Mid-Rise 2.0

Innovative Approaches to Mid-Rise Wood Frame Construction

A CASE STUDY

The Heights
Vancouver, BC

King Edward Villa
Vancouver, BC

Virtuoso
Vancouver, BC

wood WORKS!
Program of the Canadian Wood Council

Canadian Wood Council
Conseil canadien du bois


Credit: Adera Development Corporation

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INTRODUCTION

The Dominion
Courtesy: Wood Design Awards in BC

Since the 2009 change to the British Columbia Building Code (BCBC) that increased the permissible height for wood frame residential buildings from four storeys to six, more than 300 of these structures have been completed or are underway around the province. Most are located in the core of smaller municipalities and in the inner suburbs of larger ones, offering a more sustainable and cost-effective option for densification than concrete or steel equivalents.

Most of these buildings have employed wood frame from the ground up, with a five- or six-storey building being constructed on a concrete slab-on-grade, or on top of a concrete basement parking garage; others have been constructed above one or two storeys of commercial accommodation, currently still required to be built in noncombustible construction. This requirement will change when British Columbia adopts the 2015 National Building Code of Canada (NBC), which will allow light wood frame assemblies, mass timber slab elements and wood beams and columns to be used in place of concrete or steel.

Over the past eight years, architects, engineers, municipal authorities and local fire departments have become familiar with the basic parameters of this new building type. Over the same period, market conditions have continued to evolve.

Beyond the energy conservation standards referenced by LEED and mandated by municipalities, there is an increasing interest in ultra-low energy buildings that comply with the Passive House standard, now formally administered in Canada by Passive House Canada.

There is also a growing need to explore new approaches to project delivery, particularly when building on infill lots that have little or no space for vehicles, materials storage and staging, and where the inconvenience to neighbours from the traffic, noise and dust generated by traditional site construction is increasingly disruptive.

Further revisions to the 2015 NBC to be introduced in British Columbia in 2017 will expand the permissible use of six-storey wood construction from multi-family residential (Group C) occupancies to business and personal services occupancies in Group D.

Prior to "modern" building codes, such buildings were often constructed using heavy timber post-and-beam systems, with solid timber floors. However, with the advent of new mass timber panel products, the opportunity has arisen for developers and design teams to explore new forms of wood construction, including hybrid mass timber/light wood frame construction.

In response to these new market conditions, traditional wood frame construction techniques and project delivery methods have been modified or adapted to achieve greater efficiency, economy and performance. This case study looks at three different projects in the Vancouver area, similar in having a predominantly multi-family residential program, but differing considerably in their approach to design, construction details and project delivery.

THE HEIGHTS

VANCOUVER, BC

THE HEIGHTS is pursuing Passive House certification, with high levels of thermal insulation and superior airtightness achieved in a building that in most other respects relies on standard light wood frame construction techniques.

Fig. 1.1: The Heights

KING EDWARD VILLA

VANCOUVER, BC

At **KING EDWARD VILLA**, off-site construction has been successfully incorporated into traditional contractual arrangements, and has delivered benefits in terms of precision, speed of erection and coordination between sub-trades.

Fig. 1.2: King Edward Villa

VIRTUOSO

WESBROOK VILLAGE, VANCOUVER, BC

In the **VIRTUOSO** project at the University of British Columbia, mass timber and light wood frame elements have been used in combination, in an exploration of the hybrid construction that may prove most suitable for the new generation of commercial buildings that will undoubtedly emerge with the upcoming changes to the BCBC.

Fig. 1.3: Virtuoso

Low Energy Construction in the City of Vancouver

In the summer of 2016, the City of Vancouver initiated a process to eliminate the requirement for new developments to meet the LEED Gold standard for energy performance, and instead encourage the move toward net zero emission buildings.

City Council directed staff to enact policies "to build all new City-owned and Vancouver Affordable Housing Agency (VAHA) projects to the Passive House standard or alternate zero emission building standard". This policy will be applicable for all City-owned and VAHA building projects by 2018. The new rezoning policy will incorporate requirements for calculating and reporting embodied emissions for proposed rezoning projects.

In the meantime, the City's Sustainability Group is tasked with removing barriers to innovation that might be present in the zoning or building bylaws, and to assist proponents in the realization of projects that support the City's carbon neutral goal for operating energy. Such accommodations may include relaxing side and rear yard setbacks to permit thicker, more highly insulated walls to be built without compromising the permissible floor space ratio; or waiving the requirement to have their project connect to a district energy plant.

In order to connect to the City's district heating systems, buildings must have hydronic heat. Such systems rely on delivering hot water through a network of pipes, and thus have a high initial capital cost and relatively high operating and maintenance costs. For a building that will be sold on completion, these costs are passed on to individual condominium owners and their strata corporations, and may thus be a justifiable investment for developers in exchange for the LEED credits they accrue under the present regulations.

However, for rental properties the priorities are different. Under the City's Rental 100 program, developers benefit from a waiver of community amenity charges and a reduced requirement for off-street parking, but in return must commit to operating and maintaining the project as a rental building for the full duration of a 60-year lease agreement. Under these circumstances, developers prefer to heat the building with electricity, as it is currently less expensive than gas.

THE HEIGHTS

Credit: Cornerstone Architecture

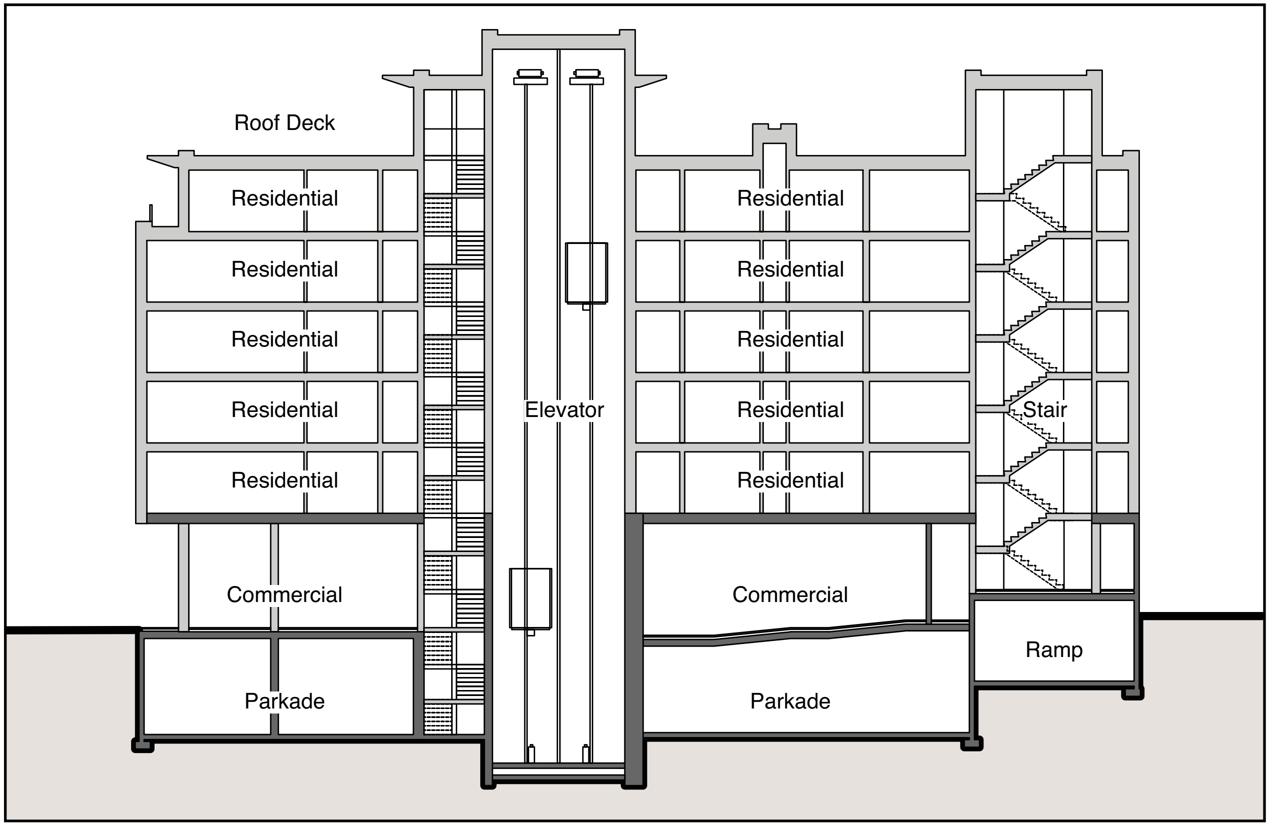


Fig. 2.1: Schematic section

Beginning construction in the summer of 2016, The Heights is a six-storey mixed-use building located on the corner of Skeena and East Hastings Streets, a rapidly developing area in Vancouver's northeast quadrant. The ground level commercial space and the single level of underground parking are constructed in concrete, with 85 apartments occupying the rear of the ground floor and the five storeys of wood frame construction above (Fig. 2.1).

The project was rezoned from existing C-2 commercial under the City of Vancouver Rental 100 program (see: Low Energy Construction in the City of Vancouver - on previous page). Cornerstone Architecture, whose track record in high performance buildings dates back 35 years to the first BC Hydro PowerSmart townhouse development, approached the City for permission to create a Passive House project.

Design Strategies for Passive House Performance

PASSIVEHOUSE CANADA Build better. Feel better.

Passive House buildings, which consume 80-90 per cent less energy for heating and cooling than conventional buildings, require a radically different approach to design.

The most important strategies for Passive House and other ultra-low energy buildings are:

- correct orientation, sizing and shading of windows to optimize passive solar heating;
- a super-insulated building envelope with minimal thermal bridging;
- airtightness to reduce heat loss through air leakage;
- the reduction of ventilation rates to the minimum required to maintain healthy indoor air quality; and
- the recapture of heat from exhaust air using heat recovery ventilation.

The cumulative effect of these strategies is to reduce the building's energy demand to such an extent that internal energy sources (such as people and heat loss from hot water tanks and other systems) becomes significant, and may provide as much as 40 per cent of required input heating energy. Much of the remainder can be supplied most of the time using passive solar energy from carefully sized and appropriately shaded south-facing windows. With Passive House construction, conventional mechanical systems can be much smaller and much simpler than in traditionally designed buildings.

Despite this different approach to design, Scott Kennedy of Cornerstone Architecture was determined to demonstrate that the Passive House standard could be achieved using traditional construction methods. His aim was to design the building in such a way that the majority of the trades would hardly notice any difference in their work practices. In collaboration with Doug Wilson of Peak Construction, Kennedy developed details that would minimize uncertainty, risk and additional cost.

Making a Business Case

Scott Kennedy had to first convince his client that the Passive House approach made sense from a business perspective. He argued that a conventional hydronic heating system would have a capital cost of approximately $450,000 and that maintenance and repairs over the 60-year life of the building had a net present value of $150,000. If this money could instead be spent on additional insulation, higher performance windows, comprehensive sealing of the building to achieve the necessary airtightness, and electric baseboard radiators, the net cost would be the same. The advantage would accrue to the developer in the form of greatly reduced operating costs.

Cornerstone designed the building with a conventional nominal 2x6 wood stud exterior wall, sheathed in plywood and supporting a rain screen system of brick veneer. These walls contain no services (these are contained within a secondary service wall - see below), facilitating the installation of insulation (Fig. 2.2). The exterior walls, interior load-bearing and shear walls were prefabricated by a specialist framing subcontractor. The use of kiln-dried top and bottom plates for the bearing walls, in combination with wood I-joists for the floors, minimized the amount of cross-grain material in the vertical section of the building and so minimized shrinkage.

Inboard of the 2x6 exterior wall, and separated from it by a two-inch gap, is a secondary nominal 2x4 wood stud service wall. This wall, together with some non-load-bearing interior walls at the lowest level, were framed by the general contractor's workforce on site, which was less expensive than using a specialist crew. The service walls were built after installation of two inches of expanded polystyrene rigid insulation on the interior face of the exterior wall. Factory finished with a polymer coating, the insulation acts as both a vapour and air barrier when appropriately sealed. Sealing takes the form of proprietary tapes at joints, and caulking where necessary. To accommodate the insulation and service wall, interior partitions were held back 5.5 inches from the exterior wall (Fig. 2.3).

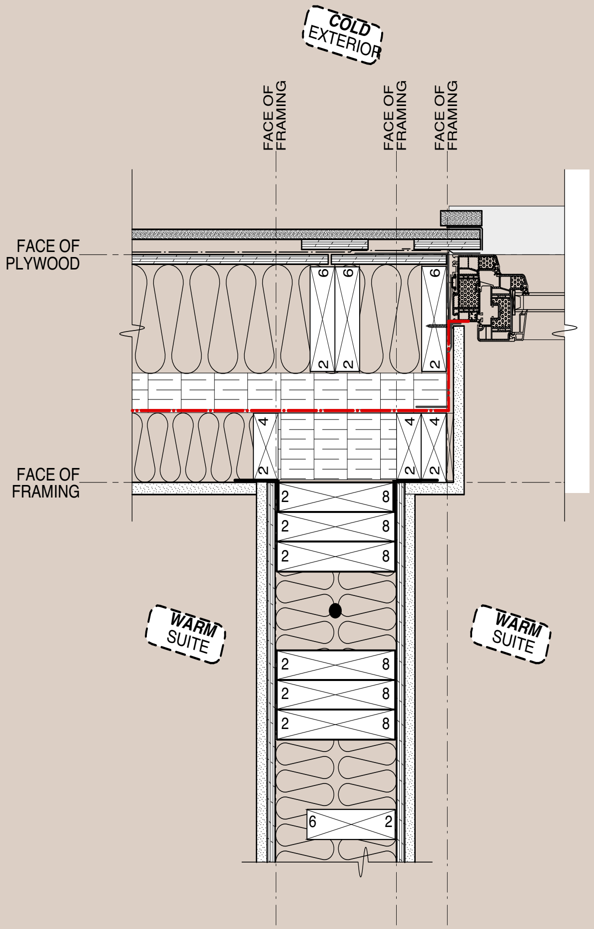


Fig. 2.2: Exterior wall plan view

Fig. 2.3: Installation of rigid air barrier

The expanded polystyrene air barrier was sealed to the plywood floor, which extends out to the exterior face of the 2x6 wall. The plywood was sealed and the barrier wrapped around the floor joists and back to the top of the inner wall on the next level down. This is a critical airtightness detail that requires careful supervision in the field (Figs. 2.4 and 2.5).

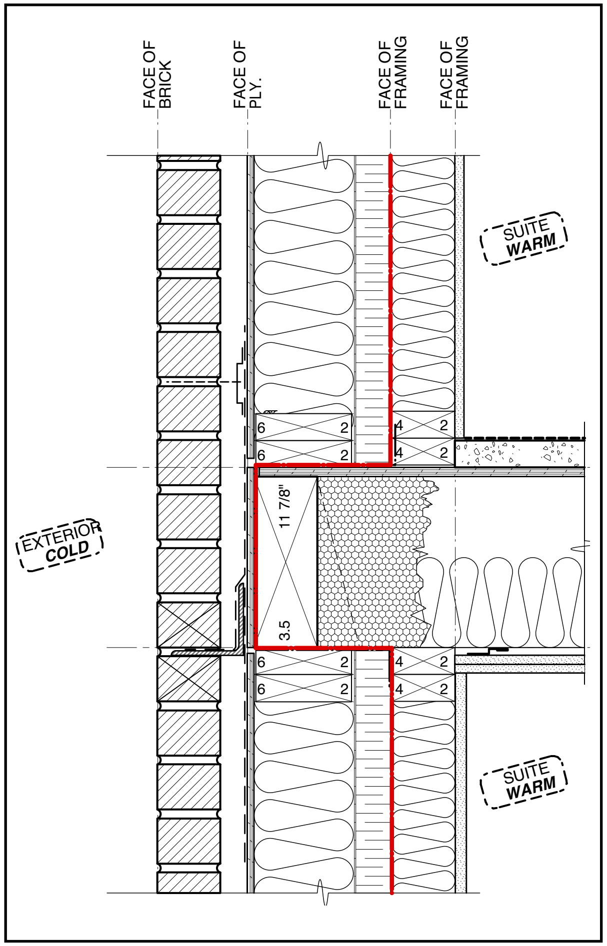


Fig. 2.4: Floorline junction

To ensure that this detail and others relating to the airtightness of the building were executed correctly, two members of the contractor's crew were trained in Passive House construction at the British Columbia Institute of Technology (BCIT) in Burnaby. These trained personnel also oversaw the installation of the flexible ductwork that distributes fresh air and draws in stale air to and from the heat recovery ventilator (HRV) units. These ducts, which are small enough to run within the wall cavities, were installed by the general contractor's workforce, further reducing costs. The specialist mechanical subcontractor was only responsible for the HRV installation from the roof, down the vertical shafts to the silencer box located on the inside wall of each suite (Fig. 2.6).

Fig. 2.5: View showing vapour barrier wrapped over floor lines

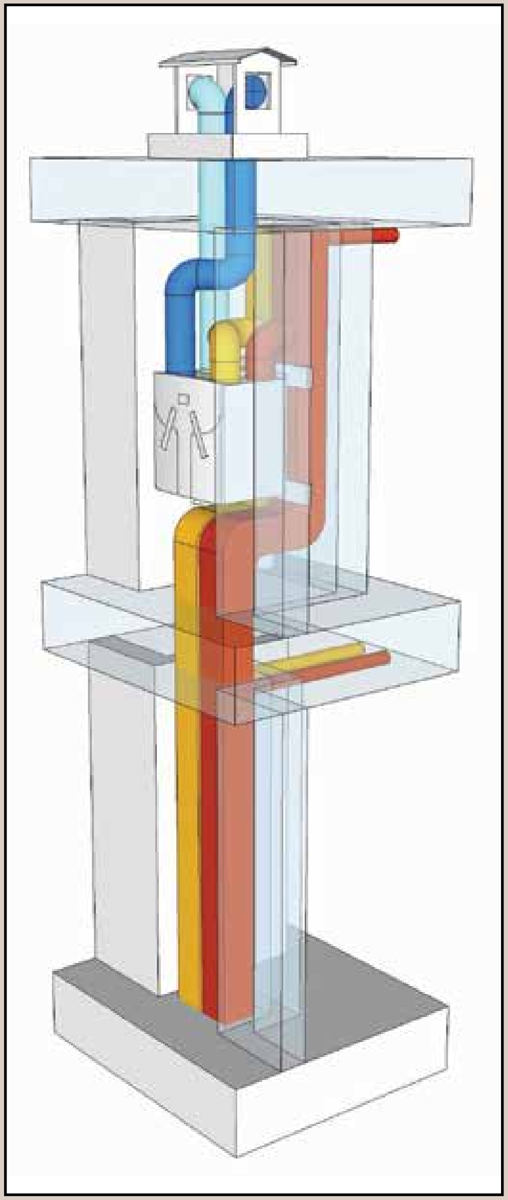


Fig. 2.6: Isometric view

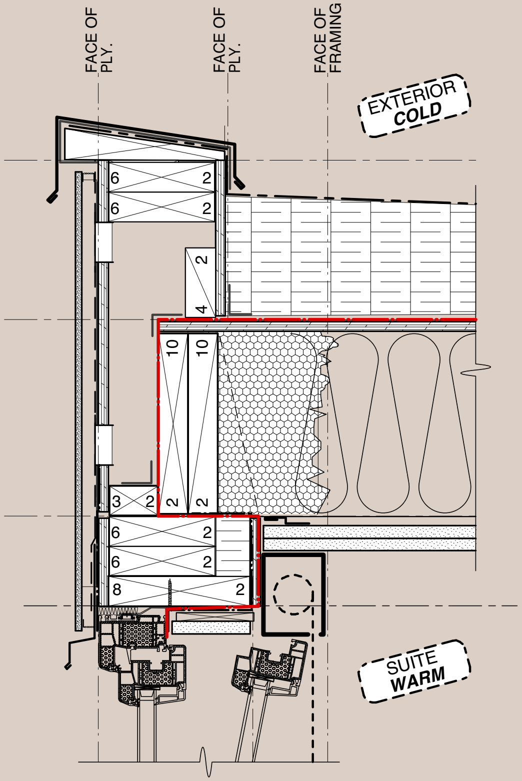


Fig. 2.8: Wall/roof junction

To eliminate thermal bridging, sunshades and balconies were hung off the 2x6 exterior wall and the fasteners did not penetrate the insulation, nor puncture the air barrier (Fig. 2.7). The interior service wall was also insulated, meaning that the vapour barrier is in the centre of the wall, and the drying out of any moisture that might become trapped within the wall happens to either the interior or exterior, depending on where it occurs. Some joist ends penetrate the wall and were treated with spray polyurethane for vapour control. The performance of the wall assembly was tested using simulation software that modelled fluctuations in temperature and humidity over the course of a year. The wall met the requirements with respect to moisture control.

The roof also has significantly more insulation than a conventional structure, with fibreglass batts between the ceiling joists, and six inches of polyisocyanurate insulation on top of six inches of sloped expanded polystyrene above (Fig. 2.8). Modelling demonstrated that this assembly also met the requirements for vapour control.

As is now common in mid-rise wood frame buildings that sit on top of a concrete podium, the elevator shaft is constructed in concrete on the retail/parking level, transitioning into nail-laminated timber (NLT) where the wood frame construction begins. This strategy eliminates the problem of differential movement that can occur at junctions between dissimilar materials (e.g. at elevator thresholds when a concrete shaft is used in an otherwise all-wood building).

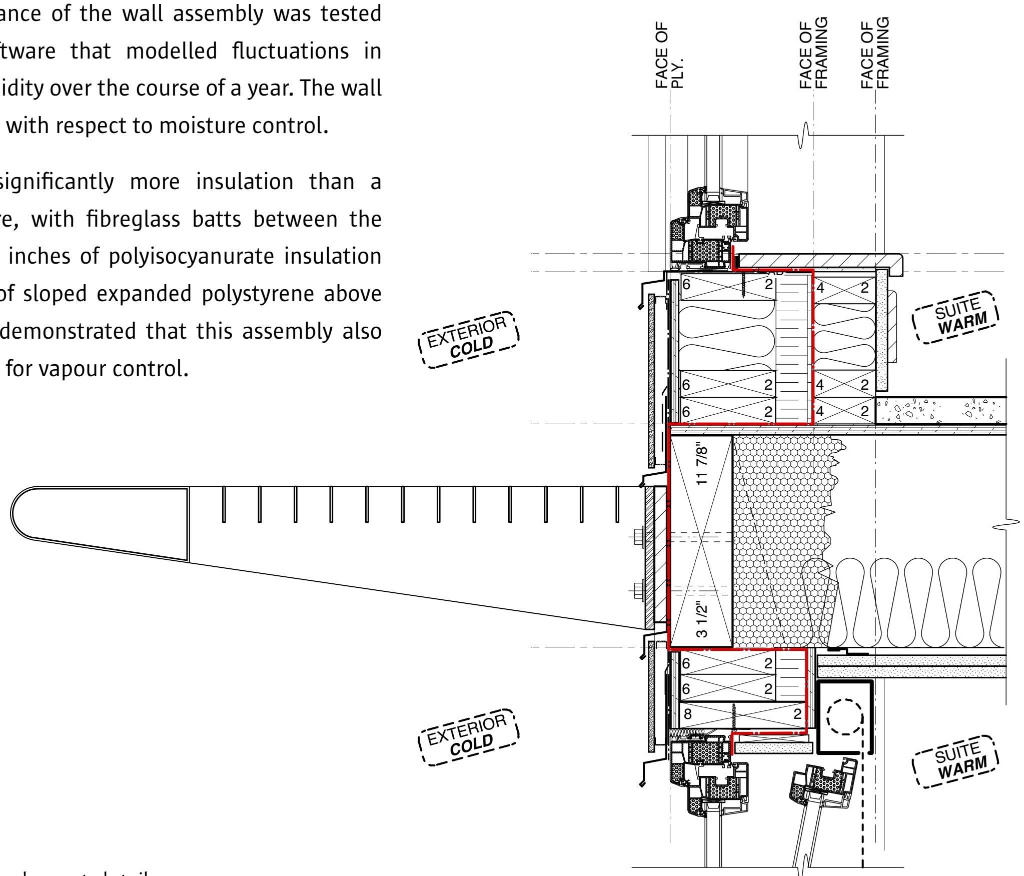


Fig. 2.7: Sunshade attachment detail

Rather than have the NLT elevator shaft (which begins at Level 2) built directly off the concrete slab, Kennedy proposed a parallel strand lumber (PSL) beam be used at this point. The intention was to exploit the lower thermal conductivity of wood to reduce thermal bridging (Fig. 2.9).

The careful attention to detailing and sealing for airtightness (Fig. 2.10) has resulted in a building envelope in which thermal bridging has been completely eliminated (Figs. 2.11 and 2.12). With its careful attention to detail, The Heights has confirmed that traditional wood frame construction techniques can successfully be applied to the new generation of high performance buildings.

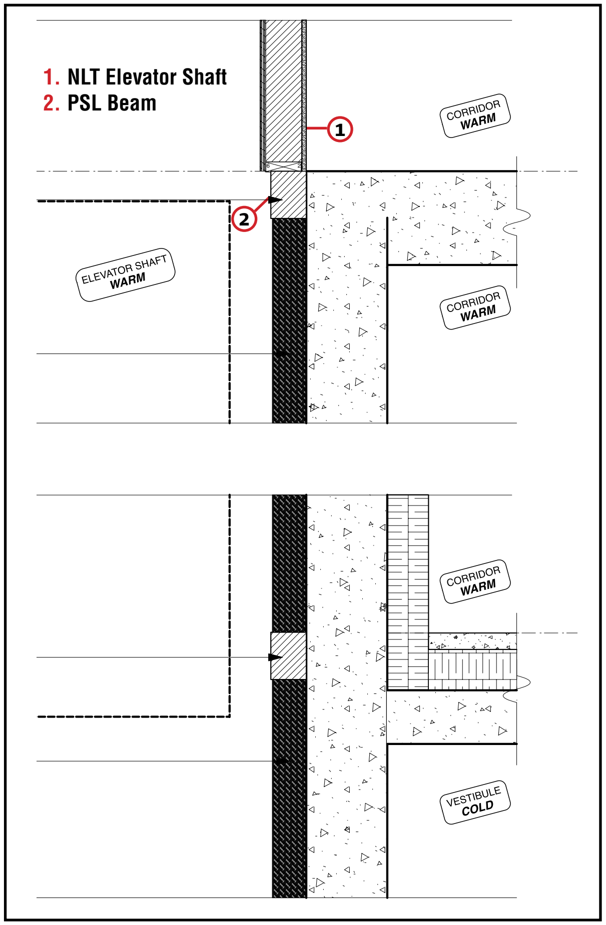


Fig. 2.9: Elevator shaft

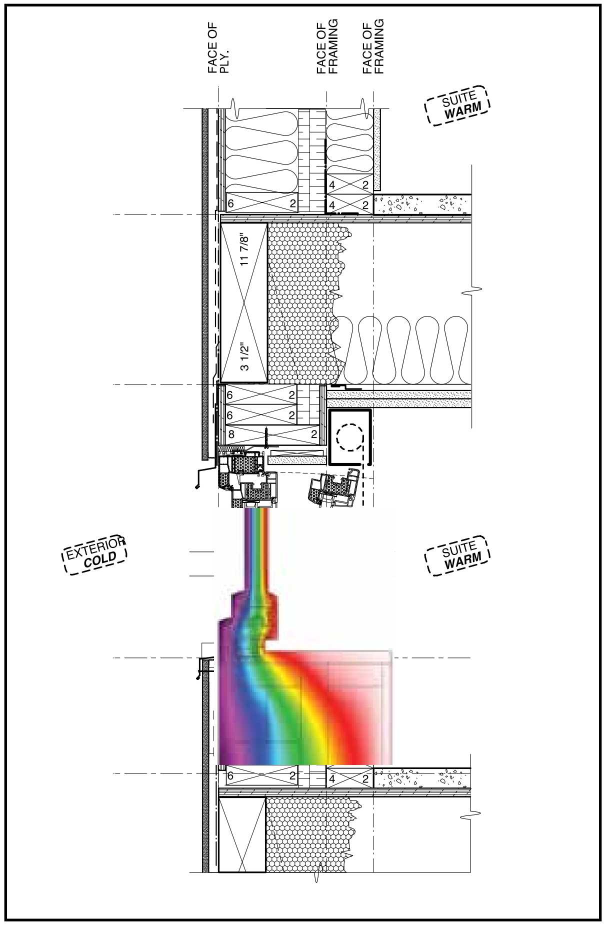


Fig. 2.11: Thermal gradient at window sill

Fig. 2.10: Taping of vapour barrier at window

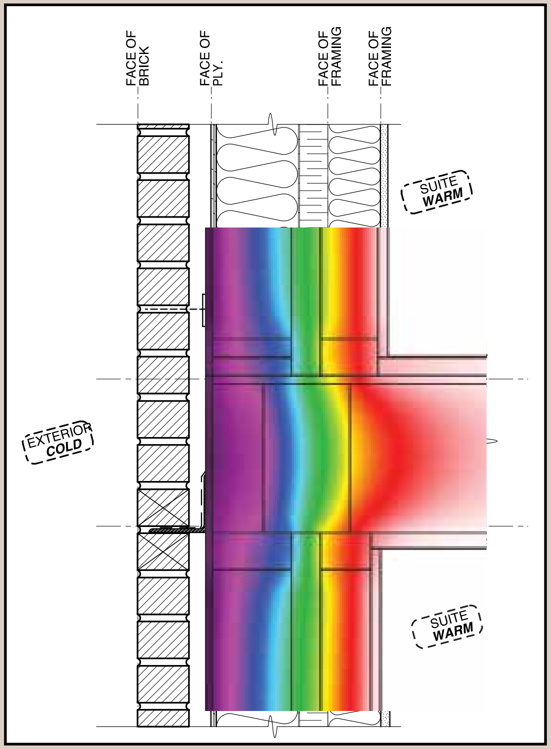
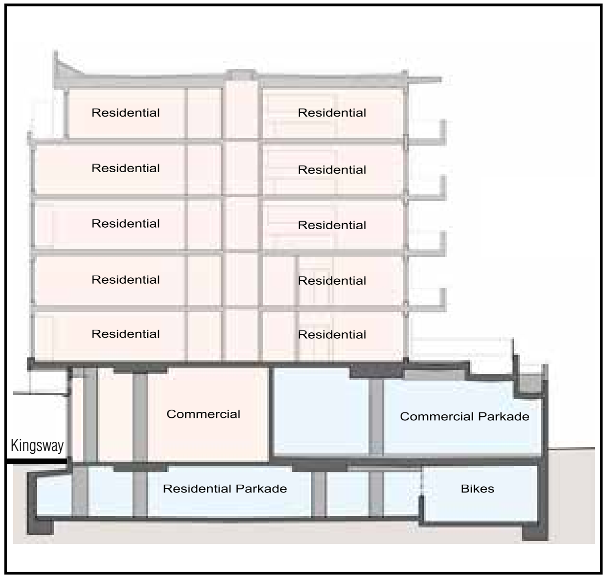


Fig. 2.12: Thermal gradient at floorline junction

KING EDWARD VILLA

Credit: Jim Taggart



3.1: King Edward Villa NE-SW cross section

Completed in the spring of 2017, King Edward Villa is a six-storey mixed-use building located on the corner of East King Edward and Kingsway Avenues on Vancouver's east side. The ground level commercial space and the single level of underground parking are constructed in concrete, with 77 apartments, ranging in size from 420-square-foot studios to 700-square-foot two-bedroom units, occupying the five storeys of wood frame construction above (Fig. 3.1).

On behalf of the family who had owned the previously C-2 (four-storey commercial) zoned lot for many years, the design team led by GBL Architects approached the City of Vancouver to rezone the property and construct a rental apartment building under the Rental 100 program. Permission was granted for a six-storey building with an overall floor area determined by the application of the pre-existing setback requirements to the new structure (Fig. 3.2).

Fig. 3.2: Aerial photo showing urban context

Fig. 3.3: Restricted site access at rear of property

With a four-foot setback from the sidewalk, the plan of the building follows the property line, making an oblique angle where the two streets meet. The ends of the building abut the property line at either side of the site, giving the long front and rear elevations a north-northeast and south-southwest orientation, respectively. The rear yard is narrow, with an opening width of only 40 feet between the building footprint and a large tree (Fig. 3.3). Leading south to the adjacent lane, this was the only vehicular access to the site.

Once a development permit had been received and building permit drawings were in process, the project was let as a construction management contract. Up to this point, it was assumed that the building would be constructed using conventional nominal 2x6 wood framed exterior walls to meet the energy requirements of ASHRAE 90.1 and achieve a LEED Gold certification as mandated by the City of Vancouver.

The contract was awarded to Performance Construction, who persuaded the developer to consider a low energy option based on Passive design principles, using a similar business case to that described previously for The Heights.

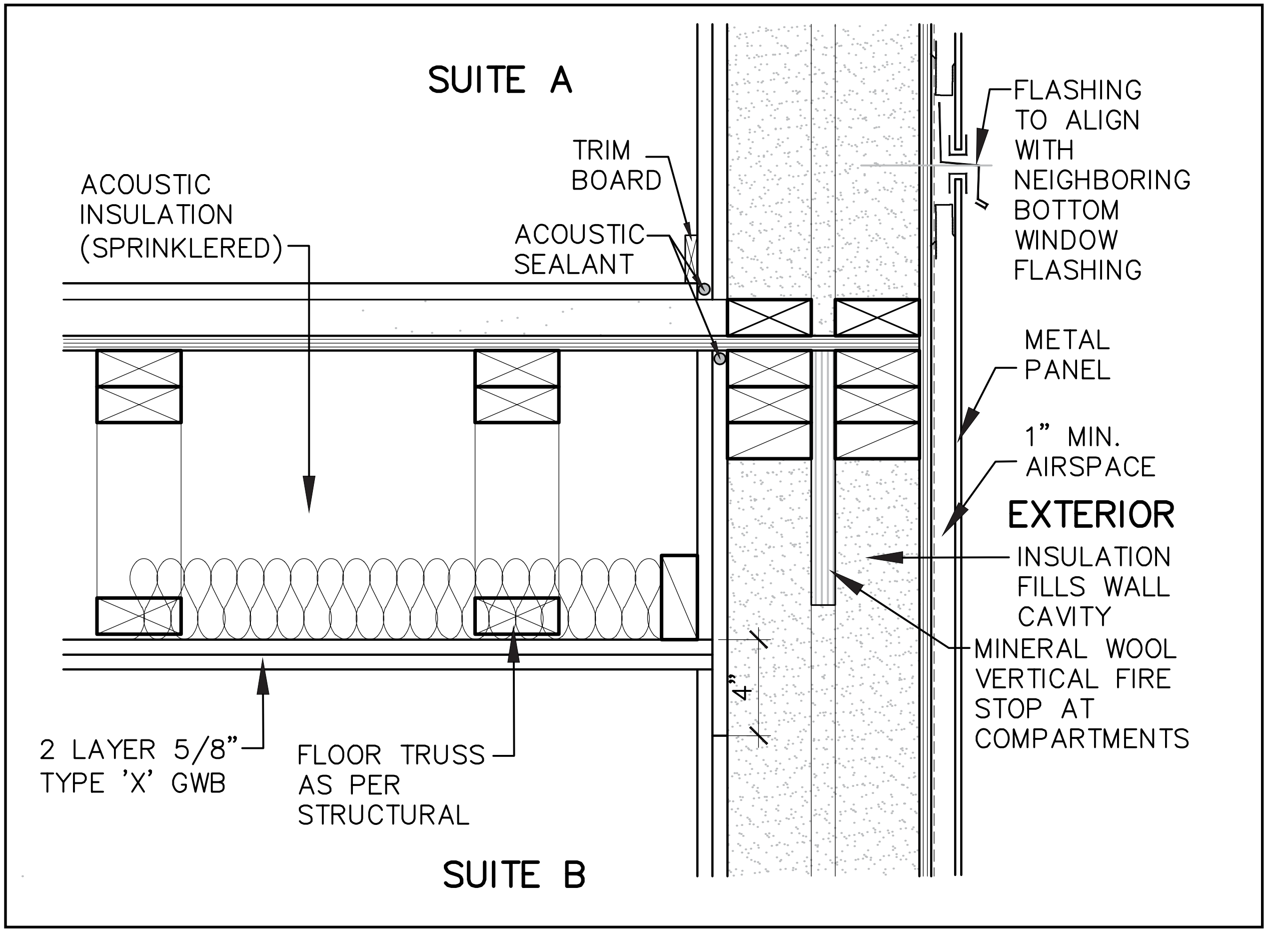


Fig. 3.4: Panel exterior wall at wood floor

A Low Energy Solution

The energy conservation strategies are the same in this project as in 388 Skeena, but the implementation differs in detail from the strict requirements of Passive House.

The super-insulated envelope was achieved by using two nominal 2x4 wood stud walls with a one-inch space between them. The exterior sheathing is plywood with a vapour permeable (breathable) peel-and-stick membrane, that also acts as an air barrier. The entire wall depth is filled with two layers of spray-applied cellulose insulation that achieves an R-value of 28. The cellulose eliminates heat transfer by convection and, because it is hygroscopic (able to absorb and release moisture), it provides added insurance against interstitial condensation (Fig. 3.4).

The inside of the wall is lined with airtight drywall with a vapour barrier paint on the interior face. Two layers of 5/8-inch fire-rated drywall were required to achieve the one-hour fire resistance rating mandated by code, and these were installed with gaskets around power receptacles and other openings, and the edges were sealed with fire-resistant caulking (Fig. 3.5).

Fig. 3.5: The edges of the drywall were caulked to meet fire and acoustic requirements

An Innovative Structural System

Because the floor structure runs parallel to the long front and rear exterior walls (see discussion of structure following), the only component that penetrates the insulation layer is the plywood flooring. Windows and doors are steel-reinforced vinyl "tilt-and-turn" units, with low-E double glazing. The steel reinforcement enables larger units to be used (Fig. 3.6) and gives the suites a bright and open feeling. The average window-to-wall ratio is approximately 32 per cent, but feels higher because the two end walls of the building are fire-resistance-rated walls with no window openings.

The drywall was installed before the gypsum concrete floor screed was poured. This increases the airtightness between inside and outside and also between suites. Baseboards were glued in place.

The air change rate is controlled by a pair of HRVs installed in each suite. The mechanical HRV systems for each suite are self-contained, and operate continuously at low speed (50 CFM) with a timed fan boost override (100 CFM) when required in the bathrooms. This configuration differs from that used at The Heights where one rooftop HRV serves a vertical stack of five suites.

Fig. 3.6: Façade detail

The five-storey residential portion of the building is constructed on top of a cast-in-place concrete basement parking garage and ground floor commercial space. Elevator and stair shafts in this area are also concrete, but everything above the ground floor (with the exception of the non-load-bearing fire-resistance-rated walls at each end of the building (Fig. 3.7) is constructed in wood.

All these components were prefabricated by Mitsui Homes, including the 2x6 NLT panels used for the elevator shaft (Fig. 3.8); the innovative parallel chord floor trusses used throughout the building; the non-load-bearing exterior walls; the load-bearing shear and non-load-bearing interior walls; and the triangular roof trusses (Fig. 3.9).

Of these components, the 12-inch-deep parallel chord floor trusses are the most ingenious. Running parallel to the exterior walls between interior load-bearing walls, their open webs permit all the main mechanical and electrical services to be run horizontally throughout each suite, with vertical drops only where needed for HRV grilles, light switches, plugs, etc. This made the installation of the mechanical and electrical services easier and hence quicker than the traditional method where piping and wiring must be threaded through rough openings drilled or cut through studs and plates (Fig. 3.10).

Another advantage of the floor trusses was established through a load path analysis performed by Mitsui Homes. The analysis determined that the trusses could be hung from their top chords only, enabling the drywall finish on party walls to be notched around them, but otherwise taken up to the underside of the floor above. This simplified the fire separation between suites, with intumescent caulking used to seal the joints, and mineral wool insulation used in the ceiling cavities (refer back to Fig. 3.5).

Demising walls between suites, as well as other load-bearing walls, were constructed using a double-wall system as described above for the exterior walls. On the southwest side of the building, these walls are topped with a 12-inch-deep PSL beam that cantilevers approximately five feet beyond the exterior wall to support the balconies (Fig. 3.11). Spanning between the PSL beams are wood I-joists. This detail means that, rather than a series of header joists penetrating the building envelope to support the balconies, only the PSL beams project, significantly reducing thermal bridging. The deep balconies act as shading devices, keeping the summer sun from striking the windows of the units below.

Fig. 3.7: Concrete masonry fire-resistance-rated wall

Fig. 3.9: Construction of roof

Fig. 3.8: Installation of NLT elevator shaft

Fig. 3.10: Parallel chord trusses enable services to be run within the depth of the floor

From the architectural and structural drawings, Mitsui Homes created a 3-D model that identified each individual wall panel and truss, giving it specific attributes and a unique position within the model. These elements were also referenced to datum points that enabled each frame that would (for example) be superimposed one on top of the other on successive floors to be laid out and fabricated with precisely the same stud positions and spacing.

Coordinated at the design stage with mechanical, electrical and structural drawings, this meant that the vertical drops for plumbing pipes, electrical conduits, tie-down anchors, etc. could all be continuous. All that was needed was a hole of the appropriate size to be drilled through the sill and header plates and the plywood flooring to create a perfectly aligned vertical drop (Fig. 3.12).

Fig. 3.12: The precision of the prefabricated frame walls enabled vertical services to be installed easily

The net result was to reduce uncertainty, mistakes and mess; speed up installation; and enable the building to be finished from bottom to top in the same way that a conventional high-rise building would be. Although not mandated by the local fire marshal, starting drywall installation at the ground floor and working upward is recommended as a precaution against fire during construction.

Mitsui Homes exports J-grade lumber to its parent company in Japan, but separates out about 10 per cent of its inventory for use in North American projects. The Douglas fir used for the framing on the first two floors, and the spruce-pine-fir (SPF) used on the upper floors is superior in quality to the majority of locally available lumber. The quality and consistency of the material lends itself to precise fabrication, with frames being factory-produced to tolerances of 1/8 inch or less. The single kiln-dried sill and header plates, the PSL beams and top-hung trusses mean that there is the minimum possible cross-grain material in the vertical load path of the building. It is anticipated that shrinkage between the second and sixth floors will be less than 3/8 inch.

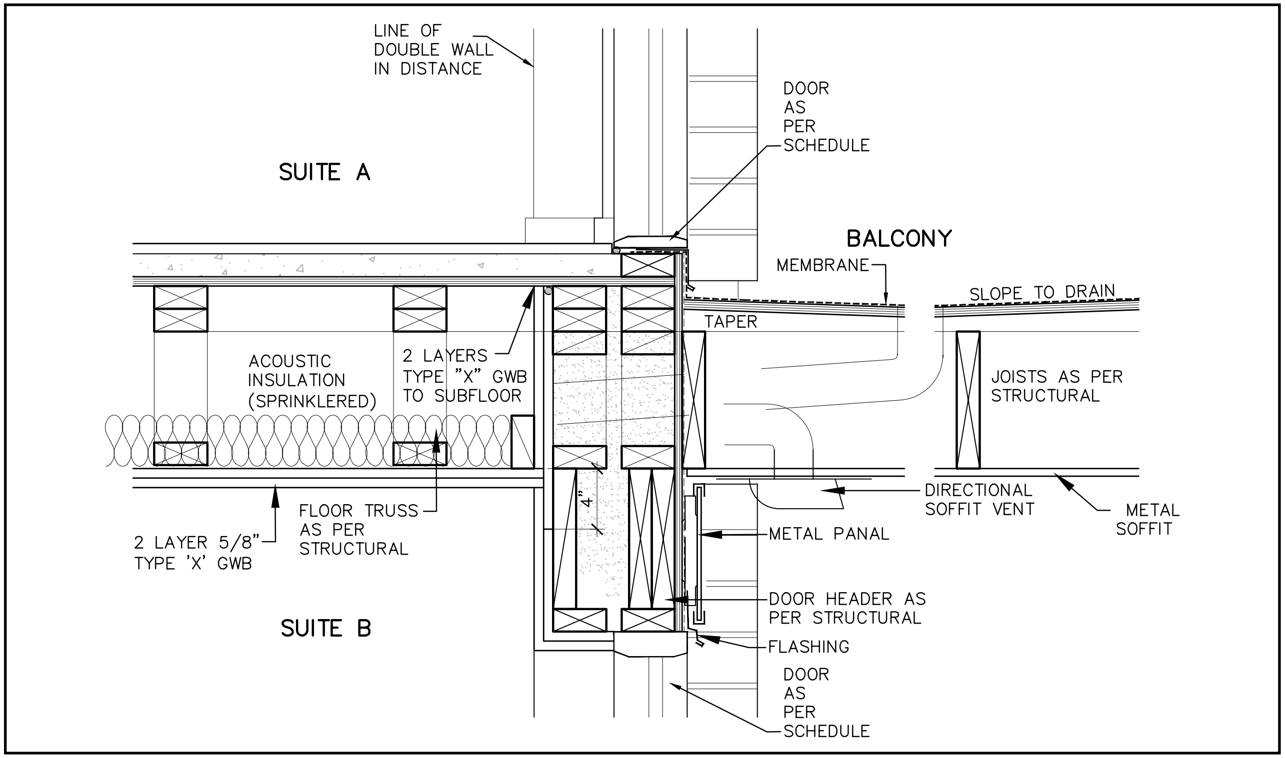


Fig. 3.11: Detail showing exterior balconies supported on projecting PSL beams

The unique code given in the factory to each completed panel identified where it was to be located in the building, and where it fit in the construction sequence. This in turn enabled deliveries to be made on a "just-in-time" basis and improved the flow of work on a tight and congested site. This was particularly important on the King Edward Villa project, where the site had only one narrow point of access.

King Edward Villa underscores the advantages of panelized construction in wood, particularly in urban areas. Off-site construction and the light weight of wood components speeds the assembly process, minimizes the noise and disruption to neighbouring properties and reduces the number of lane closures that are necessary to accommodate equipment, such as concrete trucks.

Credit: Adera Development Corporation

Changes to the National Building Code of Canada

Requirements for the specification of structural wood products and wood building systems are set out in the model NBC, which is concerned with health, safety, accessibility and the protection of buildings from fire or structural damage. Since its inception in 1941, the NBC has been subject to regular reviews approximately every five years. In the 2015 edition of the NBC, changes were made to increase the permitted height limit for wood construction for some buildings. These changes are currently under review and scheduled for implementation in 2017 in the BCBC.

The recommendation to move from permitting a maximum of four storeys up to five and six storeys of wood construction is the result of a rigorous, broad-based engineering and scientific review by expert committees of the Canadian Commission on Building and Fire Codes. These independent committees are made up of professionals from all aspects of the construction industry, including developers, designers, builders, construction material manufacturers, the regulatory community (e.g. building officials and fire service personnel) and general interest groups.

The new five- and six-storey mid-rise wood construction option will provide builders with "code compliant" alternatives that fully meet the safety, health and accessibility, as well as fire and structural protection objectives of the NBC. Whether built with light wood framing materials or engineered wood products, the added height and area of these buildings will give designers new options for an expanded range of occupancy types.

The BCBC mid-rise changes will be applicable to residential and office-type buildings, but will also allow mixed-type occupancies on lower storeys, so that buildings may have office, residential, mercantile, assembly, low hazard or storage/garage-type tenants.

Enhanced Fire Safety Requirements for Wood Mid-Rise

In relation to these new types of mid-rise buildings, several changes to the model 2015 NBC are designed to further reduce the risks posed by fire. These include:

- increased use of automatic sprinklers in concealed areas in residential buildings;
- increased use of sprinklers on balconies;
- greater water supply for firefighting purposes; and
- 90 per cent noncombustible or limited-combustible exterior cladding on all storeys.

Wood building systems (floors, walls and roofs constructed of lumber and/or engineered wood elements) must be designed to perform well under fire conditions, meeting or exceeding NBC fire-resistance requirements. It is anticipated that these conditions will most easily be met using a combination of mass timber and light wood elements.

VIRTUOSO

Credit: Adera Development Corporation

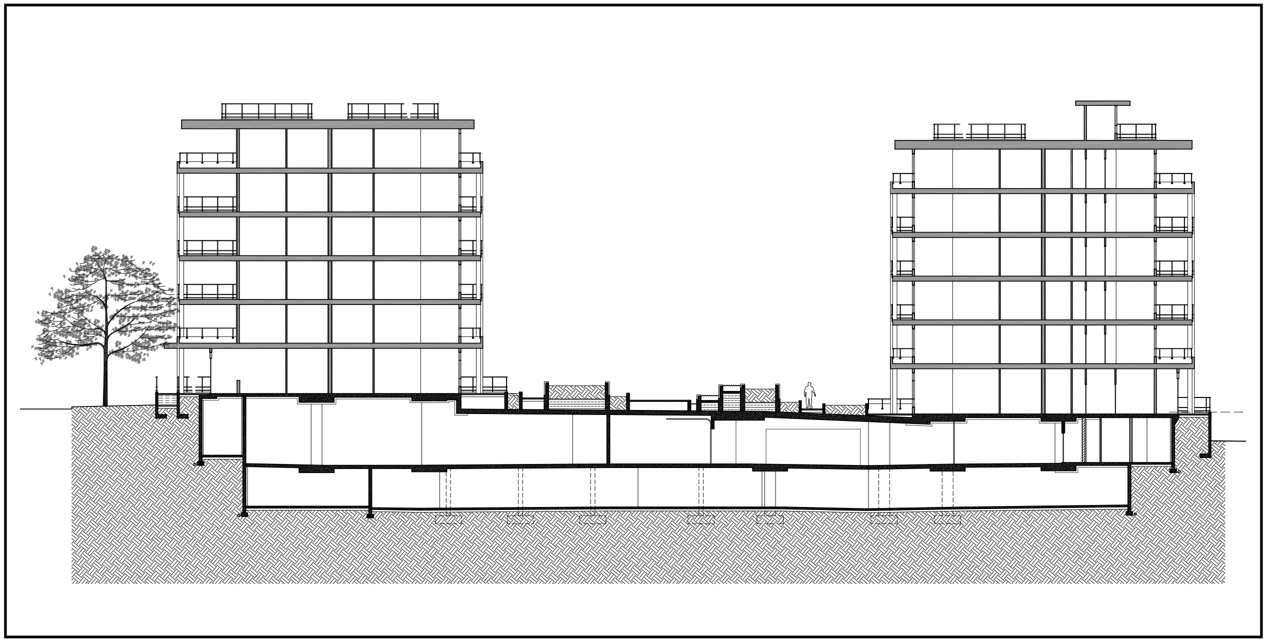


Fig. 4.1: Schematic section

Virtuoso is the 10th project to be undertaken by developer Adera in the new Wesbrook Village neighbourhood on the Point Grey campus of the University of British Columbia. Arranged around a central garden, the six-storey wood structure was constructed on top of a two-storey concrete underground parking garage, and includes 106 two- and three-bedroom apartment units ranging in size from 1300 to 1600 square feet (Fig. 4.1).

Adera Development Corporation also owns Structurlam Products, a BC-based fabricator of glulam beams and cross-laminated timber (CLT) panels. Always interested in pushing the envelope of economy, efficiency and quality in wood construction, Adera chose to explore the possibilities of hybrid light wood frame/mass timber construction in the multi-family residential market, recognizing that the technology would soon find a broader application in buildings with a major Group D commercial occupancy.

A Hybrid Structure

The project features traditional light wood frame walls, combined with CLT floors (Fig. 4.2), balconies, roof and elevator shafts. In addition, glulam beams were used around the perimeter at each floor level (their outer face visible on the exterior of the building) and to support the cantilevered balconies.

Exterior walls throughout the building, together with the interior load-bearing walls on the first four floors, are of nominal 2x6 wood stud construction. On the ground and second floors, the framing used is Douglas fir, whereas on the upper floors it is SPF. All the lumber is dried to a moisture content of 15 per cent or less.

The walls have single sill and header plates, minimizing the amount of cross-grain material (and hence shrinkage) in the vertical section of the building. Interior demising walls, which perform as both fire and acoustic separations between suites, consist of two separate 2x4 wood stud walls with a one-inch gap between them. They are lined on both sides with two layers of 5/8-inch fire-rated drywall.


Fig. 4.2: Light wood frame walls support CLT floors

Rather than the familiar I-joist and plywood floors found in most mid-rise wood frame buildings, the floors in the Virtuoso project consist of three-ply CLT panels that span either nine or 14 feet between the interior walls (Figs. 4.3 and 4.4). The panels are four inches thick and four feet wide. Their adjacent long edges are stitched together with closely spaced stainless steel screws set at opposing 45-degree angles in what is known as a “dragon’s claw” pattern (Fig. 4.5). The surfaces of the CLT floor panels are not generally visible; suspended ceilings are used to conceal the ductwork for the air-conditioning system beneath them, and the floor finishes on top are hardwood or ceramic tile laid on a rigid substrate. This eliminated the need for concrete toppings on this project.


Fig. 4.3: Three-ply CLT panels prior to installation


Fig. 4.4: Installation of CLT panels

The ends of the floor panels are supported either on double-stud demising walls, or on 2x6 load-bearing or shear walls (Figs. 4.6 and 4.7). In the former case, a gap is left between the panel ends to maintain the discontinuity that is necessary for acoustic separation. In the latter case, the panel is continuous over the supporting wall. The roof is constructed in the same manner.

Where required, interior load-bearing walls were topped with a glulam beam that projects approximately six feet beyond the building to support exterior balconies (Fig. 4.8). The balcony floors are made from CLT panels with an export grade (J-grade) layer on the bottom. This soffit layer, which is free of visual defects, is left exposed. As balcony soffits are not considered part of the building envelope, they are not required to be of noncombustible construction.

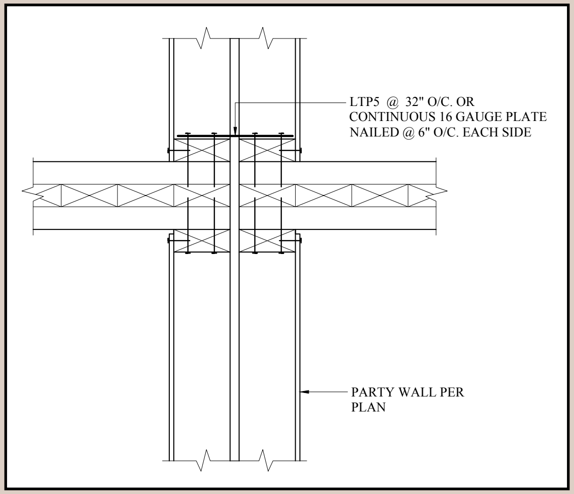


Fig. 4.6: A gap is maintained at party walls to improve acoustic isolation between suites

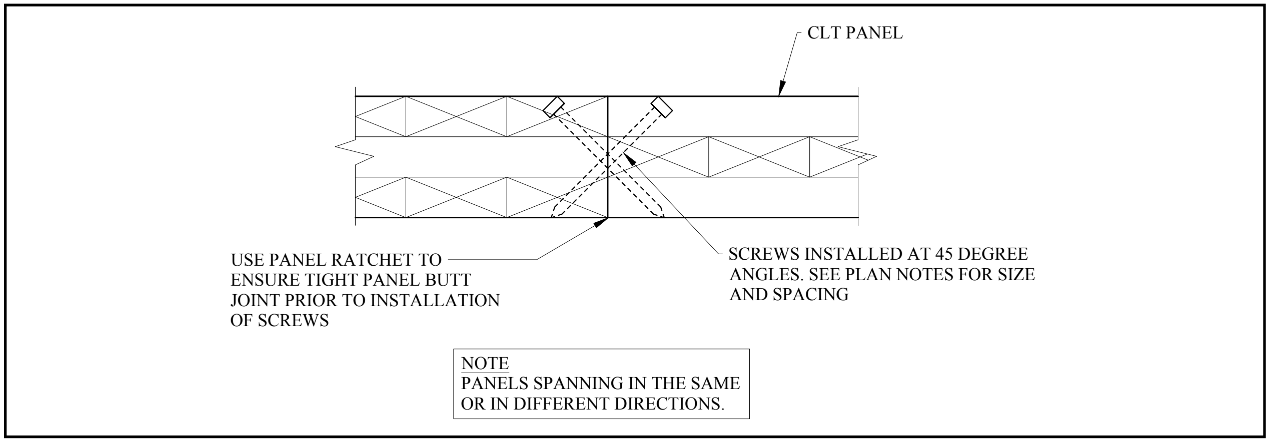


Fig. 4.5 Dragon's claw connection of CLT panels

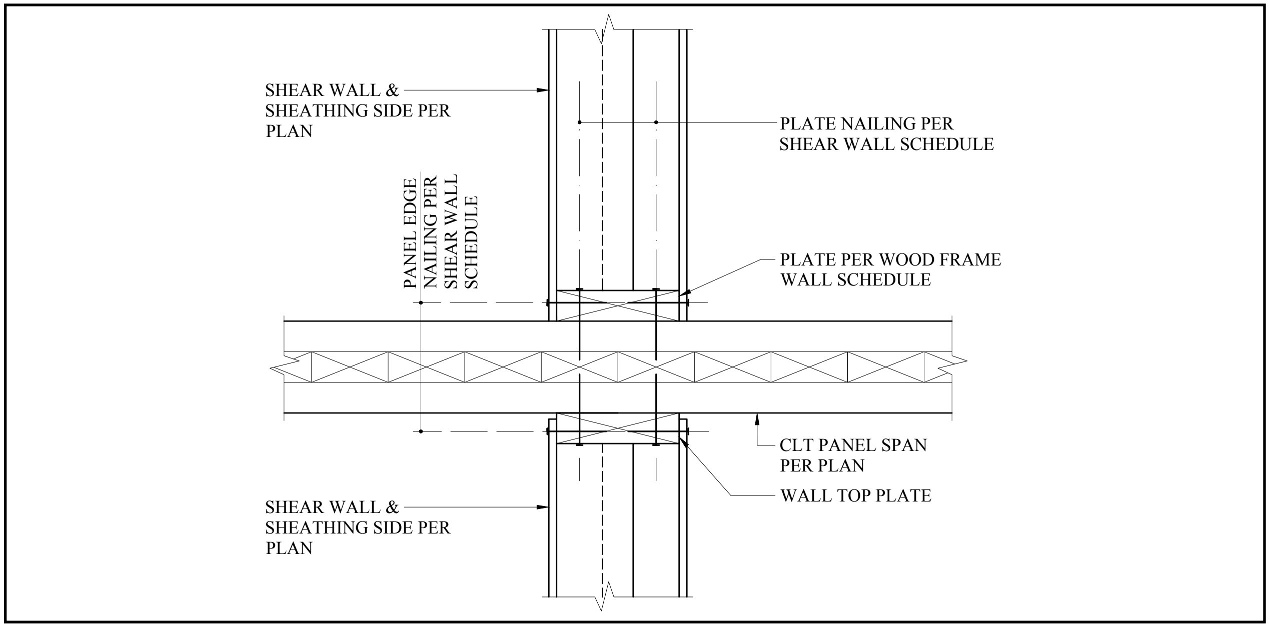


Fig. 4.7: Detail showing continuous CLT floor panel at interior load-bearing wall

Three-ply CLT was also used for the walls of the elevator shafts. These panels are set vertically and connected with a “dragon’s claw” arrangement of screws. For the shorter side of the elevator shaft, only a single panel was required, whereas for the longer side, two panels were needed, placed side-by-side. The shaft is continuous, meaning that where it passes through each floor, the edge of the CLT floor panels is supported on a ledge (Fig. 4.9). These shafts are not part of the lateral system for the building, which consists entirely of shear walls that are located between suites and along corridors. These shear walls are of light wood frame construction with plywood sheathing on one or both sides.

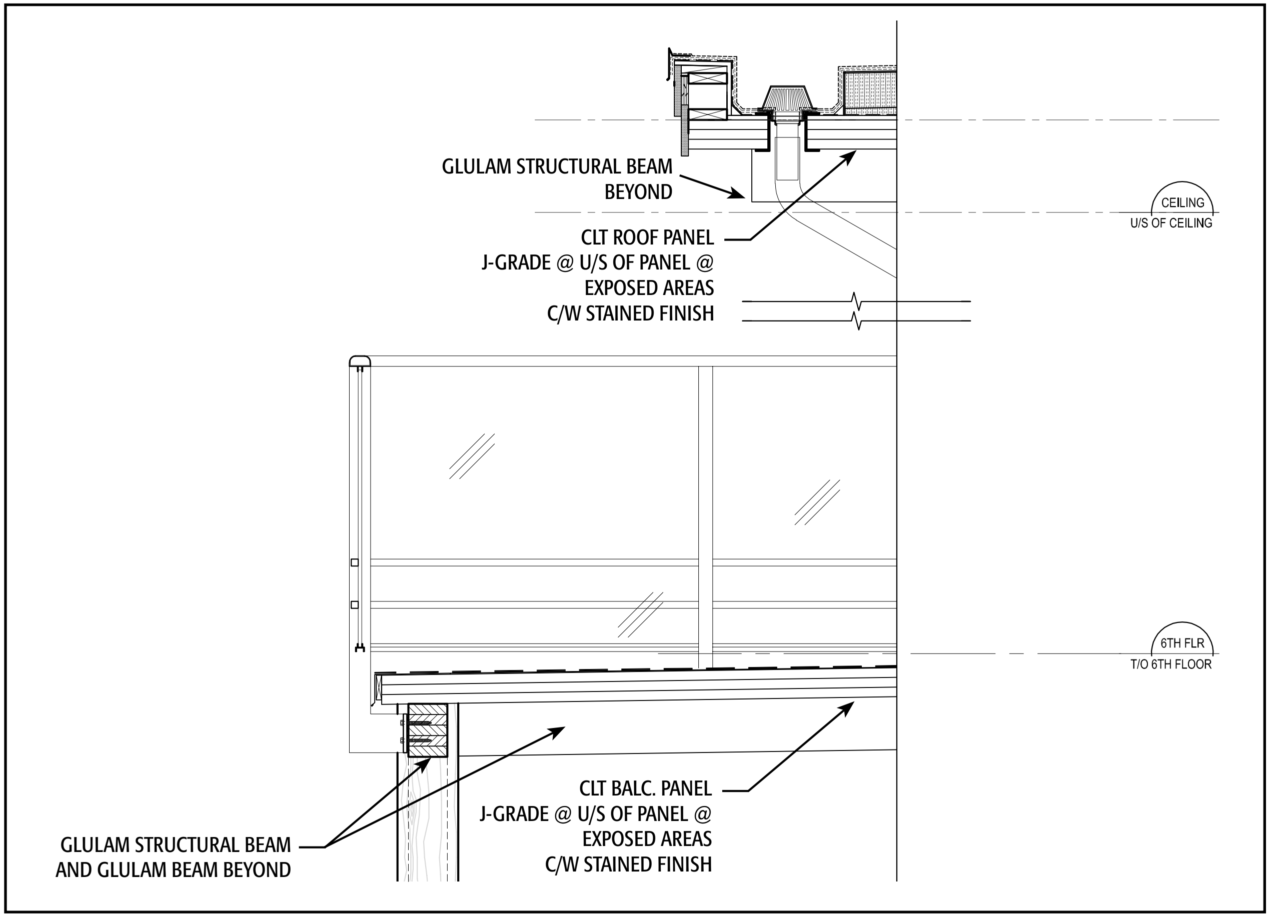


Fig. 4.8: Detail section at balcony showing CLT floor panels supported on projecting glulam beams

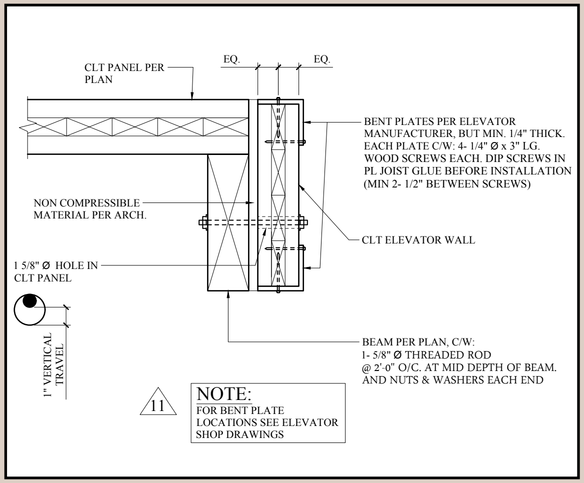


Fig. 4.9: At the CLT elevator shafts, CLT floor panels are supported on a ledger

A Virtual Model

Considerable time and effort was expended at the design development stage to optimize panel layout, dimensions and details, and to minimize waste and maximize economy and efficiency. A 3-D model was produced to identify each individual panel, its place within the building and the location of any holes that needed to be pre-drilled in the factory. These were mainly required to accommodate the tie-down anchors that pass through the shear walls, resisting uplift forces and increasing the lateral resistance of the structure. These tie-downs, which consist of sectional steel rods, must be accurately aligned from top to bottom of the building to function effectively. The remaining holes (for conduits, pipes, etc.) were drilled on site.

The Virtuoso project has demonstrated that the use of CLT floor and roof panels in a hybrid mass timber/light wood frame application can offer shorter construction times. The "just-in-time" delivery and easy installation of the prefabricated panels (Fig. 4.10 and 4.11) can be quicker and more efficient than traditional site construction.

Fig. 4.10: CLT floor panel being lifted into place by crane

Fig. 4.11: Aerial view of CLT floor being installed

CARBON CHARTS

Carbon impacts of energy vary with the primary sources of energy generation. Coal and fossil-derived electricity, for example, has a higher carbon footprint than hydroelectric generation. Likewise, the carbon footprint of vehicles varies with the type of vehicle.

Passenger vehicles are defined as two-axle four-tire vehicles, including passenger cars, vans, pickup trucks, and sport/utility vehicles.

The figures in this calculator are based on an aggregated average of passenger vehicles and homes in the United States.

The Heights

ESTIMATED ENVIRONMENTAL IMPACT OF WOOD USE

Volume of wood products used: **594 cubic metres**

U.S. and Canadian forests grow this much wood in: **2 minutes**

Carbon stored in the wood: **516 metric tons of CO_2**

Avoided greenhouse gas emissions: **1,096 metric tons of CO_2**

Total potential carbon benefit: **1,612 metric tons of CO_2**

THE ABOVE GHG EMISSIONS ARE EQUIVALENT TO:

341 cars off the road for a year

Energy to operate **170** homes for a year

Estimated by the Wood Carbon Calculator for Buildings, cwc.ca/carboncalculator.

**CO2 refers to CO2 equivalent.*

King Edward Villa

ESTIMATED ENVIRONMENTAL IMPACT OF WOOD USE

Volume of wood products used: **1,023 cubic meters**

U.S. and Canadian forests grow this much wood in: **3 minutes**

Carbon stored in the wood: **871 metric tons of CO_2**

Avoided greenhouse gas emissions: **1,851 metric tons of CO_2**

Total potential carbon benefit: **2,721 metric tons of CO_2**

THE ABOVE GHG EMISSIONS ARE EQUIVALENT TO:

575 cars off the road for a year

Energy to operate **287** homes for a year

**Estimated by the Wood Carbon Calculator for Buildings, cwc.ca/carboncalculator.*

**CO2 refers to CO2 equivalent.*

Virtuoso

ESTIMATED ENVIRONMENTAL IMPACT OF WOOD USE

Volume of wood products used: **3,032 cubic meters**

U.S. and Canadian forests grow this much wood in: **8 minutes**

Carbon stored in the wood: **2,559 metric tons of CO_2**

Avoided greenhouse gas emissions: **3,313 metric tons of CO_2**

Total potential carbon benefit: **5,872 metric tons of CO_2**

THE ABOVE GHG EMISSIONS ARE EQUIVALENT TO:

1,241 cars off the road for a year

Energy to operate **620** homes for a year

**Estimated by the Wood Carbon Calculator for Buildings, cwc.ca/carboncalculator.*

**CO2 refers to CO2 equivalent.*

CONCLUSION

Since its introduction in the late 19th century, light wood frame construction has continued to evolve, whether in response to new code requirements, technological advances or market expectations. As a renewable resource that sequesters carbon and has low embodied energy, wood has an increasingly important part to play in the creation of more sustainable built environments (Fig. 5.1).

Now, with wood frame construction recognized as a key component in the long-term mitigation of climate change, the technology is being asked to deliver larger buildings that are more durable and use less energy over their service life.

As The Heights, King Edward Villa and Virtuoso have demonstrated, light wood frame construction, in pure or hybrid form, can meet or exceed these new expectations. The success of these projects sets an important precedent, one that will instill confidence in other designers and developers, and so move such innovative approaches into the mainstream.

Fig. 5.1: Courtyard at Virtuoso

PROJECT CREDITS

THE HEIGHTS

Owner/Developer: 8th Avenue Properties

Architect: Cornerstone Architecture

Structural Engineer: Weiler Smith Bowers Consulting

Construction Manager: Peak Construction

Wood Supplier: Dick's Lumber (Burnaby)

KING EDWARD VILLA

Owner/Developer: Richard Wong

Architect: GBL Architects

Structural Engineer: Bryson Markulin Zickmantel

Mechanical/Electrical Engineer: SRC

Construction Manager: Performance Construction

Wood Prefabricator: Mitsui Homes

Code Consultant: Protection Engineering

VIRTUOSO

Owner/Developer: Adera Development Corporation

Architect: Rositch Hemphill Architects

Structural Engineer: Wicke Herfst Maver Consulting Inc.

Construction Manager: Adera Development Corporation

Engineered Wood Supplier: Structurlam Products

NATIONAL FUNDERS

Natural Resources Canada | Ressources naturelles Canada

BSLC

PROVINCIAL FUNDER

Forestry Innovation Investment

NATIONAL PARTNERS

CertainTeed SAINT-GOBAIN

StructureCraft

STRUCTURLAM Intelligence in Wood

western archrib structural wood systems

Guardian Structures

Weyerhaeuser

LP

PROVINCIAL PARTNERS

COFI Council of Forest Industries

Coast Forest PRODUCTS ASSOCIATION

CMSA

Boise Cascade Engineered Wood Products

rothoblaas

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