood-frame walls and steel frame walls showed that wood framing stayed in place longer than steel framing. As the temperature from the fire rises and the steel loses strength, the attachment of the drywall to the studs fails, and the wall fails, allowing flame or heat to spread through the wall.

So, fire safety is complex. Good housekeeping, living habits, smoke detectors, good electrical installation, and the careful adherence to building codes are all necessary for a high level of fire safety. Build it right with wood and provide a code-approved level of fire safety.

For further information on fire safety issues and the role wood-frame construction plays in fire safety, see:

1. Fire Safety in Residential Buildings: **http://www.cwc.ca/publications/building_performance/build_perform_fire/**
2. Christian, W.J., The Effect of Structural Characteristics on Dwelling Fire Fatalities, Fire Journal, Vol. 68, No. 1, National Fire Protection Association, Quincy, MA 1974.

Wood – A Sound Performer

Wood-framed walls and floors are good performers when it comes to keeping the noise out. The years of research and experience in wood-frame construction gives builders the design details for walls and floors that provide peace and quiet for building residents.

Keeping airborne noise, structural vibration and impact sounds to acceptable levels is complex. A change that lowers one type of sound can compromise another. Sound transmission is not usually a problem in single-family homes, at least not for wood-frame construction. Homeowners of other types of frame construction report concerns with noise and vibration.

Sound transmission classifications (STC's) are used to measure the ability of building assemblies to resist the transmission of sound. North American building codes contain many options for meeting sound transmission requirements with wood-framing. Special techniques such as installing resilient channels, offsetting back-to-back electrical outlets and double layers of gypsum wallboard will further reduce sound transmission.

Wood is often used where reflected sound is a concern, for example in concert halls. The low density and cellular structure reduce echoes, making wood a good choice for interior finishes.

Wood-frame construction provides living spaces that are quiet.

For more information about the sound transmission performance of wood-frame assemblies, see:

1. Gypsum Association: **http://www.gypsum.org/**
2. Association of the Wall and Ceiling Industries: **http://www.awci.org/**
3. APA-The Engineered Wood Association, Noise-Rated Systems: **http://www.apawood.org/pdfs/managed/W460-N.pdf**

The New Advantage – Going Easy on Our Environment

As designers strive more and more to design buildings that lessen the demand on the environment, the benefit of wood construction is becoming ever more apparent. Wood makes a major contribution to improving the overall environmental performance of any commercial or residential building by reducing energy use, reducing resource use, and reducing environmental impacts.

Wood – The Only Renewable Building Material

Wood is the only major building material that is renewable. And satellite tracking shows the area of North America's forests have increased by 20 million acres since 1970.

The long-term supply of wood and forests for a range of other uses like recreation is being taken care of by forest management techniques and certification programs to ensure performance. Today the United States has about the same area of forestland as it did in 1920, even though there has been a 143 percent increase in population. And in North America, 2.15 billion trees are planted every year.

In Canada, 90% of the original forest cover has been maintained – more than any other country – despite growing to a population of 30 million. And Canada has the largest area of protected forests (80 million acres) of any country.

Although recycling is important when dealing with non-renewable materials like steel, recycling metal still requires a lot of energy. Steel used for structural purposes also requires a high proportion of virgin metal to keep certain properties high. But the renewability of wood and its low manufacturing energy needs make it the best choice for communities and homeowners concerned about the careful use of resources.

A Leap Ahead of Other Building Systems

Wood is not only renewable, it is easier on the environment in terms of energy use and air and water pollution.

Life Cycle Assessment (LCA) is a tool for comparing how different building systems affect the environment by examining factors like energy and material usage and emissions to the air and water at each stage of a product's life cycle. One of the best-respected LCA systems is ATHENA™ (a limited version of the software is available online at **http://www.athenasmi.ca/**).

When the ATHENA™ life cycle assessment software was used to compare the life cycle environmental effects of a 2,400 ft^2 single family home built of wood, steel or concrete, this is what was learned:

TOTAL ENERGY USE: The wood building used the least energy. The concrete option required 2.2 times as much energy as wood. The steel option required 1.5 times as much energy. Wood simply does not require much energy to manufacture.

GLOBAL WARMING POTENTIAL: The wood house had the lowest effect on global warming. Steel produced 1.22 times more and concrete 1.5 times more greenhouse gases.

AIR TOXICITY: The wood design had the lowest air pollution index. The steel building produced 1.7 times and the concrete building produced 2.15 times the air pollution.

WATER TOXICITY: The materials for the wood house had a lower effect on water toxicity. Steel was 3.47 times higher and concrete was 2.15 times higher.

WEIGHTED RESOURCE USE: The wood house was lowest. Steel was 1.15 times higher and concrete was 1.93 times higher.

SOLID WASTE: The construction site waste was slightly lower for steel and concrete was 1.57 times higher than the steel house.

CONCLUSION: The house built with wood had lower environmental impact for energy use, greenhouse gases, air and water pollution and ecological resource extraction than the steel or concrete building. A similar case study for a commercial office building (comparing wood, steel and concrete construction) produced similar findings in terms of wood's superior environmental performance.

For more information about the environmental advantages of wood construction, see these sources of information:

1. Green by Design: **http://www.cwc.ca/environmental/**
2. Life Cycle Analysis for Residential Buildings: **http://www.cwc.ca/publications/tech_bulletins/**

BUILD IT RIGHT…AND BUILD IT WITH WOOD

Wood – Easy to get, easy to use. Strong, safe and energy efficient. It is renewable, reliable, and backed by decades of research and technological advancement to meet any building challenge. It is easy to build with and it is easy to remodel. It is easy on the environment and it gives North American builders the reputation of building the best houses in the world. These are the reasons why wood is by far the material of choice for builders and homeowners.

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Other titles in the Canadian Wood Council Building Performance Series

- *No.1 Moisture and Wood-Frame Buildings*
- *No.2 Fire Safety in Residential Buildings*
- *No.3 Termite Control and Wood-Frame Buildings*

These may be obtained free of charge by faxing to [613] 747-6264.

Canadian Wood Council

Conseil canadien du bois
1400 Blair Place, Suite 210
Ottawa, ON K1J 9B8
Tel: 1-800-463-5091
Fax: 1-613-747-6264
http://www.cwc.ca/
e-mail: info@cwc.ca

Our Web Sites:

Canadian Wood Council:
www.cwc.ca

Wood Durability:
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www.woodmags.com

WoodWorks® Design Office Software:
www.woodworks-software.com

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