Designing Mass Timber Schools in Calgary

Reid Costley, P. Eng.
Buildings Discipline Manager
ISL Engineering and Land Services Ltd.

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The Team

Owner: **Calgary Board of Education**

Design Team:

Architect	Group2 Architecture Interior Design Ltd.
Structural Engineering	ISL Engineering and Land Services
Mechanical Engineering	TYZ Engineering
Electrical Engineering	MP&P Engineering
Civil Engineering	MPE Engineering
Landscape Architect	SMM Landscape Architects

The Set-Up

CBE initiates a Design-Build competition for the design of two K-9 schools.

1. McKenzie Towne School
2. New Brighton (now renamed Dr. Martha Cohen School)

Projects have identical architectural programs. GFA = 8,181 m^2 (4,731 Main + 3,450 Second)

Fall of 2014 the projects bids come in approx. $6M over budget.

Winter of 2014/2015: CBE considers different approaches to reduce capitol cost without reducing program.

CBE approaches Group2 to assemble a team to design a wood school in an effort to reduce capitol cost.

The Challenge

Design the two schools using primarily a wood structural system *(i.e. seek an innovative design solution!)*

Maintain the original architectural program *(which went over-budget!)*

Start-up the project Feb 24, 2015.

Have the project tendered on May 1, 2015 *(65 days from start-up to IFT!).*

Use a design-bid-build procurement method *(i.e. use a very conventional, commodity approach to construction!)*

The Design Philosophy

- Use a mass timber superstructure on a concrete structural foundation.
- Second floor to be Cross-Laminated Timber on glulam beam and post system.
- Roof to be glulam post and beam/purlin system with 29mm thick plywood deck.
- Perimeter and corridor walls will be conventionally framed providing lateral load resistance.
- Fire separations (3 buildings) to be precast concrete.

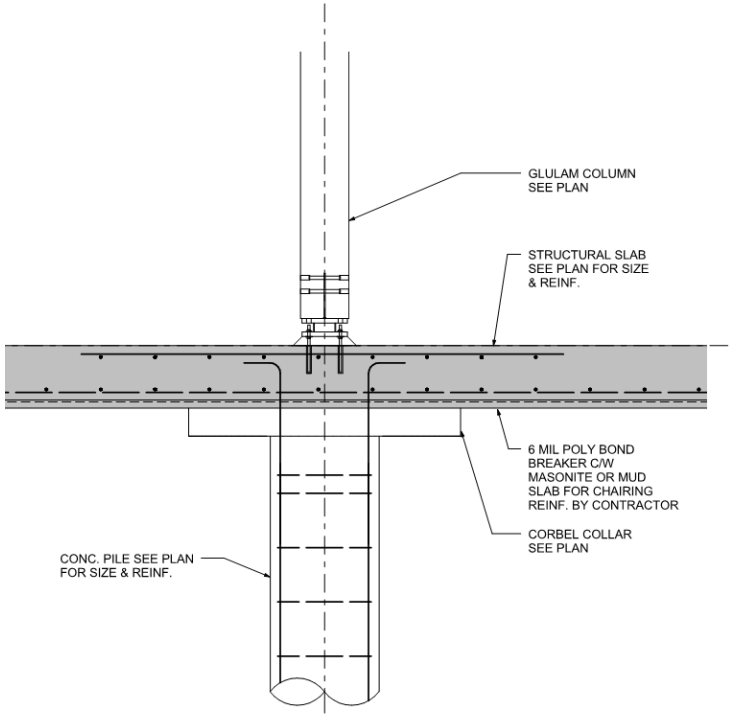
All structural components above main floor can be shop manufactured and assembled on site. Reduce site waste. Reduce site labour. Reduce time exposed to the elements.

The Design Philosophy - Foundation

Foundation:

Concrete structural slab at grade supported by concrete grade beams and belled concrete piles.

The is essentially a concrete podium commonly seen in multi-family construction.

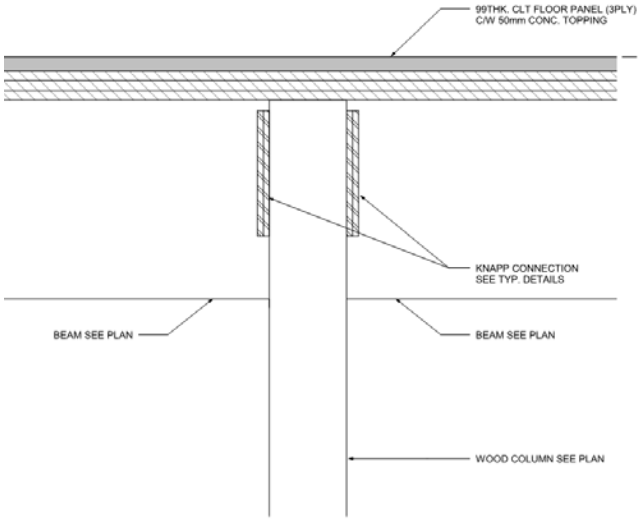


The Design Philosophy – Second Floor

Second Floor:

3-ply (99mm) CLT with 50 mm concrete topping on glulam beams and columns.

This can be rapidly site-assembled in days, not weeks.

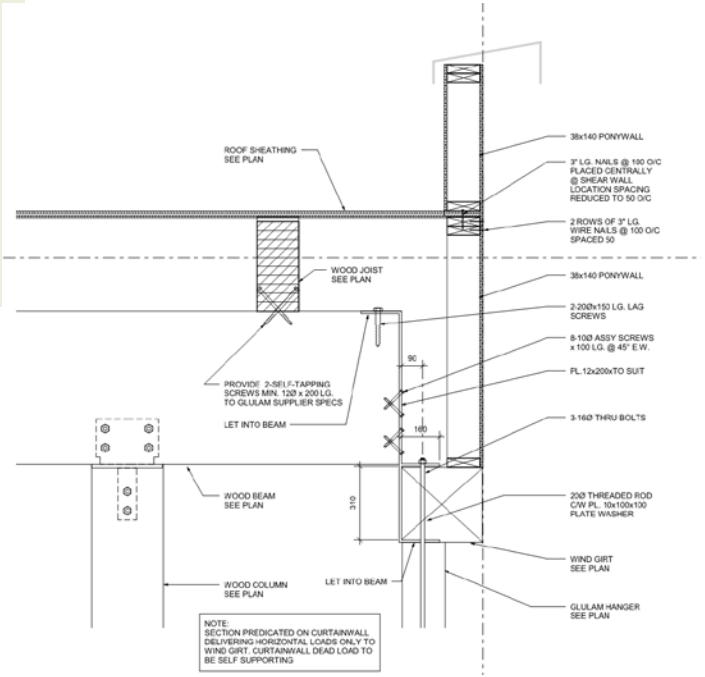


The Design Philosophy – Roof System

Roof System:

29mm thick plywood sheathing on glulam purlins on glulam beams and columns.

This can also be rapidly site-assembled in days, not weeks.



Real-Time Construction Animation

The Variance(s)

City of Calgary requires 2 variances:

1. CLT as a structural alternative to Heavy Timber
2. CLT fire resistance equivalence to Heavy Timber

Note: ABC 2014 was not the ‘code-of-the-day’ for this project.

Seeking the variances produced reports by ISL and GHL that were extensive and likely never to be required again!

Reference: **BP2015-06458 McKenzie Towne School;**
Variance Application for Structural Use of Cross Laminated Timber (CLT)

An alternate solution has been developed to satisfy the intent of the Code. Division A - Clause 1.2.1.1.(1)(b) and Division C Section 2.3 Alternative Solutions confirms that compliance with the Building code may be achieved through an alternate solution. To establish the alternate solution, documentation demonstrating compliance with the Code shall be provided.

The following alternative solution is proposed to address the use of Cross-Laminated Timber (CLT) panels for the second floor structure for the above noted school.

Alternative Solution	**Structural Use of CLT**
Code References	Division B; Sentence 4.3.1 references the Design Basis for Wood. Section 4.5 references Objective and Functional Statements attributed to acceptable alternate solutions.
Acceptable Solution	Attributes of the Objective and Functional Statements listed in Table 4.2.2.1. under 4.3.1.1 Design Basis for Wood.
Objective Statements:	The objective statements listed in Division A, Part 2 are related to structural safety, occupant health with respect to vibration and deflection, and the structural sufficiency of the building. There are no statements specifically related to the alternative proposed however all the statements are aligned with the principles of good structural engineering design practises. The specific objective statements include OS2.1, OS2.3, OH4, OP2.1, OP2.2, OP2.4 found in Division A, Part 2. The intent of the objective statements is to ensure that the alternate solution provides structural materials and systems with similar limits of

The Procurement Method: The Race to the Bottom

Project goes out to Tender to a pre-qualified group of contractors experienced in building schools in the Calgary area.

The Tender Results

Project Budget:	$42M ($21M per school)
Original tender:	approximately $48M
Tender results for wood school:	$39.4M
Savings from original design:	approximately $8.6M
Under original budget:	approximately $2.6M

The Construction Challenges

Successful bidder commences construction.

It soon becomes clear that the design philosophy is not going to be employed.

Other construction decisions begin to take shape and influence outcome.

- All walls will be site framed
- Precast supplier is switched to a new, unproven company.
- An unsuccessful attempt to change the CLT to GLT is made.
- Contractor pits one site against the other to encourage ‘healthy competition’

The Shortcomings – Precast Concrete

Precast concrete supplier is switched from the one in the GC's bid to a new supplier with a brand-new modern plant.

- Delays in shop drawing production are encountered.
- Changes in connection philosophy are proposed to speed production and assembly.
- Finish colours and textures are not produced to specs.
- Embedded plates and other connections are consistently mislocated or absent.
- Delays in production and quality control issues necessitate full time shop monitoring of precast production.
- Panels continue to show up behind schedule and with defects.
- Construction completion dates are in peril.

The Shortcomings – Concrete Topping

All CLT floors are to receive an unreinforced, bonded concrete overlay, 50 mm thick.

Contractor proposes a proprietary mix design – Agilia.

The first pour occurs on a Friday of a long weekend…the results are tragic!

The Shortcomings – Humidity and Moisture Control

Glulam materials sourced in BC will always undergo a transition to EMC (Equilibrium Moisture Content) to suit the end-user environment.

The limits and rate of change of MC and temperature should be controlled in order to minimize checking and drying shrinkage.

A program to control the environmental condition is requirement in the contract documents.

The Shortcomings – Schedule

The original schedule was for delivery of the schools for use in the fall of 2016.

Delays in precast delivery and rework necessitated a delay to end of November 2016.

Topping repairs and preparation for flooring application further delayed delivery to February 2017.

There were other circumstances contributing to these delays but the main culprits are listed.

The Lessons Learned

This was an innovative, niche design of a commodity product.

The design period was short but the drawings were concise and well done.

The choice of lump-sum tender delivery method for construction was wrong from the outset. Vetting of short-listed contractors was insufficient.

The pool of available contractors that can deliver niche products is shallow.

A further commitment to CLT tall walls for the firewalls and gym would have eliminated precast in its entirety and likely the associated delays.

Moisture and humidity was ***monitored*** but not effectively ***controlled***. More control criteria in the contract documents would have helped.

Concrete topping material selection should be explored to ensure more reliable results.

A commitment from the outset to innovation is required in a projects design and delivery. A construction management approach would likely have been more successful.