THE HEIGHTS: MULTI-UNIT RESIDENTIAL PASSIVE HOUSE

CASE STUDY

At the time of construction, The Heights was one of the first multi-unit residential buildings in Vancouver seeking Passive House certification. At six storeys high, this building would be among the largest structures built to the Passive House standard in Canada. This project is estimated to have 90% less heating energy costs than a code-level equivalent. Lessons learned in achieving this level of energy reduction are presented in this case study.

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PREPARED BY

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THE UNIVERSITY OF BRITISH COLUMBIA

CORNERSTONE

PROJECT OVERVIEW

A SIMPLE FORM

allowed for a low form-factor (surface area to floor area ratio), and reduce heat transfer to the exterior - **page 03**

INCREASED INSULATION

resulted in an R35 exterior wall assembly, more than twice as effective as one that is code-built. This significantly reduced operating energy costs - **page 04**

THERMAL BRIDGING

was minimized between the unconditioned and conditioned spaces to reduce the energy demand of the building - **page 04**

EFFICIENT FENESTRATION

with Passive House certification offers exceptional thermal performance, and was sourced locally, minimizing shipping costs and transportation delays - **page 04**

AIRTIGHTNESS

of 0.3 ACH @ 50Pa was achieved. An airtight envelope ensures no warm air (or cool air in the summer) is lost unnecessarily through envelope air leakage - **page 04**

MINIMAL HEATING

is required and is provided by small baseboard electric heaters, each using only 1/3 of the energy required by a hairdryer - **page 05**

HEAT RECOVERY VENTILATION

(Zhender ComfoAir 550) system brings with 85% efficiency brings in filtered fresh air while minimizing energy use - **page 05**

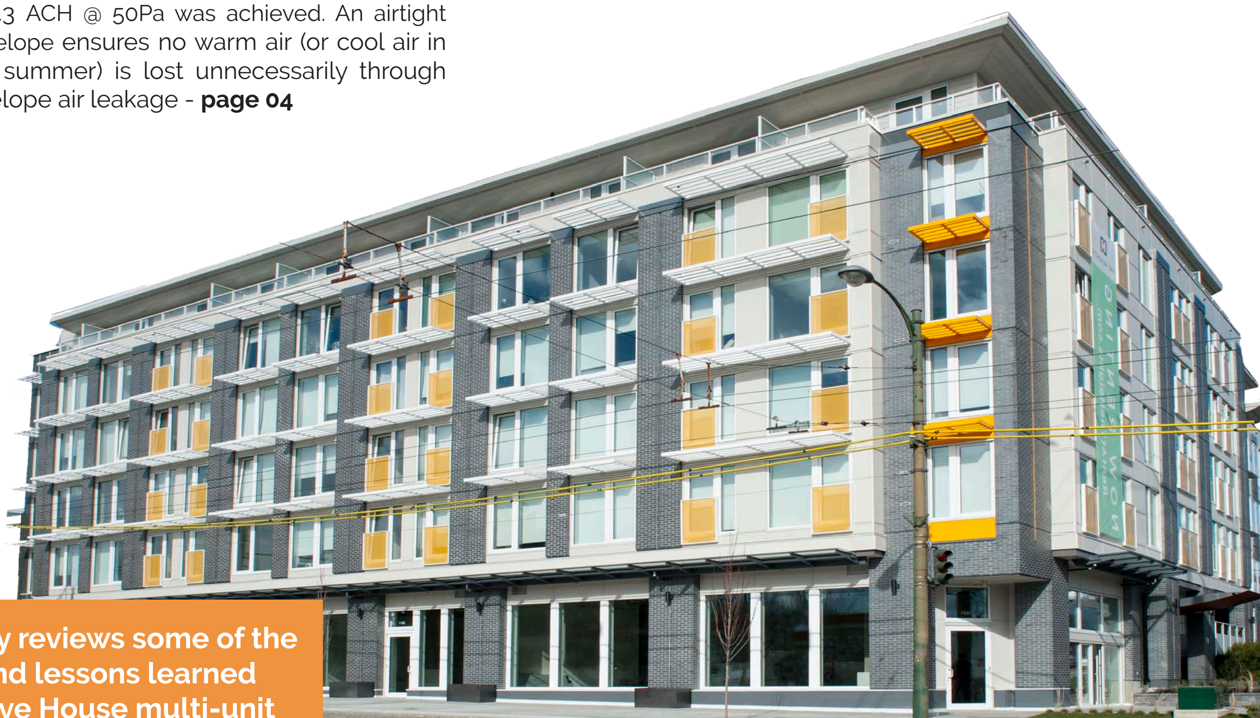
PASSIVE COOLING STRATEGIES

were employed through shading and operable windows - **page 05**

EFFICIENT APPLIANCES

like the Energy Star washer and ventless dryer contribute to house's energy demand reduction - **page 05**

One of Vancouver's first Passive House multi-unit residential buildings, The Heights has achieved an estimated 90% heating energy costs reduction compared to a code-level equivalent.



This case study reviews some of the key features and lessons learned from this Passive House multi-unit residential building.

GENERAL OVERVIEW

The Heights is a six storey multi-unit residential building and is one of the largest buildings seeking Passive House certification in Canada. The building's construction cost was similar to a code-level equivalent but is estimated to have 90% less heating energy costs.

Project Overview

Building Type	Multi-unit residential
Climate Zone	4: Cool-Temperate
Location	Hasting Sunrise, Vancouver
Gross Floor Area **Treated Floor Area**	5,917 m² / 63,690 ft² 4,191 m² / 45,112 ft²
Building Height	19.7 m / 64.8 ft
Number of Floors / Suits	6 storeys / 85 units
Project Completion Date	February 2017

Project Team

Owner & Developer	Eighth Avenue Development Group Ltd.
Architect	Cornerstone Architecture
Structural Engineer	Weiler Smith Bowers Consulting
Mechanical Engineer	Integral Group
Envelope Engineer	Aqua-Coast Engineering Ltd.
Construction Manager	Peak Construction Group
PH Consultant	Cornerstone Architecture
PH Certifier	Passive House Academy

Andres Vargas


Andres Vargas

Project Context

In response to global climate change concerns, the City of Vancouver developed the Zero Emissions Building Plan, which sets a roadmap for making all new buildings zero emissions by 2030. To catalyze this transition, City of Vancouver provides incentives for early adopters who are pursuing these future targets by building to zero emsission and zero energy building standards, such as Passive House.

The Heights is composed of 85 residential rental units, with commercial units on the main floor. Thus, the long-term operational energy costs were of great interest to the developer and owner. The building was the largest Passive House project in Canada at the time of construction. With construction costs similar to a code-level equivalent but is estimated to have 90% less heating energy costs.

Design Highlights

As an early example of Passive House in Canadian mid-rise buildings, the main focus of the design process was on meeting the certification requirements. In the Passive House standard, the efficiency of the building form is assessed by form factor, which is the ratio of external surface area to internal treated floor area. A higher form factor indicates more exposed surface area that can lose or gain heat. In general, larger buildings have lower form factors. The building has a simple and compact box-like shape to prevent excessive heat loss or gain from the building envelope. The Heights achieved a form factor of 1.2, which is low compared to a typical single-family Passive House that may have a form factor of around 3.

The two underground levels and the ground floor which provide parkade, storage, retail, and some residential spaces have a concrete structure. The top five floors that house the majority of residential suites have a stick-frame structure.

HIGH-PERFORMANCE ENVELOPE

The energy demand of the building was minimized through a highly insulated, airtight and thermal bridge free envelope. Special attention was given to preventing thermal bridges between conditioned spaces on ground level and unconditioned spaces underground, as well as in plumbing and duct penetrations.

Envelope

All the conditioned spaces above ground are enclosed in a thick, highly insulated envelope with thermal bridge-free detailing. These include the suites, retail spaces, corridors, stairs and elevator shafts. The team made sure there are no thermal bridges between these conditioned spaces and unconditioned spaces underground. For instance, the elevator shaft at the parkade level was insulated on the inside.

Heat loss via plumbing vent stacks running vertically up the building and through the roof was an unforeseen challenge. To minimize the heat loss, additional insulation was added around the pipes. This was challenging due to the tight space in the wall cavities. In future projects, the team proposes the use of air admittance valves as an alternative approach.

The windows are Euroline ThermoPlus, which were the only locally made Passive House certified windows at the time of construction. A remaining challenge, however, is the lack of Passive House certified fire-rated doors that meet accessibility and fire rating standards.

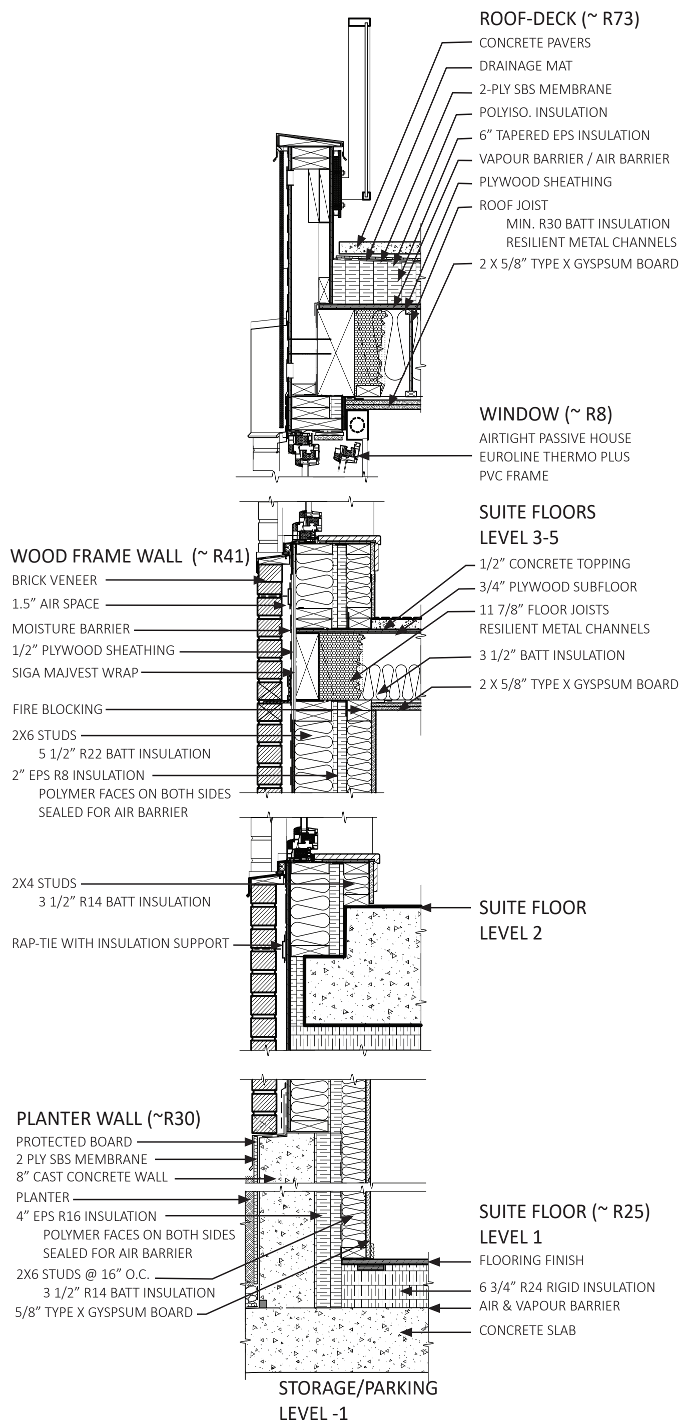
Thermal Performance of Exterior Components (Cornerstone Architecture)

Envelope Component	Thickness (cm / inch)	Average Assembly U-Value (W/m²K)
Rainscreen Wall	30 / 12	0.138 (R41)
Planter Wall	41 / 16	0.187 (R30)
Ground Floor	56 / 22	0.212 (R25)
Roof Deck	50 /20	0.078 (R73)
Exterior Windows	-	Glazing: 0.62 Framing: 0.80
Exterior Doors	-	Glazing: 1.26 Framing: 2.40

Airtightness

Due to limited exterior access, the rigid Expanded Polystyrene (EPS) insulation on the inside of the exterior wall was used as the air barrier. This allowed the airtightness layer to be completed by one trade in dry indoor conditions. However, they had to await the installation of the exterior moisture barrier. The envelope engineer conducted a simulation analysis to ensure moisture will not accumulate in the envelope in the long-term. This is verified by monitoring sensors over the first year of operation.

At the time, the City of Vancouver had a mandatory mid-construction air tightness test requirement. This proved to be impossible because of the construction sequencing in multi-unit residential buildings, as different floors were at varying stages and thus the test results were skewed. The City has recognized this issue and is revising their requirements.



Brick Cladding Wall Section (Cornerstone Architecture)
The thick insulation layer with no thermal bridges, continuous air barrier, and Passive House certified windows contributed to achieving a high-performance envelope.

ENERGY EFFICIENCY STRATEGIES

The high-performance envelope, solar heat gain, and highly efficient heat recovery ventilation system made it easy for this project to meet the heat demand requirements of the Passive House standard. However, further cooling strategies may be required to prevent overheating risks in future projects.

The Heights Passive House Performance Characteristics

Parameter	Characteristic	Unit	Passive House		Building Performance
			Criteria	Alternative	
Airtightness	Air change rate per hour	ACH @ 50Pa	≤ 0.6	-	0.3
Space heating	Annual demand	kWh/m²a	≤ 15	-	7
	Heating load	W/m²		≤ 10	8
Space cooling	Annual demand	kWh/m²a	≤ 15	-	-
	Cooling load	W/m²	-	≤ 10	-
	Frequency of overheating	% (> 25° C)	≤ 10	-	5
Primary energy requirements	Non-renewable (PE)	kWh/m²a	≤ 120	-	119
	Renewable (PER)	kWh/m²a	-	≤ 60	95

HRV Closet (Cornerstone Architecture)

Heating & Cooling

By focusing on the building envelope design and construction, the heating targets were easily met. Small electric baseboard heaters supplied the heating needs of the suites. Each of these heaters use only one third of the energy required by a single hairdryer, and allow residents to control their own suite's temperature to their comfort level.

To supply domestic hot water, gas-fired hot water tanks with 95% efficiency were used. The central system was installed on the roof outside of the thermal envelope.

Passive cooling is provided by operable windows in the units. Sunshades were also used to prevent overheating. However, measured data from summer of 2018 indicated overheating on the warmest summer days. Overheating in this building is comparable with conventional multi-unit residential buildings without air conditioning, especially in a warming climate.

Passive House projects may be more prone to overheating due to high-performance envelopes that are built to retain as much thermal energy as possible. Thus, in future projects the team will incorporate more heat gain reduction strategies, including lower solar heat gain through windows and more extensive shading. They may also add cooling to the air ventilation system.

While this project was one of the first multi-unit residential buildings pursuing Passive House, there are many more mid-rise projects that are currently being designed or developed. Further studies of the performance, indoor comfort and air quality of this building will inform current and future projects.

Ventilation

The building has a semi-central ventilation system in which five suites in each floor are served with a single Zhender comfoAir 550 heat recovery ventilation (HRV) unit with 85% efficiency rate. This ensures the majority of previously generated heat is transferred to circulating fresh air entering the suites. To avoid overheating, HRVs automatically switch to bypass mode during summer nights when outside air is cooler, to bring in air without capturing inside heat.

The shared HRV system is located on the sixth floor to simplify maintenance and replacement of filters without disturbing tenants. While all the suites are connected to the HRV system, each suite can boost its ventilation with a control placed in the washroom and kitchen. For additional energy reduction, recirculating charcoal filters for range hoods and ventless heat-pump dryers are used.

Trades Training

As the first mid-rise Passive House project, the architect required two tradespersons on the site to attend the BCIT Trade Person Training course to better understand Passive House practices and construction methods and become familiar with Passive House systems that are not common practice, such as HRVs and their unique ducting systems.

While learning these new methods is not difficult, proper training is vital to meet performance targets. Additionally, to ensure installation quality and building airtightness, the project team recommended conducting duct air leakage tests mid-construction, or early in the installation of the HRV and ducting.

GLOSSARY

Key terms, definitions, and abbreviations used in this case study arranged alphabetically

Air Admittance Valves:
Specialized plumbing devices that eliminate the need for plumbing vent stacks. They are one-way vents that open when there is a discharge of waste water within the drainage system. This releases a vacuum and allows air to enter the plumbing vent pipe which balances the pressure into the system in order to drain correctly. Currently, it is unclear whether BC local governments will integrate this alternative approach to plumbing vent stacks into the building code.

BC Energy Step Code
A voluntary provincial standard that provides an incremental and consistent approach to achieving more energy-efficient buildings that go beyond the requirements of the base BC Building Code.

Form Factor
The form factor is the ratio of external surface area to internal treated floor area used in the Passive House standard to assess the efficiency of a building form.

Heat Pump
A mechanical device that transfers thermal energy in the opposite direction of natural heat transfer by absorbing heat from a cold space and releasing it to a warmer reservoir. Heat pumps are used for space heating and cooling and heating domestic hot water.

Heat Recovery Ventilator (HRV)
A mechanical energy recovery system which recovers heat from the exhaust air to pre-heat the filtered incoming fresh air stream. This reduces the energy required to bring outside air up to ambient room temperature.

Non-renewable Primary Energy (PE) Demand
The total energy demand for operation of a building, including heating, cooling, hot water, lighting, and plug loads. To account for energy losses along the generation and supply chain, Passive House Institute (PHI) multiplies the building energy requirement by a PE factor.

Passive House
An internationally recognized certification program, developed by an independent research institute based in Germany. The program is intended to result in buildings with extremely low space heating and cooling needs and consequently lower environmental impacts, as well as a comfortable indoor temperature and air quality.

Passive House Planning Package (PHPP)
PHPP is an energy modelling tool specifically developed to design Passive House buildings and is based on a combination of several existing, proven and verified calculation methods that are compliant to the European standard for the thermal performance of buildings (EN 832).

Plumbing Vent Stack:
A drain-waste-vent that maintains neutral air pressure in the drains, allowing free flow of water and sewage down drains and through waste pipes by gravity.

Primary Energy Renewable (PER) Demand
To account for renewability of different energy sources, Passive House Institute developed new Primary Energy Renewable (PER) factors to replace PE factors.

R-value
The capacity of an insulating material to resist heat flow. The higher the R-value, the greater the insulating power.

Thermal Bridge:
An area or component of the envelope which has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer, causing heat loss to the exterior.

U-value
A measure of thermal performance or heat transfer through a surface due to conduction and radiation. The lower the U-Value, the more energy efficient the surface is.

Vancouver Zero Emission Building Plan
A phased plan that establishes specific targets and actions to achieve zero emissions in all new buildings in Vancouver by 2030.

NOTES

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A MULTI-UNIT RESIDENTIAL PASSIVE HOUSE

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