GRANDVIEW HEIGHTS AQUATIC CENTRE

Surrey, British Columbia

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Fast + Epp

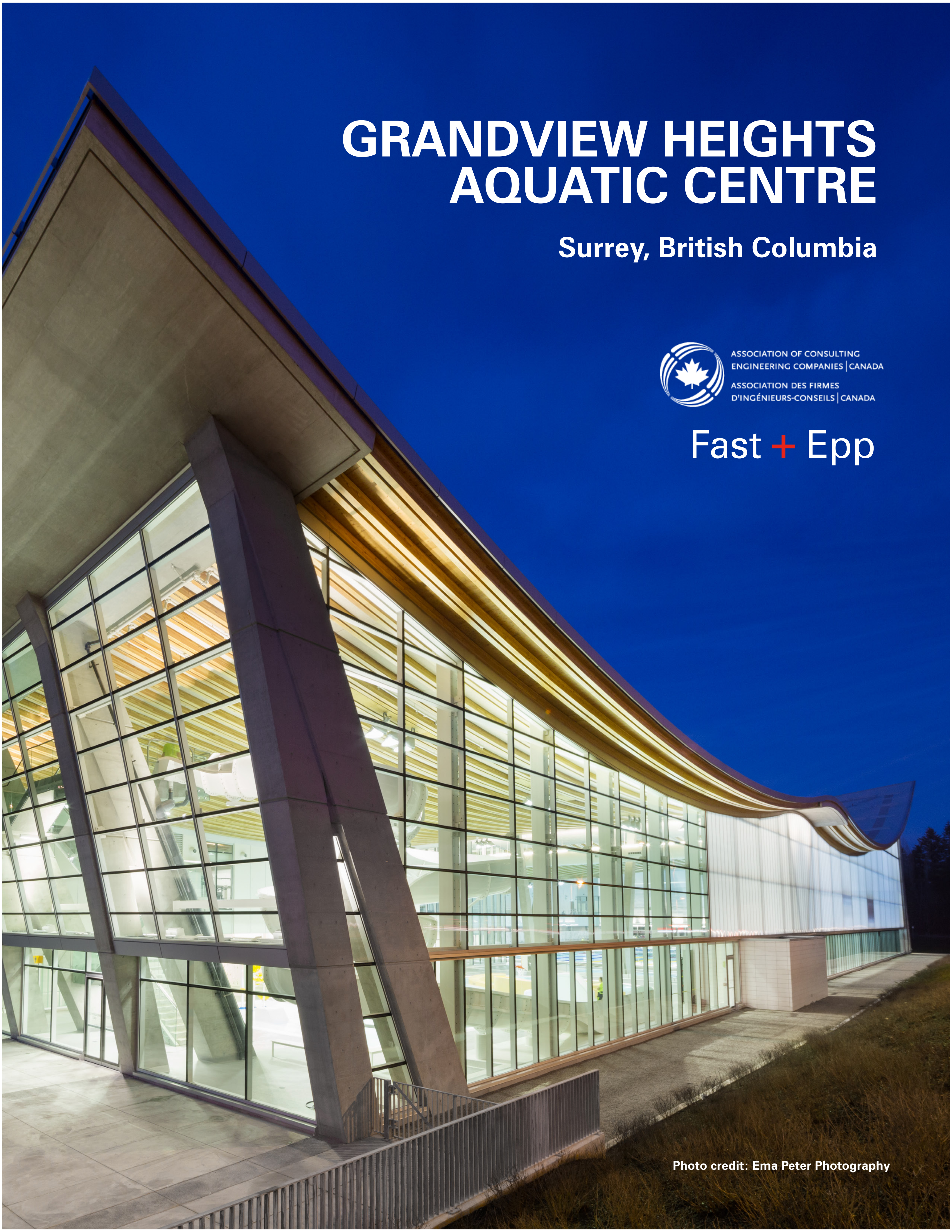


Photo credit: Ema Peter Photography

Constructed to meet the needs of a diverse population, the Grandview Heights Aquatic Centre features an undulating roof structure with hanging timber 'cables', suspended between large concrete buttresses. While most hanging systems have historically used steel cables, Fast + Epp took a novel approach, pioneering one of its most ambitious and daring designs in the firm's 30-year history.

Engineers chose wood as a cost-effective, structurally-efficient and aesthetically-pleasing alternative, cleverly balancing form and function. The resulting structure fulfills the Client's desire for an iconic building that will be a catalyst for civic growth, and is believed to be the world's most slender long span timber catenary roof.

"With the record number of users at Grandview Heights Aquatic Centre, the facility is already a winner with our residents and families ... I am proud to say that our newest aquatic facility has achieved our goal of both form and function."

~ Mayor Linda Hepner, City of Surrey

Exterior view of the Grandview Heights Aquatic Centre. Photo by Alison Faulkner, Fast + Epp.

INNOVATION

It's not every day a design team is asked to build "world-class architecture" outside a city's downtown core. Yet this was the City of Surrey's mandate for its $55-million Grandview Heights Aquatic Centre (GHAC), a recreational hub it hoped would act as a pivotal first piece in a larger recreational master plan.

For an aquatic centre of such size, the design team recognized the roof structure as a crucial point of visual interest. The architect challenged the team to "think outside the box" and explore spanning the primary structure across the long span rather than the short span – despite knowing this break with convention had the potential to substantially increase costs.

Shying away from typical ribbed ceilings of steel that would eventually corrode from the chemicals and harsh humidity of an aquatic environment, Fast + Epp chose to use wood for its hanging suspension roof. The Architect (at first somewhat surprised by the audacity of a timber 'catenary' roof) jumped on board with the revolutionary idea, working hard with the entire team to overcome obstacles.

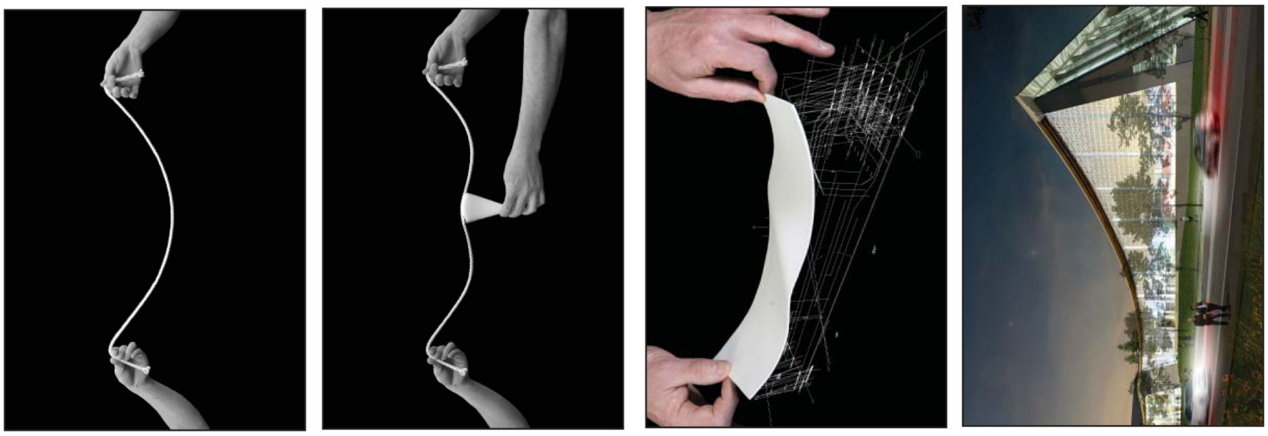
The engineers investigated the feasibility of an almost-exclusively wood roof solution and developed what is likely the world's most slender long span timber catenary roof, free spanning 55 metres (180 feet). The design made use of small 5-inch x 10-inch long span glue-laminated wood beams, acting as cables under a double layer of plywood sheets as the main structural system. They hang between narrow and twin concrete slabs that transfer the tension loads to post-tensioned concrete butresses.

The roof not only achieves the significant clear spans required for the pools, but uses only a 300mm deep structure (compared with a typical 3,000mm steel truss structure). By minimizing the building volume, engineers were able to ensure long-term energy cost savings for facility operations.

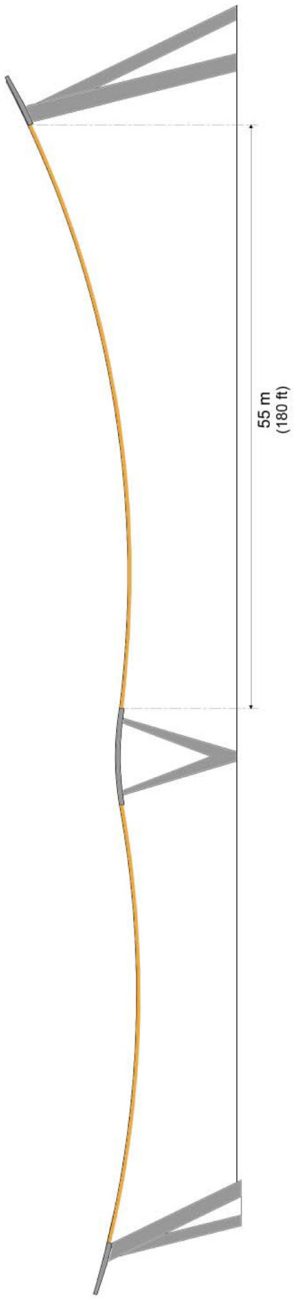
The deep pool excavations were efficiently utilized to bury concrete foundations deep underground and resist the overturning forces.

A key to the success of the structural concept was the refinement of the roof geometry. The clear height requirements varied drastically from extreme high at dive towers and water slide to low over swim areas. Thus the roof shape was warped, in order to minimize building volume and create slope for rainwater management. Initially this resulted in no less than 14 radii of glulam cable curvatures and prohibitive costs for each custom glulam jig manufacture – enough to sink the structural concept. The geometry was then refined so that only one radius of curvature and jig was used for every glulam cable. By simply lengthening and raising the ends of each adjacent glulam slightly, the warped roof geometry was achieved by much more economical means. The spaghetti-like glulams were erected in just 12 days.

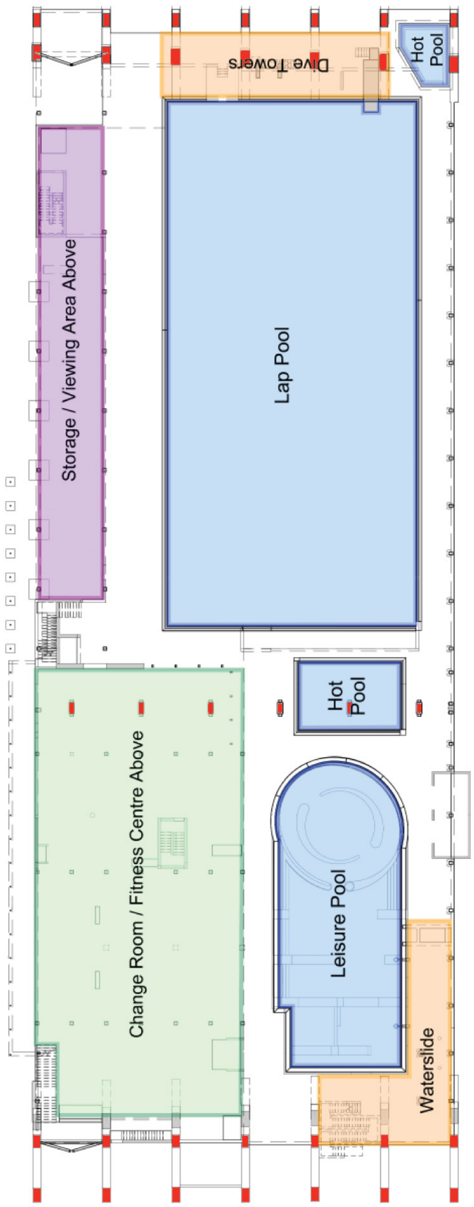
The final roof design represents engineering efficiency and striking architecture – lending credence to the saying, "good structure is good architecture".



Early concept development.
Renderings courtesy of HCMA Architecture + Design.



Building Section



Building Plan

COMPLEXITY

Championing technical excellence, GHAC's distinctive roof undulations were driven by functional needs, rather than purely aesthetic goals – a perfect union of form and function. Once a decision was made to orient the leisure pool and lap pool end to end on site (normally side by side), the challenge was to create a roof structure that would span 40m x 105m. Rather than employ conventional steel roof trusses with sizes in the order of 3,000mm high, 250mm high glue-laminated timber 'cables' were introduced, reducing the effective structural depth by 90%.

A novel structural approach typically presents a range of technical challenges. The following are key technical difficulties encountered and solutions provided >>

By using glulam timber cables, engineers reduced the effective structural depth by 90%. Photo by Alison Faulkner, Fast + Epp.

>> Unbalanced snow loading

Following analysis of unbalanced snow loading, vertical deflections were in the order of 1,000mm (which nearly caused the architect to faint!). By breaking the timber cables at the central column support or roof slab structure and bracing this central structure with a shear wall at one end and steel brace at the other end, engineers effectively reduced roof sag to a more acceptable 250mm.

>> Wind uplift forces

The relatively-light timber cable structure had insufficient self-weight to prevent wind forces from lifting the roof. Adding concrete topping weight to the roof would be structurally counterproductive and costly, while adding hold-down cables inside the building would be unsightly. Thus, wood cables were sized to have sufficient strength to resist snow loads and self-weight in tension, and just enough strength to resist wind uplift as skinny compression arches – the perfect balance.

>> Dynamic Excitation

A further concern also related to wind forces; given its extremely slender profile, could the roof be subjected to unacceptable dynamic excitation (effectively becoming a Galloping Gertie of Tacoma Narrows fame)? Engineers felt the proposed warped roof geometry, as well as the damping effect of glued roof insulation would sufficiently mitigate the potential for resonance. To confirm this, Fast + Epp recommended accelerometers be placed on the roof after erection, and that together with a metronome and a 'jumping party', they could determine if a problem existed. The results revealed no further roof stabilization was required.

Individual glulam beams were crane-lifted into place in just 12 days. Photos by Alison Faulkner, Fast + Epp.

"[Fast + Epp's] role as the Structural Engineer was crucial to the project. We are extremely happy with the creativity of their staff in generating a very exciting structural concept for the roof. The roof design showcases local wood, which was a very important goal for the owner."

~ Scott Groves, Civic Facilities Manager, City of Surrey

SOCIAL & ECONOMIC BENEFITS

Compared to a more typical ‘box with a flat roof’ to accommodate tall diving towers, GHAC’s roof shape saves money in the long run, by reducing the cubic volume of air to be heated and de-humidified, and decreasing operational costs for the Client. The design represents outstanding value for money, and met the City’s budgetary expectations.

The design maximizes security and accessibility, with clear views from the central lobby into the natatorium. The linear orientation of the roof, parallel to the pool lanes is a benefit to competitive swimmers for orientation in the water.

Initial reaction to the superstructure design of the building suggests that its striking aesthetic expression and ambiance will make it a favourite for years to come, and a key element of the regional master plan to be constructed over the next decade.

ENVIRONMENTAL BENEFITS

The facility is seeking LEED-certification, and meets stringent FINA standards to host regional, provincial, national and international sporting events in its 10-lane, 50m Olympic size competition pool and dive platform. However, the best contribution a structural engineer can make to sustainability is to design efficient structures with minimal material – Fast + Epp’s roof structure delivers on this. By reducing the effective roof structure depth from 3,000mm to 300mm, the building volume was drastically reduced and significant life cycle energy cost savings were achieved.

The façade structure (up to 20-metres high) was constructed with steel tube columns, which serve a double function – they not only resist wind loads but are perforated and connect to the basement air supply ducts, acting as ventilator ducts to prevent condensation at exterior glazing. This eliminated costly and unsightly mechanical ducting.

Moreover, the best scientific research tells us that wood is a much more sustainable material versus concrete and steel; it is a rapidly-renewably resource with low-embodied energy and carbon-sequestering capabilities.

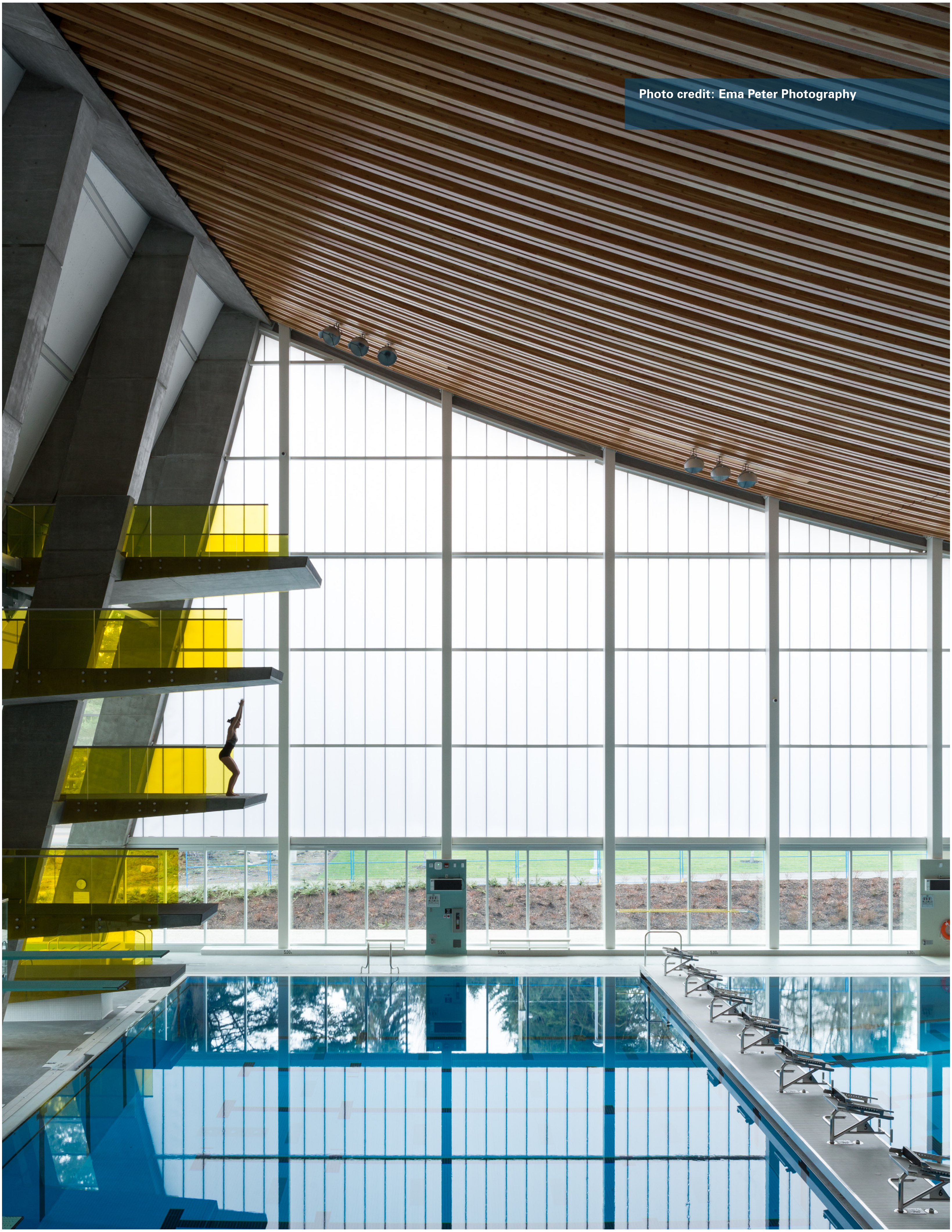
Right: The wood roof structure saves on energy costs, sequesters carbon, and provides the community with an architecturally delightful and warm recreational environment. Photo by Ema Peter Photography.

MEETING THE CLIENT'S NEEDS

The City of Surrey has gained a reputation for expecting functionally-efficient and architecturally-striking buildings when selecting consulting teams for their projects. Having already been involved in a number of landmark projects in Surrey, Fast + Epp was included as structural consultant to support the design team for GHAC.

As Surrey's density rapidly increases, there is a growing need for recreational and community spaces to promote wellness, learning, healthy living and sports excellence. The City's desire for a "destination pool" to entice families, athletes and international competitions drove the design for GHAC. The aquatic centre's recreational and architectural-expressive structural features thrill and delight. The central lobby has clear views into the natatorium promoting openness and security, and with seating for up to 900 spectators, is poised to act as a premier venue for competitive diving and swimming, synchronized swimming and water polo events.

Since its opening to the public in March 2016, GHAC has surpassed anticipated visitor numbers and exceeded the Client's expectations.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