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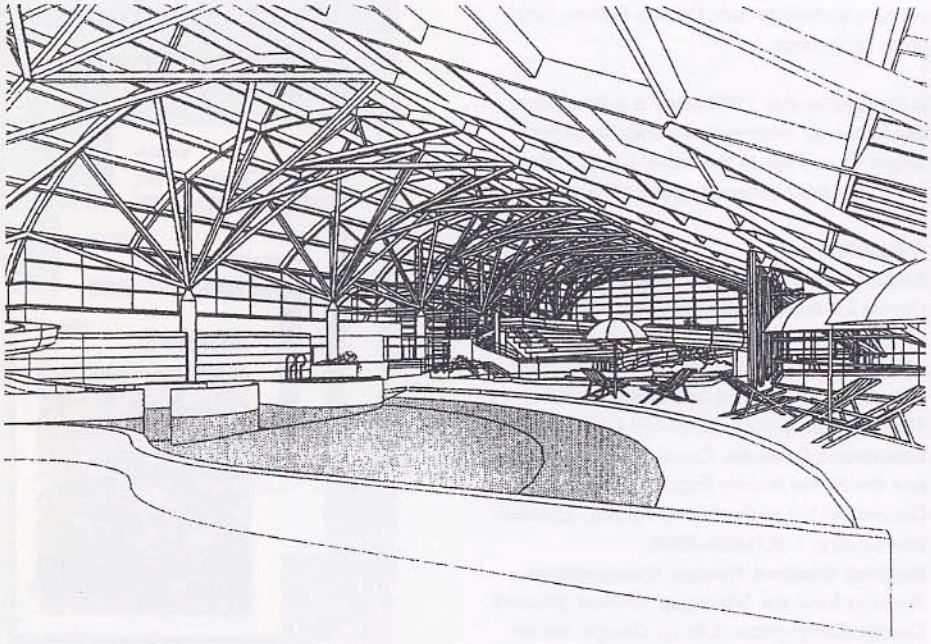
Essay

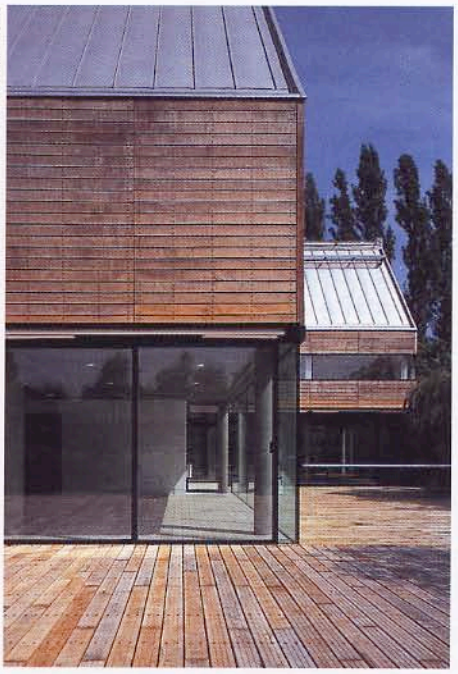
Modernizing Timber Design

by Jim Taggart

Innovations in timber design that have established themselves in Europe are only starting to emerge in Canadian architecture.



CARDUNER ASSOCIÉS/FRANCOIS COSTE



RICHARD BRYANT/ARCAID

Above left: a perspective drawing of the composite glulam and concrete structure of the Raoul Fonquerne Aquatic Centre in Sète, France. Above: the green oak cladding at David Chipperfield Architects' River and Rowing Museum, Henley-on-Thames.

Unique among building materials, wood has the capacity to humanize the structures and spaces we inhabit, and to articulate, through the art and craft of building, the intimate connection between culture and nature. This is nowhere more evident than in the traditional buildings of Japan, where the unique characteristics of timber contributed to the evolution of an architecture at once elemental and elegant that both reflected and shaped Japanese culture for more than 1,000 years. These traditional buildings continue to exert a powerful influence on architects around the globe.

On this continent, the native peoples of the Pacific Northwest developed a rich tradition in the applied arts, fashioning artefacts from baskets to buildings using the products of the cedar tree. Monumental post and beam longhouses, incorporating towering totem poles, were potent symbols of status, kinship and the veneration of ancestors.

Timber structures also occupy an important place in the psyche of the European cultures that settled North America from the 1600s on. 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 defined the character of architecture in this country until the early twentieth century.

When the International Style caught hold in the 1950s, it brought with it new materials such as aluminum, and a new sleek industrial aesthetic. With the exception of glue-laminated beams, timber technology failed to advance with the times, and, for the most part, wood was relegated to use in small, low-tech buildings. Even the avant-garde houses of Ron Thom and other exponents of the West Coast Style were remarkable for their approach to space rather than for innovative technology.

Sluggishness in the timber industry has been encouraged by the abundance and affordability of this primary resource, and by the large and unsophisticated domestic market dominated by the low-tech homebuilder. As a consequence, in Canada timber has never taken its rightful place in the palette of modern materials, and while it is used with consummate skill in traditional ways, its potential as a structural material has never been fully realized.

Elsewhere, particularly in Europe, architects approach the use of timber with a distinctly different sensibility. There, the aesthetic integration of timber with industrial materials such as steel and aluminum is made possible by the widespread use of dimensionally stable kiln dried lumber, and by ready access to high precision manufacturing techniques—most significantly to Computer Numerically Controlled (CNC) cutting machines.

These machines, first developed for the furniture industry, are capable of shaping, drilling and routing timber components to tolerances of less than one millimetre. This compares with the 3mm to 12mm tolerances that are the accepted norms in North America, where components are still fashioned by hand or with bench-mounted tools. The contrast is striking. Currently, there are only six CNC machines in use in North America, while in Germany alone, there are more than 300.

CNC machines are driven by CAD files created with design software such as CADwork. These programs are capable of modelling complex three-dimensional structures and of creating shop drawings for individual components, allowing for the appropriate manufacturing and fabrication tolerances. Smaller tolerances permit the design of more efficient jointing systems, leading to greater flexibility in design and economy in the use of material. Patented connection systems designed by specialist timber engineers are becoming in-

creasingly common in Europe. There, timber frame structures often incorporate steel members—the timber used for elements required to resist compression and bending, and the steel for those resisting tension forces. This gives a lightness of appearance that is in striking contrast to Canadian practice, where the all-timber structure still predominates.

One recent project that demonstrates the elegance and sophistication of European timber engineering is the Raoul Fonquerne Aquatic Centre in Sète, on the Mediterranean coast of France. Designed by Carduner Associés Architectes of Paris and Francois Coste of Montpellier, it was engineered by Michael Flach. The asymmetric, wave-like form of the 3,000 square metre roof is supported on tree-like structures, each made up of nine glulam elements branching from the top of a cylindrical concrete column. The branches provide the support for a series of faceted glulam ribs spaced at 10 metre intervals, which in turn define the undulating form. The junctions between branches and ribs are complex in their geometry, yet the surfaces are accurately cut and mated. The connections are made with compact tight-fit bolts that develop twice the strength of conventional loose-fit bolted joints, and greatly reduce member sizes. The concealed plates maintain the overall visual integrity of the timber structure. Without CAD/CAM and CNC technology, this structure would have been virtually impossible to build.

It is not only in the field of structural engineering that timber is seen as an advanced material in Europe. As cladding, it is often detailed in a non-traditional way to fit within an overall contemporary aesthetic. One example is David Chipperfield Architects' River and Rowing Museum at Henley-on-Thames, England. Here, green oak was chosen for its durability and economy as well as its reference to the fabrication of rowing shells. Weathering characteristics are like those of cedar; a silver layer forms on the surface that inhibits the loss of natural tannin. The cladding is detailed as a rain screen, with open joints for ventilation. The finely machined boards are fastened with stainless steel screws and washers onto a Colombian pine sub-frame. Slotted holes are precisely drilled to permit movement perpendicular to the grain of the timber. The sub-frame is in turn secured to a softwood stud wall stabilized by steel portals, and finished internally with drywall.

A rare American example of timber integrated into a contemporary palette of materials can be seen in the National School of Theatre in Mexico City, by Taller de Enrique Norten (TEN) Arquitectos. The building houses theatres, a library and classrooms; the functions are articulated as separate volumes beneath a soaring elliptical vault. The tubular steel rib structure was engineered by Ove Arup and Partners and manufactured with the assistance of Texan oil rig technology. The building, with its sophisticated structural expression, is more characteristic of Europe than the Americas. Yet within this European vocabulary, architect Enrique Norten has unusually, and successfully, incorporated the most American of materials, California Redwood. The wood takes the form of a sheer slatted screen that shades the top four storeys of the precipitous south facade.

Several recent projects demonstrate how Canadian architects and engineers are striving for greater sophistication in the use of timber. Brad Cameron's Fishtrap Creek Park Structures in Abbotsford, B.C. borrow from European building codes to achieve the desired lightness of expression. Cameron was concerned that the structures (entry pier, railway deck, reading platform, and picnic shelter) should fit comfortably into the landscape, and be as light and transparent as possible. Timber post and beam construction was chosen to evoke the area's agricultural past, and timber piles were used both to eliminate a second trade and to avoid the possibility of leaching from concrete foundations into a fish-bearing stream.

This was Cameron's first project using heavy timber, and from the outset he applied to it the same aesthetic rigour as he uses in his work as a furniture designer. Seeing these structures as inhabited furniture, he sought to achieve the same qualities of functional elegance, lightness and tectonic expression. The precision detailing of the structural connections celebrates the act of making. Structural engineers Josef Novacek and Robert Malczyk took up the challenge of resolving the lateral forces without the use of shear walls or cross-bracing, a task made more difficult by the piled foundations, which prevented the use of moment connections at column bases.

European codes provided alternatives to the conservative joint designs dictated by the

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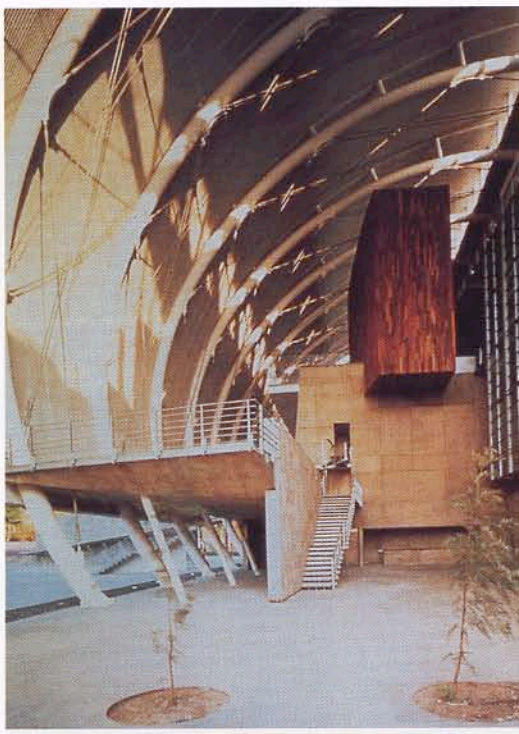

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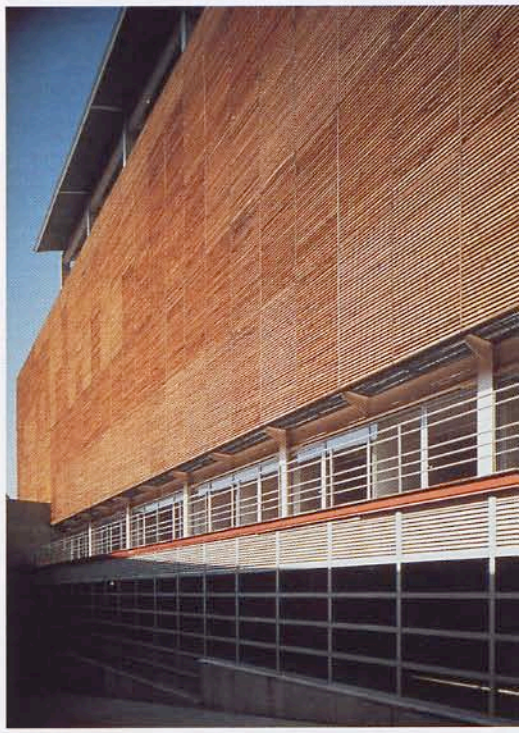


Top: a tubular steel rib structure carries the soaring elliptical vault that roofs Mexico City's National School of Theatre. Above: a slatted screen of California Redwood shades the school's top four storeys.

BRAD CAMERON

BRAD CAMERON

Canadian Timber Design Code. Instead of using traditional loose-fit bolt connections, they used tight-fit bolts. In this technique, bolts are driven into holes which are 1mm narrower than the bolt shaft. This increases the contact surface between bolt and wood, improving both stress distribution and load transfer between members. This technique requires the use of kiln-dried lumber, as any shrinkage would reduce the effective contact area. Stress distribution was also improved by the use of a non-rectilinear bolt pattern. Neither technique is currently recognized in the Canadian code, and independent testing was required to obtain local approval. Connections were standardized across all four structures to maximize economy and efficiency.

The engineers also used notching to increase the efficiency of the structures. Because timber is four times stronger along the grain than across it, notching where members intersect (to create equal angles to the grain at the mated surfaces) can reduce loads, and hence member sizes. This technique, once common everywhere, has almost vanished from North America.

The overall result of these innovations has been the creation of structures which are light and agile in appearance, and which feature fewer perimeter columns and more dramatic cantilevers than would have been possible through strict adherence to local codes.

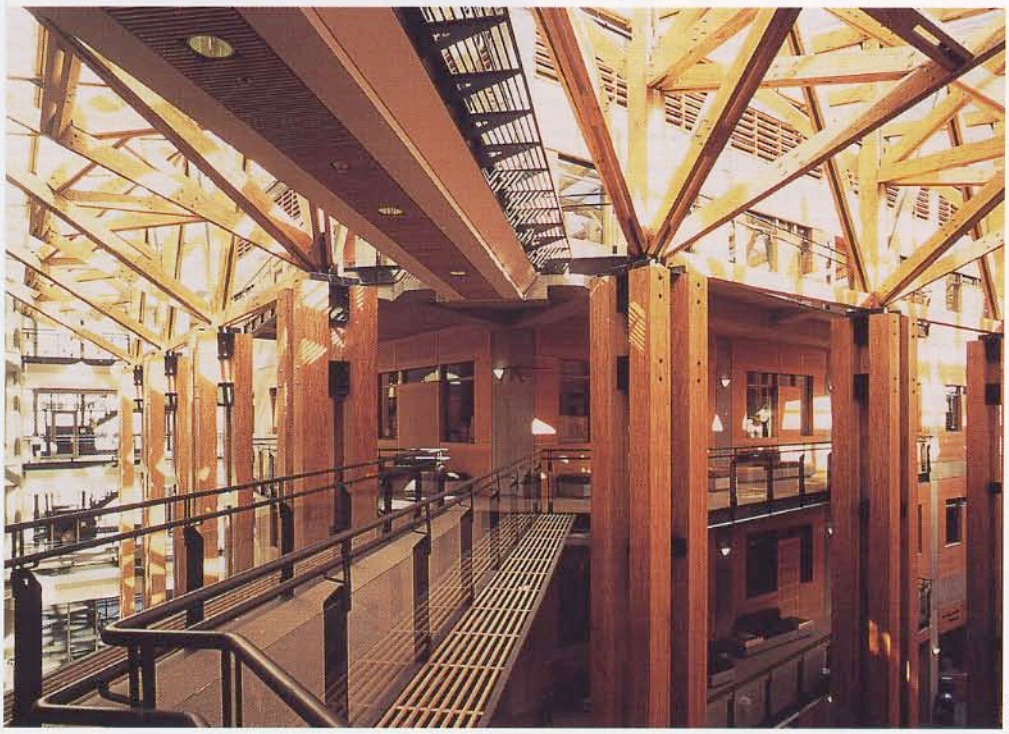
The Forest Sciences Centre at the University of British Columbia, designed by Dalla-Lanna Griffen Dowling Knapp (DGBK) Architects of Vancouver, was seen by both the client and the forest industry as an opportunity to showcase local timber products and engineering expertise. To accommodate a large program on a restricted site, the phase one building needed to be four storeys in height. Under normal circumstances, this would have required the building to be of entirely non-combustible construction. However, with a combination of careful program organization and the maintaining of required fire and life safety standards through code equivalencies, the architects were able to incorporate an unprecedented amount of timber.

The program is divided into three functional components within a single four storey volume. The laboratory component, square in plan, and the L-shaped office component are separated by an atrium that houses vertical circulation and shared facilities, such as lecture theatres and food services, at ground level.

From a building code perspective, the atrium is considered equivalent to an uncovered open space. This equivalency has been achieved through a series of mechanical system enhancements—such as sprinkler curtains and smoke venting—designed by code consultants Locke, McKinnon, Doningo Gibson.

The code equivalency process opened the door to the use of combustible construction in the office component, where spans, loading, occupancy and area permitted three storeys of wood frame to be built on top of a concrete podium. It also allowed for the use of heavy timber construction to support the roof of the atrium. The high hazard use of the laboratory block required it to be of non-combustible construction. The concrete frame chosen for this area also deals with loading and vibration.

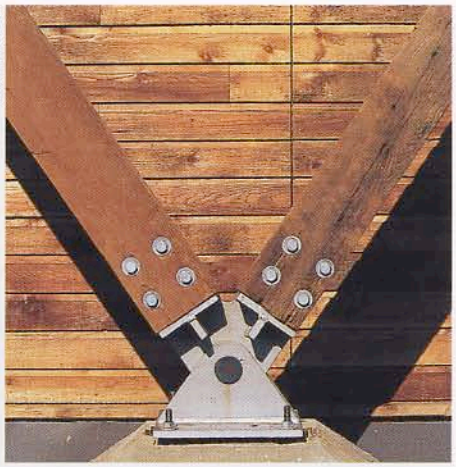
While the stud frame structure of the office block is concealed behind gypsum wallboard, the atrium space has become precisely what the sponsors of the building had hoped—an



DGBK

Top left: the picnic shelter at Fishtrap Creek, Abbotsford, B.C. Above left: detail of the picnic structure's timber construction. Left: the L-shaped atrium at the Forest Sciences Centre at the University of British Columbia.

MARTIN TESSLER



MARTIN TESSLER

Above left: Vancouver's Asphalt Testing Plant is almost entirely constructed of recycled material, including the expressive timber truss. Above: detail of the heavy timber V frames that support the truss.

exhibition of innovative wood construction.

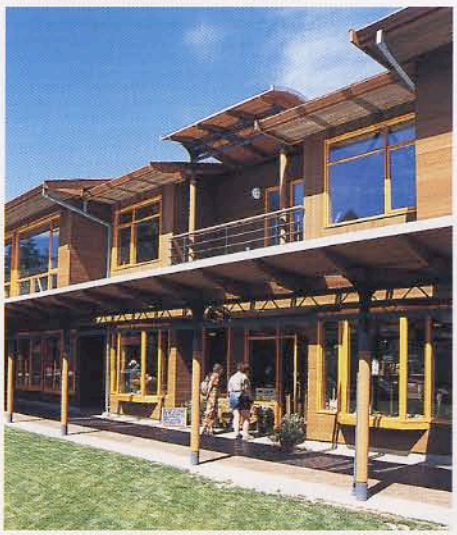
The atrium space is dominated by a central row of Parallam tree columns. Each comprises a 13 metre high trunk, crowned with a spreading system of Parallam branches which lift the glass roof a further five metres above the atrium floor. The trunks are made up of four Parallam members each 400 x 400mm, connected together by steel plates at each floor level. The branches are made from smaller Parallam members, riveted in pairs to steel connecting plates.

Attaching a connector plate to each end of every member was an innovation devised by the subcontractor, Timber Systems of Markham, Ontario. It reduced the size of the complex steel connection nodes where in some cases as many as 22 members come together. This in turn made it easier to achieve the construction tolerances necessary for the assembly of large components at high level. Together with the glulam rivets, used with Parallam for the first time on this project, the plate system simplified the connections and achieved more elegant results.

The recycling of timber from obsolete industrial buildings is a new and fast-growing business in Western Canada. Much of the salvaged material is re-milled and used for panelling and millwork in high end residential projects. Where structural members are re-used, the resulting buildings often have an *ad hoc* quality. The Asphalt Testing Plant for the City of Vancouver presented Busby + Associates with an opportunity to explore how aesthetic imperatives could be met in a building that aimed to incorporate 95% recycled material. The project illustrates the flexible approach to design and contract administration that is required when dealing with reclaimed materials. The City had budgeted for a pre-engineered building to accommodate the required 3,500 square feet of offices and testing facilities. However, the architects proposed that existing warehouses on the site, slated for demolition, might provide material for a new building of higher quality at a competitive price.

A hypothetical model was created in response to the program requirements to establish a "shopping list" of materials and quantities. This confirmed that the heavy timber trusses, glulam purlins and tongue and groove decking would provide most of the structural material necessary for the project. The structural timber was bought from the demolition contractor for $2,000. Additional materials including doors, windows and plywood sheathing were sourced through salvage companies at prices between 10% and 50% of the cost of new material.

A structural scheme was devised for a rectangular two storey building incorporating the reclaimed material. It is essentially a post and beam system, using built-up timber, heavy timber and glulam components. The suspended floor utilizes salvaged glulam purlins laid side by side on the flat. The roof is supported by similar purlins used in their conventional orientation. The main architectural expression



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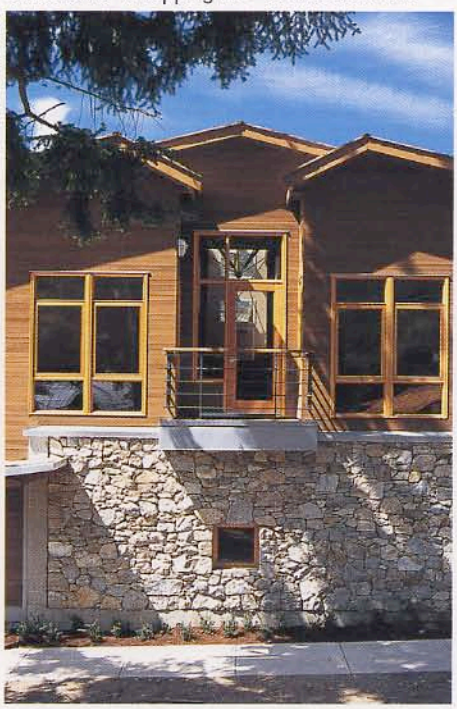

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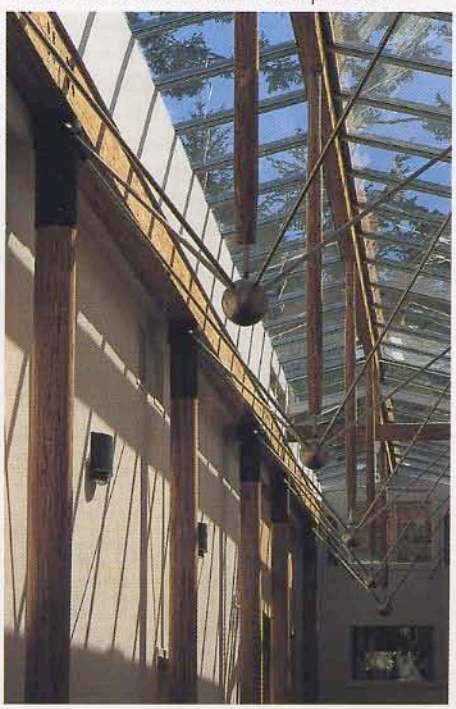

DE HOOG & D'AMBROSIO

Above: storefronts at Mattick's Farm, Saanich, B.C. Right: end elevation of office component, Mattick's Farm. Far right: the corridor skylight at Mattick's Farm is supported by an elegant composite structure of Parallam and stainless steel king post trusses.

CHRIS CHIEI

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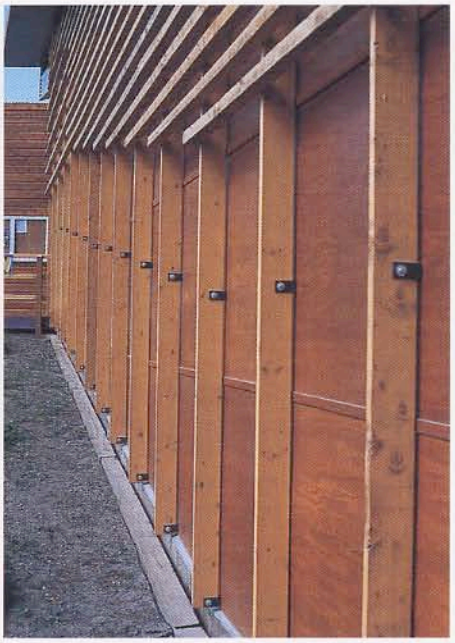

CHRIS CHIEI

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Above left: the Tr'ondek Hwech'in Cultural Centre in Dawson City, Yukon. Above: a detail of the wood lattice screens that refer to traditional fish drying racks. Far left: the random, rough sawn plank cladding on the circular exhibition space recalls Tr'ondek Hwech'in brush huts used for winter shelter. Left: connection details for the rough sawn cladding.

comes from the re-use of two 90-foot long heavy timber trusses, exposed on the long sides of the building, which carry the perimeter roof loads. These trusses are supported by additional heavy timber V frames, fabricated from other salvaged timber. Breaking the span in this way reduced the design loads and enabled the original connection details to meet current codes. In the absence of grading marks or definitive grading rules for reclaimed lumber, structural engineers Fast and Epp Partners had little choice but to take a conservative approach. The resulting robustness gives the diminutive building a substantial presence in its industrial setting.

Tender documents included a schedule for comparing the prices of new and recycled materials, as well as cost allowances for special items. For some items, it was impossible to obtain guarantees of availability from suppliers for the duration of the tender period, so bids were based largely on new material prices. However, it was clear from the submissions that the budget could be met if recycled substitutes could be found once the contract was let. The successful contractor set up a mill shop on site to re-size and re-finish all the reclaimed timber, thereby avoiding costly handling and off-site shop charges. The project proceeded, meeting budget and recycled material targets, but with schedule delays due to difficulties inherent in the acquisition of recycled materials of the appropriate specification in the required quantities.

Structural engineers for the Asphalt Testing Plant, Fast and Epp Partners, have adopted a more European approach in the design of several timber structures, such as Kispiox School (Larry McFarland Architects) and the Vancouver Aquarium extension (Bing Thom Architects). However, their use of composite wood and metal trusses is not limited to large buildings or long spans. On Vancouver Island, the firm has worked with de Hoog, D'Ambrosio Architects of Victoria on small-scale projects, such as the Matticks Market redevelopment in rural Saanich.

Here, the architects have refurbished and added to a historic farmers' market, inserting a tightly detailed wood frame building that incorporates Parallam as a feature material. The new two storey building completes an incipient square with specialty retail shops facing the new courtyard on the ground floor, and with upper level offices accessed from the rear. In an environment where one might expect to see log cabin vernacular, the building is refreshingly lean in the detailing of its wood cladding and interior plywood panelling.

Of greatest structural interest, however, is the continuous skylight that illuminates the upper floor office corridor. The architects wanted to minimize the impact of the skylight structure and maximize the feeling of openness and transparency. Turned Parallam posts at 10 foot centres support central Parallam king posts by means of a specially designed system of stainless steel rods, radiating from a spherical stainless steel node. The rods resist the tension forces, leaving the vertical Parallam king posts to deal with compression. The result is a structure that lends an air of understated sophistication to a modest and inexpensive building.

Canadian architects have established an international reputation for cultural sensitivity in design and for sophisticated "place-making" within the vernacular tradition of timber building. The most celebrated examples of the past decade are projects designed for First Nations clients in British Columbia, the majority of which derive their tectonic inspiration from the post and beam structures traditional among the natives of the Pacific Northwest. More recently, architects from other parts of the country have successfully addressed similar cultural and programmatic concerns without reference to such a strong built tradition.

In Dawson City, Yukon Territory, Maurer Kobayashi Architects of Whitehorse have recently completed a new cultural centre for a First Nations client. The project provides a permanent home and new cultural focus for the formerly nomadic Tr'ondek Hwech'in people. In this case, there were no substantial architectural precedents to draw upon.

Nonetheless, Maurer Koyabashi have created a formal vocabulary that convincingly incorporates potent cultural symbols. The forms, which are achieved through the creative use of simple wood stud construction, are informally arranged along the bank of the Yukon River. The composition and the interplay of structure and skin successfully capture the temporal yet timeless quality of a traditional Tr'ondek Hwech'in encampment. A sophisticated plan generates a range of spaces in which light and materials are sensitively handled. In this way, the building reflects the seasonal duality of life in the North. The circular exhibition space, dark and introverted as a Yukon winter, recalls in its vertical sheathing of random, rough sawn planks the brush huts that protected the Tr'ondek Hwech'in from the seasonal extremes of cold. In contrast, the L-shaped southern section of the building, containing a gathering space, theatre and administration area, is oriented to the south and open to the summer sun. On terraces overlooking the river, light filters through a filigree of lattice screens, abstract references to the fish traps and drying racks that were central elements of traditional summer life.

The Tr'ondek Hwech'in were displaced from their ancestral lands by the stampeders who invaded the Yukon in the 1890s in search of gold. Ironically, the new cultural centre lies within what is now the Dawson City Historic Park and is the only major structure to be allowed a variance from the gold rush era design guidelines. The building, lifted above the permafrost on steel piles, stands level with the top of the Yukon River dyke. Built to control flood waters, the dyke has effectively cut off the rest of the city from the river.

The placement of the building acknowledges the historic importance of the river as a transportation route and source of food for the Tr'ondek Hwech'in. The new cultural centre stands as a solitary symbol of reconnection between people and land, and of reconciliation between natives and non-natives. Most importantly, in a society striving to embrace social and cultural pluralism, it challenges the legitimacy of design controls that aim to preserve the heritage of one culture at the expense of another.

At the opposite end of the country, in a forest clearing on the banks of the Saint-Maurice River 450 km northwest of Quebec City, Côté, Chabot, Morel architectes of Quebec City recently completed the Wemotaci Secondary School for the Wemotaci Band Council. The building contains all the functional spaces associated with a contemporary secondary school, as well as an industrial arts training facility with wood, metal and mechanical workshop spaces.

The two storey building is modern in conception, its primary functions articulated within a simple rectangular volume. On the south side, the sawtooth facade of the classroom block recalls the rows of tents that used to line the riverbank, while on the opposite side the curved form of the main entrance generates an arc through the building plan, mediating one's discovery of the river and reinforcing the importance of the circle in native spirituality. At roof level, a linear skylight runs the length of the building, allowing daylight to penetrate to the central circulation spine below.

What is inhibiting Canadian architects and engineers appears to be lack of access to leading edge technology—but it may also be lack of interest.

Wood was chosen as the primary material both for structure and for interior and exterior finishes, because of its ability to simultaneously honour the craft traditions of the Atikamekw people and to express their contemporary aspirations, as represented by the industrial arts. The exterior skin of the building reflects this duality. While the surfaces facing the forest are clad mostly in traditional wood shingles, the south facade, which is open to the river, is covered in a composite system of Pyroc panels.

These panels, made from cement reinforced with wood fibre, are designed as a rain screen and mounted away from the supporting wall on a system of galvanized steel angles and clips not unlike those used for the installation of veneer stone. The panels, 12mm thick, measure approximately 1500mm by 600mm, and are arranged, like traditional shingles, overlapped with staggered vertical joints. Beams project from the wall at roof and floor level, bearing on slender exposed steel columns. The effect is both unusual and striking—a modern abstraction of the Atikamekw's traditional skin and pole shelters.

The marriage of cultural tradition and contemporary technology can be a successful and stimulating one. What is inhibiting Canadian architects and engineers appears to be lack of access to leading edge technology—but it may also be lack of interest. More than 250 papers were presented by international leaders in the field at last year's Fifth World Conference on Timber Engineering held in Montreux, Switzerland. Among the audience of 500, drawn from across the world, only two Canadians were present. Next year, however, local consultants will be offered a chance for redemption, as the conference moves to Whistler, B.C. A fitting occasion, perhaps, for timber to reassert its historic, defining role in Canadian architecture. ◉

Jim Taggart is an Associate of the Architectural Institute of B.C. *The author would like to thank Robert Malczyk, P.Eng., of Equilibrium Consulting Inc. Vancouver, for technical advice, and Mariette Smith for assistance with research.*

Below left: the south facing sawtooth facade of the Wemotaci Secondary School's classroom block. Below: a view of the school's composite Pyroc cladding system. The school's expression is meant to evoke traditional Atikamakw skin and pole shelters.

CÔTÉ, CHABOT, MOREL

CÔTÉ, CHABOT, MOREL