

Využití speciálních dřevěných konstrukcí ve stavbách v Kanadě

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Robert Malczyk, P.Eng., Struct.Eng. - *Equilibrium Consulting Inc.*

Robert Malczyk obtained his Master's degree from the UBC with a specialization in timber connections. He then acquired his MBA from SFU. Robert started his professional career with J. Novacek and Associates and in 1998, he co-founded Equilibrium Consulting Inc. His broad field of expertise and successful experience includes renovation work, upgrades and new construction on projects as well as high profile architecturally oriented public projects. Robert is a recognized expert in the field of timber engineering. He is also a regular nationwide lecturer for the Canadian Wood Council *Woodworks!* Program, and a member of the Canadian Timber Code Technical Committee (Engineering Design in Wood: O86.1).

<http://www.eqcanada.com/index.html>

Canadian Wood Council / Wood *WORKS!* BC Wood Design Awards 2009

Category:	Engineer Award
Recipient:	Equilibrium Consulting Inc. of Vancouver
Project:	Art Gallery of Ontario, Toronto, ON



ART GALLERY OF ONTARIO – TRANSFORMATION Engineer – Timber Connections & Erection Engineering

Stringent architectural requirements and a complex geometry require the use of advanced glulam CNC technology and sophisticated and creative connection design.

PROJECT IDENTIFICATION AND CHALLENGES In 2008, the Art Gallery of Ontario re-opened after a significant expansion and renovation by architect Frank Gehry. The new construction makes extensive use of glass curtain walls supported by glued-laminated timber (glulam). At the time of its design, the Art Gallery of Ontario was the largest public project in Canada to use wood not just aesthetically but structurally. A five-storey tower and an extensive 3,600 sq. ft. central skylight feature over Walker's Court use rectilinear glulam mullion grids to support glazing, while the feature Galleria runs 600 feet along Dundas Street and is entirely curvilinear. Concealed connections, complex geometry (where no two pieces are alike), slender cross sections and significant axial and flexural forces acting simultaneously about multiple axes all made for unparalleled technical challenges. Creating this structure was made possible only by use of advanced timber engineering design of connections, CNC machines and the 3D CAD systems to feed them. The challenging fabrication procedure, construction sequence and hidden connection design were all possible thanks to the tremendous advances in engineering and technology in British Columbia in the past 10 years, much of which we are proud to say we have been a part of.

The design process started with 3D solid models from Gehry's office using *Digital Project* software. The design team and fabricators used this model to develop details, look for interferences between trades, produce shop drawings and to start the information flow to CNC machines.

Dundas Façade (*Galleria Italia*)



The 600 foot long glazed façade acts as a link between gallery spaces and as a connection between the Art Gallery of Ontario and the city.

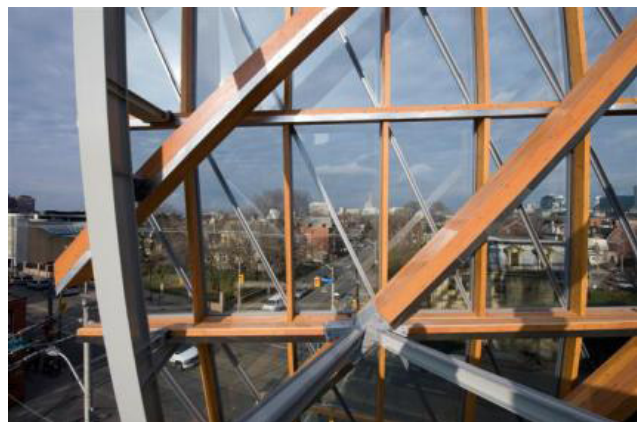


The façade rises 70 feet above Dundas Street. The central 450 feet of façade is an enclosed sculpture gallery that provides access to the main gallery spaces.



Two exterior tear-away sections flank the ends of façade.

The façade structure is a system of structural layers used primarily to resist rain, snow, wind and earthquakes. The innermost layer consists of 47 glulam arches, spanning up to 65 feet, and radiating out from near-vertical at the centre of the façade up to approximately 45° at the extreme ends. These arches are supported at floor level and near the roof level. A series of horizontal glulam beams tie the arches to prevent them from twisting about their axes.



In front of the arch layer lies the rectilinear glulam mullion grid that is linked back to the glulam arches using stainless steel connecting rods with pivoting ball joint connections. The mullion grid curves over and around the arches and is allowed to move within its own plane relative to the glulam arches to accommodate relative movement. The glazing system is mounted to the face of the glulam mullion grid.

Tower, Walker's Court Skylight and Dundas Street Storefront Glulam

Glulam was used significantly in three other major areas of the Art Gallery of Ontario. Similar principles were used in the design of the other areas of the building where concealed glulam connections were used extensively to support glazed curtain walls.

EQUILIBRIUM CONSULTING INC. – MEETING THE CHALLENGE

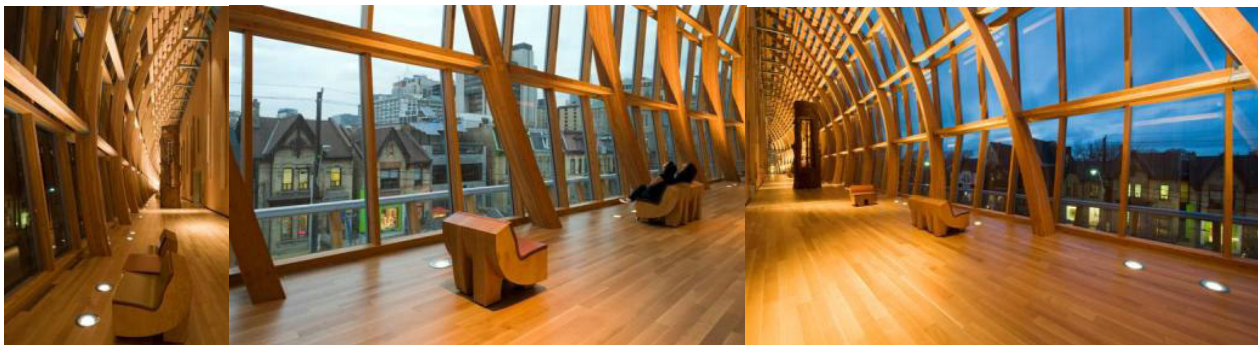
Connections are designed to be concealed and, where expression is necessary, the member profile is carried through the connections. Equilibrium Consulting Inc. developed a new philosophy in connection design using the CNC technology to carve out glulam members to precise angles to receive concealed connectors. Over 5000 hours were required for connection engineering by Equilibrium Consulting Inc. Each unique connection type evolved over numerous iterations to develop connections that resist very high loads, many requiring resistance to forces in all 6 degrees of freedom. Members are not oversized to conceal connections. On the contrary, the very slender members are loaded near capacity while the connections still remain concealed, adding tremendous complexity to the challenge. Most connection locations have 4 intersecting members. Some have as many as 8.

Equilibrium Consulting worked closely with the fabricator to optimize the connection designs to meet aesthetic, technical, and economical goals as well as requirements for construction tolerances. The engineered connection design had to work from a fabrication standpoint and, while remaining concealed, the connections were designed to allow for erection.

CNC machining was used to achieve the curvilinear geometry: individual members are faceted and some are shaped, all using CNC machines. There are over 1000 glulam members and over 2500 connections on the façade, each with its own geometry.

The challenging construction procedure had to be carefully analysed and planned out, piece by piece due, in part, to the confined urban location, while maintaining stability of the highly irregular structure.

SETTING THE STANDARD FOR FUTURE PROJECTS



The Art Gallery of Ontario is a landmark public project that showcases Canadian heritage through the extensive use of wood in glulam structures, wood panel finishes and wood flooring. The Gallery stands on the world stage as an example of what is possible and will inspire future generations of designers.

BC'S WOOD CULTURE

Vancouver's Equilibrium Consulting Inc. developed new design methodology for the design of concealed connections, making full use of CNC technology, here in BC.

This project has shown that the value added to BC wood products through BC engineering and BC technology can be readily exported to markets in North America and around the world. Equilibrium Consulting Inc. continues to push the envelope in heavy timber engineering and connection design in North America. Equilibrium is always innovating, researching and implementing designs that challenge the traditional methods of timber construction and reach new technical and aesthetic heights. There are no boundaries.