



Clayton  
Community Centre





## A novel two-way wood system creates a tree canopy draping over a mix of community spaces.

Nestled within an existing park, the expression of this project reflects the unifying theme of a tree canopy draping over a mix of community spaces. The roof structure's reciprocating frame is composed of an assembly of "pinwheel" shaped modules of glulam beams. The two-way wood system allows the wood structure to span to discrete column locations without the need for dropped beams, all the while achieving the unique architectural expression desired. A truly innovative approach.

### THE VISION

Clayton Heights is a growing neighbourhood located in the city of Surrey, BC, approximately 40 km south-east of Vancouver. The architect for the project is HCMA Architecture + Design, a Canadian firm well-known for its design excellence in recreational facilities. The aesthetic goal of the facility was to establish a "lattice-like" structure resembling tree canopies native to the area, allowing natural light to filter through to the building's interior spaces, centred around a dramatic spiral staircase, representing the tree's trunk.

Wood is considered a desirable construction material for many reasons, including its sustainability as a material and its beauty as an architecturally expressed element. A challenge with the use of wood is the difficulty to create connections that can transfer bending moments, leading to framing schemes that typically rely on simple span wood members and dropped beam conditions.

For Clayton Community Centre, there was a strong desire by the project team to use wood as a primary building material, but the required spans and architectural intent led us to develop the concept of a two-way wood system. The innovative approach is a system composed of three-member reciprocating wood modules that are repeated and expanded to create a full roof system. The system is both structurally efficient and architecturally expressive, giving rise to a unique synergy between design intent and building structure.

*The proposed wood pinwheel system realizes the architect's vision while achieving a unique true two-way timber structure.*





*The aesthetic goal was to establish a "lattice-like" structure resembling the tree canopies native to the area*



## CONCEPTS OF TWO-WAY CONSTRUCTION

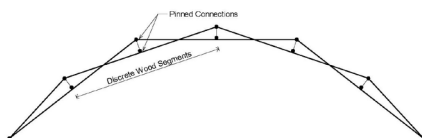
With existing two-way systems in wood construction, for example, CLT, wood members are placed in different layers. However, there are two practical difficulties using CLT to create a two-way system; limitations in fabrication and transportation constrains the size of CLT elements that can be brought to the site. In addition, there is no effective way of making moment connections, joints that allow the transfer of bending moment forces, on site. Given these practical limitations, CLT is best described as a two-way element, rather than a complete two-way system.

The conceptual difficulty of achieving a two-way wood system is clear. Once a dominant span is chosen, the other wood members within the same plane must physically be placed in a discontinuous crossing direction. Without an effective way to make these discontinuous members continuous, the system remains one-way. To achieve two-way continuity then, there cannot be a dominant span. The members in both directions must be discontinuous to begin with: these members must be placed in a way such that they interlock with one another through shear connections only, thus achieving continuity in both directions.

## THE PINWHEEL MODULE CONCEPT

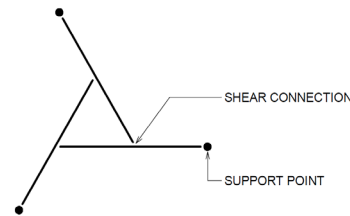
Connecting discrete wood members with shear connections to create continuity is not new. This technology was employed in ancient China, using wood members with limited length to build structures with significant span.

This general idea was modified and built upon to arrive at the two-way interlocking system. The basic module is composed of three wood members placed in three different directions, creating a minimalistic “pinwheel” element. The



**Guanmu Model:** Guanmu Jiegou, an ancient Chinese use of interlocking wood members with limited length to build long span structures.

## Basic Pinwheel Model



triangular form can engage neighbouring identical pinwheel elements, interlocking and combining to form a truly two-way system. The advantages of this two-way system are in many ways similar to concrete flat plate construction.

- Flexibility in column placement, i.e. the supporting columns do not need to be placed on rigid column grid system
- All of the members are in one plane, so there are no dropped beams. This leads to a particularly attractive architectural approach where a clean ceiling can be achieved. At building corners, the floor or roof can cantilever out both ways without dropped beams so that the ceiling can read continuously through.
- The two way systems are inherently more efficient compared with one-way systems in terms of spanning capacity. The continuation over the support would further enhance the structural efficiency.

With the three wood members placed in three different directions, this minimalistic “pinwheel” element has the ability to engage neighbouring identical pinwheel elements, interlocking and combining to form the two-way system as shown:







### AN IDEAL SOLUTION

A conventional approach to a “lattice-like” structure in heavy timber construction would be to frame beams in one way and then add infill pieces between the beams to create a pattern. The infill pieces would be of the same size as the main beams so that the entire wood structure reads in one plane. This would lead to a “fake” two-way system and the oversized infill pieces would not contribute to the capacity of the structural system, resulting in a significant waste of material from a structural point of view.

The proposed pinwheel system is an ideal solution to the design constraints for this project. The system realizes the architectural vision while achieving a true two-way timber structure. The leaf-like heavy timber interlocking pinwheel units resemble a forest canopy, enveloping the spaces of the building under a unified system.

### CHALLENGES IN DESIGN

The form of the two-way system posed a number of technical design challenges. The architectural vision leads to a system where all wood members are of the same width and depth, creating a need for optimization of the structure at an early stage. Using the flat-plate analogy was useful to our engineering team in our approach to this design.

### System Optimization and Reinforced Glulam Members

The entire system was modelled and tested through the design development phase to validate the approach and

determine the optimal sizing for the pinwheel members. To optimize the design, key members were reinforced for moment and (or) shear to minimize the depth, and therefore cost, of the overall system.

The shear reinforcement for the support members was achieved through diagonally installed self-tapping wood screws. Moment reinforcement was achieved through the attachment of a steel plate at the top of the glulam beam, again with diagonally installed self-tapping wood screws. This type of reinforcement for glulam beams is not codified in Canada so a testing program was carried out by the University of British Columbia Timber Engineering and Applied Mechanics Laboratory to validate the design. No visible damage to the wood, screws, or plates was observed, and all specimens returned to a zero displacement condition, indicating a fully elastic behaviour, and therefore, a successful design.



*Glulam with Moment and Shear Reinforcing*

### System Redundancy

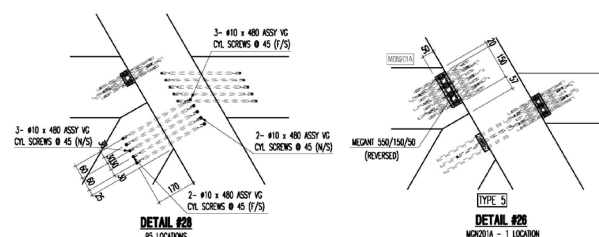
As a two-way system, the pinwheel framing has certain qualities of redundancy similar to other two-way systems, such as concrete flat plate construction. For example, if a rectangular plate is supported by four columns, the failure of one of the columns does not lead to an immediate catastrophic collapse. On the other hand, the pinwheel module depends on the interlocking of the reciprocating members. In a single, three-member module, if one member fails the module will collapse. This quality of the framing

scheme led the design team to investigate the redundancy of the system to preclude the risk of progressive failure. The first approach was to test the redundancy of the system by randomly removing members from the analysis model. The system as a whole proved to be quite robust, with none of the tested removals leading to instability.

As a secondary measure, and in keeping with the flat-plate analogy, a series of “integrity plates” were introduced to improve system redundancy, similar to the integrity steel mandated by most concrete building codes for concrete flat plate systems. The continuous steel plates are strapped to the top of the structure spanning to key lines of support. The approach is similar to the concept of integrity reinforcing in concrete flat plate construction. The integrity plates also act to compartmentalize the system, preventing propagation of progressive collapse.

## Connection Detailing

An essential aspect of the system implementation was to develop workable and aesthetically clean connection details at the nodal points of the pinwheel system. There is an inherent congestion at the node points, where three members must meet at a single location. Working with wood connection engineers at WesternArchRib, a combination of Ricon Megant connectors and self-drilling screw connections were utilized. Both types of connections were able to leave the exposed wood surfaces free from visible steel parts, creating the seamless appearance desired by the architect.



Typical Connection Details

## Non-Structural Aspects of the Roof Design

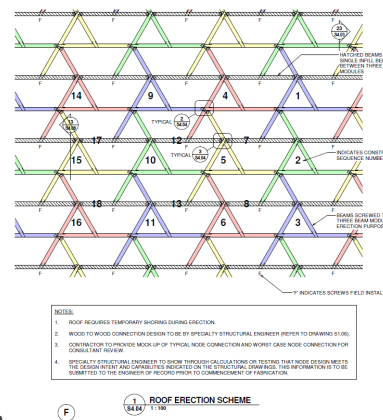
The exposed soffit of the roof structure meant that the typical available routes for mechanical and electrical services were unavailable, posing a significant challenge for the entire design team. The solution was a combination of chases that pop-up above the main roof level for running water and electrical mains. Smaller branch lines were then run through the steel roof decking. This required an enhanced multi-disciplinary effort to coordinate the steel decking, integrity plates, and services all running above the wood roof plane.

## ASPECTS OF CONSTRUCTION

Construction-wise, there were a number of challenges in implementing the pinwheel system on a large scale. The engineering team worked closely with the supplier and erector, Western Archrib and Seagate Structures, to develop feasible and cost-effective construction methods. The reciprocating nature of the system meant that temporary shoring of at least the leading edge of the erected structure was needed and had to remain in place until all of the wood connections were in place. A platform was created adjacent to the building, where three-member pinwheel modules were prefabricated on the ground, labelled and stacked. The modules were then lifted by crane into place using the proposed erection procedure developed (pictured below). The repetitive pinwheel module lends itself to prefabrication prior to erection.



Prefabricated units with installed connectors (above) & Proposed Erection procedure – structural drawings (right)





*The two-way wood system allows flexibility  
in column placement*





# A dazzling social gathering space provides a hub for community engagement

## INSPIRING COMMUNITY GROWTH

Clayton Community Centre is a project conceived as a gathering place and social hub for the fast-growing and culturally diverse community of Clayton Heights in Surrey. Housing a unique mix of spaces such as a branch library, gymnasium and fitness centre, childcare and art spaces under a single roof, the centre uniquely combines a variety of city services into an integrated community centre.

The 78,000 sq. ft., two-storey building features a dazzling double-height social gathering space at the main entry, providing a hub for community engagement. Its location between two secondary schools and the growing neighbourhood led to a design that would meet the needs of local youth, while also supporting the growing population.

By working closely with local residents through engagement and programming sessions, the centre recognized and incorporated additional offerings tailored to suit the specific needs of the area. These spaces include a community kitchen and associated community garden, a tool-sharing centre with a community workshop, a café, and childcare.

The structural scheme provides flexible, open spaces allowing a range of programming and easy adaptation for future needs. The exposed wood structure provides warmth and comfort - inspiring the community members to gather and enjoy one another's company doing the activities they love.

## SETTING STANDARDS IN SUSTAINABLE DESIGN

Environmental and sustainability targets were a high priority for this project. Targeting Passive House certification formed a guide to the centre's design and layout from early on. Achieving a Passive House certification, Clayton Community Centre is on track to be the first community centre to be Passive House certified in North America and Canada's largest Passive House facility to date.

Being the first project of its kind in North America made this project a unique challenge for the design team from the start, requiring consideration of many aspects of design that are not typically considered in recreation and community centres. Through building massing, materials selection, consideration of solar orientation and shading, and close attention to key details, Clayton Community Centre sets a new standard in sustainability for recreation and community centre design in North America.

Close collaboration between the project team was essential in reaching energy efficiency goals. The structure is formed of stacked boxes with an upper-level overhang to help control solar gain within the facility. We worked to develop structural details to accommodate the very specific envelope requirements of a Passive House design. These include insulation around foundation elements, thick insulation on the walls and roof,







and structural details to minimize thermal bridging. Thermal break elements were utilized at rooftop mechanical units and roof anchor connections. Skylights were carefully placed to maximize natural light while minimizing thermal impact.

Sustainability is also highlighted through the choice of material using wood as both structural and architectural elements. The timber contributes to an eco-conscious solution, given that the locally sourced wood emits a low embodied carbon footprint and the pre-fabricated glulam “pinwheels” allowed for simple erection with lessened debris on site.

This dynamic community centre looks to the future, providing a highly energy-efficient facility, with a flexible layout that is able to adapt to the community needs for decades to come.

#### WORKING TOGETHER TO MEET CLIENT GOALS

The City of Surrey engaged a team that could provide a design that would embody the core values of health, wellness, and sustainability, in a building that provides a welcoming and aesthetic atmosphere for the growing cultural community that surrounds. The City set an ambitious goal for the design team to combine four aspects of the City of Surrey's community services—recreation, library, arts and parks - into a seamlessly integrated facility. The expectation was to provide an innovative, engaging space that could simultaneously meet ambitious energy targets.

Our team contributed through the innovative use of wood as a structure, and our collaborative approach to design that was needed to create a Passive House building. The wood structure is a reference point for the building, in a structural scheme for the roof that wraps around the exterior wall structure and embraces the vision for a dynamic, welcoming community centre.

Through the development of this truly innovative structural wood system utilizing the reciprocating “pinwheel module” honeycombed shaped glulam system, our engineering team was able to realize the architectural vision using intricate geometric shapes in a creative way to allow light, nature, functionality and economy to come together, and guide the tree to life.







This project was completed in collaboration with

City of Surrey - Owner  
HCMA Architecture + Design - Architect  
EllisDon - Construction Manager  
Seagate Structures - Fabricator  
Western Archrib - Supplier

Creative Thinking **Practical Results**