TOWARD A CULTURE OF
WOOD ARCHITECTURE

BY JIM TAGGART

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The text contains two types of references: those indicated with a superscript F are footnotes and are to be found on the spread where the annotation occurs; those indicated with a superscript R are technical and academic references and are to be found on pages 138 and 139.

FOREWORD

Canadians live on the edge of the largest forests on earth. A precious part of our natural heritage, these forests also represent one of the greatest carbon sinks on the planet. Each tree is a beautiful part of the answer to climate change, and yet we are only beginning to ask of its potential.

I'm a lumberjack and I cut down trees. Not really of course, but each time I choose to build in wood as an architect I am, in essence, part of a critically important chain of responsibility that will see the elegance of the living tree through to a new life in a building. That responsibility includes understanding the tree's genesis, its place in the ecosystem, its unique characteristics, in life and its remarkable potential when incorporated into the built world.

Our history as a nation has been built on the foundation of forestry and wood architecture; from coast to coast to coast. Even north of the tree line in the Canadian Arctic a single piece of driftwood is cherished and celebrated for its unique potential. With such a noble history as a wood nation, it is no surprise that we have produced some wonderful buildings, buildings that this book explores within the context of a national body of work.

Despite many excellent examples of progressive work now emerging in Canada, we have in some measure conceded our leadership role as a nation of wood innovation. However there is reason for optimism that this role may soon be reclaimed.

A new wave of innovation is upon us and a new will to regain our credentials has emerged, triggering some significant Canadian developments over the last decade. The desire to revitalize our forestry economy and the increasingly urgent need to find a more environmentally responsible approach to building structures have resulted in increased public and private sector investment and some positive and productive solutions.

Today we understand that wood is far superior to concrete and steel in its strength to weight ratio and its overall carbon footprint. We understand how to build increasingly larger buildings by stepping beyond the traditions of the past into new engineered wood systems. We are on the cusp of a new era where tall wood buildings will dot our skylines.

In many respects our situation parallels that of the architects and engineers of the 19th Century, who first designed structures in cast iron. Although they did not know it then, their work was the precursor to the steel skyscrapers we take for granted today. What happens next as we move towards a culture of wood architecture is ours to determine, both as architects and as a nation.

Ironically, the challenges we face have less to do with the capacity of our forests or the capacity of wood to build large structures, and more to do with today's emotionally driven building codes. The restrictive nature of our current fire code is the great hurdle to overcome before we can build higher, but fire simulation and structural modeling have already demonstrated what is possible. While fire and life safety are always paramount in any building, they are manageable concerns in the hands of well-trained engineers and architects.

From an early age we begin to understand the issue of combustibility. I remember igniting twigs on the pavement with my magnifying glass in the sun. I remember how wood burned but the concrete sidewalk did not. What I also remember is that igniting a large piece of wood was completely impossible. This simple childhood exercise tells the story of how mass wood changes the parameters of safety and therefore possibility.

Fire science has confirmed that heavy timber beams and columns and mass timber panels will burn but will do so very slowly, and at a predictable rate. Testing confirms that these wood elements will only char on their outer surface, and that this charring will insulate and protect the inner structural portion of the members from damage. Encapsulating wood or any other combustible material in a fire rated wall assembly effectively erases the primary differences between steel, concrete and wood in fire.

Wood and natural fiber-based structural materials are essential tools in our attempt to address climate change. They are also the most positive way we can begin to tackle the world housing crisis that will require us to build affordable homes for 3 billion people in the next 20 years. With increasing urbanization, particularly in the third world, multi-family housing utilizing tall wood technology is a critical component of the solution. The alternative — continuing to use high environmental impact materials like concrete and steel — is untenable.

Simply put, wood is the material that offers our best hope. Exploring its potential starts with understanding its properties, its history as a building material, and the increments of legislative change and technological innovation now manifesting themselves in buildings across Canada and around the world.

This book provides a wonderful context within which to examine the future potential of wood as a building material. Its historical explorations identify aspects of our wood culture that have been lost or forgotten, and which may now illuminate the way forward. As the 21st Century unfolds, 'Toward a Culture of Wood Architecture' argues that revitalizing our wood building tradition will bring with it many benefits. Applying the principles of Constructive Environmentalism to the design of our buildings can create new synergies between the natural and built worlds, distribute both social and economic benefits, and contribute to the mitigation of climate change.

MICHAEL GREEN

INTRODUCTION

This book brings together for the first time ideas and insights gained from more than a decade of research, writing and lecturing on the role of wood in contemporary architecture, both in North America and abroad. As an architect working in British Columbia in the 1980s, I had become aware of a subtle yet very real distinction in architectural practice between those who designed and built almost exclusively in wood, and those who rarely did. This was a distinction, not solely in construction materials, but also in building scale and production methods that over time had created two parallel approaches to architecture that co-existed but whose paths seldom crossed.

In the early 1990s, I left the project-specific focus of architectural practice and entered the broader realm of professional education and communications. This expanded context allowed me to step back and consider the process of architecture as a cultural phenomenon, and its creations as artifacts reflecting the values of the society that produced them.

In the 20 years since I had begun my architectural education, I had seen the stylistic pendulum swing from the rigorous functionalism of the International Style to the capricious formalism of Post-Modernism. By the early 1990s, it seemed as though the possibilities of both had been exhausted, and Canadian architects were seeking new ways to bring meaning to their work. Some began to explore the potential of wood to express regional identity through its unique material and structural properties.

I began to chart this growing interest in wood as a structural material for non-traditional applications, writing a succession of articles for Wood Design & Building and Canadian Architect magazines. Then in 1999 the Canadian Wood Council invited me to create a professional-development seminar on Contemporary Architecture in Wood for presentation at its Wood Solutions Fairs in the US and Canada. So began a series of more than 70 such presentations, which evolved as my research expanded in geographic breadth and technical depth.

What appeared to be a different attitude toward the use of wood among architects and engineers in other parts of the world (most notably Europe) compared to that of their North American counterparts proved to be based partly on differences in the respective practice environments, but also on differences in perception.

While the North American wood industry had historically been based on volume, the contemporary European industry was clearly based on value. In Europe, wood figured prominently in prestigious public buildings alongside a wide variety of other quality materials, whereas in North America it was still mostly confined to smaller, less ambitious structures. In Europe, architects seemed to view wood as the ultimate sustainable material, whereas in North America — a continent with more than 20% of the world's forests — there was still widespread concern about the negative impacts of harvesting practices and deforestation.

Research revealed both the historical reasons for these differences, and the efforts now being made in North America to bridge what had become a considerable technological and philosophical divide. For me as an architect, the cultural reasons for advancing wood use were compelling, but perhaps fell short of justifying a treatise on the subject. However, that justification came in 2005 during an interview with Professor Julius Natterer, one of Europe's leading timber engineers, when I began to understand — qualitatively at least — the relationship between wood use, sustainable forest management and the mitigation of climate change.

Natterer refers to the management of this relationship as "constructive environmentalism," an approach to building that privileges wood for its environmental benefits, and seeks ways to maximize its use in buildings of all types and sizes.

What began as intuition is now backed by a global scientific consensus which compels us to rethink the way we manage our forests and use the wood they yield. This book endeavours to explain how such rethinking could be applied to the Canadian context and provides examples of projects that are leading the way. While the impetus might be environmental, expanding the use of wood can connect Canadian architecture back to its historic roots, and reinforce regional and national identity.

While the Intergovernmental Panel on Climate Change has concluded that sustainable forest management, complemented by increased wood use, is the most effective long-term measure to mitigate the effects of global warming, constructive environmentalism can form only part of the solution. The survival of our planet and our species will depend upon the universal adoption of similar practices in every sphere of human activity — practices that respect, replicate and reinforce the Earth's natural systems, rather than working against them.

JIM TAGGART
VANCOUVER BC, MAY 2011

CHAPTER ONE

WOOD: CONNECTING CULTURE AND NATURE


1.01

More than any other building material, wood has the capacity to humanize the structures and spaces we inhabit, communicating through its lines, surfaces and junctions the art and craft of building. Since ancient times, the careful selection of suitable trees, the cutting and shaping of timbers to form structural members, and the crafting of joints to create framing systems have been important mental and manual processes that have reinforced the symbiotic relationship between human beings and their environment, between culture and nature.

In architecture, a discipline that combines art and technology to fulfill a social purpose, the term culture can be understood to mean an integrated system of design and construction practices based on shared knowledge or beliefs that evolve over time through formal explorations and technical innovation. In Western architecture these attributes can be most clearly identified in the great stone-building traditions of Classical Greece and the Gothic period in Western Europe, both of which sought aesthetic refinement through the development and mastery of new construction techniques.

Historically the application of this shared knowledge was nuanced by local climate, geography and materials, resulting in architecture that was rooted in both place and time. In most parts of the world, wood was the first building material to be used, and in some areas, notably Japan and Norway, it has remained the material of choice over many centuries. In these countries, traditional wood architecture evolved to a high degree of sophistication, and is widely considered to be an integral part of the national cultural heritage.


1.02


1.03

Japanese Wood Architecture

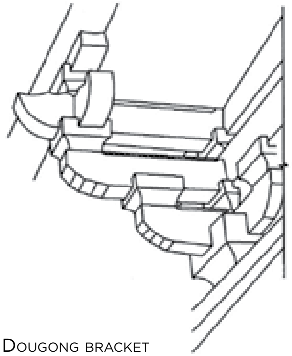
The most celebrated and enduring example of a culture of wood architecture is to be found in Japan, where the abundance of high-quality construction timber contributed to the development of an architectural language whose expression was at once elemental and elegant. The evolution of wood building technology has both reflected and influenced Japanese culture for almost 1500 years, and evidence of this relationship is still to be found in the nearly 4000 historic wood structures that have been designated by the national government as Important Cultural Properties.

Among the buildings on the national register are both the oldest and largest surviving wood structures in the world: both temples located near the ancient capital of Nara. Parts of the Horyu-ji Temple complex (Figure 1.01) have been carbon dated to the early 8th century, with some of the timbers believed to have been fashioned from trees felled more than 100 years earlier. Nearby, the Todaj-ji Daibutsu-den (Figure 1.02), the greatest of all Buddhist temples, measures 46m in height and has a plan area of 2880m^2 — roughly equivalent to half a city block.

Japanese master craftsmen understood the variations in the growth patterns of trees planted at different orientations and elevations, for example selecting 'tight-grained', slow-growing trees from north-facing slopes for applications requiring superior strength. Logs would be split to form members with straight grain for carrying vertical loads, or curving grain for resisting bending stresses.

Wood building technology came to Japan from mainland China with the arrival of Buddhism in the mid 6th century, and was slowly adapted to better suit the local wood species and climatic conditions. These adaptations included new framing methods and joinery techniques for earthquake resistance, extended eave overhangs to deal with heavy rain, and lattice-screen walls to promote ventilation in hot and humid weather[R1] (Figure 1.03). These measures, together with the cultural value ascribed to the buildings, have ensured their survival, both in the Nara region and elsewhere in Japan.

[1.01] Dating from the 7th Century, Horyu-ji Temple is one of Japans' most celebrated ancient structures.
[1.02] The Todaj-ji Daibutsu-den temple, built in the 8th Century is still the world's largest wooden structure.
[1.03] Climatic and stylistic adaptations are seen in the 14th Century Ujigami Jinja Temple near Kyoto.



1.04 Dougong bracket

1.05

The outward simplicity and elegance of Japanese joinery belie an inner complexity. Without mechanical fasteners, the geometry of the timbers is maintained using wooden pegs and wedges. Some techniques were adapted from Chinese precedents, notably the ingenious dougong, an inverted pyramid of wood members that connect vertical posts to roof beams (Figure 1.04). The dougong performs much as the abacus and capital do on a stone column, increasing the area through which load is transferred, and hence distributing forces more evenly. The flexibility inherent in their construction has proven invaluable in absorbing the shocks of earthquakes and typhoons over many centuries. In addition to its structural contribution, the form of the dougong is also in harmony with that of the upturned eaves it supports. This upturned form, emblematic of status and wealth, has long given the dougong symbolic as well as structural significance in Japanese architecture.

1.06

[1.04] Dougong – an inverted pyramid of wooden members that helps absorb the shock of seismic and wind forces.
[1.05] The 17th Century Shokin-tei House epitomizes the simple elegance of Japanese domestic architecture.
[1.06] The entrance bridge of the Japan Pavilion symbolizes the connection between ancient and modern Japan.
[1.07] The interior of the Imai Hospital Daycare is a reinterpretation of traditional bent wood box construction.

Throughout its evolution, the Japanese tradition of wood building has been applied to temples and castles, garden pavilions and teahouses. While the striking forms and decorative embellishments of the temples and castles are iconic symbols of the country and its culture, it is Japan's modest vernacular buildings that have had the most profound influence on architecture elsewhere in the world. The aesthetic purity of vernacular building gained favour among the Japanese nobility in the early part of the 17th century, and was applied to the design of teahouses and other modest structures in their palace gardens, nowhere more elegantly than in the grounds of the Katsura Imperial Villa near Kyoto (Figure 1.05).

With their rhythmic structure and interpenetration of indoor and outdoor space, Japanese domestic buildings like this inspired Modern architects such as Frank Lloyd Wright and his contemporaries in the early 20th century. To this day they remain a paradigm of understated elegance for architects around the globe.

The intense period of rebuilding and modernization that followed the devastation of World War II saw Japanese architects briefly turn their backs on their own heritage and instead work in a Western idiom, using imported ideas and technologies. Concrete, steel and glass predominate in Japan's dense urban centres, but in the 1980s and 1990s wood began to reclaim its place in Japanese architecture. In a technologically sophisticated society, wood buildings are helping to reconnect the present with the past.

Structures such as the Japan Pavilion for Expo 92 in Seville by Tadao Ando (Figure 1.06), and the Imai Hospital Daycare Centre by Shigeru Ban (Figure 1.07), along with many others, combine leading-edge design and fabrication technology with traditional forms and construction techniques contributing to the re-creation of a vibrant, progressive and culturally relevant architecture.

1.07

1.08

Norwegian Wood Architecture

In Norway, the use of wood also dates back to ancient times, with the construction of log buildings with notched corners believed to have been imported from the eastern Baltic in the early medieval period. With minor modifications, this method of construction remained the norm for domestic buildings for several centuries. Over this period of time, innovation in wood building techniques was more evident on water than on land.

During the Viking period (from the 8th to the 10th century), design and construction expertise was applied most comprehensively and successfully to the ocean-going longships that took Norwegian marauders as far as Constantinople in the east and Newfoundland in the west. Great assimilators of ideas, the Vikings may well have first seen buildings using what became known as 'stave' construction on early visits to Britain.

1.10

The stave technique is a form of post-and-beam construction that originally involved burying the ends of upright framing members and vertical plank siding directly into the ground. A series of horizontal beams at eaves level connected the corner posts and provided a base for the construction of a simple gable roof.

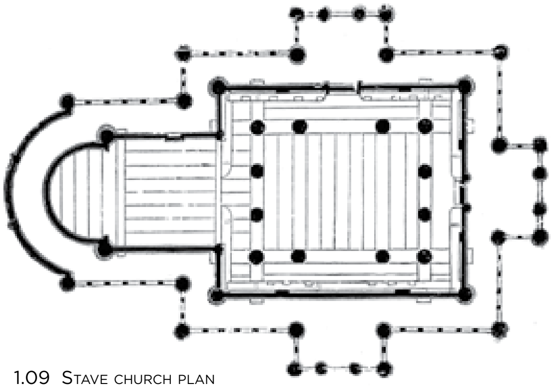
As in Japan, this new culture of wood building gained momentum with the arrival of a new religion — in this case Christianity, which reached Norway in the year 1015. Whereas pagan rituals had taken place outside, with small, centrally planned temples serving only as repositories for sacred relics, the practice of Christianity required an interior worship space with an axial organization and an orientation to the east. So began a 250-year period of church building which has left the world one of its greatest legacies of wood architecture.

The practice of burying the post ends in the ground resulted in premature decay of the structure; in response, the Norwegian builders of the late 11th century developed the stone or gravel strip foundation upon which timber grade beams were placed, and the structure erected as before. The vertical planks were set side by side in continuous grooves cut into the grade and eaves beams. Some scholars contend that the stone strip foundation, rather than the post-and-plank construction, is the defining characteristic of stave churches. Holtdalen church is a surviving example of this type (Figure 1.08).

In later churches the grade beams were notched, overlapped and extended about 1m beyond the foundations in a configuration we would now recognize as a number sign. An inner framework of tall poles was then built on the inner square, and secondary grade beams running between the free ends of the main beams formed a base for the outside wall. Internally, this created a central worship space defined by the tall posts and flanked by side aisles (Figure 1.09). Externally, a lean-to ambulatory was often constructed around the building, creating a tiered effect. Subsequent developments of this technique enabled the construction of churches with complex multi-tiered roof forms and heights in excess of 21m, as seen at Borgund, Hopperstad, Lom and Heddal (Figure 1.10).

To overcome the technical challenges of these taller structures, the Norwegians introduced air-drying of timbers, and developed connections that could be adjusted and tightened using wedges. These refinements increased the stability, precision and longevity of their buildings. In its timing and in its technical and aesthetic development — if not in its scale — the evolution of Norwegian stave churches roughly parallels that of Gothic cathedrals in Western Europe.

In the words of architectural historian Christian Norberg-Schulz, “The combination of unity and multiplicity renders Norwegian stave churches the unchallenged high point of European wooden architecture.”[R2]



1.09 Stave church plan

[1.08] The stone foundations of Holtdalen church are a hallmark of stave construction.
[1.09] The double column plan made possible the multi-tiered roof forms of later stave churches.
[1.10] Borgund Stave church, a high point of Norwegian wood architecture.

[1.11] The wooden warehouses of Bergen's Bryggen District date from the early 18th Century.
[1.12] Stiftsgården, a Renaissance palace reinterpreted in wood.
[1.13] The Olympic Hall in Hamar was inspired by the form of a Viking longship.
[1.14] The plenary chamber of the Sami Parliament in Karasjok echoes the form of the traditional Sami tipi or latok.

1.11

1.12

Like most of Europe, Norway was ravaged by the bubonic plague known as the Black Death in the mid 1300s. The building of stave churches ceased abruptly and Norway entered a period of artistic decline that lasted almost three centuries. However, commerce flourished through Norway's participation in the medieval trading network known as the Hanseatic League. One legacy of this involvement is the historic Bryggen (wharf) district in the North Sea port of Bergen, where the earliest remaining warehouse structures date from 1702 (Figure 1.11).

The original buildings were constructed using a post-and-log technique, in which squared-off logs or planks were stacked between grooved vertical posts. The method (albeit with regional variations) was common in northern Europe at this time, and was one of several timber framing methods that made its way to North America with early European settlers.

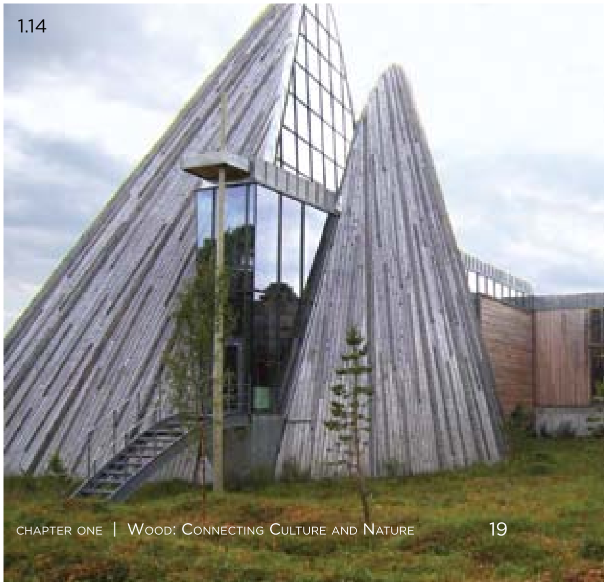
In the 17th and 18th centuries, increased trade with Europe exposed Norway to the latest cultural trends and architectural styles from Germany and elsewhere. However, as far as buildings were concerned, the cost of importing non-native materials meant


1.13

that for the most part these styles, including Romanesque and Baroque, were reinterpreted in wood. Among the examples that survive, the most impressive is Stiftsgården, the 140-room royal residence in Trondheim, built in 1774 (Figure 1.12).

Contemporary Norwegian architecture shows no such stylistic borrowings, drawing much of its inspiration from local building traditions and the relationship of buildings to landscape. This architecture resonates more closely with contemporary Norwegian cultural values and has achieved recognition at home and abroad, setting new precedents in scale, sensitivity and technological innovation. Among the most prominent examples are the Olympic Hall in Hamar by Niels Torp (Figure 1.13), and the Sami Parliament in Karasjok by Stein Halvorsen and Christian Sundby (Figure 1.14).

These projects and others like them have reaffirmed the pivotal role of wood in Norwegian architecture, not just for small-scale buildings, but for large and prestigious public projects. Wood is not simply a resource to be exploited, but an intrinsic part of Norwegian culture.


1.14

CHAPTER TWO

WOOD BUILDING IN CANADA

2.02

In both Japan and Norway, the value ascribed to wood, and its re-emergence as a primary building material in contemporary architecture, can be interpreted in a variety of ways: as a means to re-engage with traditional building forms and materials; as a means to reaffirm regional and cultural identity in a globalized context; and as a response to a range of environmental imperatives. Additionally in Norway the value-added wood industry is increasingly important to the national economy through the manufacture and export of engineered wood products and prefabricated building systems.

In contrast, in Canada, wood is regarded primarily as a commodity within the context of a resource-based economy, rather than as a material with both unrealized technical potential and intrinsic cultural value. Comparatively little attention is paid to our historic wood structures and even less to the technological ingenuity they embody. Much of our wood heritage is being lost to neglect and decay. With few exceptions, the wood industry continues to be volume rather than value driven, and as a building material wood continues to be greatly underutilized.

However, the roots of a wood culture, or rather two distinct wood cultures, do exist in Canada, one evoking the timeless unity between culture and nature, the other founded on a pioneer spirit of enterprise and ingenuity. In a world whose future depends on both stewardship and innovation, there is much to be learned from the achievements of both.


2.01

[2.01] Acclaimed artist Emily Carr Painting at Ninstints.
[2.02] Kwakwa ka ’wakw longhouse with carved and painted gable panels.
[2.03] Kwakwa ka ’wakw village on the British Columbia coast.

Native Traditions

While many indigenous cultures of the Americas worked and built primarily in wood, those on the eastern side of the continent were the first to encounter European explorers and to succumb to the previously unknown diseases they brought with them. Dramatic population decline made it impossible for native peoples to successfully resist displacement from their ancestral lands, and many great towns and settlements were abandoned to the elements or the destructive whim of the invaders.

Thus the built history of great nations like the Cherokee and Iroquois persists mostly in the form of ceremonial mounds and defensive earthworks; the large post-and-wattle council and residential buildings of major towns like Chota in modern Tennessee, or the vaulted roundwood longhouses of Hochelaga on the site of what is now Montreal, disappeared long before they and their creators sparked the interest of anthropologists and ethnographers.

Initially protected from the same fate by the remoteness of their geography, the native cultures of the Pacific Northwest survived almost intact into the mid 19th century — long enough to be at least partially documented by Victorian academics, artists and photographers (Figure 2.01). The achievements of these ancient cultures, which in architecture and the applied arts equal or surpass all others in North America, have captured the imagination of the world.

The Haida, Kwakwa ka ’wakw, Tsimshian and other Aboriginal people of the Pacific Northwest fashioned artifacts, from baskets and boats to buildings, using virtually every part of the cedar tree. Monumental post-and-beam longhouses, designed to accommodate extended families or clans, were typically arranged in a line facing the sea shore or river and incorporated towering totem poles or carved gable panels that recalled the history of the lineage, and welcomed visiting kinsmen (Figures 2.02 and 2.03).


2.03

2.04

For cultures that had not yet developed metal tools, red cedar in particular combined the virtues of versatility, workability and durability. Peeled trunks were used to create post-and-beam structures, split logs were fashioned into horizontal or vertical planks to clad roofs and walls — the horizontal ones fastened using ropes woven from peeled and braided cedar bark, the vertical ones installed into grooved sill and header beams as in a stave church. Lapped planks secured with poles laid across them and tied with cedar ropes were used for the roofs. In the interior, where the semi-submerged pit house was the common form of winter dwelling, bark peeled from the structural members was used to create a waterproof layer beneath the earthen roof (Figure 2.04).

For these cultures, reverence for wood has always been part of a broader relationship with the environment — a relationship that is characteristic of indigenous peoples the world over. Remarkably, this connection has survived the devastating population collapse, and even today it remains central to the beliefs and cultural practices of many of Canada's First Nations.

On the Pacific coast, and particularly in the archipelago of Haida Gwaii, remnants of historic villages can still be seen at several locations, including Tanu on Louise Island and Ninstints on Anthony Island, both abandoned around 1880 (Figure 2.05). Totem poles and house frames stand in silent testimony to the great Haida civilization, which thrives once more by foraging and fishing in these lands and waters as it has for 10,000 years. At its peak, the village of Ninstints had a population of around 300 people; by the mid 19th century smallpox had wreaked such devastation that fewer than 25 inhabitants remained.

In 1981 the global significance of this site (now renamed S'Gang Gwaay) was recognized by its inscription on UNESCO's World Cultural Heritage Register. The Advisory Committee Report made the case that "a series of unit dwellings and cedar long houses still exists of which ten are in good condition. But it is above all the 32 totemic and mortuary columns on the edge of the dwellings which contribute to the world renown of the site, frequently illustrated in handbooks of ethnography, art history and religious history."[R3]

Conservation of the site consists of clearing vegetation from around the buildings and stabilizing the poles to prevent them from falling. Otherwise, no physical protection is offered against wind and weather, and the structures will eventually decay, decompose and nourish new growth in a manner resonant with the Haida's cyclical understanding of time.

It is from remains like these, and from the careful stitching together of many other fragments of the past, that the rich tapestry of Aboriginal culture is being rewoven for a new generation.


2.05

[2.04] REMNANTS OF A HAIDA HOUSE FRAME AT TANU.
[2.05] THE SEMI-SUBMERGED PIT HOUSE WAS CONSTRUCTED FROM A FRAME OF PEELED LOGS.

2.06

European Traditions

In contemporary North America, buildings are more generally regarded as commercial commodities than as the manifestations of a vital and technologically progressive culture. They eschew innovation, settling instead for replicating commercially successful precedents.

But this was not always so. The spirit of enterprise that fueled European discovery and development of the continent had both a commercial and a creative component. In confronting and overcoming the challenges of day-to-day life, necessity was indeed the mother of invention. Distanced by time, we now tend to regard the built products of this pioneering age as little more than engaging anachronisms. Yet even these unselfconscious structures born of expedience have a role to play in defining the Canadian identity, and form part of the foundation upon which a new wood culture can be built.

In the New World of the 1600s vast forests provided raw material first for the humble cottages, barns and boat sheds of the east coast, and later for the factories, warehouses and mills that came to symbolize the strength and vigour of the emergent nations. These simple and robust structures were to define the character of architecture throughout North America until the turn of the 20th century.

Even today, with their numbers in rapid decline, Canada's historic wooden structures remain an important part of the Canadian psyche; among them log cabins, trading posts, grain elevators, covered bridges and railroad trestles.

European settlers in eastern Canada brought with them their traditional methods of wood construction — English half-timber framing, its French equivalent, 'en colombage', and the squared-log construction typical of Hanseatic buildings which had its origins in northern Europe.

Both English and French construction systems were originally based on heavy timber post-and-beam framing, with horizontal and vertical members most often connected using mortise and tenon joints, and stiffened with diagonal 'knee' braces. In Europe, the spaces between the framing members were traditionally filled with mud or plaster reinforced with straw or sticks. However, in the harsher climate of Canada, other materials proved to be more durable.

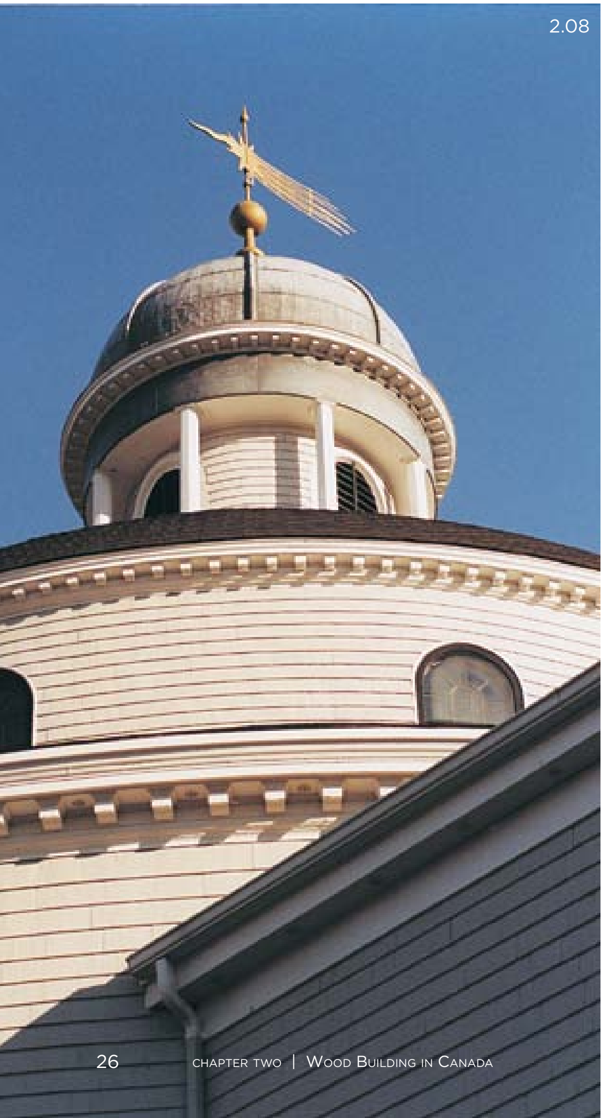
The first application of this framing system in Canada was in Samuel de Champlain's Port Royal Habitation, constructed in 1605 on the shores of Annapolis Bay, an inlet of the Bay of Fundy in what is now Nova Scotia. The structure took the form of a wooden stockade, framed using the *en colombage* method, and clad in wooden boards. Organized around a central courtyard, it comprised a series of self-contained working and living areas with the steeply pitched roofs characteristic of Norman architecture (Figure 2.06). The original building was destroyed in 1611, to be replaced some three centuries later with a replica built by the government of Canada.

The 'en colombage' technique was used throughout New France, including what is now the eastern seaboard of the United States. In Canada it spread west with the French settlers and traders, and was adapted to local climate and materials. One such adaptation, based on Norman precedents, was known as 'colombage pierroté'. In this technique, closely spaced timber uprights were infilled with stones or masonry rubble.

One of the best surviving examples of this construction technique is Maison Lamontagne in Rimouski QC, built around 1744 (Figure 2.07). The simpler geometry of 'colombage pierroté' made it quicker and easier to construct; however the exposed rubble also proved susceptible to erosion in the harsh Quebec winters.


2.07

[2.06] The reconstructed Port Royal Habitation replicates the original en colombage frame and vertical cladding.
[2.07] The 18th Century Maison Lamontagne remains a fine example of the colombage pierroté technique.


2.08

As a result, the technique fell out of favour in Quebec by the end of the 18th century, but continued to be used by French carpenters elsewhere in Canada for another hundred years — albeit with the wood structure protected by stone or other facing material. Remaining examples include the Charles Ermatinger House in Sioux Ste Marie ON (1812) and the Men's House at Lower Fort Garry MB (1830).

English timber-frame construction was introduced after the cession of Nova Scotia to Britain in 1713. Perhaps the finest early example of this technique is St George's Round Church in Halifax NS (Figure 2.08). Begun in 1801 and believed to have been built by a team of Royal Navy shipwrights stationed at the port, this is the only surviving church of its kind in North America. With its round arches, classical columns and impressive dome, St George's is a heavy timber reinterpretation of the Neo-Classical style popular in England at the time.

Rising above the 18m-diameter worship space, the 14.5m-diameter 'umbrella' dome has a skeletal structure made up of 12 curved heavy timber ribs that originally rested on 12 circular wood columns. The dome is topped with a 3.6m-diameter cupola, complete with a weather vane commemorating the appearance of Halley's Comet in 1835.

A fire destroyed much of the dome in 1994, but fortunately a decade earlier the parish had commissioned architects Fowler Bauld & Mitchell to prepare as-built drawings of the building, enabling the reconstruction work to be faithful to the original.

Also widely used at this time was the post-and-groove technique, employed by Hanseatic carpenters in Bergen, and most likely imported in the early 1750s by the German, Swiss and Montbeliardian French settlers brought to Nova Scotia as part of a British colonization plan. Several examples of this technique (known as 'coulisse' construction in French) are still to be found in the historic town of Lunenburg NS (Figure 2.09).

2.09

[2.08] Detail of the rotunda and cupola of St George's Round Church, the only one of its type in North America.
[2.09] The historic waterfront of Lunenburg, a UNESCO world heritage site.


2.10

The advantage of ‘coulisse’ construction as compared to other forms of log building is that the vertical posts support the roof, separating the functions of structure and enclosure. Hence the seasonal expansion and contraction of the wood, which is ten times greater across the grain than parallel to it, does not affect the squareness of the frame. Where gaps open up in the horizontal timbers it is easier to seal them against wind and cold. The ‘coulisse’ method also lends itself to the construction of larger span and multi-storey buildings.

Like S’Gang Gwaay, the central area of Lunenburg, comprising 404 buildings, was recognized by inscription on the UNESCO World Cultural Heritage Register in 1994. The Advisory Board Assessment Report summarized its significance as follows:

> “The ‘Old Town’ District of Lunenburg, Nova Scotia, is an excellent example of a sustained vernacular architectural tradition spanning more than 240 years. In its clearly legible model town plan, its building forms and fabric, and its cultural evolution based on the pursuance of the shipbuilding and fishing industries, this architectural ensemble illustrates successive stages in the human history of North America.”[R4]

The ‘coulisse’ technique had many regional names in English Canada, and outside the country was often known simply as Canadian construction. It eventually found its way to the west coast, where it was used by the Hudson’s Bay Company and others until mechanized mills replaced the squaring axe, and log construction gave way to the light wood framing we know today.[F1]

Among the remaining structures of this type in British Columbia, the most notable is the Craigflower Manor in Victoria (Figure 2.10). The two-storey farmhouse was built by the Puget Sound Agricultural Company (a subsidiary of the Hudson’s Bay Company) in 1853 as part of a self-sufficient farming community established to support the growing population of nearby Fort Victoria. Its survival is credited to the use of a stone foundation similar to that used on stave churches.

[F1] Replica buildings in *coulisse* construction can be seen in several of Canada’s historical parks including Fort William Historical Park in Thunder Bay ON.

[2.10] Craigflower Manor is a rare surviving example of Hudson Bay squared log construction.
[2.11; 2.12] The covered bridge at Nelson Hollow is the oldest in New Brunswick.

If wood was important to the establishment of the first European settlements on the east coast, then it was even more critical in connecting them to a growing country. Countless covered bridges spanned the rivers and streams of New Brunswick and Quebec; wooden lock gates controlled the waters on the canals of Ontario; and magnificent railroad trestles carried trains across the river valleys and mountain gorges of the western provinces.

However, time and neglect have taken their toll on these structures. In Quebec fewer than 100 covered bridges remain from the more than 1000 that existed in 1900, and in the west wooden trestles have suffered a similar fate. In many cases these losses have less to do with functional obsolescence than with larger economic and cultural forces.

As witnessed by the many ancient examples that survive in Europe and Asia, well-designed wood structures can last many centuries. Despite the romantic associations ascribed to them, the primary purpose of enclosing covered (or 'kissing') bridges was to protect the structural members from exposure to the elements. With regular maintenance, such structures can endure indefinitely.

Among the covered bridges of New Brunswick the oldest surviving example is at Nelson Hollow and dates from 1870 (Figure 2.11). It was built using the Brown Truss technique (Figure 2.12), one of several different methods of construction (others include Town Lattice and Bowstring trusses) chosen according to the circumstances of the project and the local availability of materials and expertise.


2.11


2.12

As an example, the Brown Truss was a patented invention of American engineer Joseph Brown that enjoyed a short period of popularity in the 1860s and 1870s because of its economy in the use of materials — particularly iron, which was still scarce and expensive. This economy was achieved by having adjacent cross-bracing elements connected top and bottom, improving stiffness and eliminating the need for vertical posts.

In Quebec, one of the most impressive remaining covered bridges is the Marchand Bridge at Fort Coulonge (Figure 2.13), whose construction is a rare combination of Town Lattice and Queen Post trusses (Figure 2.14). Built in 1897 for the Quebec Department of Colonization and Mines, the bridge stretches 152m across the Coulonge River in six spans. The strength and rigidity of its composite construction have been the bridge's salvation on several occasions when floods, log jams and ice build-up threatened to destroy it. Saved from demolition by public outcry in the 1950s when the increased weight of truck traffic forced the construction of a new concrete bridge, the Marchand covered bridge is now a provincially designated historic monument. It remains in service for light vehicular traffic.[F2]

[F2] More about the history of this and other covered bridges in Quebec can be found in Gerald Arbour's book 'Les Ponts couverts au Québec'

[2.13; 2.14] The Marchand Bridge has carried traffic over the Coulonge River since 1897.

2.13

West of the Great Lakes, settlement on the prairies transformed the landscape into the bread basket of the world, and the necessity of storing and transporting large quantities of grain led to the construction of grain elevators — the vast majority of them in wood — in the many small communities that lined the railroad tracks. With the first constructed in the early 1880s, grain elevators were a remarkable example of the settlers' ingenuity in wood construction. With heights of 25m or more, they dominated the prairie landscape much as windmills did in the polders of Holland (Figure 2.15).

These historic grain elevators are still a potent, though seriously threatened, symbol of the Canadian west. Of the more than 3000 examples that dotted the Saskatchewan landscape in the 1930s, only 304 remained at the turn of the 21st century. The oldest, in the town of Fleming near the Manitoba border, dates from 1895.[R5]

[2.15] Sadly, this iconic image of the Canadian prairies may soon be a thing of the past.
[2.16] The Harris grain elevator near Saskatoon, still in service in 2010.

2.15

Wooden elevators were typically built using crib construction, a technique made possible by the introduction of mechanized sawmills and mass-produced wire nails. In crib construction, successive layers of dimension lumber are laid on the flat in a square or rectangular plan, with each layer nailed to the one below it, and rise to form a solid wood construction of enormous strength. Boards on adjacent sides are alternately longer and shorter, overlapping in a kind of dovetail configuration at the corners. The bottom third of the elevator where the lateral forces from the stored grain are greatest typically uses 2x8 inch boards, with the section sizes being reduced incrementally for the upper sections of the structure where lateral forces are smaller. The result is a structure that is both pragmatic and elegant, a successful blend of form and function.

Horizontal shiplap cladding was traditionally used to protect the crib construction — nowadays Saskatchewan elevators are usually clad in metallic shingles, giving them a characteristic silver colour.

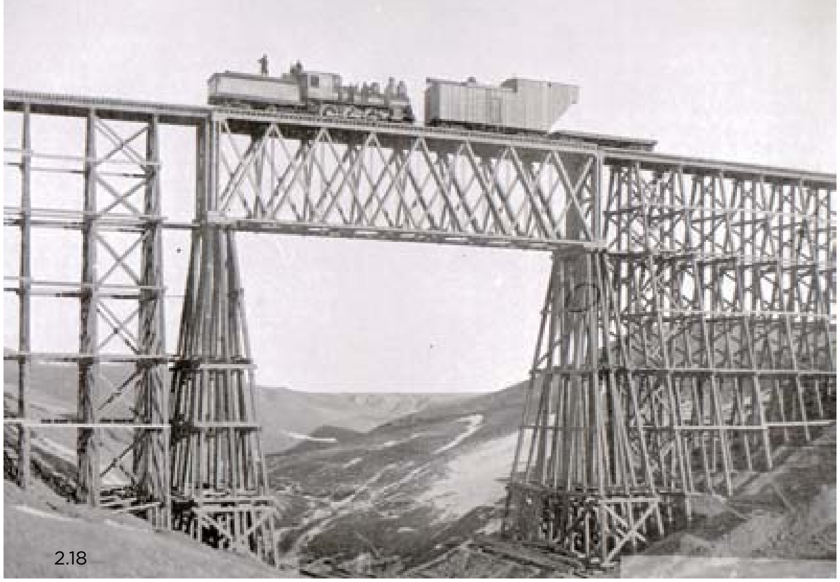
One of the most interesting of the remaining elevator complexes is to be found in the town of Harris, west of Saskatoon (Figure 2.16). In addition to the traditional elevator which is still in use, the complex includes a second barn-like storage building that is an ingenious combination of heavy timber and light frame construction. Externally, the appearance is that of a series of horizontal ribs projecting from the walls of the building. In fact these are heavy timber beams laid on the flat and separated vertically by short sections of frame wall. The lateral forces exerted by the stored grain are resisted by tie rods that pass right through the building, connecting the pairs of beams on opposing exterior walls. The regular pattern of the tie rod anchors is visible on the outside of the building.

As the railroad pushed westward, the challenging mountain terrain called for even greater ingenuity in overcoming the many geographic obstacles. The most versatile structure for spanning across washes, valleys, rivers and swamps was the trestle (Figure 2.17 – next page). With the earliest US examples dating from around 1855, trestles carried the rail bed over such obstacles on a series of closely spaced, triangulated supports known as bents, connected longitudinally by diagonal braces.

Trestle construction began with the felling of trees in the late winter, when they contained the least sap and would therefore be least prone to checking and splitting. The logs were moved by oxen teams to the banks of rivers to be carried downstream to the construction site. There, they would be debarked and dressed with broad axes. Timbers were used full size where possible, and connections were often made using let-in joints that improved stability and load transfer. Iron hardware including nuts, bolts and washers was typically forged by a blacksmith assigned to the construction crew.

2.16


2.17

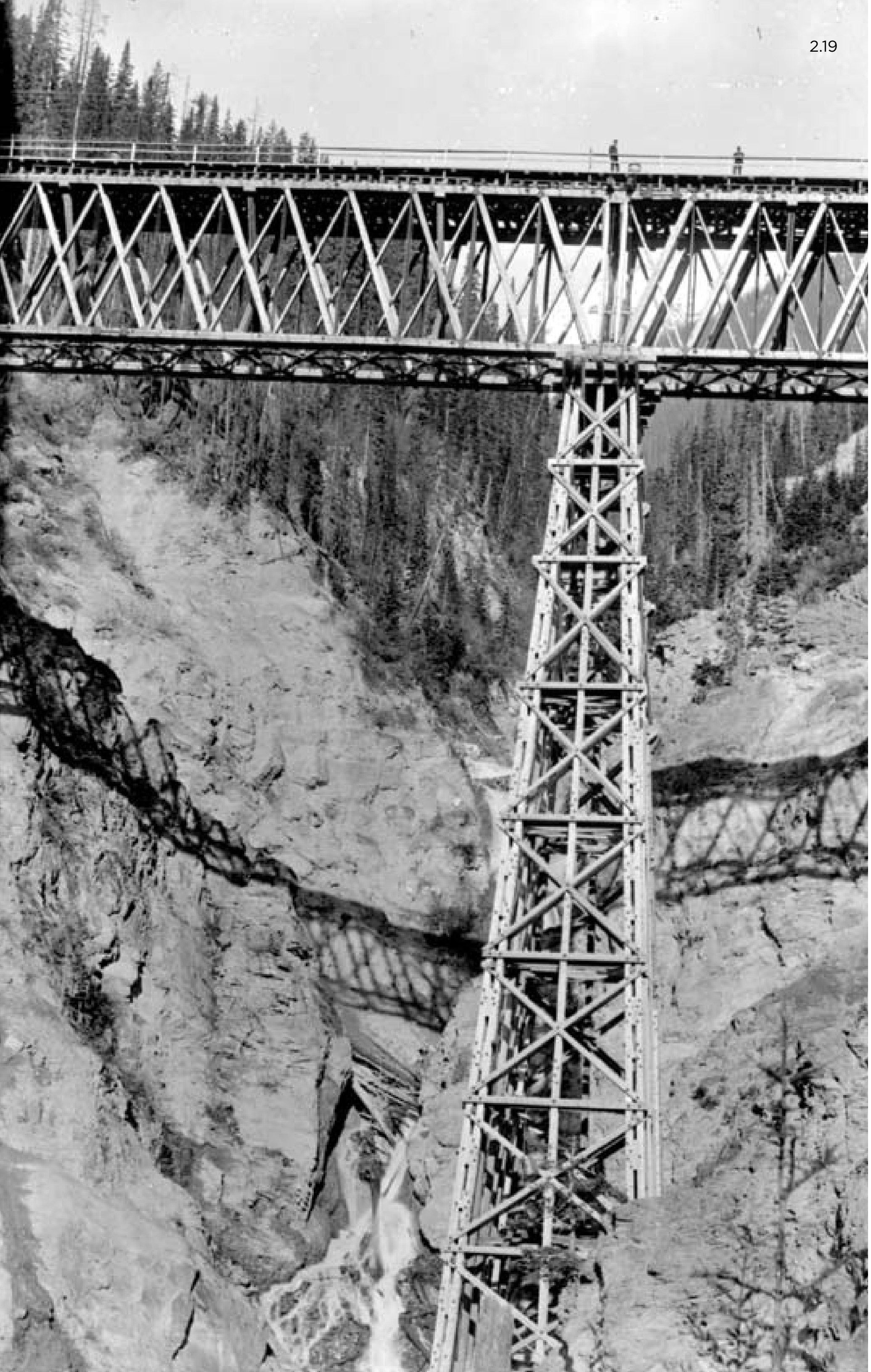

2.18

Assembly began with the triangular bents, which were raised into place by oxen, horses or teams of men. Once the first few bents were set, stringers and braces would be slid out over light boards and lowered into place using ropes. Once bolted together, the structure became an extremely strong and rigid base for the rail bed. Lateral cap beams supported longitudinal stringers, upon which the rail ties and then the rails themselves were spiked. Load testing was done using railroad cars of increasing weight pushed out to mid-span. Additional bracing was added if necessary, until the engineers were satisfied that the structure would carry a loaded train (Figure 2.18).

Engineering masterpieces abound in the mountains of British Columbia and it was not uncommon for a short stretch of track to include numerous structures of unprecedented length and height. One such piece of terrain was the Rogers Pass in the Selkirk Mountains, where in 1885 the CPR's Manager of Construction, was James Ross. Parks Canada's 'History of Glacier National Park' notes:

> "At Mountain Creek, Ross's forces built a trestle which stretched across a gap in the valley wall for 331 metres and stood 50 metres above the mountain torrent. A few kilometres farther up the line at Stoney Creek, a bridge was constructed which towered 64 metres above its footings (Figure 2.19). This bridge was heralded by the engineers of the day as the highest such structure in the world."[R6]

2.19



[2.17] Railroad trestles were among the most majestic achievements of 19th Century engineering.
[2.18] A loaded train was the ultimate test of strength for a newly completed bridge.
[2.19] When completed in 1885, Stoney Creek Bridge was the highest of its type in the world.

2.20

Innovation in wood continued, as traditional craft techniques were modified and improved with the introduction of other complementary materials and technologies. Epitomizing this increasingly sophisticated understanding of timber engineering was a trio of wooden suspension bridges over the Fraser River in British Columbia, designed by structural engineer J. A. L. Waddell and built between 1903 and 1911.

The first bridge to be built was at Sheep Creek in the Chilcotin region and, with the exception of steel cables and iron bolts and connectors, the entire 100m span was made of wood (Figure 2.20). The deck comprised a series of identical prefabricated panels, ingeniously designed so that individual timber rail and deck components could be replaced without decommissioning the structure (Figure 2.21).

Although Waddell's design included pin joints at the base of the wooden towers, for some reason these were not installed. This oversight increased the stress in the vertical members which began to show premature signs of failure, prompting their replacement in 1906 with cast-iron towers. This same tower design was then used on the two bridges that followed. Of the original bridges, only that at Lillooet survives, still providing access to the Lillooet First Nation.

In an appraisal of the Lillooet Bridge, Vancouver structural engineer Josef Novacek wrote:

> "The detailing of the trusses shows how well Waddell understood the specific problems of structural design in timber and his practical approach to fabrication. Cast iron blocks 'replace' complex and labor-intensive timber to timber connections. This detail simplifies fabrication considerably in that the diagonal timbers have square end cuts.
>
> Because of the clear conceptual design and simple prefabricated connections, construction in the field did not require exceptional skills or equipment. Furthermore, structural repairs, maintenance and replacing of individual members were easy to make.
>
> It is likely that, during the regular maintenance, some wood members, mainly in the deck, have been replaced over the past 90 years. But it appears that the majority of the members in the trusses are the original timbers. The durability of well-detailed timber structures in a comparatively dry climate is demonstrated here."[R7]

2.21

Waddell’s design reflects his deep understanding of the structural properties of wood and how to optimize its performance with careful detailing. Equally importantly, he also recognized the constraints imposed by the remoteness of the site, and the limitations of locally available technology and fabrication expertise. In the intervening 100 years, this intimate relationship between man and material has been lost, and is only now being rediscovered.

[2.20] As originally designed, even the towers of the Sheep Creek suspension bridge were made of wood.
[2.21] The decks and handrails of Waddell’s bridges were made up of modular prefabricated components.

There are a few other major wood structures that survive from the first two decades of the 20th century, including an impressive series of aircraft hangars at Camp Borden in Ontario, birthplace of the Canadian Air Force (Figure 2.22).[R8] Originally 15 in number, and completed in 1917, these were the first purpose-built military aircraft hangars in Canada. Those that remain are the only surviving examples anywhere in the country from World War 1. The 36m-wide hangars are spanned by bowstring trusses, with a faceted top chord, straight bottom chord and a web made up of a lattice of dimension lumber.

The historical importance of the remaining Borden hangars was confirmed in 1987 when they were included on the register of significant structures by the Federal Heritage Building Review Office. Hangar 11 has since been restored and now houses the Airforce Annex of the Base Museum. However, the fate of the other structures remains uncertain. Three were demolished in the 1990s, a reminder that heritage designation, while undoubtedly raising the profile of buildings such as these, does not provide any legal protection or financial support for restoration. Only buildings owned and administered by Parks Canada enjoy this level of protection so, apart from Hangar 11, the Borden hangars continue to deteriorate (Figure 2.23).

2.22


2.23

[2.22] Birthplace of the Canadian Airforce, the WWI hangars at Camp Borden are of great historical significance.
[2.23] Apart from Hangar 11, the remaining structures continue to deteriorate.

The Collapse of Canada's Wood Building Cultures

The collapse of the indigenous cultures of North America was a human tragedy on an unprecedented scale. The literal decimation of populations broke the continuity of oral traditions and the collective knowledge of practices that had been the lifeblood of these cultures. Among the traditions lost were those of the art and craft of building in wood.

In contrast, the collapse of the European wood building culture in North America was the result of what today might be termed 'market forces'. It was less devastating and less immediate but, by about 1920, equally comprehensive.

At Stoney Creek, James Ross's fixed-span bridge survived until 1930, when deterioration of the wooden structure prompted its replacement with a steel and concrete span. It was the desire for modernity, as much as concern over maintenance, that drove the move away from wood. The Canadian Encyclopedia provides some insight in this regard, foreshadowing the contemporary cultural divide between North America and Europe:

> "The massive timber trestles of Canadian railways that Canadians took for granted, or even found embarrassing because they were not of iron and steel, were much admired in Europe as engineering feats on a par with the still standing aqueducts of the ancient Romans."[R9]

If embarrassment provided the motivation, then more tangible events provided the means.

Chosen initially for its abundance and local availability, wood ironically became, in some measure at least, a victim of its own success. The completion of canals, highways and railroads facilitated the movement of raw materials and finished goods, making both steel and cement more readily and widely available.

The situation was compounded in the last decades of the 19th century, when a succession of fires in cities across the United States and Canada destroyed many wood-framed buildings, prompting a call for regulations that would limit the size and type of structures that could be built in wood.

Simultaneous advancements in reinforced concrete and steel construction made it possible to build taller and taller buildings, while the perfection of the electric elevator in 1880 (which unlike its hydraulic predecessors had no practical operating height limit) made it possible to move people efficiently within these structures. At this point, the form and fabric of North American cities began to change, and wood was relegated for the most part to residential and small commercial construction. Even the availability of automated sprinkler systems (first installed in a New England piano factory in 1874) could not stem the tide of change.

However, while the culture of wood building may have collapsed, one cannot say that the wood industry in Canada suffered by it. Successive tides of immigration to both Canada and the United States supported an ever-expanding housing market and ensured a steadily increasing demand for exports of sawn lumber. This being the case, there was little incentive either to develop new products or to pursue new and more diverse markets. Hence, the wood industry settled for the status quo, and entered a long period of stagnation while other construction sectors continued to develop and evolve.

[2.24] Double curved glulam arches created new aesthetic possibilities, seen here in the Burquitlam Safeway BC.
[2.25] A classic of West Coast Modernism, Ron Thom's Forrest House in West Vancouver BC.

2.24

2.25

When the Modern Movement in architecture began in Europe in the 1920s, it was as much a technological revolution as an aesthetic one. With few exceptions, architects turned their backs on natural materials such as wood, brick and stone — preferring instead manufactured products such as steel, concrete and glass. When this ideology took root in America in the 1930s with the arrival of seminal figures such as Walter Gropius, Marcel Breuer and Ludwig Mies van der Rohe, the continent already had two distinct architectural traditions, differentiated by the construction methods and materials used.

One comprised all-wood structures in which the easy workability of the material was exploited in site-based construction of small buildings, while the other used a palette of manufactured materials and products that could more readily be incorporated into advanced construction practices, and applied to buildings of any scale.

The one manufactured wood product introduced mid-century was glulam (glued laminated timber). It offered many advantages over solid-sawn heavy timber, being much stronger, more dimensionally stable and available in lengths of up to 30m, typically made up of multiple laminations of 2x material, glued together under pressure, glulams could also be formed into curved profiles, offering the possibility of constructing simple and economical arched roofs.

Glulam found a place in suburban supermarkets, hockey arenas and other structures of similar size, some of which have become iconic symbols of their time (Figure 2.24). But the potential of the material was blunted by inflexible building codes, keen competition from the steel industry, a lack of wood engineering training in Canada's post-secondary institutions, and compartmentalized thinking within the design community. These impediments to the wider application of wood are only now being seriously addressed.

2.26

[2.26] Interior view of Etienne Gaboury's Church of the Precious Blood in St. Boniface MB.
[2.27] For more than 60 years, this wooden coaster has thrilled riders at Vancouver's Pacific National Exhibition.


2.27

During this period, wood did contribute to the creation of some landmark Canadian buildings, notably the West Coast houses of Ron Thom, Barry Downs and others (Figure 2.25 – previous page) and Etienne Gaboury's spiraling Church of the Precious Blood in St Boniface MB (Figure 2.26), although these are recognized by historians more for their formal and spatial innovations than for their technical virtuosity.

Arguably the most ambitious wooden structure built mid-century was the 25m-high, 280m-long roller coaster conceived by US ride designer Carl Phare for Vancouver's Pacific National Exhibition. Completed in 1958, the bolted, treated wood structure was engineered by Cyril Maplethorp, and is one of only a handful of wooden roller coasters still operating in North America.

The technical and regulatory barriers that were conspiring to limit the use of wood in large buildings (if not in large roller coasters) coincided with the post-war housing boom in the USA, which saw 500,000 houses built in 1946 and another million in each of the next two years. This unprecedented demand enabled Canada's commodity-based wood industry to flourish with minimal need for new product development, technological advancement or improved forest management practices.

As times and attitudes changed, this left the industry open to criticism on a variety of fronts. As the environmental movement began to coalesce in the 1970s, Greenpeace (founded in Vancouver in 1971) and others protested the cutting of old-growth forests, as well as harvesting practices that resulted in soil erosion, siltation of lakes and rivers and destruction of animal habitat.

Despite its continued importance as an economic driver in British Columbia, northern Ontario and Quebec, confidence in the forest industry declined and wood became associated in the public's mind with environmental destruction. Given the strength and breadth of public sentiment on this issue, it is not surprising that in Canada the struggle to change the image of the forest industry has been a long and difficult one. Only now is this perception beginning to change, enabling wood to assume its natural role as a technologically progressive and environmentally responsible building material.

CHAPTER THREE

A New Foundation

Wood architecture was an integral part of First Nations culture in North America before the arrival of European explorers and settlers. Similarly, enterprising and innovative wood building technology played an important role in the creation and development of Canada as a nation over the next two centuries. Both these traditions have their roots in pragmatism – responding to functional needs, using a material that was abundant, inexpensive and readily available almost everywhere.

However, as this locally developed culture of wood architecture receded, so it was replaced by a more universal architecture based on non-native materials, centralized production and long-distance transportation. There are many reasons to revive a wood building culture in Canada: to reaffirm cultural identity, to re-establish regional character, to resuscitate local economies and, perhaps most importantly, to make a contribution toward the mitigation of climate change.

However, this new wood culture must be founded on a solid base of professional education and expertise, a regulatory framework that supports greater and more innovative use of wood in buildings, as well as access to high-performance materials and leading-edge design and manufacturing technology. Over the last two decades there have been advances in all these areas, and the goal, which so recently seemed unattainable, is now within our grasp.

Education and Expertise

The federal government established wood products research laboratories in British Columbia and Quebec as long ago as 1913. Although they have undergone several changes in name and organizational structure, they have operated in those locations ever since.

Industry advocacy began a little later, with the establishment of the Canadian Wood Development Council in 1959. Renamed the Canadian Wood Council (CWC) in 1964, it is the national association representing manufacturers of Canadian wood products used in construction, and provides support to industry through technical publications and promotional programs.

Early research and marketing efforts focused primarily on fire and other code-related issues, and were undoubtedly successful in developing the residential market in Canada and the US. However, the built works of the mid 20th century provide little evidence of innovation in other market sectors.

In 1979 the research laboratories came under the auspices of Forintek, an industry organization whose mandate was to become "the leading force in the technological advancement of the wood products industry, through the creation and application of innovative concepts, processes, products and education."

As industry perspectives began to broaden in the early 1980s, so the CWC's program offerings began to diversify. These gathered momentum in the 1990s with the publication of the Wood Design Handbook, the introduction of WoodWORKS! design software, the launch of Wood/leBois and Wood Design & Building magazines and a program of Wood Solutions Fairs designed to bring trade and technical information and professional development opportunities to architects and engineers in cities throughout the US and Canada.

Then, in 1998, CWC launched the WoodWORKS! program in British Columbia, a campaign to increase the use of wood in commercial, industrial and institutional construction. This was followed in successive years by similar initiatives in Quebec, Ontario and Alberta, supported by regional and national wood design awards programs.

With industry support, the universities of British Columbia (UBC) in Vancouver (1998) and Laval in Quebec City (2005) have expanded their faculties of forest sciences to include advanced wood-products research facilities. In 2007 UBC created an Endowed Chair in Wood Building Design and Construction — the first of its kind in the country.

[3.01; 3.02] The Forest Sciences Centre is adjudged by code to be two buildings separated by an interior street.


3.01

The Regulatory Framework

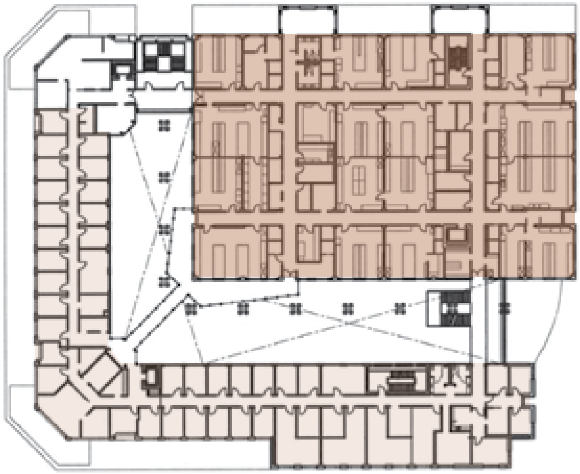
In 1941 the federal government of Canada published the first National Building Code (NBC) with the aim of unifying the different standards that had been in force across the country up until then. The NBC was adopted by the various provinces and municipalities in Canada over the next 20 years. Since 1960 there has been a new edition of the NBC published approximately every five years.

The publication of codes now comes under the auspices of the Canadian Commission on Building and Fire Codes. Requirements for the specification of structural wood products and wood building systems are set forth in the National Building Code, which is concerned with health, safety, accessibility and the protection of buildings and their occupants from fire or structural damage. From the outset, the NBC differentiated between combustible and non-combustible construction, a decision that severely limited the size and types of buildings that could be built in wood.

In 1985, some relaxations were introduced, allowing the use of certain wood elements in non-combustible buildings in conjunction with sprinklering. In 1990, the maximum height for residential buildings of combustible construction was increased from three to four storeys, and in 1995 extended to Group D and E occupancies, which include most retail and service commercial uses. In 2009, at the provincial level, British Columbia further increased the permissible height of combustible construction for residential buildings to six storeys.

Nonetheless, in contrast to the objective-based codes prevalent in Europe, which place the onus on design professionals to demonstrate the ability of a particular building wall, floor or roof assembly to perform to the required structural or fire-safety standard, the NBC remained prescriptive. Rather than supporting innovation, prescriptive codes make it much easier for architects and engineers to select from a range of construction assemblies deemed by previous testing to comply with the appropriate standard.

Under these circumstances, architects needed great ingenuity to maximize the potential of wood use in large-scale buildings. One project that reflects this approach is the UBC Forest Sciences Centre, designed by DGBK Architects with structural engineers CWMM, and completed in 1998. The strategy was to divide the four-storey, 15,400m² building programmatically into two components separated by an L-shaped interior atrium (Figures 3.01 and 3.02).



3.02 Typical floor plan

▨ LABS

▨ OFFICES


3.03

[3.03; 3.04] The wood-encased steel structure of the GC Osaka Building was demonstrated by independent testing to meet the required fire resistance rating.

The administrative component, with its short spans, modest loading requirements and low-hazard occupancy, follows the shape of the atrium on the west and south sides of the building and is built in light wood frame construction. The laboratory component, with its longer spans, higher loading requirements and higher hazard occupancy, forms a rectangular block on the other side of the atrium and is built in concrete.

Bridges connect the two components across the atrium, which through the use of fire-suppression and smoke-dispersal technology was demonstrated by code consultants LMDG to provide an equivalent level of fire and life safety to that of an unenclosed street. Hence the wood frame and concrete components are considered by code to be separate buildings.

Challenges to the prescriptive requirements of the code were based on this principle of equivalency until 2005. Such challenges generally required extensive and costly testing, and were thus not a viable option for many projects. However, recent advances in fire behaviour simulation software have made the evaluation of design alternatives more cost-effective, and enabled designers to challenge existing preconceptions about wood.

Elsewhere in the world, a combination of virtual modeling and stringent testing has already transformed the understanding of wood, from that of a combustible material whose use must be restricted, to one that can protect other materials from fire[F3]. In Japan, the steel structure of Shigeru Ban's GC Osaka Building, a mid-rise office tower in Osaka, is protected by two layers of 25mm-thick particleboard (Figures 3.03 and 3.04), while in Australia the cruciform columns and wide-flange beams of Morris Nunn Associates' Forest Eco Centre in Scottsdale, Tasmania, are protected by solid sections of eucalypt hardwood (Figures 3.05 and 3.06 – next page).

With respect to structural design, the NBC also takes a very conservative approach, recognizing only straightforward structural systems and a limited range of simple, rather inefficient connections. However, the code does allow structural engineers to propose alternative solutions that lie beyond its own scope, and to provide supporting evidence of their acceptability in other jurisdictions, or calculations that otherwise demonstrate their compliance.

These regulatory changes have been supported by other government initiatives, notably in British Columbia, where in 2009 the provincial government declared the Wood First Act,[R10] requiring wood to be considered as a structural and finishing material for public buildings wherever possible. This change was made in recognition of the environmental benefits of building in wood (See Chapter Six) and is similar to policies promulgated previously in France and New Zealand.

[F3] Because wood chars at a predictable rate, over sizing structural members can provide a calculable degree of fire resistance. As these international projects demonstrate, the same logic can be applied to the protection of steel structures, although to the author's knowledge this has not yet been done in Canada.


3.04

3.05

New Materials and Manufacturing Technology

Largely because of the high-volume and low-tech nature of the domestic housing sector, the North American wood industry has lagged behind Europe in the development of engineered wood products and the introduction of sophisticated manufacturing technology. In the mid-1990s the per capita use of glulam in Canada was reported to be among the lowest in the developed world, being one quarter of that in Europe and one half of that in the USA. [R11]

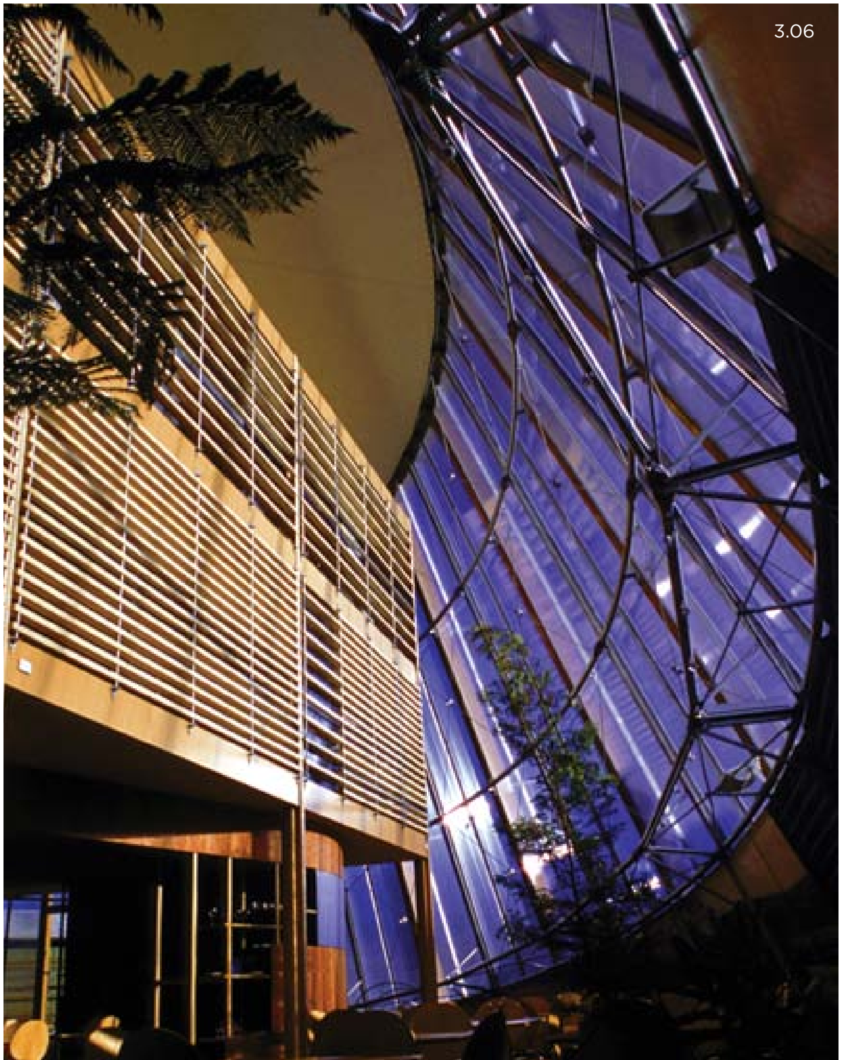
Engineered Wood Products

The term engineered wood product (EWP) refers to an increasingly broad range of panel and beam products that are manufactured from wood fibre, wood veneer or small wood sections, combined with glue in a heat-press process. The advantages they have over conventional solid-sawn lumber include more efficient use of wood fibre, increased strength, predictability of structural performance and improved dimensional stability.

Patented around 1860, but not mass-produced until the early 1900s, plywood was the first EWP, and provided a quick and economical alternative to sheathing and boarding with solid-sawn planks. Plywood consists of multiple layers of wood veneer, glued together with the grain of alternate laminations at right angles to one another. This cross-lamination gave early wood-frame structures superior resistance to lateral deformation (shear) although it has been in other industries such as furniture, boat and even aircraft manufacture that the true strength and versatility of plywood have been most comprehensively explored.

Glue-laminated timber (glulam) followed in the 1950s, primarily as a substitute for the heavy timber beams that were increasingly difficult and costly to produce due to a growing scarcity of suitable and accessible large-dimension trees.

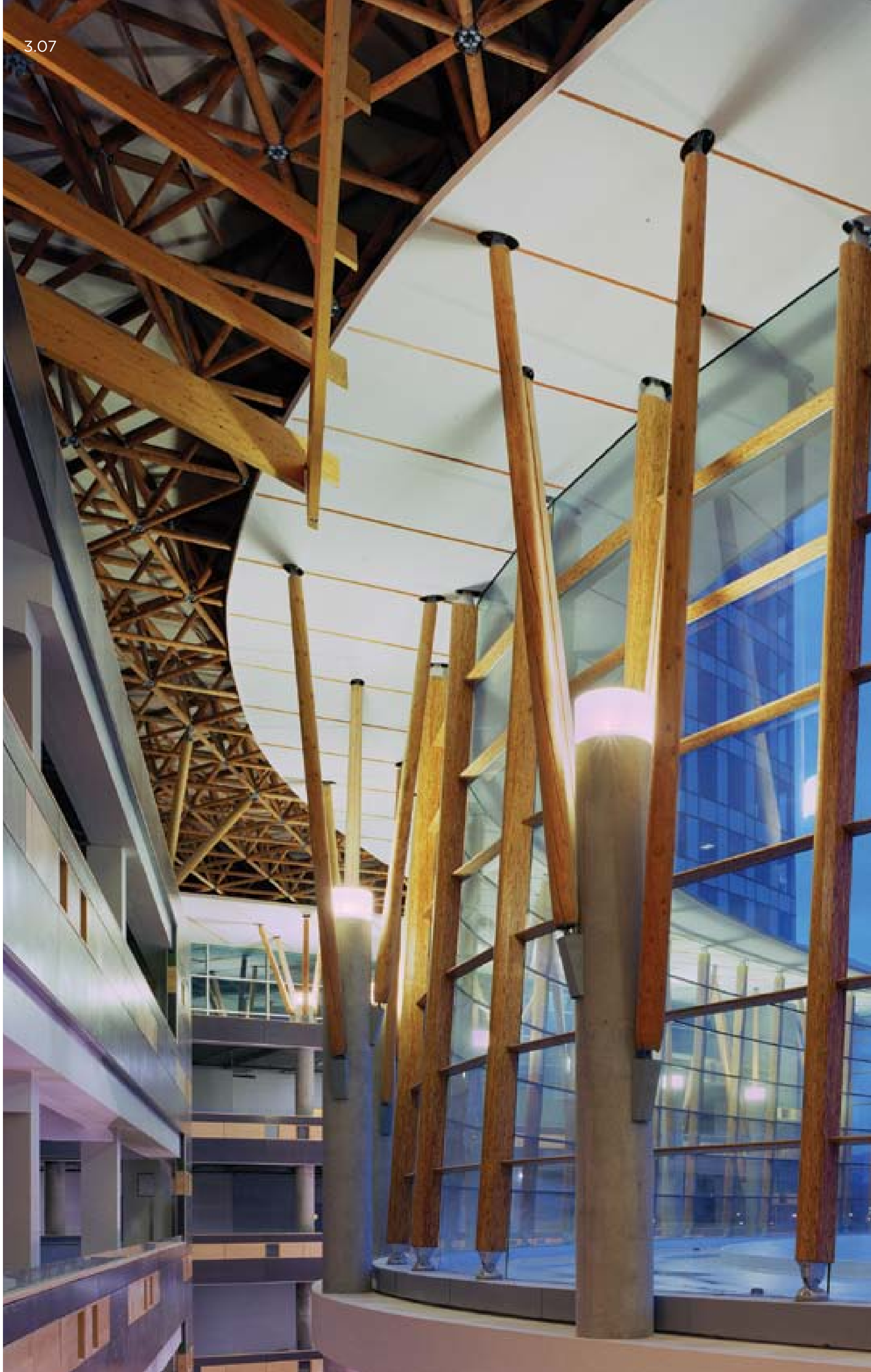
By the 1980s, the pressure to bring North American forest practices into line with emerging international principles of sustainable forest management (see Forest Certification, p.65), which further constrained the supply of large-dimension timber, provided the impetus for research and investment in product development and manufacturing technology. One result has been the introduction of a variety of new EWPs that together provide the designer with an expanded range of options and possibilities.


3.06

[3.05; 3.06] In the Forest Eco Centre, an exterior polycarbonate envelope shelters a freestanding steel office structure. Fire protection is provided by wood sections secured to the steel members.

[3.07] PSL columns and muntins support the upper section of the atrium north wall at Surrey Central City.
[3.08] Ductile iron castings make for an elegant connection at the column bases.

3.07



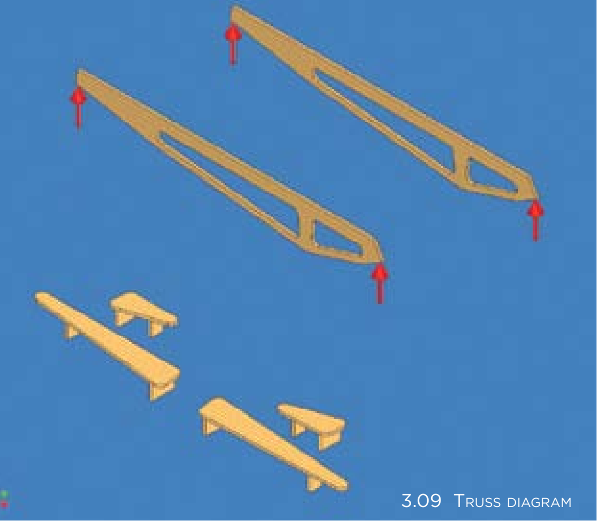
For the most part, the wood industry has introduced these products for conventional beam, column and panel applications as substitutes for traditional solid-sawn products. Thus when they reach the retail environment these EWPs, which are manufactured in large-scale beams or billets, have been cut into relatively small pieces. However, some architects and engineers have begun to recognize the potential of the uncut products for very different end uses.

The first of the new generation of EWPs to reach the market was parallel strand lumber (PSL), introduced in the modular pavilion structures at Vancouver's Expo 86 World's Fair. In common with the other products that followed, parallel strand lumber uses high-grade veneers peeled from small-dimension trees and bonded together with water-resistant, thermosetting glue. PSL comprises shreds of veneer that are mixed with glue and extruded into billets up to 25m in length. For the retail market, the material is then cut to a range of standard sizes for use as beams, columns and truss members.

Square-section PSL, in lengths up to 13m, was used for the tree columns in the Forest Sciences Centre at UBC, and since then has begun to appear more frequently in non-residential buildings. The most impressive application to date is at Surrey Central City in Surrey BC, where turned and tapered PSL columns and muntins are used to support the glazed entrance façade of this 100,000m^2 office and retail development. Designed by Bing Thom Architects and completed in 2003, the wood components, here and elsewhere in the complex, were designed, fabricated and installed by StructureCraft Builders.

The curving glass entrance façade measures 25m in height and more than 75m in length (Figure 3.07). The supporting structure is divided into two tiers, separated horizontally by a projecting concrete canopy. The 13m-high, 600mm-diameter columns on the lower tier were built up from rectangular sections of PSL, before being turned on a custom-built lathe. Turned PSL muntins transfer the lateral loads from the glass to the columns. Connections top and bottom are custom ductile iron castings (Figure 3.08). A similar but smaller-scale version of this system is used for the upper tier of the structure, extending from the canopy to the roof. PSL lends itself to this kind of turned and tapered application as, unlike laminated products, the thin strands of wood fibre result in a finished member that has a similar appearance when viewed from any angle.


3.08



3.09 Truss diagram

3.10

Laminated veneer lumber (LVL) and laminated strand lumber (LSL) are related products with similar properties and applications. LVL, like plywood, is laid up using full veneers, although it is parallel-laminated rather than cross-laminated, making it stronger in one direction than the other, and hence useful for beams and similar applications. LSL uses smaller sections of veneer and hence exhibits less obvious layering when viewed in cross-section. Although thicker than plywood, both LVL and LSL have similar properties in flexure when used in panel form.

Engineers Fast + Epp have experimented with LSL panels in two separate applications. In 1998 the firm, working with Henriquez Partners Architects, designed intriguingly counter-intuitive roof trusses for the False Creek Community Centre in Vancouver BC. Rather than building up a truss in the conventional manner from discrete linear elements, they instead started with a solid panel of LSL and cut out the negative shapes (Figure 3.09). The truss is completed with a steel cable extending along the bottom edge as a tension chord (Figure 3.10).

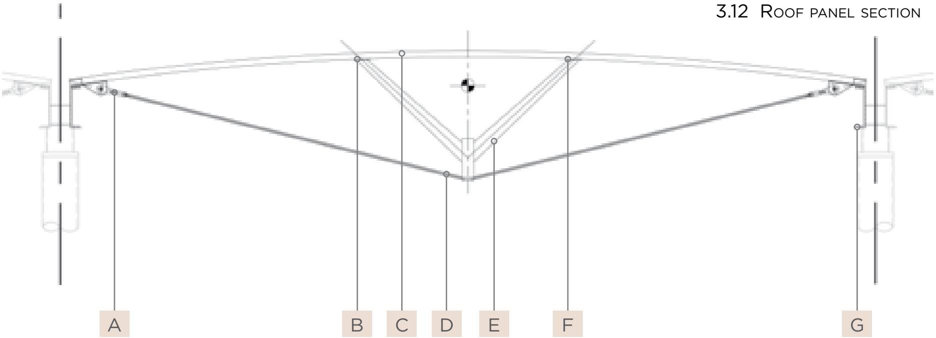
Then in 2001, capitalizing on the inherent flexibility of the material, the firm designed a simple and elegant roof system for Perkins+Will Canada Architects' Gilmore transit station in Burnaby BC. The roof system consists of 64 identical pre-tensioned curved LSL panels supported by a simple structural steel frame (Figure 3.11). Each panel measures 2.4m by 4.8m and is bowed with stainless steel wires stretched over a cast steel spreader bar assembly (Figure 3.12).

The wood I-joist is perhaps the most commonly used of all the newly introduced EWPs, having wide application in residential and small commercial construction. Manufactured in long lengths, the joists typically have an oriented strand board or plywood web with solid-sawn lumber flanges, and are designed to provide a secondary roof and floor framing system that can run continuously over a number of supports. Holes can be drilled in the web to accommodate ductwork and other services, making wood I-joists a viable alternative to open-web steel or composite joists.

3.11

[3.09] Conceptual drawing of LSL trusses for the False Creek Community Centre.
[3.10] Each truss is cut from a single panel of LSL, with a steel tension cable forming the bottom chord.
[3.11; 3.12] Curved LSL panels create a light and economical roof system for Gilmore Transit Station.

3.12 Roof panel section



A	Stainless steel fork assembly
B	King post bearing plate
C	38mm thick timberstrand roof panel
D	12.7mm diameter stainless steel wire
E	cast ductile iron king post
F	3mm rubber bearing pad
G	Steel supporting framework

3.13

These attributes were exploited in a novel way in the two-storey Mountain Equipment Co-op store in Ottawa, designed by architects Linda Chapman and Christopher Simmons with structural engineers Cleland Jardine Engineering Ltd (Figure 3.13). Completed in 2000, the structure is built largely from materials reclaimed from the dismantling of buildings that previously occupied the site.

Within a post-and-beam frame of reclaimed heavy timber, new I-joists were used as a wall framing system, providing increased structural depth and spanning the full height of the building from sill to eaves. The I-joist studs are secured top and bottom with steel brackets, and the cavities are filled with cellulose insulation (Figure 3.14). The joists themselves offer the same advantages as when used as a flooring system, enabling services to be run through holes drilled in the web — a simple solution readily transferable to a variety of other situations.

Glulam still has a significant role to play, both structurally and aesthetically, and new fabrication techniques offer the possibility of shaping individual members, or creating complex structures with members curving in two directions.

3.14

One innovation in fabrication is the introduction of clear polyurethane glues that permit the milling of curved cross-sections without the black marks between laminates caused by traditional glues. The first use of this technique was in the Salteaux Community Centre in northern British Columbia, designed by Communities + Architecture/Marshall Arts with structural engineers Equilibrium Consulting, and completed in 2003 (Figure 3.15). The centre roof beam and two circular supporting poles are tapered over their entire length and, together with the exposed wood joists, evoke the fine craftsmanship of traditional Salteaux artefacts such as quill breastplates (Figure 3.16).

In Canada, the unique ability of glulams to be fabricated in curved sections has never been more dramatically exploited than in the roof structure of the Carlo Fidani Peel Regional Cancer Centre in Mississauga ON. Here, architects from the Farrow Partnership, together with structural engineers Halsall Associates and glulam fabricator Timber Systems, created a highly complex organic structure that would have been virtually impossible to achieve in any other material.

3.15

3.16

[3.13] The MEC Ottawa building utilizes timbers reclaimed from demolished structures on the site.
[3.14] Wood I-joists are used for wall framing, and run continuously from sill to eaves.
[3.15; 3.16] The structure of the Salteaux Community Centre includes glulams turned and tapered using CNC technology. Clear polyurethane glue gives the members a clean appearance.

3.17

The structure, which covers nearly 1000m^2 and rises through three storeys, comprises nine tree-like columns whose uppermost branches come together to form a canopy-like space frame (Figure 3.17). Both structural analysis and fabrication were complex, with the many glulam components connected by embedded steel plates, most of which are concealed to maintain the visual integrity of the overall concept (Figure 3.18). Because of the complex geometry of the structure, a high pressure misting system (rather than conventional sprinklers) had to be used for fire protection.[F4]

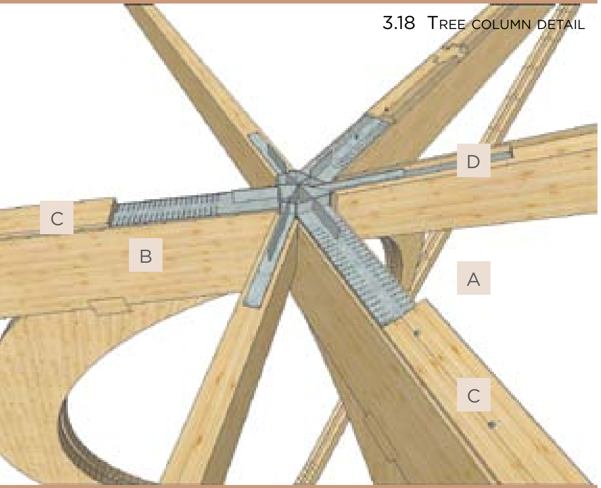
CAD/CAM Technology

The most significant recent advance in the design and fabrication of wood structures is undoubtedly the application of computer-aided design and manufacturing (CAD/CAM) software and the transfer of computer numerically controlled (CNC) manufacturing technology from the furniture industry to structural wood components of an architectural scale.

The software is able to model entire structures in 3-D, and to generate fully dimensioned fabrication drawings, complete with tolerances, for each structural member in digital format. These digital files can then be used to instruct CNC machines that can cut, plane, drill and route components of almost any size and shape to tolerances of 0.5mm. Each component can be labeled and referenced to an assembly diagram before being shipped to site.

Prior to its arrival in Canada in 2002 (when a ‘five-axis’ CNC machine was acquired by Structurlam Products of Penticton BC), CNC technology had been applied to many prominent European projects, some of considerable scale and complexity. For example, in the Richard Rogers Partnership’s Bordeaux Tribunal, completed in 1998, 3-D software was used to model the vertically tapering courtroom pods which, because of their unusual geometry, could not have been defined mathematically nor easily drafted by conventional means (Figure 3.19). The digital design files were then used to instruct CNC machinery which cut the more than 1400 unique structural and finishing components for each of the seven courtrooms (Figure 3.20).

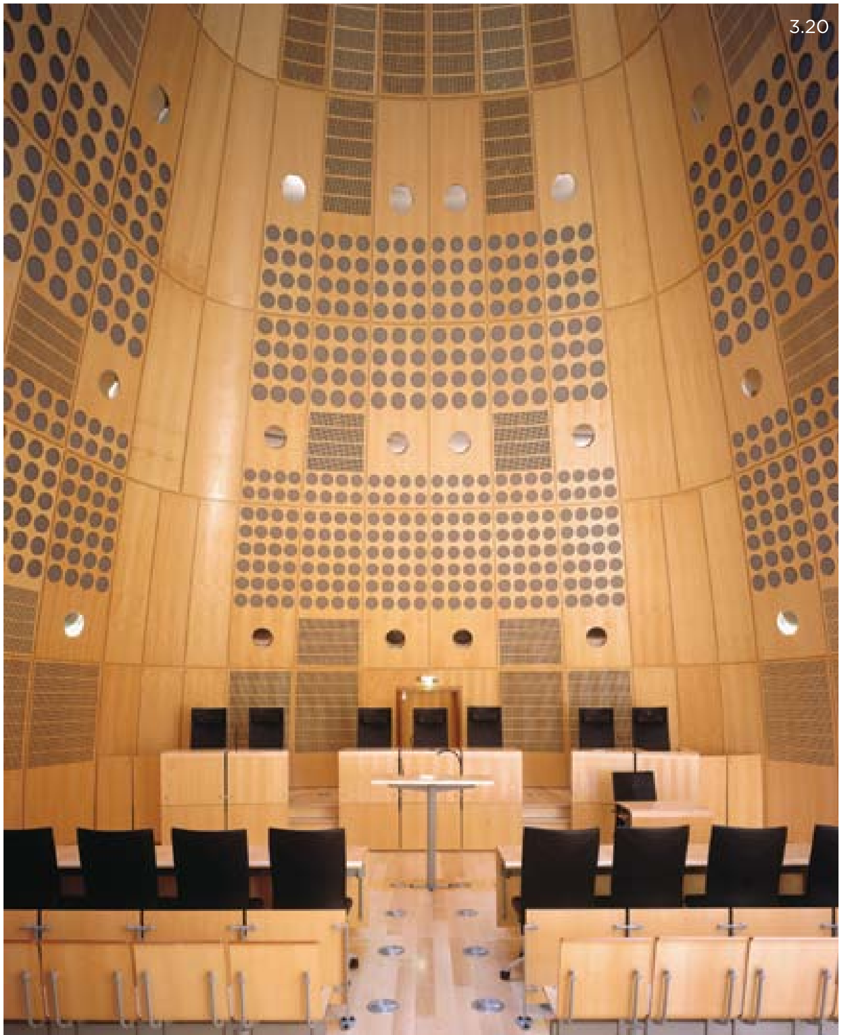
A	Concealed steel dowel connection
B	Steel strap assembly using timber rivets
C	Bevelled nailer
D	Shear key



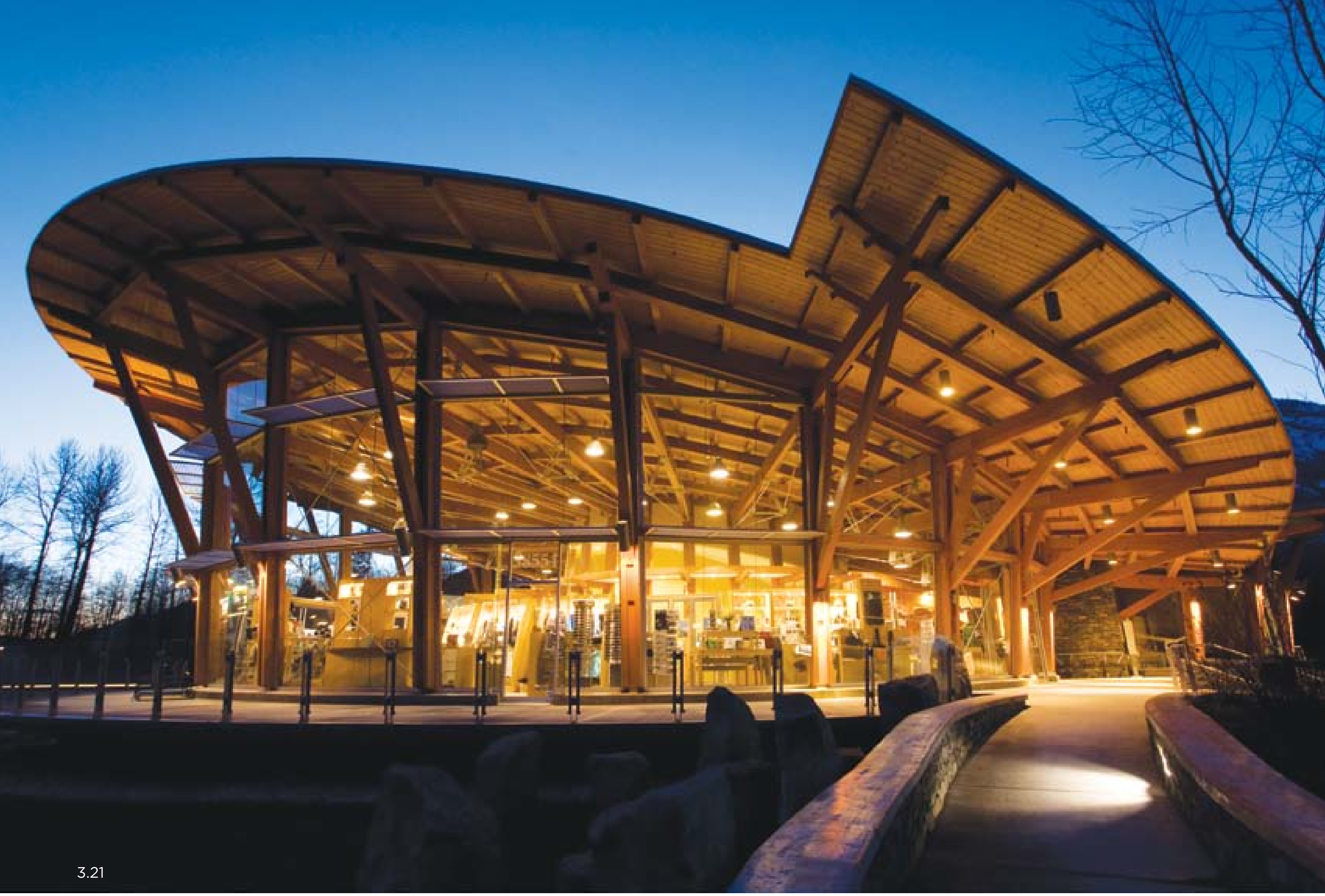
3.18 Tree column detail

[F4] Water vapour is released from heads mounted 1.5m above the ground in specially designed light fixtures. It rises with the warm air to coat every surface of the structure creating a barrier to fire.


3.19


3.20

[3.17; 3.18] Details of the glulam structure at the Carlo Fidani Peel Cancer Centre.
[3.19; 3.20] The seven courtroom pods at the Bordeaux Tribunal, each comprise 1400 unique wood components fabricated using CNC technology.



3.21

[3.21] The curvilinear form of the Squamish Adventure Centre posed a challenge for designers and fabricators. [3.22] The accuracy of CNC fabrication enabled glazing to be installed directly into the glulam framing.

Since 2002 the Structurlam machine has created components for a number of precedent-setting buildings in the interior of British Columbia, beginning with the Salteau Community Centre. The potential for the technology is now widely recognized by architects and engineers, more of whom are willing to embark on the steep learning curve. Similarly, other fabricators are experimenting with CNC technology at a variety of scales.

The Squamish Adventure Centre in Squamish BC, which opened in 2005, is the result of one such experiment. The elliptical geometry of the building posed challenges to the architects and engineers from the Iredale Group, as well as to their detailers and fabricators, who had to calculate hundreds of precise member dimensions, and design connections with complex compound intersecting angles (Figure 3.21).

CAD/CAM software was used to create a 3-D model that enabled each member to be designed and fabricated complete with pre-drilled bolt holes, pre-cut mitres and kerf grooves. This level of precision enabled timbers to be fitted together perfectly on site and permitted the glazing to be installed directly into the structural frames without the use of cover plates (Figure 3.22).

Connection Systems

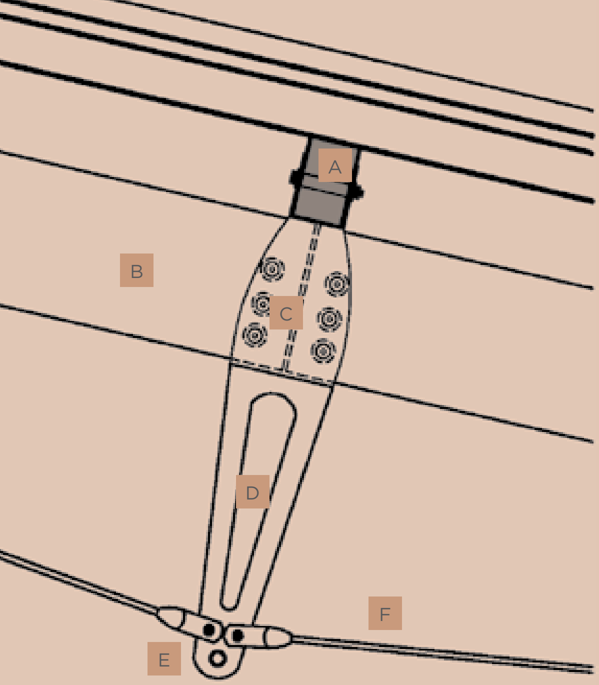
The engineers for the Squamish Adventure Centre also designed a universal swiveling king-post connection to accommodate the incremental changes in joint geometry that occur throughout the wing-like form of the roof (Figures 3.23 and 3.24 – next page). Custom universal connectors represent one approach that has been used to address an often cited disadvantage of wood structures — the cost and complexity of connection design.

Connections are typically the weakest and most expensive part of a timber structure, and simple, loose-fit bolt connections (until recently the only connection type specifically recognized in Canadian codes) are particularly inefficient. Thus historically it has been connection design, rather than load-carrying capacity, that has governed the size of structural members in Canadian wood buildings. As a consequence, wood structures in Canada have tended to appear heavier and less elegant than their European counterparts.

3.22

A	Glulam purlin
B	Glulam top chord
C	Steel saddle
D	Steel king post
E	Adjustable connector
F	Steel tie rod

3.24 Detail of universal connector




3.23

Of late, there has been an increasing interest among engineers in the intrinsic properties of wood, and in the most efficient ways to transfer loads through wood to wood connections. The knowledge that is being acquired today through computer modeling and laboratory testing is reaffirming the empirical understanding that was part of Canada's wood building culture of the 19th and early 20th centuries.

Joseph Novacek's interest in the Lillooet Bridge was not purely academic; he was instrumental in reviving parts of that lost tradition in the Fish Trap Creek Park structures in Abbotsford BC, designed with architect Brad Cameron and completed in 1997.

Cameron, also a furniture maker, wanted to create a feeling of lightness and transparency, eliminating if possible the use of solid shear walls, in the picnic shelter, reading platform and entrance pier he had been commissioned to design (Figure 3.25).

In response, Novacek drew on European codes to design moment connections[F5] that use small tight-fit bolts, rather than conventional loose-fit ones. Driven into slightly undersized holes in members made from kiln-dried lumber, these connections are more compact and efficient as they also transfer loads through friction. Novacek also arranged the pins in a non-rectilinear pattern, a strategy that European codes reward by reducing the required distance from the connection to the loaded face of the structural member.

For bracing elements, Novacek used 'let-in' connections (similar in principle to those used in railroad trestle construction), in which members are notched or chamfered at their point of contact so that the angle of the grain to the mated face is approximately equal in both members. Because the compressive strength of wood parallel to grain is much higher than it is perpendicular to grain, this geometry equalizes stress and enables the joint to be more efficient in transferring loads.

3.25

[3.23; 3.24] Adjustable king-post connectors respond to the changing geometry of the roof.
[3.25; 3.26] Highly efficient connections derived from European codes enable the Fishtrap Creek park structures to achieve a light and dynamic quality.

The combination of techniques applied here reduces member sizes, eliminates the need for shear walls, and makes possible the dynamic roof planes that give these structures an uncommon lightness and agility (Figure 3.26).

Research has confirmed that reducing tolerances is critical to improving the efficiency of load transfer, and to increasing the overall strength of structures. CNC technology has not only facilitated improvements in the performance and reliability of traditional connection systems such as bolts, but also made possible a new generation of high-efficiency, pre-engineered connection systems.[R12]

These proprietary connectors typically come in a range of sizes, each with a predetermined capacity, and can therefore be specified to meet the requirements of any given application. They can greatly reduce the time and cost of detailing a wood structure, making it more competitive with steel or other alternatives.

First imported in 2003, German-designed Bertsche connectors made possible the unique heavy timber lattice-roof structure at Ib G Hansen's Sk'elep School of Excellence in Kamloops BC. Engineered by Equilibrium Consulting and prefabricated on site, each roof module comprises a perimeter frame of deep glulam beams, with an internal lattice made up of three layers of 6x6 solid wood members.

3.26

[F5] A Moment Connection is a connection between a beam and a column where the end of the beam is restrained from rotating, thus creating a rigid frame without the use of conventional cross-bracing.

3.27

The Bertsche connectors are used to secure these internal members to the perimeter beams. The connectors have two main parts, a threaded steel sleeve that is inserted in a pre-drilled socket in the end of the heavy timber member; and a base plate which in this case is embedded in the glulam edge beam (Figure 3.27). The sleeve is secured by pins passed laterally through the beams, and connected to the base plate by a threaded rod. The result is an elegant and unusual roof structure in which only the lateral securing pins of the connectors are visible (Figure 3.28).

Engineers Fast + Epp have also devoted considerable attention to improving the elegance and efficiency of wood-to-wood connections, in structures whose configuration reflects the natural flow of forces through the members to the ground. A good example is the West Vancouver Aquatic Centre, designed with architects Hughes Condon Marler, and completed in 2002.

In the roof structure, the curved beams and wishbone columns act together as moment frames, with the connections between them achieved using techniques derived from European practice (Figure 3.29 – next page). Steel plates welded to steel rods are epoxy-glued into sockets cut and drilled in the underside of the beam and the top of the columns. The plates protrude slightly, and when brought together leave a gap just large enough for a welded connection to be made (Figure 3.30 – next page). With the completed joint reading only as a shadow line, it is the overall form rather than the connection design that lends character to the structure.

[F6] PEFC was founded in 1999, as an international umbrella organization providing independent assessment, endorsement and recognition of national forest certification systems, taking into account local environmental, social and economic realities.

[F7] Some jurisdictions, also limit the size of clear cuts, although these limits are generally larger than those mandated by FSC. BC's Forest Practices Code for example has clear cut limits of 40 or 60 hectares according to region, while the FSC limit is 10 hectares.

[F8] LEED awards credits in six key areas of design: Sustainable Sites, Materials and Resources, Energy and Atmosphere, Water Conservation, Indoor Environmental Quality and Design Innovation. According to the total number of credits achieved, a building may be awarded a Certified, Silver, Gold or Platinum rating.

Forest Certification

Elsewhere in the developed world, wood is widely acknowledged as the most sustainable of the major construction materials. However, in North America there has been a credibility gap between the forest industry and the public over the issue of forest management practices. It is only in the last decade or so, since the introduction of third-party certification of sustainable forest management (SFM), that this gap has begun to close.

Originally conceived as a way of reducing tropical deforestation, SFM certification has now spread to other climate zones and offers consumers the best possible guarantee that the wood products they purchase have been obtained from properly managed forests, and will not therefore contribute to the overall loss of forest cover. Numerous certification systems have been developed and are now administered by a range of industry and other organizations. In Canada three main systems are in use: Sustainable Forests Initiative (SFI); the Canadian Standards Association (CSA) and the Forest Stewardship Council (FSC). Between them these systems now cover 134 million hectares of commercial forest in Canada — a larger area than in any other country.

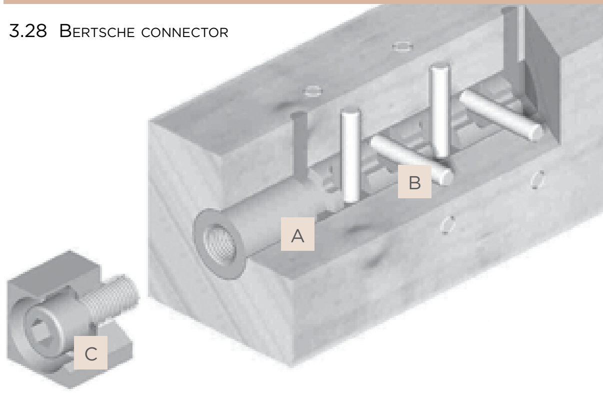
In addition to individual certification systems, there are also international endorsement programs for forest certification. All three systems mentioned above have been endorsed by the Swiss-based Program for Endorsement of Forest Certification schemes (PEFC). This endorsement provides additional assurance that the leading systems are all based on sound science.[F6]

However, forest certification is a highly politicized subject, and complete unanimity remains elusive on whether the various certification systems are equivalent, interchangeable or in some cases even credible. Distilled to its essence, the debate centres on the 'triple bottom line' definition of sustainability, and the proportions in which the economic, social and environmental interests are represented in the development of each individual standard.

With a mandated 33% representation in the decision-making process for each of the three interest groups, regulations limiting the size of clear cuts,[F7] a prohibition on the use of genetically modified plant material and a requirement to protect the rights of indigenous people, FSC is the most prescriptive of the major certification systems.

This unequivocal approach to the development of standards may be one reason that to date FSC is the only certification system accredited by the Canada Green Building Council (CaGBC), the organization that administers the increasingly influential Leadership in Energy and Environmental Design (LEED) rating system for buildings.[F8]

A Theaded steel dowel/epoxy grout
B Steel securing pins
C Theaded base connector



3.28 Bertsche connector

[3.27; 3.28] The prefabricated lattice roof structure of the Ske'elep School of Excellence uses proprietary Bertsche Connectors.

3.29

Because the demand for FSC lumber from Canadian forests currently exceeds the supply, this exclusivity has led on occasion to Canadian projects anxious for LEED credit choosing to obtain lumber from FSC sources in the United States, rather than sourcing local non-FSC material.

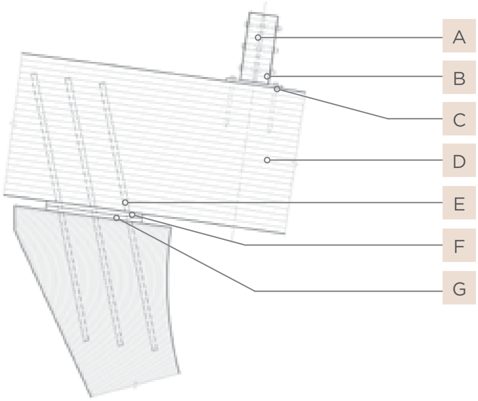
Industry lobbying around this kind of anomaly, together with the accreditation of other systems by organizations such as PEFC, led the USGBC (the 'parent' organization of CaGBC) to review its own position on the subject. After four years of research and consultation, USGBC proposed a new set of SFM 'benchmarks' that would have opened up the possibility of LEED accreditation to other certification systems. However, in December 2010, after a heated public debate, the proposal was rejected by a majority of USGBC members. This means that, for the foreseeable future, only projects in which a minimum 50% of the wood used is from FSC sources will receive a certified wood credit under LEED.

Meantime the Forest Products Association of Canada (FPAC), whose member companies are responsible for 75% of the country's working forests, have adopted progressive new environmental standards independent of LEED. In May 2010 FPAC signed an agreement with nine environmental organizations to adopt the FSC National Boreal Standard as the baseline for the management and conservation of more than 70 million hectares of Canada's globally significant boreal forest. This represents a significant turnaround from just three years previously, when member companies of FPAC were strongly criticized by Greenpeace for forestry practices that it claimed were systematically destroying this same forest.[R13]

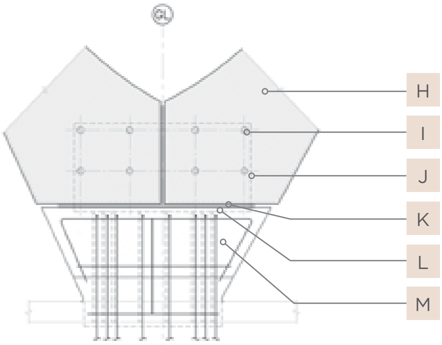
The new accord addresses many of the lingering concerns about the commitment of Canadian forest companies to environmental stewardship and, in the words of Antony Marcil, President and CEO of FSC Canada, "positions Canada as a world leader in Conservation."[R14]

[3.29; 3.30] The wishbone column and beam structure of the West Vancouver Aquatic Centre employs elegant glued and welded connections adapted from European codes.

3.30 Wishbone column connection details

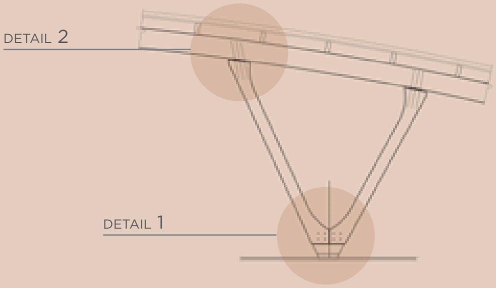


detail 2: section



detail 1: section

A	19mm knife plate
B	glulam purlin
C	19mm bearing plate
D	19mm weldable rebar
E	glulam arch beam
F	non-shrink grout
G	25mm plate
H	glulam wishbone column
I	19Ø pin
J	19mm knife plate
K	non-shrink grout
L	25mm base plate c/w 15m675 weldable rebar 10mm filet weld
M	concrete pedestal



elevation

CHAPTER FOUR

Aboriginal Affirmation

As a self-proclaimed champion of multiculturalism, human rights and racial tolerance, it will forever be to Canada's shame that, up until the close of the 20th century, it continued to treat its own indigenous people with premeditated and institutionalized inhumanity. For more than two centuries, Aboriginal lands were appropriated by force and deception, freedoms curtailed by confinement to reservations, and families broken apart by the removal of children to residential schools. Even now, Aboriginal people remain the most economically and socially disadvantaged population in Canadian society.

[4.01; 4.02] The undulating form of the Seabird Island School is the outward expression of a complex heavy timber frame structure.

Acts of Oppression

Implemented by the federal government, the reserve system imposed containment as a condition of Indian status, while the even more insidious residential school system forced assimilation into an alien culture: policies deliberately designed to undermine and ultimately eradicate native language and tradition.

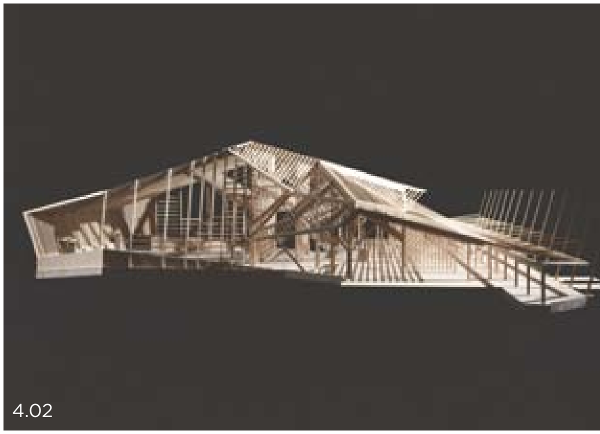
The first Indian reserves appear to have been established by Catholic missions in New France in the 18th century, the land being variously assigned by treaty, Crown grant or purchase using funds received from surrenders. The origins of the residential school system are clearer: they lie in the pre-confederation Gradual Civilization Act of 1857 and the Gradual Enfranchisement Act of 1869. Both were predicated on the assumption of British superiority and the belief that Indians must be assimilated — made to speak English, practice Christianity and adopt a settled agrarian lifestyle.

The confinement of nomadic and semi-nomadic people within the arbitrary boundaries of reserves curtailed the hunting and gathering activities that had sustained them for millennia, and imposed instead a sedentary lifestyle, on federally controlled land and supported by government handouts.

4.01

Patrick Stewart, an Aboriginal architect and former President of the Architectural Institute of BC, has noted, “First Nations communities were essentially a government creation, people were not necessarily there by choice, and the reserve system controlled how development could occur. Until recently, buildings on reserves were formulaic, functional commodities provided by the federal government and not designed to reflect the social order and organizational structure of the reserve community.”[R15]

Direct involvement of Aboriginal people in their own education began in 1970, when the Blue Quill First Nation in northern Alberta occupied their school to protest against its planned closure, and ultimately took over its operation themselves. It took more than a decade before policies were introduced that supported the establishment of schools, clinics and cultural facilities on reserves, and permitted band councils to retain outside consultants to design them. The last government-operated residential school was closed in 1996.



4.02

4.04

New Beginnings

While there is no question that the preservation of language and the passing on of traditions that these facilities support are more significant than the buildings themselves, the new architecture that has been created on and off reserve for Aboriginal clients is nonetheless an important outward symbol of the reaffirmation of native culture in a contemporary context.

This is nowhere more evident than in British Columbia, where the Department of Indian Affairs and Northern Development established a school-building program on reserves in the 1980s, under Regional Architect Marie-Odile Marceau. Prominent architects were commissioned and in several instances worked in collaboration with Aboriginal contractors to realize striking and original projects. Best known among them is Seabird Island School, designed by Patkau Architects with structural engineering by C.Y. Loh Associates and completed in 1991.

Located in the Fraser Valley near Agassiz BC, the building forms one end of an incipient civic square, with its classrooms arranged in linear fashion along a veranda that faces the community. The veranda structure incorporates inclined PSL poles reminiscent of the racks traditionally used by native peoples for drying salmon. The organic, almost zoomorphic form of the building is the outward expression of an irregular heavy timber frame structure, whose complexity presented a series of challenges that helped to develop the skills of numerous native carpenters (Figures 4.01 and 4.02 – previous page).

Not on reserve, but also commissioned around this time was the First Nations House of Learning at UBC, designed by McFarland Marceau Architects with structural engineers CWMM. Completed in 1993, the facility provides support services for Aboriginal students, many of them dealing with the stresses of urban and academic life for the first time. Its secluded site in the university's former arboretum sets it apart from the more conventional campus buildings. In form and materials, the main building is inspired by northwest coast longhouse construction, with massive heavy timbers, projecting rafters and planked siding (Figure 4.03). The entrance is reached by steps that lead down from a pit-house-like structure at street level and a boardwalk that parallels a rocky stream bed (Figure 4.04).

4.03

4.05

Away from the west coast, other traditional indigenous structures provided formal inspiration for the new Aboriginal architecture. Some 400km north of Quebec City the saw-tooth façade and composite cladding panels of the Wemotaci School recall the rows of native tipis that once lined the banks of the St Maurice River (Figure 4.05). Designed by Coté Chabot Morel architects with structural engineering by Genivar, the building was completed in 1998. It includes a trade school in which woodworking and other skills are taught.

Wood was chosen for its ability simultaneously to honour the craft traditions of the local Atikamekw people and to express their contemporary aspirations. This duality is also expressed in the cladding materials: traditional cedar shingles over most of the building, and much larger, composite cement and wood-fibre panels on the river elevation. With projecting glulam beams supported on slender steel columns, the overall effect is an abstraction of the pole-and-skin shelters that were the traditional structures of the Atikamekw (Figure 4.06).

4.06

[4.03; 4.04] The First Nations House of Learning juxtaposes traditional and contemporary materials and detailing.
[4.05; 4.06] The form and materials of the Wemotaci School evoke traditional tipi construction.

4.07

Seasonal structures also provided the inspiration for Kobayashi + Zedda Architects' Tr'ondek Hwech'in Cultural Centre in Dawson City YT, designed with Wood + Associates structural engineers and completed in 1999. Perched on the dyke above the Yukon River, the building symbolically reclaims the band's traditional territory, surrendered more than a century earlier to the 'stampeders' of the Yukon gold rush (Figure 4.07).

Forms abstracted from the conical brush huts that sheltered the Tr'ondek Hwech'in during the long winters, and from the fish traps and drying racks that were the backdrop to summer activities, create the architectural language for a building that captures the seasonal duality of life in Canada's north (Figure 4.08). At the north end of the building, a drum-like exhibition space, lit only from above, evokes winters spent around the fire, while to the south expansive glazing and exterior trellises capture and filter the low summer sun.

Designed to make the most of local materials and technology, and built by the Tr'ondek Hwech'in themselves, the building nonetheless addresses some broader issues. The first building in Dawson City's historic district to be granted a relaxation from the gold-rush era design guidelines, the project successfully challenged the injustice of policies that preserve the heritage of one culture at the expense of another.

Toward an Aboriginal Architecture

As the relationships between architects and their native clients have continued to evolve, contemporary Aboriginal architecture has been distilled to a new level of simplicity and refinement, perhaps best exemplified by Perkins+Will Canada Architects' Nicola Valley Institute of Technology in Merritt BC. Designed with structural engineers Equilibrium Consulting and completed in 2001, this post-secondary institution serves the five First Nations that have occupied the surrounding territory since time immemorial.


4.08

[4.07; 4.08] Perched on the dyke overlooking the Yukon river the Tr'ondek Hwech'in Cultural Centre symbolically reclaims the band's traditional territory.

[4.09; 4.10; 4.11] The partially earth sheltered design of NVIT evokes the traditional pit house, while the ventilation atrium recalls the traditional tipi. The inspiration is functional rather than formal. [4.12] North façade of the Squamish Lil'wat Cultural Centre.

4.09

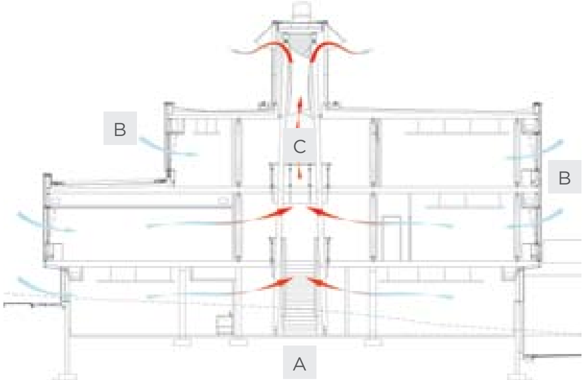
4.10

Unlike its predecessors, NVIT reinterprets traditional architectural archetypes, not as an assemblage of formal symbols and metaphors, but as functional environmental systems. The partial earth sheltering of the building conserves energy by exploiting the thermal mass of the earth as pit houses were designed to do (Figure 4.09), while the three-storey central atrium induces natural ventilation by convection in much the same way as traditional tipis did (Figures 4.10 and 4.11).

Working with Perkins+Will Canada on NVIT, and then with a succession of native clients of his own, Metis architect Alfred Waugh has developed an approach to design that embodies four concepts he believes are integral to the creation of a new and meaningful Aboriginal architecture. He relates these conceptually to the four cardinal directions that have a symbolic importance in Aboriginal culture:

- Culture and Tradition: Identifying which elements of traditional architecture can be taken from the past and interpreted in a contemporary way.
- Order and Community: Establishing how program organization can reflect the social structure of the users, and how the building can relate to its physical context through orientation and integration.
- Respect for the Environment: Embodying the traditional values of environmental stewardship through energy efficiency and ecologically responsible design.
- Technology and Materials: Selecting predominantly natural materials from the local region, and employing appropriate and practical technology.

Waugh observes, “In recent projects I have found the steering committee and community members happy to use the pre-European typologies to reinforce the memory of the past. Thus when given the opportunity to reflect on custom and tradition, the people I have worked with are willing to explore a traditional typology expressed in a new way.”[R16]



4.11 SECTION AT VENTILATION ATRIUM

A	VENTILATION BY NATURAL CONVECTION
B	FRESH AIR INTAKE AT BUILDING PERIMETER
C	STALE AIR EXHAUST FROM ATRIUM

TRADITIONAL TYPOLOGIES, CONTEMPORARY INTERPRETATIONS

These values informed Waugh’s design for the Squamish Lil’wat Cultural Centre completed in 2008 with joint-venture architects TRB Architecture and structural engineers Equilibrium Consulting. The project is located in the resort town of Whistler BC, where the traditional territories of the Squamish and Lil’wat First Nations overlap.

4.12


4.13

The form of the building evokes both the longhouse of the Squamish and the istken (traditional earthen pit house) of the Lil'wat. Building into a steep north-facing slope provided the opportunity to create a double-height great hall with a radial plan and a window wall that exploit the panoramic mountain views (Figure 4.12 – previous page). The window wall is ingeniously designed to recall the lapped plank cladding system used on traditional Squamish longhouses.

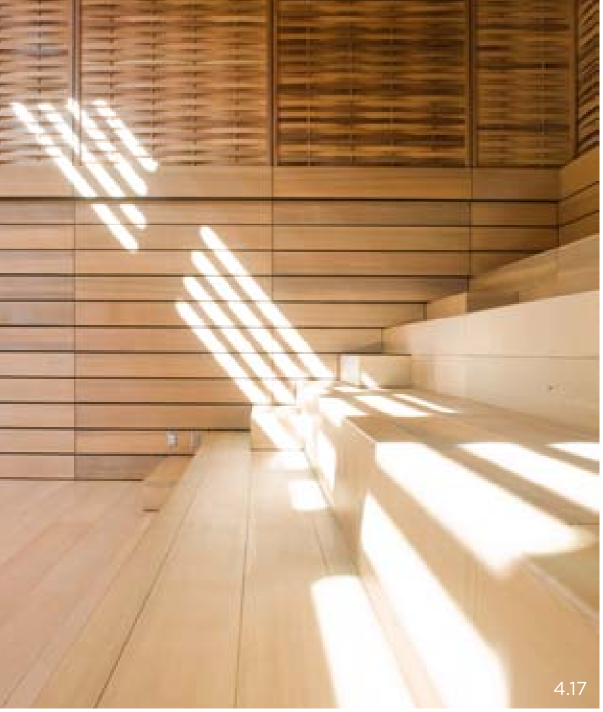
[4.13; 4.14] The structure is a contemporary interpretation of traditional longhouse construction, with slender composite columns and a curtain wall of glass planks suspended on steel cables.
[4.15] The shallow shed roof of the First Peoples House ties it to its site.

4.14


Innovative engineering gives the traditional structure a new economy and elegance, and the great hall a light and airy quality (Figure 4.13). In addition to the cable-suspended glazing system, the design features composite glulam and steel columns that combine great strength with striking slenderness (Figure 4.14). Although the forms are familiar, the technology and construction methods used are unmistakably contemporary. Thus the architecture plays a significant role in communicating the dynamic and progressive nature of Squamish Lil'wat culture to visitors from around the world.

Simplicity and elegance are also the hallmarks of Waugh's First Peoples House at the University of Victoria BC, completed in 2010, again with Equilibrium Consulting. The program is arranged within a roughly rectangular plan, either side of a central east–west circulation spine. The main functional areas are clad in beach-salvaged cedar, and differentiated from one another by bands of horizontal and vertical glazing. On the north side, the administrative areas have a flat, vegetated roof, while to the south the ceremonial hall and classrooms have a shallow pitched roof, like that of a traditional pit-house (Figure 4.15).

4.15



4.17

4.16

The simple rectilinear structural frame emerges from the building at its east end, with deep glulam beams supported on carved house posts forming a grand entrance to the ceremonial hall (Figure 4.16). The hall is lit by a central skylight, and the walls lined with panels of cedar lathe woven like traditional basketwork (Figure 4.17).

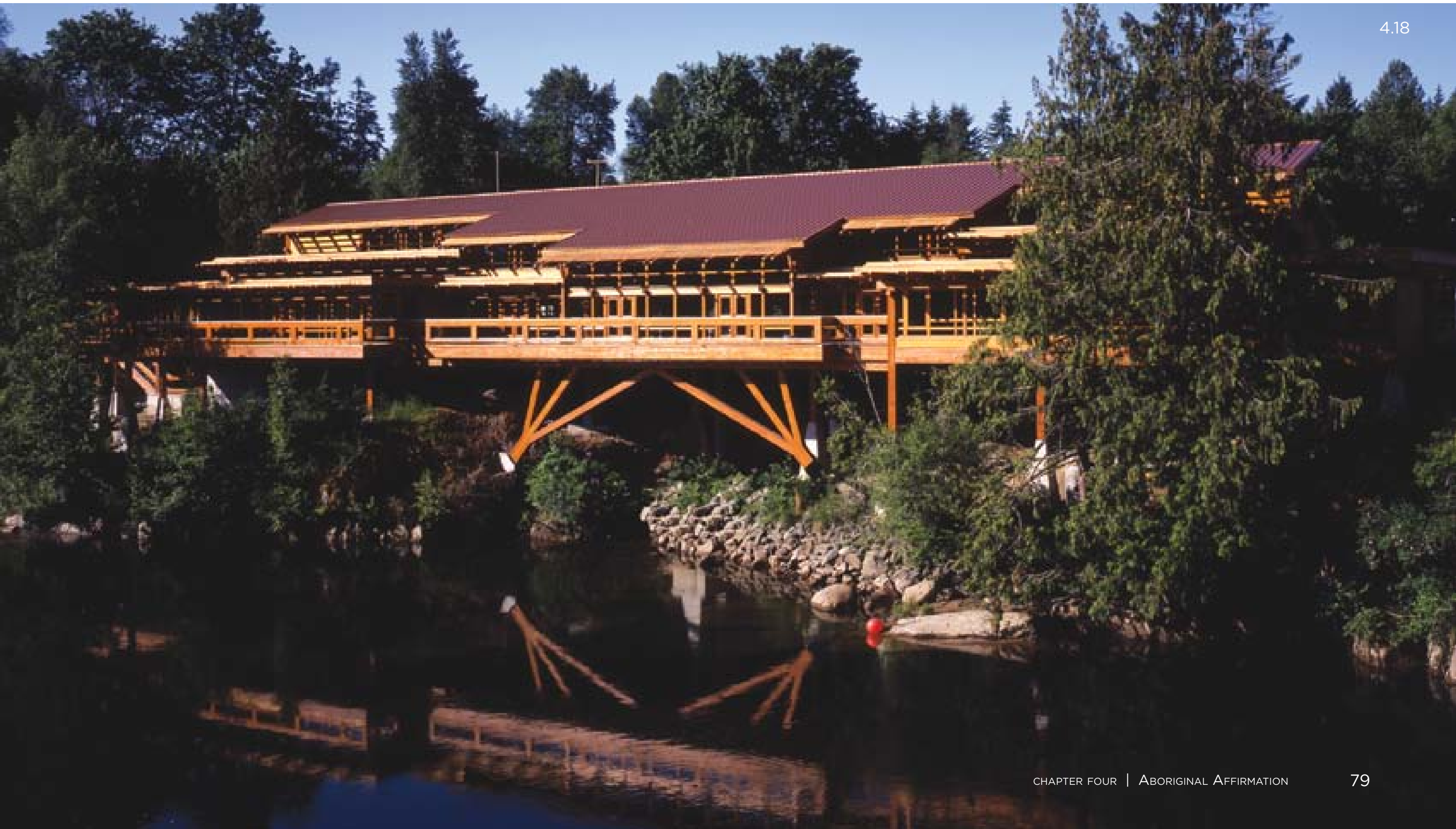
According to Patrick Stewart, there is also a growing understanding among First Nations clients that architectural services can extend beyond the design of individual buildings to deal with the broader issues of community development. As relationships with Aboriginal communities have evolved, the resulting architecture has been enriched by a deeper understanding of community values and organization, and a focus on measured functional responses, rather than overtly formal ones.

One recent example of this approach is Lubor Trubka Architects' Tseshaht Multiplex in Port Alberni BC, completed in 2006. The important design ambition for this project was to embody traditional values of respect for the environment and an affinity for wood in the creation of new accommodation for the Tseshaht First Nation, from which they could run their various businesses and fulfill community health, cultural and social functions.

The natural yet challenging character of the site, a large granite bluff above the salmon-bearing Somass River, offered a unique opportunity for an environmentally responsible solution. With structural engineering by John Peddle, the building follows the contours of the rocky bluff as an elevated wood structure that is at times cantilevered above the river's edge (Figure 4.18).

[4.16; 4.17] The entrance loggia of the First Peoples House leads to the cedar lined Great Hall.
[4.18] The Tseshaht Multiplex cantilevers dramatically over the river bank.

4.18



4.19

4.20

The structure is an open-framed post-and-beam system infilled with glazing and strategically placed shear walls, utilizing a multitude of engineered and sawn lumber products harvested and milled by the Tseshaht from their own forest reserves. To maintain the symbiotic relationship between internal and external environments, extensive clerestory windows are used to catch the movement of the sun throughout the day (Figure 4.19).

The majority of Aboriginal communities are located in rural areas, but the urban diaspora in Canada's metropolitan centres continues to grow. With that growth has come an increasing need for support services of various kinds. Buildings such as the First Nations House of Learning, NVIT and the First Peoples House are designed to serve the particular spiritual and educational needs of a broadly based Aboriginal community, but such facilities remain rare outside the university campus environment.

One exception is the Native Child and Family Services Centre in downtown Toronto, completed in 2009 by Levitt Goodman Architects and Blackwell Bowick + Partners structural engineers. The facility offers a range of targeted and culturally relevant services to urban Aboriginal people of all ages, and includes a daycare, child drop-in centre, health clinic and administrative offices.

The centre is located in a converted four-storey concrete office building, conveniently situated but lacking any cultural markers. Accordingly, the design incorporates a sweat lodge and ceremonial fire pit in the rooftop garden (Figure 4.20), and a free-standing meeting room on the ground floor and (Figure 4.21). A structure within a structure, this 50-person meeting room takes the form of a traditional bent-wood longhouse, given a contemporary expression using a structural lattice of curved cedar frames, clad in overlapping cedar lathe (Figure 4.22).


4.21

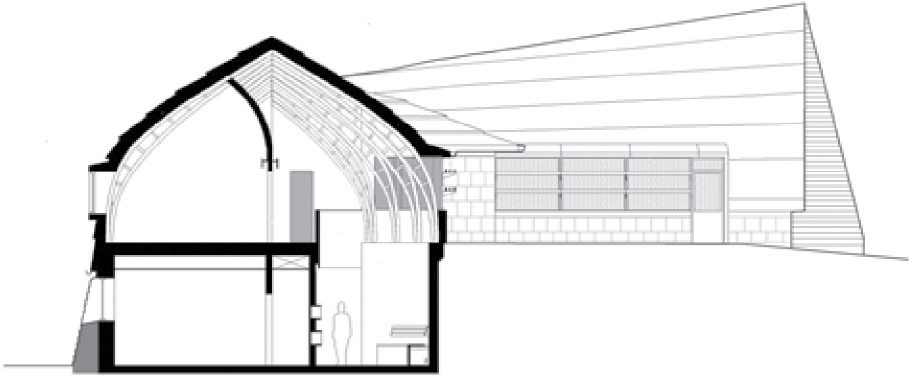

4.22

[4.19] Natural light illuminates the warm wood interior of the Tseshaht Multiplex.
[4.20] The roof garden of the NCFST is an oasis of calm amid the office towers of Downtown Toronto.
[4.21; 4.22] The meeting room of the NCFST is a free standing wooden structure that recalls local Aboriginal building traditions.

4.23

On the Atlantic coast, where the thinning of Nova Scotia's plantation forests yields small-diameter saplings, similar forms are being achieved using a very different method of construction. For a number of years, Halifax-based designer Richard Kroeker has adapted traditional aboriginal materials and techniques to the design and construction of buildings for the Mikmaq First Nation in Cape Breton. These structures are characterized by a formal and tectonic language that derives from the intrinsic properties of the materials used.

The Pictou Landing Community Health Centre is the main civic structure for the Mikmaq community of Pictou Landing NS. Beneath its vaulted roof, the building contains clinics for doctors, dentists and community health workers, as well as a community meeting space and public health education room (Figures 4.23 and 4.24).



4.24 Building Cross Section

[4.23; 4.24; 4.25] The Pictou Landing Community Health Centre employs traditional materials such as bent wood poles and wood shingles in a contemporary interpretation of historic Aboriginal building forms.

The roof structure comprises opposing pairs of boomerang-shaped trusses, fabricated in a jig, using green saplings for the chords and stainless steel strapping for the web section. Immersing the ends of the saplings in water kept them pliable and easier to bend to the required curvature (Figure 4.25).

This method of fabrication was derived from traditional construction techniques used for longhouse structures, snowshoes and other artefacts. Many prototypes were built, before a composite bentwood truss with predictable performance characteristics was developed. Engineer Chris Williams of Buro Happold was instrumental in performing the structural analysis, although the engineers of record were Brandies, McBride and Richardson.

Canada's Aboriginal people are a growing force in contemporary society. As ancestral stewards of the land and its resources, they have positioned themselves at the forefront of the environmental movement. It is appropriate, therefore, when commissioning new facilities, that Aboriginal clients should espouse the principles of green building, enhancing the empirical understanding of traditional building typologies with the latest environmental performance modeling techniques and leading-edge environmental systems.

In this context, the role of wood is crucially important. As Alfred Waugh notes, "The use of wood in buildings fulfills a need to carry forward custom and tradition into the 21st century. Simply put, wood and other fibrous material carry on the memory of the First Peoples' traditional connection to the land and all the spirits embodied in it." [R17]

In response to this need, wood, and new wood-manufacturing technology, have created a bridge between past and present.

4.25

CHAPTER FIVE

Regional Revival

While the future may bring a blending of Aboriginal and non-Aboriginal values to Canadian architecture as a whole, the forces behind the revival of wood architecture outside of Aboriginal communities are somewhat different from those at work within them. As in most other parts of the developed world, 20th-century architecture in Canada was strongly influenced by international theory and discourse.

International Ideologies

Over this period, there was a distinct separation between mainstream Modern architecture and vernacular traditions of building. This disconnection grew out of the ideological revolution that began at the Bauhaus in the 1920s. Under director Walter Gropius, the influential German art school promoted a new architectural expression in which form was derived not from abstract rules or historical precedents, but instead from the separate articulation of functional spaces. The intent was to create an architecture whose buildings were mechanisms, organized on rational principles and realized with the minimum of means from industrially produced materials.

At the outset, this new Modern Movement had laudable social and political ambitions: economy of production would translate into affordable housing for the masses, and the new Modernist aesthetic would challenge the power structures associated with historicist styles.

However, this conceptual framework promoted a homogeneous global aesthetic that blurred the cultural, climatic and geographic distinctions between regions, and privileged centrally produced industrial materials like steel and concrete at the expense of traditional, locally produced ones such as stone, brick and wood (Figure 5.01). In spite of its rhetorical emphasis on function, the relationship between Modern architecture and the natural environment was primarily a formal one, in which large areas of glazing were used to emphasize the skeletal nature of steel and concrete structures, and the visual connection of indoor and outdoor space. Little heed was paid to solar orientation, energy conservation or other aspects of bio-climatic design that are characteristic of the empirical approach taken to vernacular forms of building.

Modernism lent itself to the creation of economic and repetitive structures and its founding principles were used as justification for countless stark and sterile offices and apartment buildings across the globe. Over time the Modernist aesthetic became dissociated from any meaningful social agenda, and for the most part disconnected from the unique cultural, historical and geographical qualities of place.

A counter-revolution began in the mid 1960s with the publication of Robert Venturi's manifesto Complexity and Contradiction in Architecture. Venturi proposed that "buildings are decorated sheds, their meaning enriched by the complexity and contradiction of the language used."[R18] Venturi's writings had a profound influence, ushering in a period of formally driven, often whimsical experimentation that became known as 'Post-Modernism'. Architects drew on a combination of Classical details and contextual references to enliven their architecture and relate it to place (Figure 5.02 – next page)

For many, Post-Modernism came as a refreshing change from the austere and featureless Modern buildings it replaced, reintroducing formal variation, colour and a rich palette of materials to contemporary architecture. In time however, the Post-Modern obsession with style and language, and its ongoing neglect of broader environmental and social issues, proved equally inadequate to the creation of meaning in the built environment.


5.01

[5.01] The rigorous functionalism of the International Style, epitomized in Mies van der Rohe's Highfield House in Baltimore MD.

CRITICAL REGIONALISM

In the early 1980s, architectural theorist Kenneth Frampton argued for what he called ‘critical regionalism’, an architecture that would synthesize the rooted aspects of a region, including physical, cultural and technological characteristics, while at the same time participating in the more universal aspects of a progressive and mobile contemporary society.

Over the last 25 years, the philosophical arguments for critical regionalism have been overshadowed by environmental imperatives. However, far from undermining Frampton’s position, the search for sustainability in the built environment has provided critical regionalism with a broader functional underpinning that has only served to reinforce the original arguments.

Across the varied climatic regions of Canada, the growing interest in sustainable building practices naturally supports the re-emergence of regionally inspired forms of architecture that deftly combine the timeless lessons of the vernacular tradition with the advanced technology and aesthetic refinements of today. As Frampton himself notes in his foreword to Peter Buchanan’s Ten Shades of Green,[F9] “As the 21st century opens to an increasingly globalized future, the ethic of sustainability comes to the fore as a compelling principle for the revitalization of architecture.”

Far from being a constraint, Frampton further argues that “there is no manifest reason why environmentally sustainable design should not be compatible with culturally stimulating and expressively vital results. Sustainability ought to be rightly regarded as a prime inspiration with which to enrich and deepen our emergent culture of architecture, rather than as some kind of restriction on the fullness of its poetic potential.”

While the impetus for this new architecture is global in scope, its approach to form, orientation and materiality must be in response to local geographic and microclimatic conditions. As Buchanan asserts, there is no singular green aesthetic; instead “sustainability in architecture arises out of a subtle, often imperceptible interaction between built form and the ambient forces that impinge upon its surface.”

[F9] Ten Shades of Green: Architecture and the Natural World was an exhibition featuring 10 of the world’s greenest buildings. It opened in New York in 1999 before travelling across the US. It was accompanied by a catalogue of the same name.

However, with respect to the construction of green buildings, he adds, “Above all they should be made of low energy materials that mellow with age, such as wood or brick, rather than with high energy synthetic substances that are often unable to withstand the long-term effects of weathering without continual maintenance.”

As John McMinn and Marco Polo documented in their 2007 exhibition (and accompanying catalogue) 41° to 66°,[R19] the search for a sustainable architecture in Canada has catalyzed the revival of regionalism throughout the country with a new form of architectonic expression based not simply on the articulation and assembly of building elements, but also on the masses and volumes that are expressive of the building’s environmental systems.

Material Differences

While the knowledge base that supports sustainable design practice is a transferable global commodity, the transformation of this knowledge into the physical assets of individual buildings and communities is more and more a local enterprise. Where wood is used in these structures, its application is beginning to take on a regional character, based on the local availability of materials, craft skills and manufacturing technology.

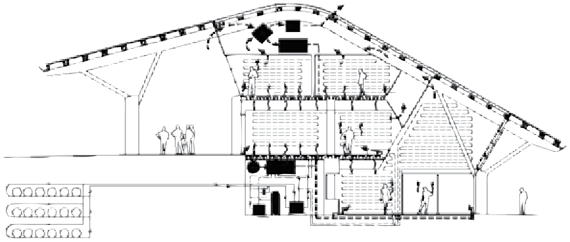
Solid-sawn lumber for heavy timber construction is still readily available on the west coast — although engineered wood is now commonly used for heavily loaded or long-span members. These materials are combined to great effect in the Gleneagles Community Centre in West Vancouver, designed by Patkau Architects with structural engineers Fast + Epp. The building also exemplifies the new integration of environmental systems and architectural form.

Built on a small, gently sloping site and completed in 2003, the three-storey building is arranged in section to permit grade access from both the lower and intermediate levels.


5.02

[5.02] The capricious formalism of Post Modernism is evident in Michael Graves’ Portland Building in Portland OR.

5.04



5.05 Building Cross section Showing Radiant Heating system

5.03

The concrete shell of the building takes the form of two rectangles, offset in plan and sheltered by expansive sloping wood roofs (Figure 5.03). Each roof is supported on segmented curved Douglas fir glulam beams between which are placed site-prefabricated heavy timber roof panels sheathed with plywood (Figure 5.04).

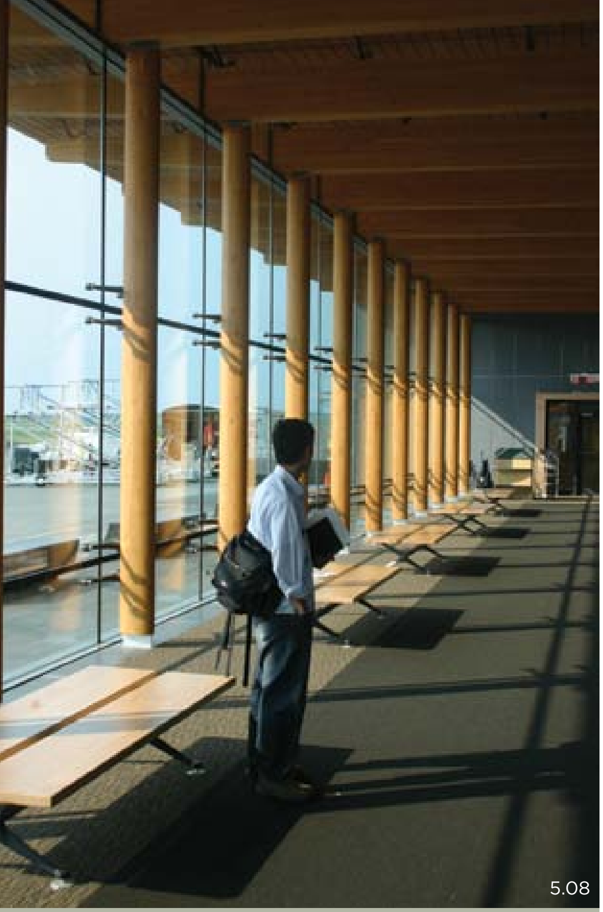
The distinctive cross-section eloquently expresses how these elements work together architecturally and environmentally: an array of piping cast into the concrete floors and walls making them a vast radiator for heating and cooling the interior; the roof overhangs acting as a parasol; and the high, sloped ceiling promoting natural ventilation through the stack effect (Figure 5.05).

Since the acquisition of a CNC machine by Structurlam Products in Penticton in 2002, the interior of British Columbia has become the unlikely hotbed of technical innovation in wood. CNC technology was used to create components for the Salteau Community Centre, the Ske'lep School of Excellence and Nicola Valley Institute of Technology, but one of the most elegant applications to date can be found in the Prince George Airport expansion project, designed by mgb architecture with Equilibrium Consulting and completed in 2005.

The design team used the familiar medium of glulam to express the contemporary aspirations of a region in which the forest industry has played a long and important part. The program is organized around a day-lit circulation spine that connects and unifies old and new portions of the building. The spine is defined by a system of glulam and steel portal frames that lifts a continuous glass skylight above the surrounding flat roof. Bands of horizontal Douglas fir sunscreens, mounted alternately on the east and west sides of the skylight, admit filtered natural light (Figure 5.06).

5.06

[5.03; 5.04] The Gleneagles Community Centre deftly integrates form, materials and environmental systems.
[5.05] The tilt-up concrete wall panels incorporate a piping array for radiant heating and cooling.
[5.06] The concourse at the Prince George Airport organizes and connects the old and new parts of the building.



5.08

In a building type where security considerations often lead to the compartmentalization of space, the design team wanted instead to reinforce the connection to place through transparency. Careful organization of the interior enables those entering the terminal from the land side to see all the way through the building to the waiting aircraft (Figure 5.07). Similarly, the airside elevation is a continuous glass curtain wall through which arriving passengers can glimpse activities within the building. CNC-milled, elliptical glulam columns support the glass panels of the curtain wall by way of multipurpose ductile iron castings (Figure 5.08).

The elegance and economy of expression celebrates the precision of contemporary craftsmanship and the increased emphasis the local community now places on value-added engineered wood products and environmental stewardship.

Building in the more remote parts of the country, far from manufacturing infrastructure, presents challenges best addressed with locally based solutions. A good example of this approach is the 600m^2 Boreal Centre for Bird Conservation in the Slave Lake Provincial Park, near Alberta's border with the Northwest Territories. Designed by Manasc Isaac Architects and opened in 2005, the facility provides a laboratory, research library and office space for staff, volunteers and visiting researchers (Figure 5.09).

5.07

5.09

5.10

[5.07] Connection to place is reinforced by the transparency of the building.
[5.08] In the departure lounge, CNC machined glulam mullions reflect the new culture of innovation and stewardship.
[5.09] Materials used for the Boreal Centre for Bird Conservation include locally sourced peeled logs and fieldstone.
[5.10] The king post roof trusses are fabricated from locally sourced dimension lumber.

[5.11] Detail of king post truss at the Boreal Centre for Bird Conservation in Slave Lake AB.
[5.12] Reclaimed masonry and cedar siding are used to clad the Restoration Services Centre.
[5.13] On the south elevation, a projecting loggia is designed to accept future solar panels.

5.11

With the exception of electricity, the Boreal Centre has no service infrastructure and is designed to be self-sufficient in water supply and waste-water treatment. The building's inverted roof form functions as a scupper, channelling rainwater to an underground storage cistern before being treated for use in the building. Architecturally, this same form evokes a bird in flight, and to reinforce the metaphor structural engineers Fast + Epp designed a supporting structure of king post trusses that is both light and dynamic (Figure 5.10 – previous page).

The truss design is based on the dimension lumber and small-scale fabrication capabilities that are the mainstays of the region's forest industry. The top chords are made from 2x10s, and the triangular king posts from 2x4s. Rather than laminating the multiple members together, they are spaced to achieve a light and filigreed effect (Figure 5.11).

In the eastern half of the country, available wood sections are generally smaller, and even modest wood structures tend to incorporate engineered wood products. One such example is Montgomery + Sisam's Restoration Services Centre, completed in 2007 and located in Vaughan ON (Figure 5.12).

5.13

In cross-section, the two-storey, 1096m^2 office building is a simple flat-roofed rectangle, the upper level being designed as a central mezzanine with double-height spaces at either end — a now common organizing strategy that promotes natural ventilation (Figure 5.13). In plan the building is elongated in the east-west direction, to maximize the benefits of south exposure for day-lighting and passive solar heating. A projecting loggia on the south side of the building provides solar shading, a supporting structure for solar panels and a trellis for climbing plants. The exterior cladding includes both wood and masonry reclaimed from demolished buildings.

Read Jones Kristofferson designed the simple glulam post-and-beam structure using material fabricated in Quebec by Nordic (Figure 5.14 – next page). Unlike traditional glulam products, the members utilize 2x2 square sections milled from small-diameter black spruce trees. These 'small block' sections are laid up and laminated horizontally to create the required section width, as well as vertically to create the required depth. A section cut across one of these glulam members reveals a distinctive checkerboard pattern.

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On the east coast, glulam also figured prominently in the 2009 expansion to the Musée de la Gaspésie in Gaspé QC, designed by Croft Pelletier architectes, Brière, Gilbert + associés architectes, and Vachon et Roy architectes. With structural engineering by BPR Roche, the 2500m^2, three-storey building is positioned on a rocky promontory overlooking the ocean, near the spot where Jacques Cartier made his first landfall in the New World in 1534 (Figure 5.15).

Old and new portions of the building are enveloped by an exterior wood lattice of vertical spruce slats mounted on a rectilinear glulam frame. This lattice or ‘hull’ unifies the composition, while making abstract reference to the vestiges of the region’s maritime tradition, and the continued close connection of its people to the land. Around the curatorial portions of the building, the slats are closely spaced, but this spacing increases to give a lighter and more transparent feeling to the new public gallery areas (Figure 5.16).

In places the wood lattice extends beyond the building edge to shelter the exterior circulation areas, and at the south end opens further to form a brise-soleil (Figure 5.17). The detailing of the wood envelope is simple and straightforward, reflecting the capabilities of the construction industry in this rural region, whose economy is based largely on agriculture, fishing and tourism.

5.16

5.17

[5.14] Roof overhangs and trellises shade the south elevation of the Restoration Services Centre.
[5.15] The Musée de la Gaspésie sits on a rocky promontory overlooking Gaspé Harbour.
[5.16; 5.17] The exterior hull of spruce slats changes character according to the program elements it encloses.

Designing with Nature

While the immigrant cultures of Canada may not have the same spiritual connection to nature as its Aboriginal people, the sustainable-design movement is at least nurturing an intellectual understanding of its value. According to Peter Buchanan in 10 Shades of Green, “The ultimate ideal would be an architecture that fostered in various ways a deep sense of communion with nature and the cosmos. Such an architecture is not only good for the planet, it is also the only one in which people can flower into their full potential.”

Those in pursuit of this ideal are now supported by empirical evidence from research in the field of public health, confirming that contact with nature brings positive benefits in human health and well-being. A summary of research in this area published by a team at Deakin University in Melbourne, Australia concluded, “Whilst urban-dwelling individuals who seek out parks and gardens appear to intuitively understand the personal health and well-being benefits arising from ‘contact with nature’, public health strategies are yet to maximize the untapped resource nature provides.” R20


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5.20

Given the amount of time that most Canadians spend indoors each day, these conclusions should affect not only how we design our cities, but how we design our individual buildings. Architects in the health-care sector were among the first to adopt strategies that are now accepted as part of a holistic approach to sustainable design. Integrating buildings and landscape, maximizing daylight and providing views to nature from occupied spaces all contribute both quantitatively and qualitatively to human health.

One of Canada's leading health-care architects, Toronto's Farrow Partnership, is now going further, introducing not only natural light but natural materials into its projects. Wood has become a material of preference in the firm's work, and is prominent in both the Carlo Fidani Peel Regional Cancer Centre and the Regional Health Care Centre in Thunder Bay ON. Both include lofty atrium spaces constructed of wood and glass, in which patients and visitors can relax and interact in an inspiring, healing, naturally lit environment. At Carlo Fidani Peel the atrium takes the form of a courtyard 'planted' with a grove of glulam trees (Figures 5.18 and 5.19), while at Thunder Bay it is a linear spine.

[5.18; 5.19] THE CARLO FIDANI PEEL CANCER CENTRE MAXIMIZES THE BENEFITS OF NATURAL LIGHT AND MATERIALS TO CREATE A HEALING ENVIRONMENT FOR ITS PATIENTS.
[5.20] THE ATRIUM AT THE THUNDER BAY REGIONAL HEALTH CENTRE IS FLOODED WITH NATURAL LIGHT AND OFFERS VIEWS TO THE SURROUNDING LANDSCAPE.

5.21

5.22

This spine is in fact a three-storey, 140m-long concourse from which the various other program elements are accessed. A glazed curtain wall supported by glulam tree columns floods the space with daylight, and connects it to the natural landscape beyond (Figure 5.20 – previous page). The building is also the first health-care facility in Canada to include skylights and wood paneling in its radiation treatment areas to enhance the therapeutic experience for cancer patients (Figure 5.21).

Of this building, Sean Stanwick of the Farrow Partnership has written:

"Beyond the project's material aspects, it is guided by humanism, the idea that concern for human values is of the utmost importance to the care of the sick, and manifests itself in visually pleasing environments consisting of natural materials, access to sunlight, and the union of architecture and landscape." [R21]

As the use of wood continues to increase in both public and private-sector projects, it is reasonable to assume that consensus is growing in regard to its benefits to occupant health and well-being. This certainly would appear to be the case at the Surrey Central City development, where architect Bing Thom not only introduced natural light, but also used wood liberally in the public spaces to "provide a visually warm and tactile complement to the moulded plastic [that is] characteristic of a contemporary high-tech workplace" [R22] (Figures 5.22 and 5.23).

Incrementally, the intuitive understanding of the benefits of nature and natural materials to our physical and emotional health is gradually being replaced by an empirical one. In this context wood is assuming ever greater importance in the creation of environments that nurture human well-being, and its ability to respond to regional constraints and prerogatives reinforces the connection of buildings to place. Yet as we confront the global environmental challenges of the 21st century, the most crucial attribute of wood is its ability to assist us in the mitigation of climate change.

[5.21] Wood features prominently in the treatment areas at the Thunder Bay Regional Health Centre.
[5.22; 5.23] At Surrey Central City, wood has been deliberately introduced to complement the palette of synthetic materials more commonly associated with large scale commercial developments.


5.23

CHAPTER SIX

Confronting Climate Change

Manufactured by the sun, and naturally self-replenishing, wood, in theory at least, is the ultimate renewable resource. What has been at issue over the last two decades is whether we can manage this resource in a way that meets our needs without reducing overall forest cover, or compromising the high-value environmental attributes of forests as purifiers of air and water, providers of animal habitat and sanctuaries of essential biodiversity. Third-party certification has provided assurance to the public that this is indeed possible, and initiatives like the 2010 National Boreal Standards Agreement are evidence that Canada's forest industry is taking its environmental responsibilities seriously.

However, what continues to make sustainable forest management a pressing global concern is the growing recognition that, together with the more widespread use of wood, it could make a significant and positive contribution to the mitigation of climate change.

The Role of Forests

Global warming is caused by the build-up of carbon dioxide (CO_2) and other so-called 'greenhouse' gases (GHGs) in the atmosphere, a process that has accelerated rapidly since the beginning of the industrial revolution about two centuries ago.[F10]

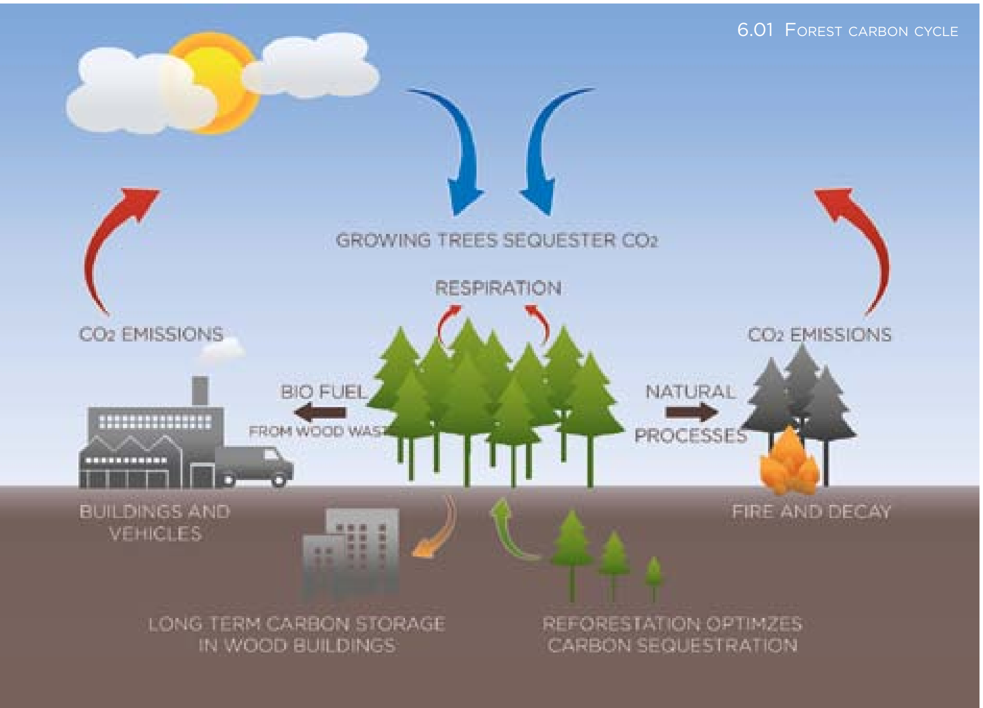
Prior to human intervention, the composition of the Earth's atmosphere was held in balance by the unique capacity of its forests (and other vegetation) to absorb CO_2 and release oxygen. Growing trees use sunlight to sequester carbon dioxide, using the carbon it contains to create cellulose, the main component of wood fibre. This carbon remains within the wood until it decays or is destroyed by fire, at which time it is returned to the atmosphere once more as CO_2. This process is part of a complex system of global carbon exchange known as the carbon cycle (Figure 6.01).

[F10] Water vapour is the most abundant greenhouse gas, but its concentration has remained relatively stable in relation to the other gases over the last two centuries, so is not included in this discussion.

Over time, the natural balance of this system has been altered on the one hand by deforestation, which reduces its capacity to absorb CO_2 and on the other by the rapid growth in the human population and the proliferation of fossil fuel technology — both of which increase the CO_2 content in the atmosphere, and hence the negative stresses imposed upon the system.

A Global Concern

Deforestation is not a new phenomenon. Beginning in ancient times with the Mediterranean, North Africa and southern Europe — lands once occupied by the great civilizations of Egypt, Greece and Rome — human activity has systematically reduced the original forest cover. This pattern was repeated in western and northern Europe during the Middle Ages, began in the New World with the arrival of European settlers in the 16th and 17th centuries, and persists today in the equatorial forests of Africa, South America and Southeast Asia. The net effect has been to reduce the area of the world's forests by about 50% over the last 2000 years. Thus in the face of accelerating climate change, maintaining or enhancing global forest cover, and improving overall CO_2 sequestration rates and long-term storage capacity are critical concerns for the international community.



6.01 Forest carbon cycle

[6.01] Sustainable forest management together with increased wood use would maximize both the rate of carbon sequestration, and long term carbon storage.

Notwithstanding the ongoing need to monitor forest management practices across the continent, independent analysis has concluded that deforestation is no longer a quantitative issue in North America. According to the United Nations Food and Agriculture Organization's 2001 Report on the State of the World's Forests,[R23] Canada has retained over 90% of its original forest cover, and the total forested area actually increased over the preceding decade as a result of reforestation (Figure 6.02).

MEASURING AND MAINTAINING FOREST CARBON STOCKS

Forests and the soils that support them constitute a significant part of the terrestrial biosphere, one of the five components or reservoirs in the Earth's carbon storage and exchange system.[F11] Although current modeling techniques provide varying estimates of the proportions of total forest carbon stored in the soil and vegetation respectively, the average is believed to be about 65% in the soil and 35% in the vegetation. In Canada's globally significant boreal forest the amount of carbon stored in the soil may be as much as 80% of the total.

Historically, the renewal of forests — and the maintenance of the carbon cycle — relied exclusively on natural phenomena such as fire.[F12] While fire can release most of the carbon stored in the vegetation it burns, it leaves the carbon in the soil largely undisturbed. In contrast, the amount of carbon released into the atmosphere from vegetation as a result of harvesting is small, but that released from the soil is potentially much greater, and varies with the harvesting method used.[F13]

Accurately gauging the total volume of wood and other vegetation in the world's forests, or even that contained within specific national boundaries or bio-regions, remains an inexact science. Such calculations are dependent on satellite photography and statistical extrapolations from necessarily limited field measurements of tree sizes and spacing. However, with the introduction of new software tools, it is now possible to make much more accurate measurements at the local level.

For the first time these tools enable us to estimate the carbon stocks in our forests at the operational scale, and to gauge the impacts of different harvesting practices, on both total forest carbon and related CO_2 emissions. The modeling tool developed by Natural Resources Canada in 2004 enables users to create, simulate and compare various forest management scenarios in order to assess their impacts on forest carbon. Adaptable to all of Canada's commercial forest types, this technique assists provincial regulators and forestry companies alike to refine management techniques to minimize the environmental impacts of harvesting.[R24]

[F11] The others are: the atmosphere, the oceans, the sediments (including fossil fuels) and the Earth's interior. The most dynamic exchanges occur between the biosphere, atmosphere and oceans.

[F12] In the forests of coastal British Columbia, windfall was historically the most important mechanism of forest regeneration.

[F13] At times, fires in the managed forest have been responsible for up to 45% of Canada's total greenhouse gas emissions. ON average the area consumed by fire is 2.5 times that harvested annually.

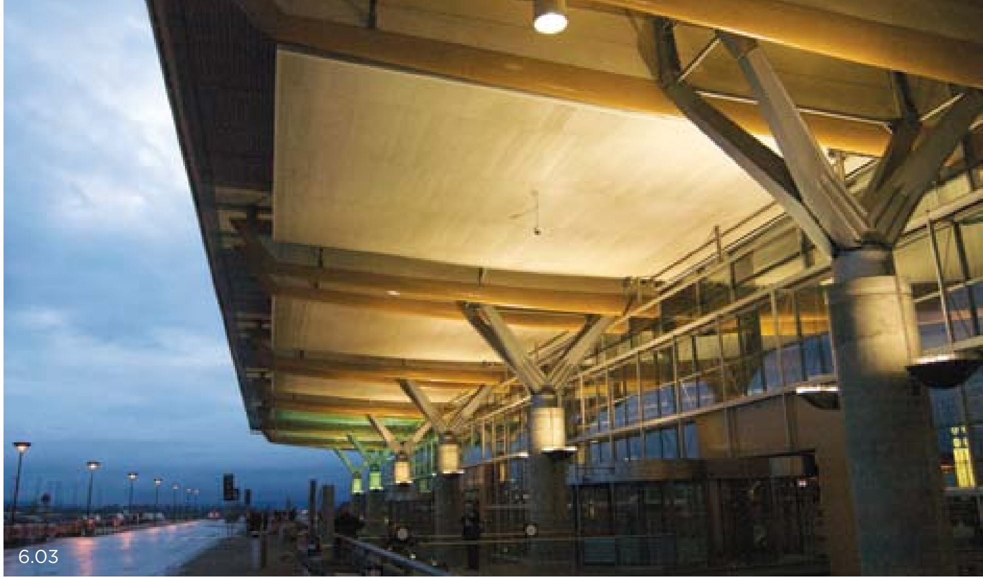

6.02 Forest regions of Canada

[6.02] Canada's forests are the most extensive in the world.

Current research confirms that, when all impacts and benefits are considered, sustainable forest management practices in Canada do not contribute to climate change.[R25] Indeed SFM, because of its other environmental benefits can contribute significantly to climate change mitigation. This contribution can be increased by optimizing the relationship between the rate of forest growth and the rate of wood production.

Carbon Sequestration

The rate of CO_2 absorption by trees varies with species, but is directly related to the rate of growth. Young trees grow very rapidly, but as they mature growth slows, and the rate at which they absorb CO_2 diminishes. In over-mature trees CO_2 absorption ceases altogether, and when dead trees start to decay, they begin to release the CO_2 they have absorbed. Without continuous regeneration, forests can actually become net emitters of CO_2.


6.03

[6.03; 6.04] A study of Niels Torp Architects' Gardermoen Airport in Oslo, Norway confirmed the GHG reduction benefits of building in wood rather than steel.

There is an optimal rate of harvest for every type and location of forest that is related to the annual growth rate referred to as the 'stem-wood increment'. Over time, harvesting at less than the optimal rate will result in a more mature forest that absorbs carbon dioxide at a slower rate than a younger one.

Research undertaken by Gustavson and others[R26] concluded that in Europe, "the current gap between stem-wood increment and harvest rate is approximately 260 million m^3 per year." In other words, increased harvest rates, supported by increased reforestation, would actually be beneficial in optimizing the carbon sequestration rates of the forest areas examined in the study.

In Canada, where less than 30% of the forested area is managed for commercial wood production, and only 0.5% of this managed area is harvested annually,[R27] there is clearly an enormous potential for increased wood production and use, without compromising other important forest values. Graduated planting and harvesting over a prolonged period, with a proportionate annual yield varying by region and species, would maximize the benefits of CO_2 sequestration and optimize carbon stocks in existing or new commercial forests.

Carbon Storage

When wood is transformed into durable building products, the benefits of carbon storage become long term. The carbon in the harvested trees remains encapsulated, while new saplings planted in their place begin to bind in new carbon, and the cycle continues.

It has become fashionable to express the carbon stored in the wood components of a building, or the energy savings that accrue during its operation, as equivalent to taking a certain number of cars off the road. These statements have emotive power but limited practical use, as the standards in the automobile industry are changing even more rapidly than those in the construction industry.

Nonetheless, as a point of reference, the various softwood species used in the Canadian construction industry absorb approximately 0.9 tonnes of carbon for every cubic metre of growth. At the same time, an average new car built to 2010 Canadian emissions standards emits approximately 180g of carbon per kilometre.[R28] Hence a cubic metre of wood has absorbed an amount of carbon equivalent to the emissions from a car driven 5000km — approximately the distance between Vancouver and Quebec City.

By implication, an increase in the use of wood would result in a commensurate reduction in the use of other major construction materials. This substitution would bring additional environmental benefits as wood requires less energy to process and has fewer negative environmental impacts than either steel or concrete.

Embodied Energy and Wood Substitution

In the context of building materials, the term 'embodied energy' refers to the amount of energy required to extract, process, fabricate, transport and install that material. Figures will be affected by the energy intensity of the extraction and production processes, and the distance between the source of the material and the building site in question. Green building rating systems such as LEED give credit for materials sourced from within a prescribed radius of the building site — typically 800–1000km.[F14]

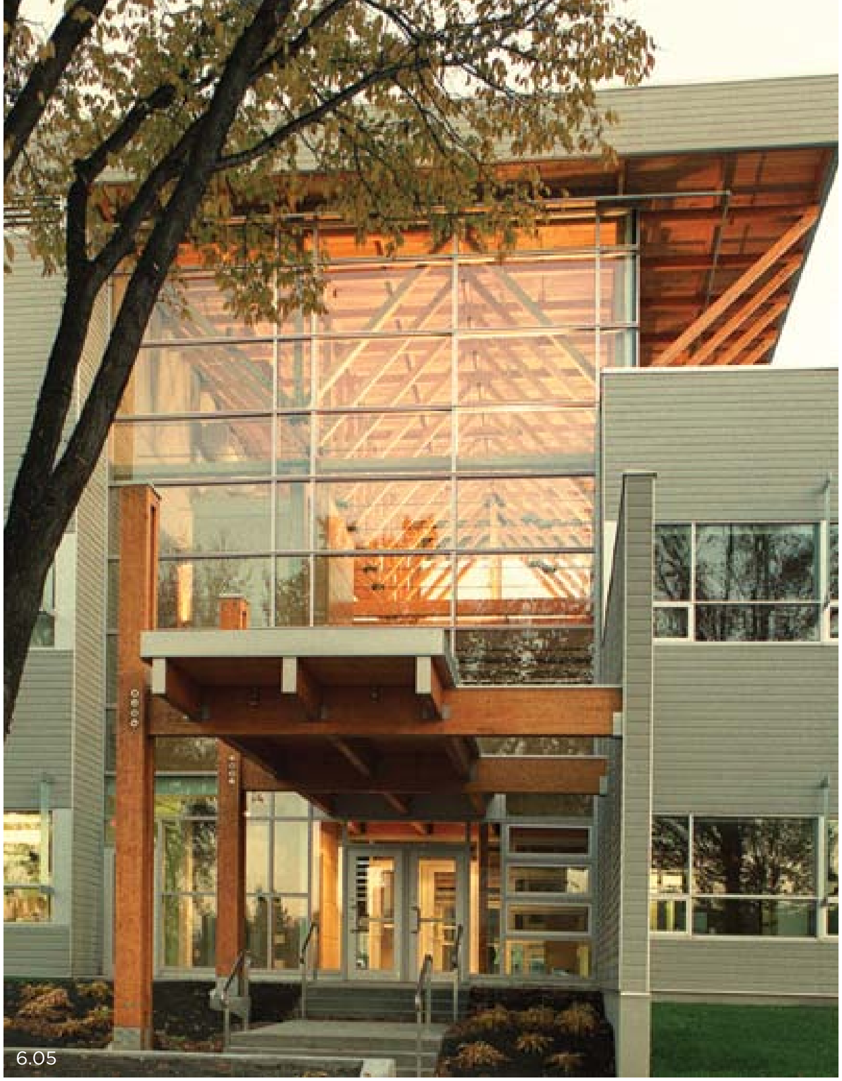
There is an assumed relationship between embodied energy and GHG emissions, although this will vary according to the source of energy used in extraction and processing — whether hydro, coal or other fuel. In addition, published data can be confusing, as comparisons can be skewed according to whether materials are compared by weight or volume.

The most meaningful method of presenting data is by way of a functional comparison, in which the embodied energy (and by implication the related GHG emissions) of identical buildings constructed in different materials is measured.

In 2002, Petersen and Solberg conducted a study[R29] on the roof of Gardamoen Airport in Oslo Norway (Figures 6.03 and 6.04), comparing the effects on GHG emissions of two construction types: glulam beams (as actually used in the building) and steel (the hypothetical alternative). Results varied according to the assumptions made about the source of steel (ore or scrap), the source of energy used for steel production and other variables; but for the base scenario, the study documents that energy consumption in the manufacturing of steel beams is 2-3 times higher, and the use of fossil fuels 6–12 times higher, than in the manufacturing of glulam beams.


6.04

[F14] However, LEED does not give credit for low embodied energy related to extraction and processing.



6.05

[6.05; 6.06] A study of the all wood Eugene Kruger building at Laval University, confirmed a 40% reduction in embodied energy compared with a steel alternative.

Studies in Canada have come to similar conclusions. When the University of Laval in Quebec City commissioned the Eugene Kruger Building, an 8000m^2 addition to its School of Forestry, it wanted to maximize the use of wood products in order to minimize the embodied energy of the building. Architects Gautier Gallienne Moisan and structural engineers BPR responded with a design that used wood products for both structure and envelope, setting a variety of structural and non-structural EWPs in a repetitive geometric composition within a glulam frame (Figures 6.05 and 6.06).

A study of the building, conducted after its completion in 2005, determined that its passive design strategies contributed to a 30% saving in operational energy, while the use of wood resulted in a 40% reduction in embodied energy compared to an all-steel alternative.[R30]

6.06

Thus building in wood contributes to climate change mitigation, not only through increased carbon storage, but also through the decreased GHG emissions that result from the substitution of wood for other more energy-intensive materials. In 2007, the scientific consensus around this research was sufficient for the Nobel prize-winning Intergovernmental Panel on Climate Change to conclude that "a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber fibre or energy from the forest, will generate the largest sustained mitigation benefit."[R31]

Strategies to increase the use of wood in buildings, and hence to maximize the environmental benefits that would result, have been articulated by European timber engineer Julius Natterer in his paper, 'A Way to Sustainable Architecture by New Technologies for Engineered Timber Structures'.[R32] Natterer refers to this approach as 'constructive environmentalism'.

CHAPTER SEVEN

CONSTRUCTIVE ENVIRONMENTALISM

7.01

Starting from the basic premise that we use only wood harvested from sustainably managed sources, there are now compelling arguments for increasing the use of wood in buildings to optimize carbon sequestration and storage — and so contribute to climate change mitigation. In this regard government, the forest industry and the design professions have a significant and pro-active role to play.

As Natterer argues in his paper, "The role that the forest of the future will have to play both for mankind and the environment cannot be assured simply through environmental protection — any more than the role of future cities can be guaranteed solely through the protection of their monuments."

Rather than relying on conservation alone, we should work toward a culture of constructive environmentalism, in which we strive for a symbiotic relationship between the built and natural environments. To increase the use of wood in buildings, Natterer advocates designing according to three basic principles:

- Increase the volume of wood in small buildings, through the adaptation of traditional solid wood construction techniques.
- Substitute wood for other materials wherever functionally appropriate to create hybrid components and structures.
- Where span and load dictate, use engineered wood for the primary structure, in combination with solid wood for secondary structural elements.

While they may not have been consciously conceived within the parameters of constructive environmentalism, a number of recently completed projects illustrate how these principles can be adapted to the different regional and technological characteristics of the Canadian practice environment.

Reviving Solid Wood Construction

Inspired by the traditional building techniques of northern Europe, Natterer has pioneered the reintroduction of solid wall and floor elements built up from sawn lumber nailed face to face in continuous panels. These elements can be prefabricated, but the end result resembles the site-built floors of our early warehouses, or the walls of grain elevators.

The revival of solid wood construction in Canada is being led by structural engineers Fast + Epp, in projects such as the Whistler Public Library (2007) in Whistler BC, four Canada Line transit stations (2009) in Richmond and Vancouver BC and the Marine Field Station (2011) near Nanaimo BC. These three applications are quite different and reflect the individual circumstances of each project.

For the roof of the library (Figure 7.01), designed with architects Hughes Condon Marler, solid wood was considered when it became known that a large quantity of 3x12 hemlock timbers could be made available to the project at a competitive price. The decision was made after a comparative analysis concluded that the life-cycle environmental and economic benefits of solid wood were at least equivalent to those of other more conventional systems such as glulam beams and purlins.

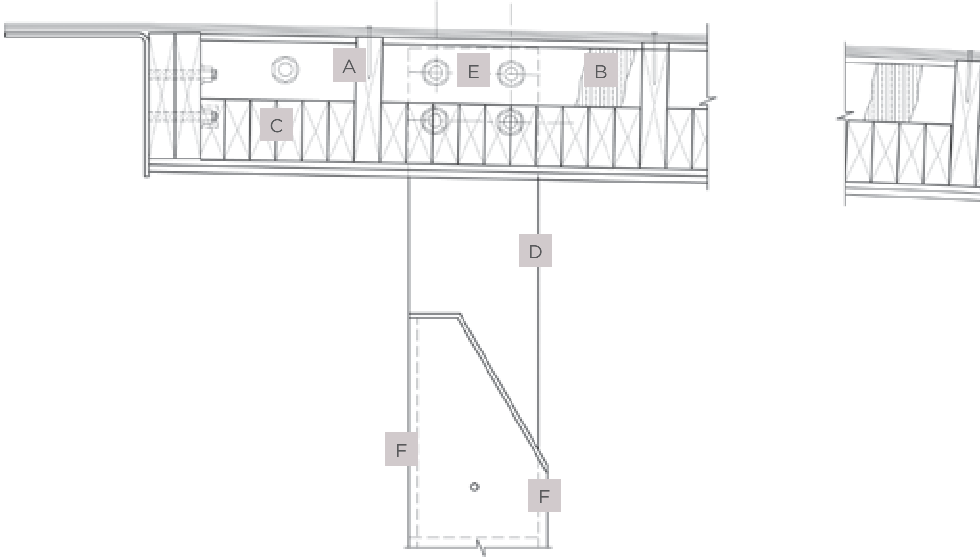
7.02 Roof panel installation

7.03

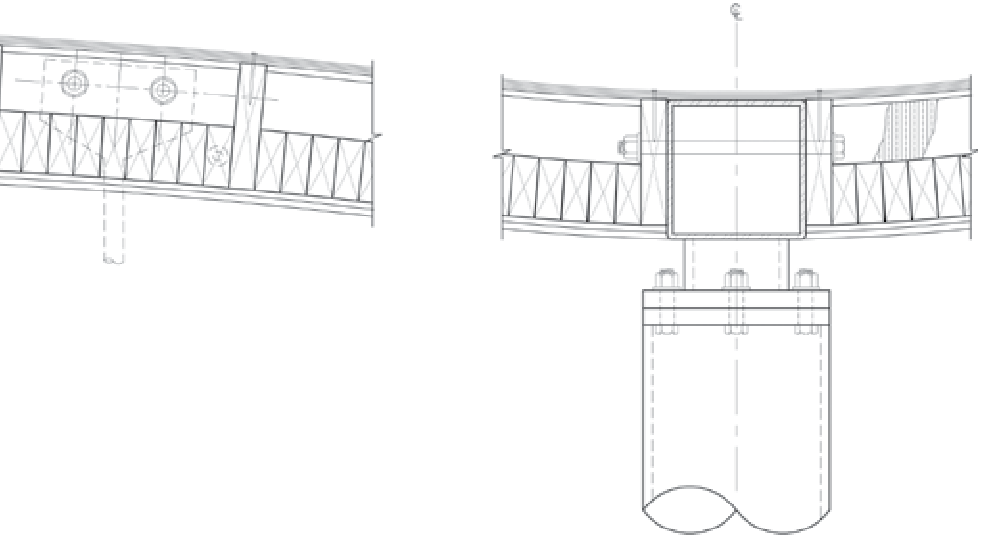
[7.01] The Whistler Public Library is a departure from the steep roofed chalet style of most Whistler buildings.
[7.02] The longest span roof panels are strengthened by a steel king post system.
[7.03] Panels are set 300mm apart to create a zone for mechanical and electrical services.

2x10 member at approx 300mm centres	A
Void for services with rigid insulation infill	B
Nail laminated 2x4 roof deck	C
Knife plate located between roof panels	D
Bolted connection between knife plate and perimeter channel	E
HSS column	F

7.05 Detail section of platform canopy



7.04



[7.04; 7.05] The platform canopies at the Canada Line stations have a flush appearance from below, but within the panel depth they contain concealed voids for services.

The solid wood alternative contained a larger amount of wood fibre, but used only locally harvested, solid-sawn lumber, reducing the need for engineered wood members which have higher embodied energy due to processing and transportation. The solid panel system also required less depth, hence less envelope area and a smaller building volume. This resulted in lower material costs for the building envelope and lower operating energy costs. In addition, local fabrication and the use of hemlock (historically overlooked as a low-value species) offered additional benefits to the regional economy.

The panels, prefabricated and installed by StructureCraft Builders, are made up of 13 hemlock members lag-screwed together face to face. Alternate laminations are offset vertically by 75mm, creating a corrugated section that strengthens the panel and minimizes the effects of dimensional variability common to the species (Figure 7.02 – previous page). The corrugated soffits of the roof panels are exposed to view inside the library, giving the interior visual warmth and texture (Figure 7.03 – previous page).

The desire for visual warmth also influenced the choice of wood for the Canada Line stations, although the client's primary concerns were for economy and speed of erection. Designed with VIA Architecture and Perkins+Will Canada Architects, the roofs are of modular construction comprising solid wood panels contained within a steel channel frame (Figure 7.04).

The basic structure is of nail-laminated 2x4s, with a 2x10 member occurring at approximately 300mm centres. The 2x10s project above the plane of the panel to provide a nailing surface for the plywood diaphragm and create a void behind the finished roof plane in which to conceal conduit and other services (Figure 7.05).

McFarland Marceau Architects' Marine Field Station at Deep Bay provides publicly accessible teaching and research facilities as an extension of Vancouver Island University's nearby Shellfish Research Centre. The program includes visitor and event facilities together with research laboratories, aquaculture tanks and administrative offices (Figure 7.06).

The lower level is cut into the sloping waterfront site, with a concrete retaining wall acting as a springboard for the shell like roof structure that shelters the main floor (Figure 7.07). A primary frame of glulam columns and beams supports suspended timber floors of solid nail laminated 2x4 construction, while the roof consists of curved composite concrete and glulam ribs supporting 89mm thick tongue and groove decking (Figure 7.08)

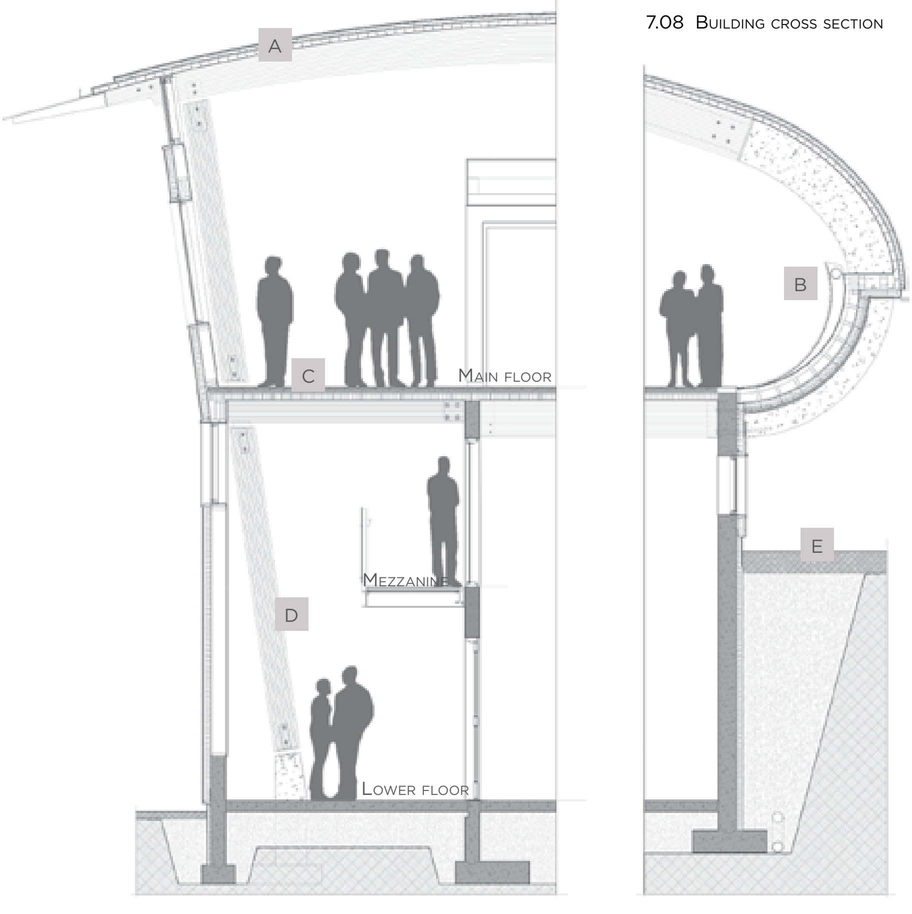
[7.06] The curved roof of the Deep Bay Marine Field Station is inspired by the form of a shell.
[7.07] The wood structure, including solid wood roof and floor soffits, is exposed throughout.
[7.08] Solid wood elements include a suspended floor of nail-laminated 2x4s, and tongue and groove roof sheathing.

7.06

7.07

These solid wood systems, which are low-tech and use local materials and labour, have potentially profound implications, being replicable or adaptable to a wide variety of building types and sizes.

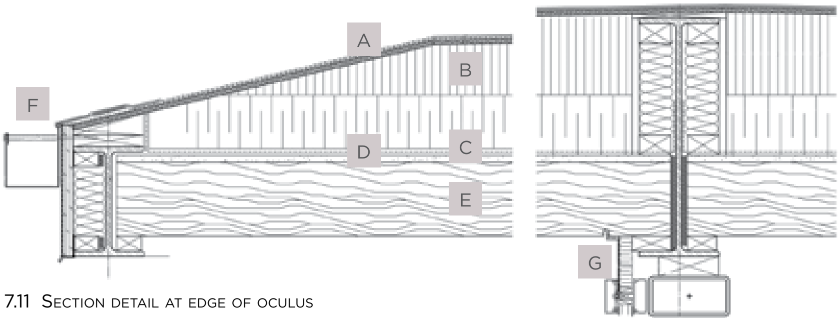
In Quebec a different kind of solid wood construction has begun to emerge that uses small block laminated panels manufactured by Nordic. These panels provide one-way spanning capability within a very shallow depth relative to that required for conventional roof and floor systems. A particularly striking example is Anne Carrier architecte's expansion to the Bibliothèque Félix-Leclerc in Quebec City. Completed in 2009 with structural engineer Gino Pelletier, the program spaces are contained beneath a folded plane of solid wood 'bridge' panels that extends beyond the building envelope to engage the adjacent park (Figures 7.09 and 7.10 – next page).



7.08 Building cross section

A	Roof structure comprising curved glulam ribs, solid T&G decking, plywood sheathing
B	Curved concrete support
C	Suspended floor structure comprising glulam beams, solid nail laminated 2x4 decking, concrete topping
D	Inclined glulam column
E	Concrete retaining wall


7.09



7.11 SECTION DETAIL AT EDGE OF OCULUS


7.10

An oculus cut into the projecting roof canopy allows sunlight to reach the exterior terrace below. The edge of the opening is detailed to accentuate the thinness of the bridge panel construction, and reinforce the planar expression of the roof (Figure 7.11).

WOOD SUBSTITUTION AND HYBRID CONSTRUCTION

In Europe, the substitution of wood for other materials has manifested itself at two scales: the scale of the building and the scale of the building element or component. The work of the Renzo Piano building workshop in particular illustrates these two approaches. Although not immediately apparent from the exterior, the auditoria at Parco della Musica in Rome are built almost entirely of wood. The three theatres, the largest of which has a seating capacity of 2800, are free-spanning shell-like glulam structures with heavy timber decking, clad externally in masonry and zinc (Figure 7.12). In contrast, the structure of the Padre Pio Pilgrimage Church in San Giovanni Rotondo is an innovative hybrid that combines stone, steel and wood elements (Figure 7.13).

In Canada we are also beginning to see substitution and hybrid construction at both scales, as witnessed by several of the examples illustrated previously. One interesting project not yet mentioned is the Moricetown Gas Bar that serves an Aboriginal community near Smithers BC.

A	Roofing Membrane
B	Tapered Rigid Insulation
C	Vapour Barrier
D	Gypsum Board
E	Glulam Bridge Panel
F	Galvanized steel gutter
G	Steel column and beam supporting structure


7.12


7.13

[7.09] The Bibliotheque Felix Leclerc uses small block laminated 'bridge' panels for the roof structure.
[7.10] The laminated wood ceilings add visual warmth to the interior of the building.
[7.11] Around the oculus, tapered insulation accentuates the thinness of the roof structure.
[7.12] The glulam and heavy timber auditorium structures at Parco della Musica are clad in masonry and zinc.
[7.13] The structure of the Padre Pio church is a composite of stone, steel and wood.


7.16


7.14


7.15

Designed by KMBR Architects with Fast + Epp and completed in 2007, the reasons for using wood in this project were more cultural and economic than environmental. The simple post-and-beam structure evokes cultural tradition, while meeting the more practical need for fast and reliable construction in a remote part of the province with a short building season (Figure 7.14).

Whatever the motivation, the Moricetown Gas Bar confirms that there is architecture to be found in the most prosaic of building programs, and that we need not accept the homogeneity which the mass-produced corporate alternative has brought to our rural and urban landscapes.

Until recently, the use of structural wood in large non-residential buildings was a rarity in urban locations. Among the first buildings to break this pattern was Richmond City Hall in Richmond BC, designed by Dialog and KPMB Associated Architects with Bush Bohlman & Partners structural engineers, and completed in 2002. Here large glulam portal frames support the roof of the double-height loggia that leads to the mid-rise administrative tower (Figures 7.15 and 7.16).

Together with other precedent-setting projects such as the Carlo Fidani Peel Cancer Centre and Surrey Central City, Richmond City Hall has demonstrated both to municipal governments and to the general public the viability of wood as a structural material in large-scale commercial and institutional structures.

However, in December 2008, the application of wood in these kinds of buildings achieved new levels of sophistication and prominence with the completion of Frank O. Gehry & Associates' Art Gallery of Ontario extension in Toronto. The wood components, engineered by Equilibrium Consulting, include a five-storey tower and a large central skylight over Walker Court, but the tour de force is the curvilinear 180m-long Galleria Italia that extends the entire length of the Dundas Street façade (Figure 7.17).

[7.14] The Moricetown Gas Bar evokes traditional West Coast Aboriginal post and beam structures.
[7.15; 7.16] The entrance loggia at the Richmond city Hall is a precedent setting application of wood in a major municipal building.
[7.17] The Galleria Italia gives the Art Gallery of Ontario a new and progressive image on Toronto's busy Dundas Street.

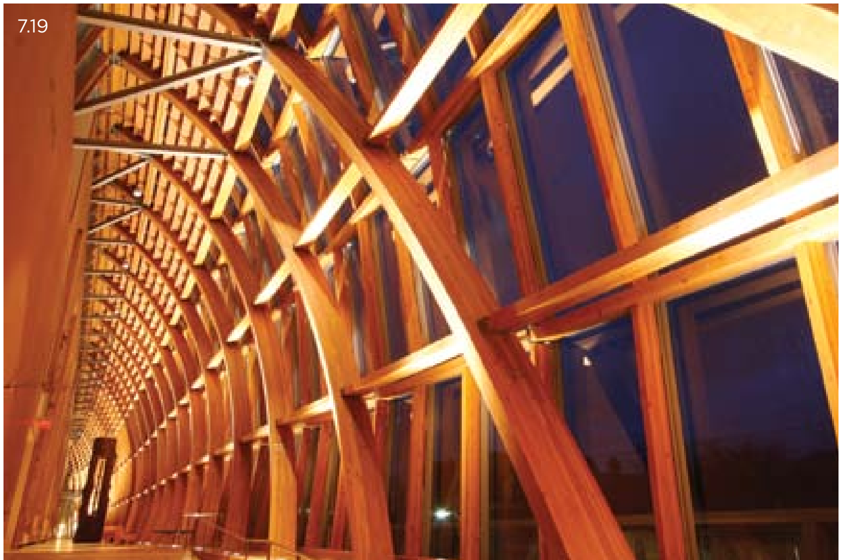
7.17

7.18

The Galleria, rising 20m above the sidewalk, acts as a link between gallery spaces and as a connection between the AGO and the city (Figure 7.18). The central 140m of the façade forms an enclosed sculpture gallery, while two exterior 'tear-away' sections flank the ends.

The façade includes more than 1000 glulam members and over 2500 connections, each with its own geometry. Individual members are faceted and some are shaped, all using CNC machines (Figure 7.19). The outward simplicity of the connections belies the inner complexity of the detailing.

7.19




7.20

Long-Span Structures

For long-span and heavily loaded applications, Natterer advocates the use of engineered wood for the primary structure, with solid wood used for secondary structure and enclosing elements. Such structures are still a rarity in Canada, although Perkins+Will Canada Architects' Brentwood Town Centre Station in Burnaby BC was probably the first to successfully combine high-tech glulam fabrication with low-tech, site-built solid wood (Figure 7.20).

Completed in 2001 with structural engineers Fast + Epp, the platform canopies comprise curved composite steel and glulam ribs that support a deck made up of 2x4 material. The 2x4s are nail-laminated side by side on edge, taking advantage of the inherent flexibility of the material to follow the double curve of the roof (Figure 7.21).


7.21

[7.18; 7.19] The subtly curving geometry of the Galleria Italia required a structure of great complexity and sophistication.
[7.20; 7.21] Curved glulam ribs sheathed in site built solid wood create the striking double curved form of Brentwood Town Centre Station.


7.22

[7.22; 7.23] Slender steel stanchions support a space lattice of glulam members to form the roof of the Canadian Plaza at the Peace Bridge Border Crossing. [7.24] Entrance canopies at the Richmond Olympic Oval give a hint of the wood roof structure within,

7.23

Similarly, the architects and engineers at NORR used a combination of glulam and heavy timber in their Canadian Plaza at the Peace Bridge Border Crossing at Fort Erie ON, completed in 2007. The project includes an administrative building and an extensive exterior canopy that covers the customs posts and the vehicles being inspected (Figure 7.22).

The construction consists of an interwoven glulam substructure supporting an exposed wood roof deck that is evocative of the traditional shelter and canoe construction used for centuries by the native inhabitants of the area. The wood lattice structure acts like a space frame, permitting extensive cantilevers in a situation where structural supports are of necessity few in number and widely spaced (Figure 7.23).

At a much larger scale is the Richmond Oval, a legacy project of the Vancouver 2010 Winter Olympic Games. Located on the south bank of the Fraser River in Richmond BC (Figure 7.24), the building was designed by Cannon Design Architecture, and the wood roof structure engineered by Fast + Epp and StructureCraft Builders.

7.24

7.25

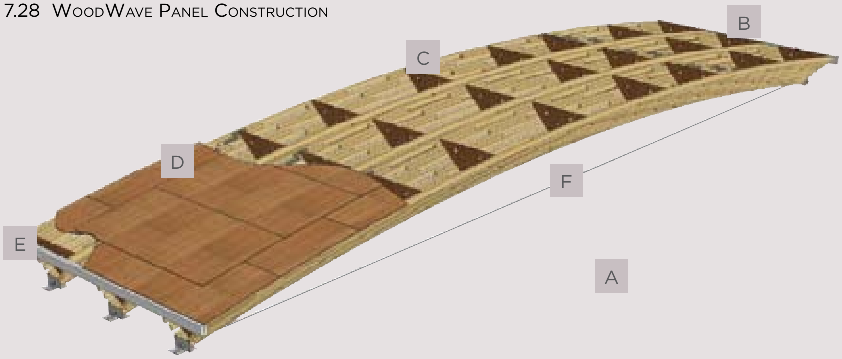
7.26

The roof structure comprises composite glulam and steel arches that span more than 90m across the former speed-skating oval, bridged by prefabricated WoodWave roof panels that are made entirely from 2x4 lumber and plywood (Figure 7.25).

The arches are set at 14m centres, and spring from concrete buttresses tied together by the floor slabs of the building. A perfect example of hybrid construction at the scale of the building element, they comprise twinned glulam members held at an angle to one another by a triangular steel truss. The trusses create a hollow core that conceals the main mechanical and electrical services (Figure 7.26).

The arches support more than 450 WoodWave roof panels that were designed, prefabricated and installed by StructureCraft Builders. Each panel comprises three hollow triangular section trusses, typically 12.5m long, laid side by side and connected together by a double skin of plywood. The two sloping faces of each V-shaped truss splay out from a central bottom chord of 2x4 solid-sawn lumber, and are built up from successive strands of the same material laid on edge. The panels were pre-cambered in the factory, and steel tie rods installed to create a stable tied-arch structure (Figures 7.27 and 7.28).

7.28 WoodWave Panel Construction



TYPICAL WAVE PANEL PERSPECTIVE VIEW	A
DOUBLE 2x6 TRIMMERS	B
1 IN. EXTERIOR DFP PLYWOOD BULKHEAD	C
SHOP APPLIED PLYWOOD PATTERN	D
DOUBLE 2x6 TRIMMERS	E
15Ø (#6) DYWIDAG BAR	F


7.27

Although the roof structure was required by code to be of heavy timber construction, consultants LMDG used fire simulation modeling to demonstrate that the proposed design, met the requirements for fire and life safety — due to the overlapping configuration of framing members, and the large volume and openness of the structure.

Designing for Durability and Reuse

Although not explicitly identified in Natterer's principles of constructive environmentalism, designing for durability and demountability is key to maximizing the carbon storage potential of wood buildings and products. Because of their straightforward connection systems, the components of older heavy timber post-and-beam structures have proven relatively easy to dismantle, re-mill and reuse. Furthermore, these reclaimed components can generally be repurposed without significant loss of structural value. By and large, the obstacles preventing the more widespread adoption of this practice are logistical and legislative, rather than technical.

This issue was highlighted as long ago as 1999, during the construction of the Materials Testing Centre, a 400m^2 office and laboratory building designed by Perkins+Will Canada and Fast + Epp. The glulam and heavy timber components salvaged from two demolished warehouses became the kit of parts used to construct the new building (Figure 7.29).

Reuse of the wood components at full structural value was made more difficult by the lack of grading stamps, uncertainty about the integrity of the glue bonds in the glulam members, and by connections that no longer conformed to the building code. This resulted in some interesting structural solutions, including glulam purlins being used on the flat to form a solid wood suspended floor, and two new exterior trusses being fashioned from the reclaimed remnants of four old ones. In the case of the trusses, conservative assumptions had to be made about material strength, and the spans were reduced through the introduction of V-supports.


7.29

[7.25] Composite glulam and steel arches span 90m across the sports hall, supporting a roof of WoodWave Panels.
[7.26] The hollow arches conceal mechanical and electrical services.
[7.27; 7.28] The more than 450 Wood Wave panels are constructed from standard dimension lumber and plywood.
[7.29] Reclaimed wood makes up more than 90% of the structure at the Materials Testing Centre.

7.30

7.31

Since then a number of public buildings have incorporated reclaimed wood, although its use remains to a great degree a matter of chance. The known availability of a secure supply of reclaimed wood at the early stages of design can give architects and engineers unique, project-specific opportunities.

Such was the case with the expansion to Macdonald-Cartier International Airport in Ottawa ON, one of the most prestigious applications of reclaimed wood to date in Canada. Completed in 2008 by mgb architecture and Arup structural engineers, the project uses large Douglas fir timbers reclaimed from the demolition of a 60-year-old aircraft hangar. The wood was re-milled to form the mullions of the glass curtain wall in the holding areas, and for interior screens and finishes (Figures 7.30 and 7.31).

While these examples represent creative reuse of reclaimed materials, there needs to be a strategic rethinking of how we design buildings in order to maximize the value of the materials and embodied energy contained within them. New buildings must be designed with durability, adaptability and disassembly in mind. To this end in 2006, the CSA published a new guideline entitled ‘Design for Disassembly and Adaptability in Buildings’, that outlines strategies from space planning to detail design in support of these objectives.[R33]

SMV Architects and Equilibrium Consulting used this approach (which goes by the acronym DFD/A) in the design of the Mountain Equipment Co-op in Burlington ON, completed in 2008. The structure comprises a glulam frame with simple bolted connections, and a building envelope consisting of prefabricated, plywood-faced structural insulated panels (SIPs). The frame is independently braced, meaning that the SIPs do not contribute to the lateral stability of the structure, and carry only their own weight. Thus they could be removed or replaced easily and individually at any time in the future (Figures 7.32 and 7.33).

In accordance with the DFD/A guideline, the design team created a disassembly manual, including a comprehensive record of design assumptions and calculations that would facilitate reuse of components in the future. The comprehensive DFD/A approach earned the building a LEED credit for design innovation.

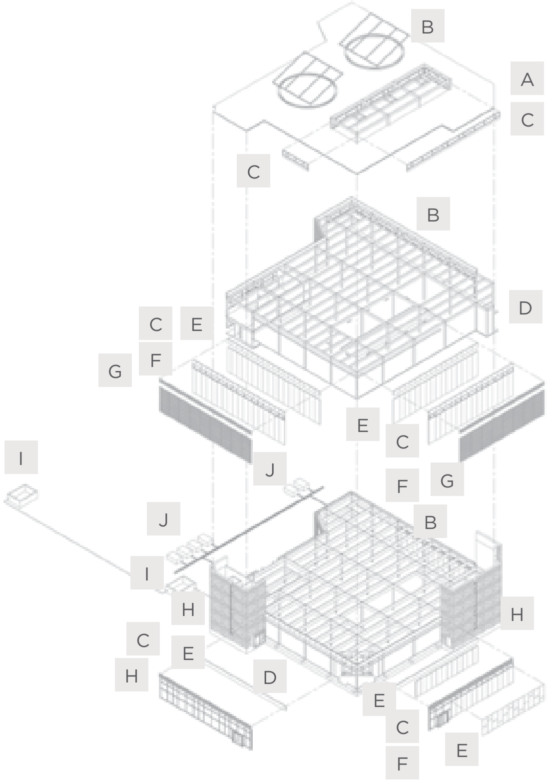
It is beyond the scope of this book to provide a comprehensive comparison of the properties of the many Canadian wood species used in construction, or to examine the art of wood detailing in depth. Suffice it to say that some species such as western red cedar are known for their weather resistance, while others such as Douglas fir are known for their strength.

[7.30; 7.31] Reclaimed wood features prominently in the Macdonald-Cartier International Airport in Ottawa.
[7.32] The simple detailing of the timber frame at MEC Burlington allows for future disassembly.

7.32

As the builders of Norwegian stave churches discovered, wood deteriorates when allowed to remain wet for prolonged periods, but is far more durable if allowed to dry out between successive exposures to moisture. End grain is particularly vulnerable, as it absorbs water through capillary action between the fibres.

Strategies for detailing exterior wood structures include preservative treatment, protecting joints from direct exposure, sloping end cuts for drainage and creating gaps between adjacent members to permit drying through air circulation. These were all employed to great effect by Waddell in his Fraser River suspension bridges, and are no less valuable today. However, many contemporary architects prefer to protect the structural frame from the elements with roof overhangs and carefully detailed cladding. Some choose not to use wood as an exterior material at all.



7.33 Assembly/disassembly diagram

A	single ply PVC roof membrane
B	glulam timber framing
C	glazing w/Low E coating
D	concrete slab on metal deck w/embedded hydronic floor piping
E	cement fiber board panels
F	structural insulated panels
G	prefinished metal siding
H	local natural stone
I	underground rainwater cistern
J	ice module condensing units

7.34

7.35

The consortium designing Metro Vancouver's Millennium Line transit stations devised a series of guidelines for the use of wood in these buildings. These guidelines included: specifying only engineered or kiln-dried wood for dimensional stability; protecting all wood members from weather; and using wood only above a 3m datum to minimize the risk of vandalism or fire. Together they informed an architectonic expression based on the complementary properties of wood and steel (Figures 7.34 and 7.35).

Recognition of the inherent properties and most appropriate applications of different materials is a key component in the creation of durable buildings, and part of a broader philosophy of sustainable design. Until recently, the role of wood in this new, pragmatic yet holistic approach to architecture has been compromised by discriminatory building codes and the lingering uncertainty about forest management practices. One remaining impediment is the limited recognition given to the environmental benefits of wood under the increasingly influential LEED rating system. Nonetheless, the advances and achievements of the last few years are but a taste of what is to come.

[7.33] At MEC Burlington, the functions of structure and enclosure are separated for maximum adaptability.
[7.34] At Brentwood Town Centre Station, steel components are used where the structure is exposed to weather.
[7.35] At Braid Station in New Westminster BC, the roof edge is castellated to protect the glulam members from weather. (Architects: Architectura/Walter Francl Architect. Structural Engineer C.Y. Loh)

CHAPTER EIGHT

Back to the Future

8.01

The ability to embrace diversity and prosper from it is arguably one of the core strengths of Canada as a nation. It is a strength that we would do well to cultivate in renewing our relationship with wood, combining the creativity and enterprise of our European heritage with the reverence and stewardship of our Aboriginal traditions.

Embracing Diversity

The buildings presented thus far can be seen as the first pieces in a mosaic, that is beginning to redefine Canada's architectural culture. In many cases these structures are based on international precedents and prototypes whose ultimate transferability will depend on successful adaptation to the unique characteristics of our own industry, geography and demography.

The alchemy of the Richmond Oval, which represents the engineering equivalent of turning base metal into gold, revives the European settlers' tradition of enterprise and ingenuity. As such, it clearly delineates one of the ways forward for the country's wood industry. More than any other, this structure demonstrates the role design can play in maximizing the potential of simple materials without heavy investment in high-tech manufacturing equipment.

At the other end of the technological spectrum, the Galleria Italia at the AGO equally clearly demonstrates the viability — and indeed desirability — of wood in even the largest and most prestigious of our civic buildings. The AGO has a sophistication and precision of execution rivaling that of the finest European structures, and sets a new benchmark for Canadian wood architecture.

8.02

8.03

A new wood culture based on the principles of constructive environmentalism must be broad enough to embrace both these approaches, and everything in between. Exactly how this new culture will manifest itself is difficult to foresee, particularly in a crystal ball clouded by the recent global recession. What is clear, however, is that it must be founded on a heightened understanding of the material properties, structural potential and other unique attributes of wood.

New design imperatives and building technologies are emerging that offer unparalleled opportunities to those in the Canadian forest and construction industries willing to fully embrace the new global paradigm of economic, social and environmental sustainability. Of these emerging trends, the most important are:

- The exploration of new technologies for mid- and high-rise construction
- An increased emphasis on the use of local materials and manufacturing technology
- The introduction of Life Cycle Assessment and carbon accounting for buildings

Mid-Rise Light Frame Construction

In 2009, the Province of British Columbia increased the maximum allowable height of wood-frame residential buildings from four to six storeys. This change has put the province in step with other international jurisdictions, including the states of Washington, Oregon and California, where six-storey construction has been permitted for several years.

The new legislation has been presented as part of a larger strategy to reduce the overall carbon footprint and environmental impact of both public and private-sector housing projects. These benefits accrue in two ways: by encouraging the densification of neighbourhoods, which in itself lowers the per capita carbon footprint; and by using wood for buildings that would otherwise have been constructed in steel or concrete.

[8.01] At six storeys, Fondaction Quebec is the tallest heavy timber commercial structure to be built in Canada in modern times.
[8.02] The structure uses small block laminated columns, beams and floor panels.
[8.03] Although the columns of Fondaction Quebec are rectangular, they have a similar end to end bearing detail.

[F15] In platform frame construction, the floor is used as a 'platform' for the construction of the walls for the next storey. Shrinkage across the grain of the joists is considerable, and its effect increases with building height.


8.04

Many had hoped that the new regulations would provide the necessary impetus for the introduction of new, European-inspired solid wood technology, but this has not been the case. Instead, the mid-rise projects now under construction around the province all employ a modified version of the familiar light wood frame technology, albeit with a greater emphasis on factory prefabrication and the use of engineered wood components.

These modifications have been necessary to address (among other things) the greater overall shrinkage values to which taller platform frame buildings are subject. [F15] As such they are serving to accelerate a transformation of the residential construction industry from an exclusively site-built enterprise to one that capitalizes on the benefits of factory prefabrication to shorten construction times, increased precision and performance, optimize material use and reduce waste.

Research carried out by FP Innovations suggests that the practical height limit for light-frame construction is eight storeys, and hence other systems will need to be developed for taller structures.

Mid-Rise Construction in Heavy Timber

In Quebec, without the benefit of legislative changes and using only the equivalency provisions of the existing building code, architect Gilles Huot and structural engineers Bureau d'Études Spécialisées have completed a six-storey, all-wood commercial building in the heart of Quebec City (Figure 8.01 – previous page).

The offices of Fondaction Quebec are of heavy timber construction that uses small block laminated glulam beams, columns and decking supplied by Nordic. This project brings together the various products used previously at the Restoration Services Centre, Eugene Kruger and the Bibliothèque Felix Leclerc (Figure 8.02 – previous page).

The vertical structure has end-grain to end-grain bearing, with columns notched to accept the main beams (Figure 8.03 – previous page). This approach addresses the cumulative cross-grain shrinkage that can be problematic in taller platform frame buildings. The one-way spanning 'bridge' panels used for the floor will in future be supplemented by a cross-laminated, two-way spanning version that could also be used for shear walls.

[8.04; 8.05] Designed deliberately to not look like a wood building, the Timber tower in fact contains eight storeys of CLT construction.

High-Rise Construction in Massive Wood

January 2009 saw the completion of a nine-storey residential building in London, England, that captured the imagination of architects around the world (Figure 8.04). Designed by Waugh Thistleton Architects, the 'Timber Tower' comprises a single-storey concrete podium with eight storeys of massive wood construction above. The wood elements used for the interior and exterior walls, elevator and stair wells, floors and roof are cross-laminated timber (CLT) panels that were manufactured and installed by KLH of Austria.

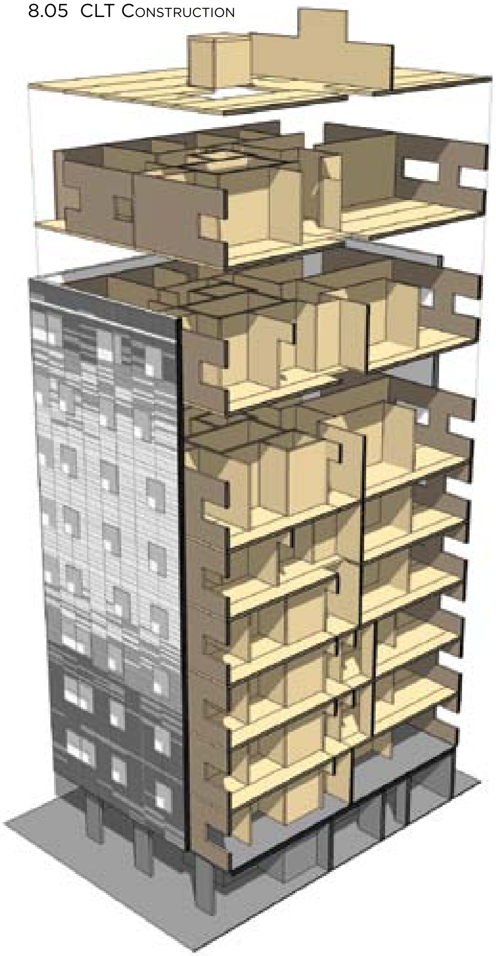
CLT panels are assembled from strips of small-dimension lumber laid up in layers of alternating orientation much like plywood and these layers may be glued, nailed or doweled together. The maximum panel width depends on the size of the CLT press, and the length is limited only by the economies of transportation. Panels may range in thickness from 125mm to 350mm depending on span, loading and application. Window, door and other openings are pre-cut in the factory using CNC machinery.

Construction using CLT or other massive wood panels bears some resemblance to precast concrete construction, but has none of the negative environmental impacts of concrete manufacture. It is also quicker and easier — the CLT elements for the Timber Tower were installed using a standard crane in just 24 days — one day each for the floors, exterior walls and interior partitions of each of the eight storeys. Structurally, the system is similar to platform framing, with each floor supporting the walls of the storey above (Figure 8.05).

Compared with light wood frame, massive wood construction has superior strength, acoustic performance and fire resistance. In addition, the mass of the panels contributes to temperature and humidity control by storing and then releasing heat and moisture. In Europe massive wood is considered comparable in quality to concrete or masonry construction.

Since the completion of the Timber Tower, CLT has been casting a shadow (or perhaps shining a light) on the future of wood construction in Canada. Requiring only small wood sections, readily and widely available from Canadian forests, it could revolutionize the value added wood industry, and make possible a new generation of large scale wood buildings.

8.05 CLT Construction




8.06

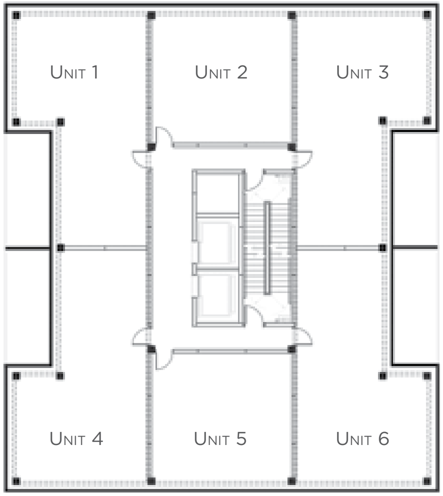
[8.06; 8.07] Rendering and floor plan of proposed high rise apartment tower built using FFTT.

In 2010, the wood industry began investigating the commercial viability of massive wood technology for various types of building in the local market. A prototype house was built in West Vancouver BC using CLT panels imported from Europe, and funding was provided for a study to determine the feasibility of high-rise construction. Technology transfer has proven less than straightforward as (issues of affordability aside) any buildings built on the east or west coast would be required to resist seismic forces not experienced in northern Europe.

Earthquakes shake the base of a building, and typically have a greater impact on taller and heavier structures than on smaller lighter ones. If a multi-storey building is not tied together vertically, it will tend to behave much as a stack of boxes might do if the bottom one were to be shaken. This behaviour makes the adoption of the platform system used in the Timber Tower problematic in seismic zones.

In response, the study team developed an alternative prefabricated panelized system in which vertical components pass through several floors in order to tie the building together. Designer’s mgb architecture and Equilibrium consulting refer to this system as FFTT (Finding the Forest Through the Trees). The team explored several structural options, each of which was developed around a central core of massive wood construction, but varied in the way internal and perimeter loads were carried.

Published in spring 2011, the study concluded that the FFTT system could be used for open plan buildings up to 20 storeys, assuming code concerns about fire resistance and exiting can be overcome (Figures 8.06 and 8.07). With structural demising walls and perimeter loadbearing walls, structures up to 30 storeys may be possible.



8.07 Apartment Tower – Typical floor Plan

■ Loadbearing glulam columns

━ Curtain wall or other exterior envelope system

┅ Structural beam above

═ Loadbearing wall

▤ Non-loadbearing wall with structural beam above

Regional Materials and Manufacturing

When the environmental movement began in the 1970s, its primary focus was the sustainability of the world's many ecosystems. Partly in recognition of the fact that much environmental degradation is inextricably linked to economic and social inequities, the generally accepted definition of sustainability has evolved over time to embrace these issues as well. Increasingly, Canadian corporations are being called upon to demonstrate that their business practices appropriately balance economic performance with environmental and social responsibility.

At one end of the spectrum, Quebec-based Nordic, with 800,000 hectares of land holdings in the boreal forest, is one major company that has publicly declared its intentions. In addition to its ISO 14001 Environmental Reforestation certification, Nordic obtained FSC certification in February 2009, the first privately held EWP producer to do so. At the other end of the spectrum, many small companies, such as Kalesnikoff Lumber in BC, have also taken a leadership role in this regard, often to the benefit of their local community.

Because Canada's commercial forests are so extensive and its forest-dependent communities so widely dispersed, the impacts of the recent period of industry consolidation have been particularly severe. Perhaps more than in any other country, the principles of constructive environmentalism, which have the capacity to spread social and economic benefits over a large area, could have a profound and positive impact. While the technology required to produce highly sophisticated engineered wood components for large and long-span buildings is expensive, and investment must therefore be made in a few centralized plants, there is no reason why the production of low-tech sawn lumber for small buildings cannot remain (or again become) the preserve of small operations located throughout the country.

One recent project in rural British Columbia demonstrates the potential for locally produced wood to deliver multiple benefits to the community. Winner of a 2009 Sustainable Architecture and Building (SAB) Award, the Crawford Bay Elementary/Secondary School was designed by KMBR Architects and Fast + Epp structural engineers.

The K-12 school serves an area population of about 1500 that is spread across the small communities along the east shore of Kootenay Lake. The structure is entirely of wood, and designed to make maximum use of locally available materials, technology and construction expertise.

8.09

Wood for the glulam post-and-beam frame was harvested locally by Kalesnikoff Lumber from its own certified forests, and sent to Penticton (a distance of only 300km) for fabrication. Dimension lumber came from the same source, and was used mostly for traditional wall and roof framing. However, the large overhanging eaves were prefabricated on site as nailed-plank panels to maximize strength and minimize the need for finishing (Figure 8.08).

The benefits to the community of this locally focused approach to design are both economic and social, through the purchase of materials, the employment of local construction workers and the commissioning of numerous local artists and artisans to create works for the school. Having fostered community connections, and animated by the many personal contributions, the building now functions as the social hub of the east shore (Figure 8.09).

8.08

Life Cycle Assessment and Carbon Accounting for Buildings

Since its introduction to Canada in 2002, the LEED rating system has become the most commonly used tool for guiding the design of green buildings and evaluating the results. Its impact as an educational tool for designers, contractors, building owners and consumers has been enormous and the kudos associated with LEED certification has successfully raised the bar to the extent that the Platinum certification that seemed unattainable in 2002 is now a reasonable and realistic target for many projects.

Despite its contribution to market transformation, criticism has been leveled at LEED for not including life-cycle assessment (LCA) of buildings. LCA is accepted elsewhere in the world as an impartial way to evaluate and compare the environmental impacts of different building materials, products and complete structures over their lifetime — from material processing and manufacturing, through transportation, installation, building operation, decommissioning and eventual disposal. In almost every situation, LCA confirms that wood is the most environmentally responsible building material. The widespread adoption of LCA in North America is only a matter of time, and the door has already been opened.

8.10

[8.08; 8.09] The all wood structure of the new Crawford Bay Elementary/Secondary School was designed to maximize the use of local materials and labour.
[8.10] VanDusen Botanical Gardens Visitor Centre, Vancouver BC. (Architect: Perkins+Will Canada. Structural engineers: Fast + Epp)
[8.11] Centre for Interactive Research on Sustainability, Vancouver BC. (Architect: Perkins+Will Canada. Structural engineers: Fast + Epp)

Recognizing that the world must move swiftly to a point of balance between the natural and built environments, the Cascadia Region Green Building Council issued its Living Building Challenge in 2006. Going well beyond the requirements of even LEED Platinum, the Living Building Challenge envisages developments that would function ‘as elegantly as a flower’. Such developments would capture and treat all of their own water using ecologically sound processes; meet their energy needs using clean, renewable resources; use only environmentally benign materials; utilize only previously developed sites and achieve a net zero carbon footprint.

Two such buildings were completed and accredited in the US in October 2010, with several Canadian contenders due to be completed in the fall of 2011. Tellingly these projects all include large amounts of wood (Figure 8.10). In each case, modeling tools, such as the ATHENA Construction Carbon Calculator, have been employed to estimate the amount of carbon used in the extraction, manufacture and transportation of all the materials used. In the case of Perkins+Will Canada’s Centre for Interactive Research on Sustainability (CIRS) building at UBC, the 600 net tonnes of carbon sequestered in the wood components more than offset the 535-tonne footprint of the other materials (Figure 8.11).

It is worth underscoring that the global adoption of environmentally benign building practices such as those required by the Living Building Challenge is the only option we have for a viable and sustainable future. Just as the impact of LEED has grown exponentially over the last nine years, so we may realistically anticipate similar or even faster growth in the development of Living Buildings. While carbon neutrality can theoretically be achieved through other forms of carbon offsets, in Canada the use of wood is clearly the most logical choice.

8.11

[8.12] A future full of possibilities.

Back to the Future

As a land transformed and connected by the technology of wood building, Canada was once identified by the many structures, large and small, that were realized in that material: log cabins, grain elevators and railroad trestles among them.

After a hiatus of almost a century, the country is poised to embrace a new culture of wood architecture in which the similarities with these historic structures may be as striking as the differences. As Darryl Condon of Hughes Condon Marler Architects puts it, “By studying the cultural history of Canadian architecture, examining traditional techniques and societal influences through the lens of today’s technological possibilities, contemporary designers will once again be able to create buildings and building systems that are functional, relevant and inspiring.”[R34]

Conditions are converging that will make the architectural culture of the 21st century a wood culture. Propelled by ecological imperatives, this new culture of constructive environmentalism can also deliver social and economic benefits. As the raw material for nailed-plank systems and other low-tech end uses, wood has the potential to be grown, harvested and processed in a highly decentralized way, distributing these benefits more widely than would be possible for any other construction material.

At the same time, new technology is providing us with the means to make value-added products from lesser quality material. The products now available, and those that are yet to be created, will give designers more choice and flexibility to develop panelized and prefabricated building systems that will improve the quality and economy of construction for all types of structures.

Computer modeling now provides the means to analyze the fire performance of buildings objectively, and a new national building code structure makes these analyses admissible evidence of compliance. These changes (and others currently under consideration) increase the opportunities for wood use. In a true performance-based code environment, we may well see wood structures of a scale not contemplated by architects and engineers on this continent for more than 100 years (Figure 8.12).

A growing body of scientific research confirms the environmental advantages of building in wood and the long-term benefits of sustainable forestry in mitigating climate change. Wood is the major construction material in all the Living Buildings now being designed in Canada, chosen because every cubic metre of the material has sequestered approximately 1 tonne of CO_2 making locally sourced wood carbon neutral or even carbon negative.

With more than 10% of the world’s forests, an increasing amount of them independently certified, Canada has much to gain and simultaneously much to offer. As we re-evaluate our relationship with the natural world and navigate the rising tide of climate change, it is imperative that Canadians take a leadership role in the stewardship and beneficial use of one of the world’s key renewable resources.

8.12

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JIM TAGGART, DIPL. ARCH., M.A., FRAIC

credit: Christine McAvoy

Jim received his Master of Arts in Architecture from the University of Sheffield, England in 1980. For 12 years he worked in design and construction in Canada and the UK, including five years with Vancouver's Expo '86 World's Fair, and three years as an Associate with Busby Bridger Architects.
Since 1992 his focus has been public and professional education and communications in the areas of architecture, urban design and sustainable development. His most notable area of specialty is the role of wood in contemporary architecture, and he has written many technical case studies and general articles on the subject for national and international publications. Jim has also delivered more than 80 professional development seminars on behalf of the Canadian Wood Council in more than 30 cities across North America.
Jim currently teaches history and theory in the architectural science degree program at the British Columbia Institute of Technology, and is the editor of Sustainable Architecture and Building magazine (SABMag). His other writing and editing credits include: the pocket architectural guides 'Downtown Victoria' (2000) and 'Historic Vancouver' (2001); the first four editions of the 'Cedar Book' (2007 – 2010); 'Busby: Learning Sustainable Design" (2007) and 'Symphony of Structure – the work of Fast + Epp' (2010).
Jim is the recipient of numerous awards including a Certificate of Special Recognition for Services to the architectural profession and a provincial Innovation Award for his role in the Architectural Institute of BC's Architects in Schools Program. He was inducted as a Fellow of the Royal Architectural Institute of Canada in 2010.

FOREWORD

MICHAEL GREEN, MAIBC MRAIC AIA AAA

Michael Green is a founding principal at Vancouver's McFarlane Green Biggar Architecture + Design (mgb). Recognized for his award winning buildings, public art, interiors, landscapes and urban environments, Michael has designed a wide range of projects from international airports, schools and skyscrapers to modest but unique retail spaces and homes. Michael's work focuses on wood innovations including ongoing research and development for tall wood buildings. Together with friends at Equilibrium Consulting, Michael is developing his FFTT structural system that uses today's readily available engineered wood panels to achieve buildings of 30 stories. His work extends around the globe including a current project for the Aga Khan Trust for Culture designing a sustainable community in the mountains of Central Asia.

Michael is dedicated to bringing attention to several of the overwhelming challenges in architecture today. The first is climate change and how the built environment is an enormous contributor to the factors damaging the very environment designers and architects are seeking to improve. The second is the profound reality that over the next 20 years, 3 billion people, or 40% of the world, will need a new affordable home. In short, solving the world's massive shelter shortage with today's building approaches will ironically trigger further environmental turmoil. Michael believes in championing the shift to new ways of building that will compliment the intersection of man's greatest building challenges.