Final Report for a Design Charrette Held to Explore the Energy Efficiency Opportunities for the Essence of White Rock Multi Residential Building

Prepared for: British Columbia Ministry of Energy Mines and Petroleum Resources

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Executive Summary

A two day design charrette was held August 25th and 26th to explore alternatives for increasing the energy efficiency of a 14 story high rise MURB project to be constructed in White Rock B.C. by Co-operators Development Corporation Ltd. Through a series of presentations, brain storming sessions and the use of computer simulations the following conclusions were drawn:

- The building must be fully compartmentalized by air sealing all suites, corridors, lobbies, elevator shafts, stairwells and other spaces from each other for reasons of life safety, durability, indoor air quality and energy efficiency.
- Training of construction crews and provision of onsite airtightness testing during and after construction is absolutely necessary to ensure compartmentalization is achieved.
- The thermal performance and durability of exterior wall assemblies should be enhanced by modifications ranging from the use of XPS insulation between the poured in place concrete exterior wall and the interior insulated steel frame wall or the use of exterior insulated rain screen wall assemblies.
- Reducing the glazing area to 50% of the exterior wall from the present 70% should be considered
- Replace the existing aluminum framed glazing system with a fibreglass framed glazing system, this will raise the glazing system thermal performance while also reducing the cost
- In each suite incorporate a balanced mechanical ventilation system with distributed fresh air supply
- Reduce the size of corridor pressurization fans and replace the gas fired furnaces used for preheating corridor air with a heat pump unit connected to the geo – exchange field.
- Consider the incorporation of flat plate solar collectors to contribute to space and water heating requirements and also consider using the collectors as shading devices over south facing windows.
- The existing roof insulation value of RSI 7 (R40) is too high from a life cycle point of view and should be reduced to RSI 3.5 (R20)
- The following electrical energy conservation measures should be considered
    - Solar powered exterior lighting
    - Energy efficient elevators
    - Energy efficient (Energy Star) exterior lighting fixtures
    - High efficiency transformers
    - Central “green” switch in each suite to allow for switching off all unnecessary circuits when leaving

Introduction

The British Columbia Ministry of Energy Mines and Petroleum Resources (BCMEMPR) in partnership with Canada Mortgage and Housing Corporation (CMHC), Natural Resources Canada (NRCan), B.C. Hydro Power Smart and Co-operators Development Corporation Ltd. (CDCL) sponsored a two design charrette focused on exploring energy efficiency measures for the Essence of White Rock MURB project to be constructed south of Vancouver. The design charrette focused on exploring energy efficiency measures including innovative building envelope design, air leakage control and mechanical systems with new ventilation strategies. The following individuals participated in the design charrette contributing both presentations and participating in the brain storming sessions that followed. A copy of the charrette agenda is contained in Appendix A and a summary of reference materials supplied to participants is contained in Appendix B

Individual	Organization	Area of Expertise
Ken Wong	CDCL (developer's representative)	Project Management
David O'Sheehan	Abbarch Architecture Inc. (project architect)	Architectural Design
Goran Ostojic	Cobalt Engineering (project mechanical engineer)	Mechanical Systems Design
Warren Knowles	RDH Building Engineering	Building Envelope Durability and Fenestration
Curt Hepting	Enersys Analytics	Energy Modeling
Colin Genge	Retrotec Inc	Building Air Tightness Testing,
Bojan Andjelkovic	B.C. Hydro Power Smart	Energy Management Engineering
Joe Thwaites	Taylor Munroe Energy Systems	Solar Water Heating Systems Design and Installation
Woytek Kujawski	CMHC	Sustainable Building Design, Integrated Design Process, Building Environmental Assessment Methods
Andrew Pape-Salmon	BCMEMPR	Project Management Energy Programs
Chris Mattock	HD+C Ltd.	Charrette Facilitator, Energy Efficiency and Green Building Design
Daisy Chan	Nemetz & Associates	Lighting Design

Individual	Organization	Area of Expertise
Luis Damy	B.C. Hydro Power Smart	High Performance Building Marketing
Greg Morandini	B.C. Hydro Power Smart	Energy Management Lighting
Tony Mauro	B.C. Hydro Power Smart	Energy Management Smart Metering Systems

The Essence of White Rock Project

The current design calls for a 5 story mixed use commercial and residential building in phase 1 and a residential building in phase 2 consisting of 5 story townhouses forming a podium and a 14 story residential tower. The design charrette primarily focused on the 14 story tower. A summary of the tower's characteristics as presented in the preliminary design are shown below.

- High rise tower of 14 floors surrounded at it's base with 5 story townhouses
- Tower incorporates 110 suites totalling 131,183 sq. ft.
- 70% of the exterior wall area is in glazing consisting of an aluminum frame double glazed, low E window wall system
- The opaque section of the exterior wall consists of poured concrete with fibreglass batt insulated 3 5/8" steel stud wall behind
- 3 meter (9'-10") slab to slab height, floor to finished ceiling height of 2.6 meters (8'-6")
- Concrete slab eyebrows extend 1'– 6" on all floors on all elevations, providing limited shading on south side and limited protection of the walls from rain
- Heating and cooling are provided by distributed packaged heat pump units located in each of the suites. The heat pumps will shuttle heat around the building as well as draw heat from and dump heat too a series of ground loop heat exchangers (geo-exchange field)under the building. The heat pumps will have a COP in the range of 3 to 3.2. For peak heating demand a gas fired boiler will provide back up. When the cooling capacities of the ground loops are exceeded an evaporative cooling tower will be utilized. The geo exchange field, cooling tower and gas fired boiler will be financed by Terasen Energy Services who will then charge the building's occupants for the energy these systems provide. The geo exchange field and backup systems will service both phases 1 and 2 of the project.
- Using the distributed heat pumps results in individual metering of space conditioning energy consumption as each heat pump is supplied through the electrical meter assigned to the suite it services.
- Heated and cooled air will be distributed within the suites by way of forced air ductwork.

– Hot water will be provided by heat rejected from the heat pumps and supplemented by the gas fired boiler, no individual metering of the domestic hot water will be done.
– Ventilation to be provided by low noise bathroom exhaust fans and range hoods with heated make up air supplied by a gas fired furnace and the corridor pressurization fan by way of the undercut suite entry doors.
– Electric fireplaces will be used in selected suites.
– Corridor and stairwell lighting will be controlled be controlled by motion detector switches
– 70% of lighting in the parking garage will be controlled by motion detector switches the remaining 30% will be left on continuously for security reasons.

Fig 1: Essence of White Rock aerial view of site

Fig 2: Rendering of Phases 1 & 2 Essence of White Rock Project

Fig 3: Site plan

Fig 4: Johnson Street (west) elevation

Fig 5: Thrift St. (south) elevation

Fig 6: George St (east) elevation

Fig 7: North Elevation

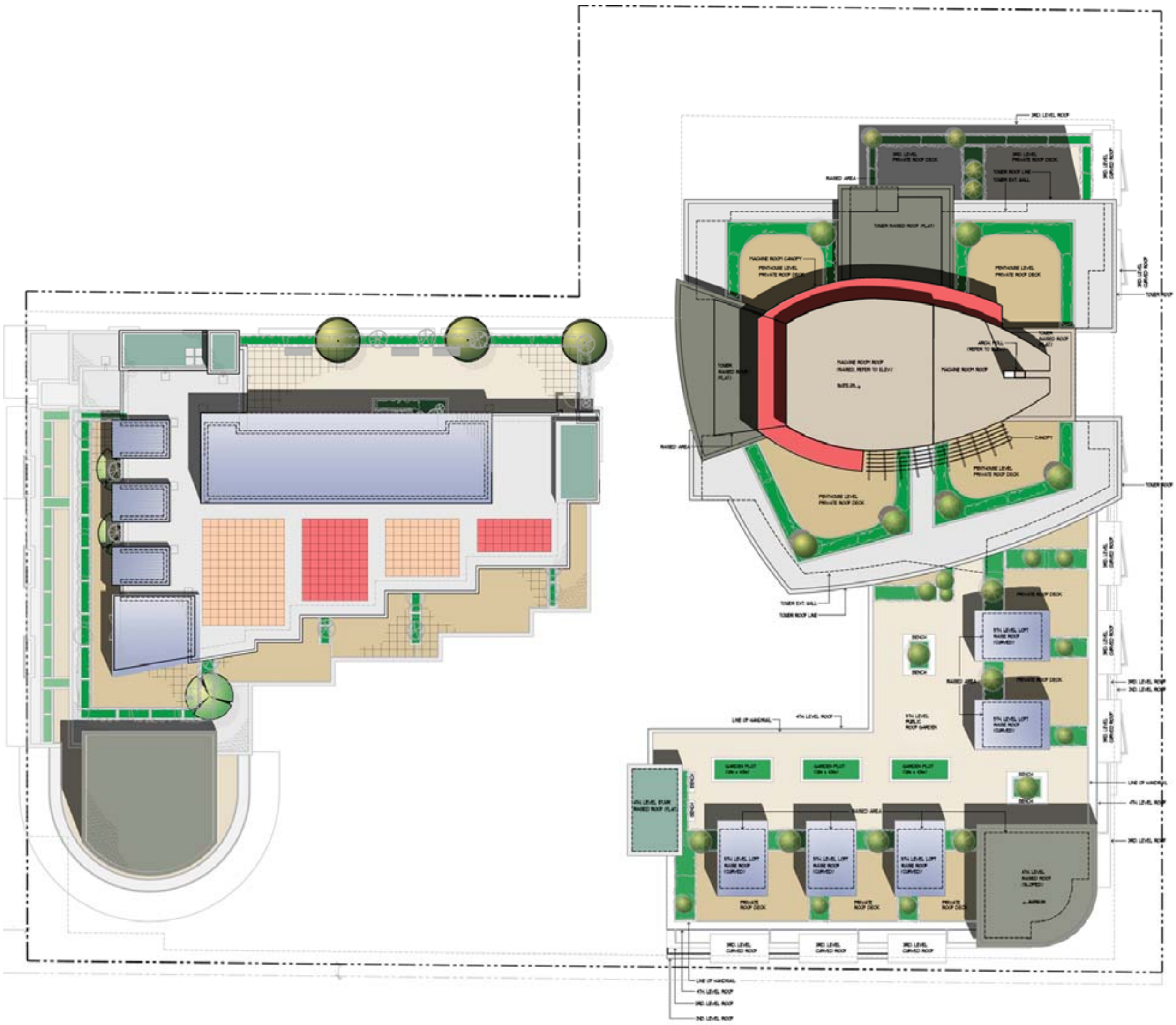


Fig 8: Roof Plan

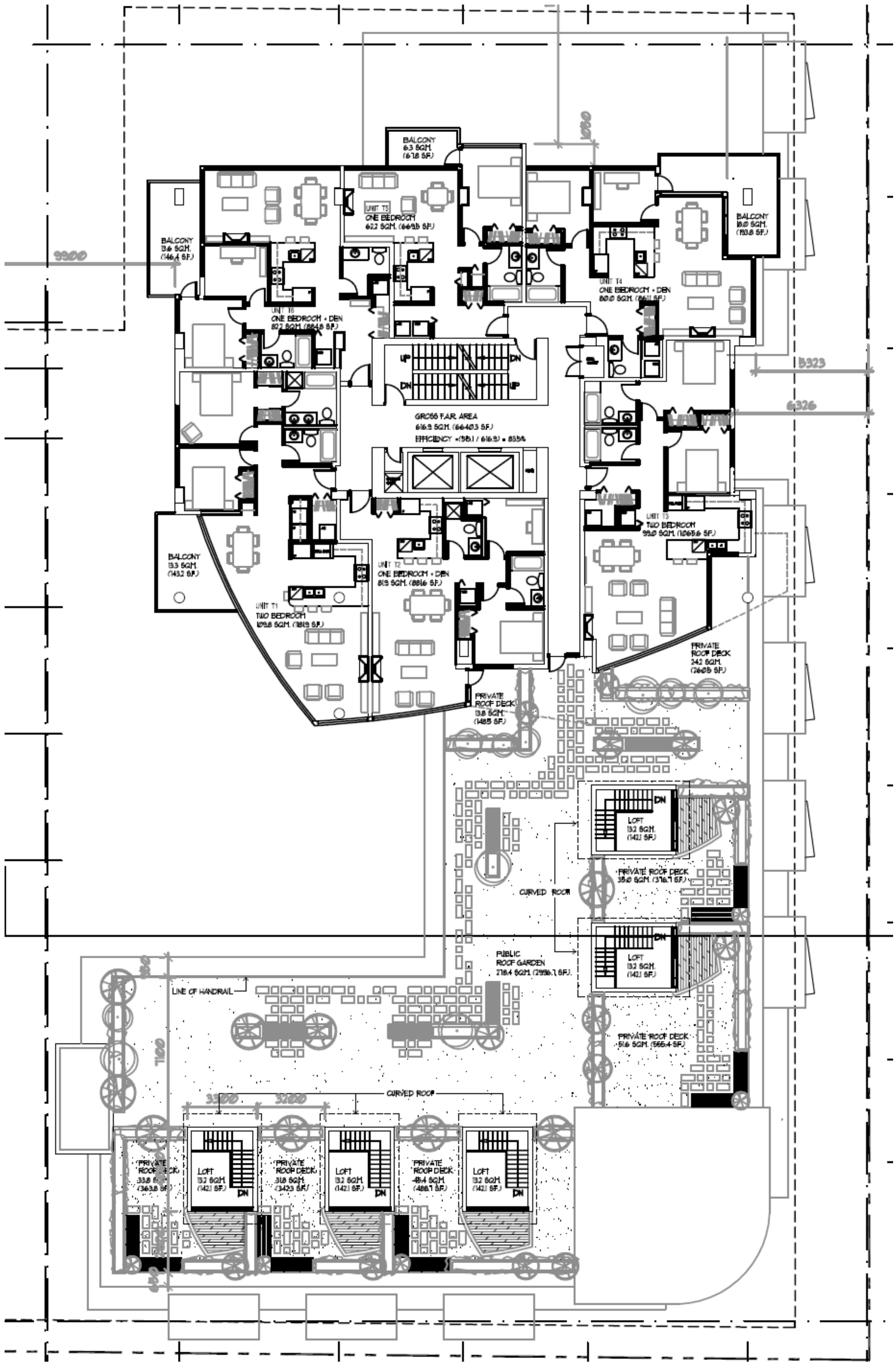


Fig 9: Floor Plan 5th floor of Tower showing roof of surrounding townhouse units

Presentations and Brian Storming Sessions

A series of presentations were made by the charrette participants. This was to

- Inform the group about the current status of the project
- Inform the group of the state of the art practices in each of the areas of the building that relate to energy performance
- To present recommendations for the project as well as propose performance targets.

Following the presentations a brain storming session was held to explore the topic presented and how it relates to the Essence of White Rock Project.

Following is a short summary of each of the presentations and the brain storming that followed.

Presentation Title: **The Purpose of the Design Charrette**
Presenter: Chris Mattock HD+C Ltd.

Not all participants were familiar with the design charrette process so a short presentation was given summarizing how a design charrette is conducted and the benefits to be derived from this process.

The steps followed in the design charrette were summarized as follows

- Presentation on project program and preliminary design
- Presentation on a specific topic with a suggested performance target(s)
- Brainstorming on solutions related to that topic and how the proposed solution interacts with other aspects of the building
- Consensus on performance target and solution
- Where possible simulation used to model impact of the suggested changes
- Successive presentations and brain storming on solutions and performance targets
- Charrette concludes with a package of suggested performance targets and solutions

The benefits of the design charrette

- Potential for reducing overall costs and enhancing building performance
- Creative synergy occurs when all stakeholders participate - producing innovative solutions
- Experience shows that time invested early is far more effective at improving quality, performance and affordability than at any other stage
- Improves communication among all players
- Helps to generate a buy-in by all parties

- Helps to spread knowledge across disciplines
- Produces optimized integrated solutions that are more than the some of their parts
- Identifies the right technologies

Presentation Title: **Overview of Essence of White Rock Project**
Presenter: David O'Sheehan: Abbarch Architects
David reviewed the design of the project as presented starting on page 2 of this report. He pointed out that any changes to the exterior wall would have to meet the intent of the DP which calls for a glass clad building.

Presentation Title: **Review of Baseline Building Model Characteristics and Preliminary Summary Results, including comparison to Model National Energy Code for Buildings**
Presenter: Curt Hepting: Enersys Analytics Inc.

Curt clarified information he had initially received on the project related to it's energy performance

- The double glazed, low E, aluminum frame windows have a composite RSI value of 0.4 (R 2.3) a shading coefficient of 0.38 and a visible light transmission of 70%
- 30% of window area assumed to be operable and 70% fixed.
- The balconies and slab edge eyebrows have an insulating value of RSI 0.176 (R1)
- The concrete walls with 92mm (3 5/8")thick steel studs and fibreglass insulation have a composite insulating value of RSI 1.23 (R7)
- The composite insulation value for the tower exterior walls when taking into account insulated walls, glazing, eyebrows and balconies was RSI 0.528 (R3)
- Garage exposed floor area has an insulating value of RSI 3.5 (R20)
- The roof is insulated to RSI 7 (R40) and could probably not be justified on a life cycle costing basis
- Building envelope air leakage is mandated by MNECB to be 0.6 cfm / sq ft exterior skin or 0.2 ach natural. The consensus was that the actual air change rate is in all likelihood about double this value.

Using a DOE 2.1 based screening tool developed by his firm Curt ran an initial simulation and provided the team with the following information.

- Preliminary energy modeling of the tower shows that it will consume 33% less energy than called for the Model National Energy Code for Buildings (MNECB). This largely due to the efficiency of ground source heat pump space conditioning system which has a COP of 3 to 3.2.
- The geo-exchange field will provide 65% of the heating on an annual basis providing heat for 98.5% of all heating hours.

- The geo-exchange field will provide 90% of the cooling on an annual basis and have enough capacity to handle 50% of the peak cooling load.

Initial Building Envelope Brain Storming Session Summary
Since the window wall area represents the largest single component of the building envelope improvements to it's performance were discussed including reducing it's area and upgrading it's thermal performance. Warren Knowles noted that other frame types are available including commercial fibreglass windows that have a higher thermal resistance than aluminum windows and run about \$54 / m^2 (\$5/ft^2) cheaper. The insulation value of a double glazed low E fibreglass window assembly is RSI 0.59 (R3.4) vs RSI 0.4 (R 2.3) for an aluminum frame window with the same insulated glass unit. Using the fibreglass windows would require obtaining a variance under the Vancouver Building Bylaw or the BCBC. This is estimated to cost about \$5,000 per building after the first precedent is established. Warren noted that staff at RDH are involved with a fibreglass manufacturing business.

Different wall assembly options were also discussed. Along with reduced glazing areas, continuous exterior insulation wall assemblies were suggested to improve both the thermal performance, and other building envelope performance characteristics.

Presentation Title: **Field experience with airtightness testing of MURBs and targets for air barrier performance**
Presenter: Colin Genge, Retrotec Inc.

Colin Genge is a manufacturer of airtightness testing equipment and has airtightness tested numerous buildings and is currently developing a large building airtightness testing protocol with the US Army Corp of Engineers made a presentation on his experience airtightness testing MURBs, the following are his observations:

- The benefits of airtightness and compartmentalization for MURBs include
    - Energy savings
    - Air Quality
        - Humidity control
        - Control of ingress of outdoor pollutants
        - Control of movement of indoor pollutants
    - Structural integrity
        - Prevention of moisture problems
    - Safety
        - Controlling smoke movement in fires
- Typical problems caused by high levels of air leakage poor compartmentalization in high rise buildings include

- Movement of cigarette smoke and cooking odors between suites
- Inability of the heating system to heat the building
- Dry air
- Entry of pollution from outdoors
- Noise entry
- Interstitial condensation and structural damage
- Mechanical ventilation system operating in reverse
- Corridors operating under negative pressure

- Where high rise buildings tend to leak air
  - In heating climates high rise buildings tend to leak air between the inside and outside mostly at the base and the top of the building, this is typically driven by the stack effect.
  - Air sealing leaks both high and low in the building will provide more benefit than air sealing towards the centre height of the building.
  - Air leakage also occurs between floors and between all areas of the building including elevator shafts, suites, corridors, stairways and parking garages etc. All of these volumes should be air sealed from each other to minimize the stack effect and movement of odors, smoke and other air borne contaminants around the building.
- The need for a uniform airtightness testing standard
  - A wide range of airtightness testing standards exist around the world leading to confusion and a difficulty in comparing data
  - Colin suggests that one point readings measuring an equivalent leakage area (EqLA) in cm^2/m^2 ($in^2/100ft^2$) at 50 Pascal pressure difference be used. Both pressurization and depressurization tests should be run to calculate the EqLA value which is then averaged as stack effect can affect test values only run in one direction
  - An area of leakage opening per unit of exterior envelope area is easier to visualize than other methods and taking readings at 50 Pa typically makes the readings more stable than at lower pressures.
  - The following tables show equivalencies between commonly used airtightness measurement units and the EqLA@ 50 Pa method for buildings of different levels of airtightness.

Standards for Leakier Buildings

		Normalized EqLA at 50 Pa	
		cm2/m2	in2/100 ft2
ASHRAE	0.60 cfm / ft2 at 75 Pa	4.2	6.0

Standards for Average Buildings

		Normalized EqLA at 50 Pa	
		cm2/m2	in2/100 ft2
ASHRAE 90.1	0.30 cfm / ft2 at 75 Pa	2.1	3.0
UK Section L for Normal Commercial	5 (m3 /hr) m2 at 50 Pa	2.5	3.6

LEED for apartments same as ASHRAE

		Normalized EqLA at 50 Pa	
		cm2/m2	in2/100 ft2
LEED	1.25 in2 EqLA / 100 ft2 at 4 Pa	2.1	3.0

Standards for Tight Buildings

		Normalized EqLA at 50 Pa	
		cm2/m2	in2/100 ft2
ASHRAE 90.1	0.10 cfm / ft2 at 75 Pa	0.7	1.0
Canadian R-2000	0.7 cm2/m2	0.9	1.3
Best Practice in UK	2 (m3 /hr)/ m2 at 50 Pa	1.0	1.43
BCBC for opaque barriers, < 55% RH	0.10 (l/s)/m2 at 75 Pa	0.14	0.2

Recommended Airtightness Levels for Buildings and Their Components

- 0.7 cm2/m2 @ 50 Pa measured with all intentional (intakes and exhaust) openings covered
  - Exterior building envelope,
  - All 6 sides of apartment units,
  - Vertical Interior partitions,
  - Stairwells, shafts and chases
- 0.07 cm2/m2 @ 50 Pa
  - Horizontal slabs

Areas of the building that must be compartmentalized

- Individual suites
- Corridors
- Lobbies
- Stairwells
- Garbage chutes
- Elevator shafts
- Garages
- Vented mechanical rooms
- Garbage compactor room
- Emergency generator room
- High voltage rooms
- Shipping docks
- Elevator rooms
- Workshops

Recommended measures to enhance airtightness and compartmentalization

- Air seal the drywall on both faces of party walls to the slabs above and below and to the exterior wall and the corridor wall.
- Cover all concrete block walls with an air barrier coating (ensure it meets fire spread requirements)
- Seal all service shafts at each floor
- Air seal plumbing, electrical, cable and other penetrations where they leave service rooms
- Air seal elevator rooms- cable holes, door controller cable holes, bus bar openings
- Weather strip stairwell fire doors, corridor entry doors
- Enclose elevator lobbies from slab to slab
- Use electronically not thermally actuated fire dampers to control smoke and air movement
- Use electronically actuated exhaust fan dampers
- Provide high quality weather stripping around all suite entry doors
- Improve weather stripping around elevator doors

Ensuring Airtightness in Construction

- Contractor air sealing training essential to get desired results
- Provide onsite training to construction crews on air sealing techniques using airtightness testing equipment as part of the procedure
- Contractor measurement of air leakage necessary as a learning and quality assurance tool
  - Allows the crew to check and see that they are meeting the specified EqLA value
  - Allows installation corrections be made immediately
- Air-leakage measurements are instantaneous using using EqLA @ 50 Pa and automated door fan test equipment
- Materials
  - Durable sealants and foams, where acting as fire stop must meet applicable regulations
  - Durable weather stripping required on suite entry doors from corridors– reduces long term maintenance
- Estimated incremental cost per suite $500

Suggested airtightness testing regime for quality assurance purposes at completion of a MURB

1) Measure total envelope to outdoors
2) Measure 10% of all individual apartments at random
3) Measure top floor leakage to outdoors
4) Measure bottom floor leakage to outdoors
5) Measure randomly selected intermediate floors to outdoors
6) Measure horizontal slab leakage
7) Measure stairwell leakage
8) Measure vertical chase and shaft leakage

Airtightness and Compartmentalization Brain Storming Summary

The consensus was that the exterior envelopes of new MURBs are reasonably airtight because of building envelope durability concerns but that compartmentalization was necessary for the following reasons:

- Life safety – prevention of smoke from fires being transported through the building
- Ventilation system effectiveness – reducing stack pressures in each suite will allow balanced ventilation systems to operate as intended
- Energy efficiency – compartmentalization reduces stack forces over the height of the building thereby reducing a major cause of infiltration and exfiltration and space conditioning energy consumption
- Minimizing condensation formation inside insulated cavities due to exfiltration of warm moist indoor air

- Preventing the movement of cigarette smoke and other odours between suites
- Reducing noise transfer between suites

A set of specifications will need to be developed for compartmentalization Colin Genge and David O'Sheen to collaborate.

Party walls between suites will require particular attention;

- The drywall on both faces of the party wall will need to be air sealed to the slab above and the slab below as well as to the wall separating the suite from the corridor and the exterior wall.
- Where connections are made to exterior walls, depending on how the exterior walls are insulated, attention must be made paid to providing a thermal break to ensure the drywall stays above the 80% RH temperature of the indoor air to prevent mould growth. All sealants must be rated as fire stop materials.
- All wiring and plumbing penetrating either drywall faces of the party wall must be air sealed to the drywall at the penetration.
- Any electrical boxes placed in the party wall must be made airtight and air sealed to the drywall.

Presentation Title: **Fenestration and cladding options for enhanced energy efficiency and targets for performance**
Presenter: Warren Knowles, RDH Building Engineering

Warren Knowles of RDH made a presentation on the energy and durability performance of MURB envelopes.

Preliminary findings from an ongoing study by RDH, CMHC, BC Hydro, Terasen Gas and HPO on the energy use of buildings included the comparison of energy use of single family dwellings to high-rise MURBs in BC:

- Typical single family home energy use per square meter of exterior envelope 93 kWhr/m^2/yr
- Mid and high rise MURBs energy use per square meter of exterior envelope 446 kWhr/m^2/yr

Glazing Systems
The most common glazing systems for MURBs in the Vancouver market consist of aluminum framed window walls. These assemblies even with a thermal break have a high enough thermal conductivity so that condensation can form on the inside face of the glazing and frame during winter. Condensation can be reduced by increasing ventilation rates to lower indoor relative humidity. In many cases occupants particularly of upper floor units open windows to vent moisture and control overheating. This indicates that conventional mechanical ventilation systems do not provide adequate air

change and due to the lack of compartmentalization upper floor units overheat due to the stack effect. All of this leads to increased energy consumption.

Condensation on the interior face of windows can be decreased by raising the surface temperature of the window assembly. This can be done by washing the interior of the window with heated air, using energy to solve the problem, or by raising the thermal resistance of the window assembly by using lower conductivity frame materials such as fibreglass and higher performance insulated glass unit. Fibreglass window frames are not currently accepted for use in non combustible construction in the same manner in which aluminum frame windows are used. At least one manufacturer of fibreglass windows is pursuing acceptance under an Alternate Solution Approach (ASA), once this has been successfully completed it will simplify the process for other projects and reduce the cost of approvals to an estimated $5000.

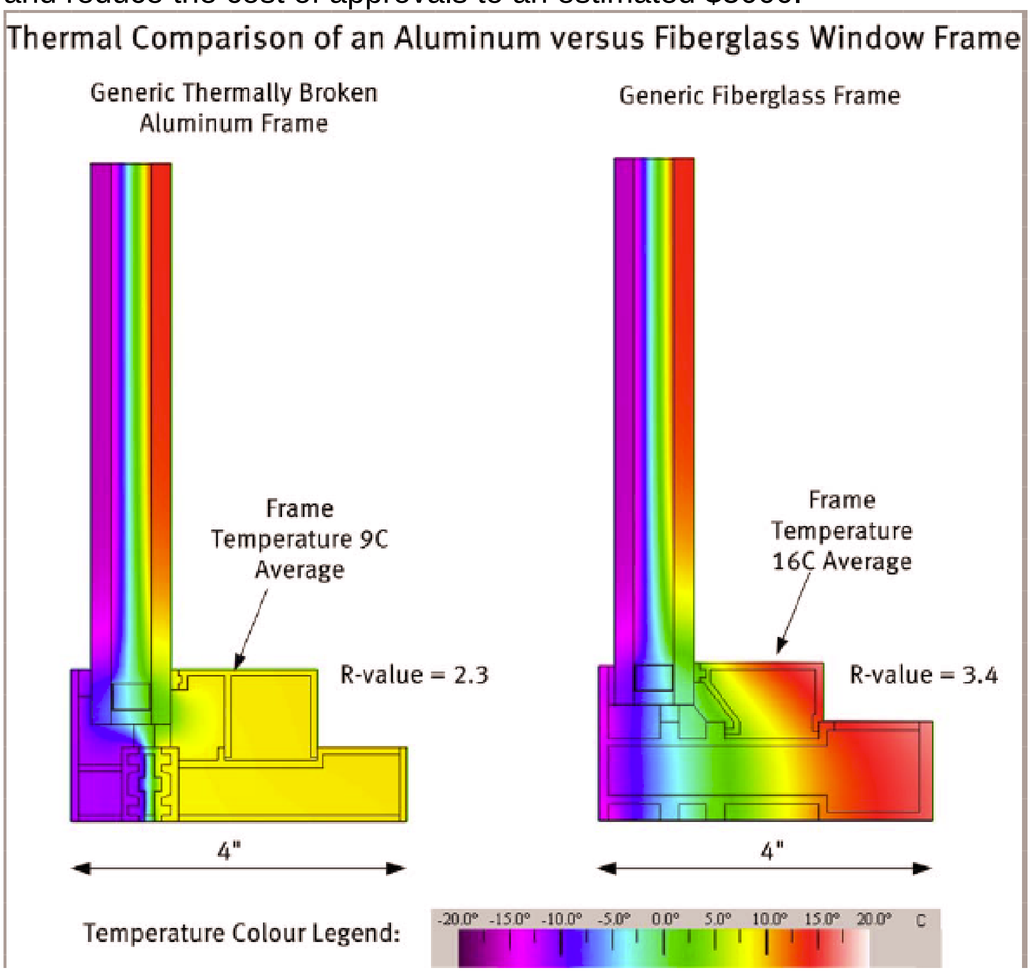


Fig 10: Thermal modeling of the temperature gradients across a generic aluminum window frame versus a generic fibreglass window frame. The lower thermal conductivity of the fibreglass frame results in higher indoor surface temperatures and lower heat loss. (Courtesy RDH Building Engineering)

Refer to appendix B which shows proposed spandrel details using fibreglass windows.

It was noted that although many window manufacturers supply argon gas filled windows not all will guarantee the level of argon gas within in the units.

The following approximate cost figures were presented for various wall assemblies

	$ / ft^2	$ / m^2
Poured in place reinforced concrete	40	430
Brick veneer	48	516
Stucco	40	430
Metal Panel	40	430
Aluminum Composite	50	538
Window Wall	65	700
Curtain Wall	95	1022

The existing opaque wall assembly for this project consists of a poured in place concrete wall with insulated steel stud behind, a very typical approach in the Vancouver MURB market. The following observations were made on the performance of these types of wall assemblies

- They typically provide an acceptable air barrier.
- This type of wall relies on the continuity of the face seal to manage exterior moisture. Discontinuities such as cracks or holes in the concrete are likely to result in rain penetration, typically due to capillary forces
- To prevent rain penetration it is necessary to provide two lines of defence (a two stage seal) at all joints and penetrations through the concrete through the use of a combination of sealants, bentonite clay strips or crystalline water proofing. These and other solutions for poured in place concrete walls are covered in “Builder Insight #3 Poured-in Place Concrete Residential Construction: Moisture Management Strategies” published by the British Columbia Homeowner Protection Office.
- Moisture related problems can also occur as a result of vapour diffusion, including inward or reverse vapour drive.
- Moisture migration through the concrete can also occur due to it’s porous nature. This can be reduced with the use of elastomeric coatings on the outside face of the wall.

- The wall's performance is improved by the use of eyebrows located at each floor level; these overhangs reduce the exterior wetting of the walls.
- Due to the high thermal conductivity of concrete, the inside face of concrete walls in winter typically run at or below the dew point temperature of the indoor air. This is exacerbated by the placement of an insulated steel stud wall on the inside of the concrete. If indoor air is able to circulate inside this assembly, significant amounts of moisture can be deposited on the inside face of the concrete wall.
- Accumulation of moisture at the concrete / stud wall interface can lead to mould growth, corrosion of the steel studs and wetting of the batt insulation further degrading thermal performance.

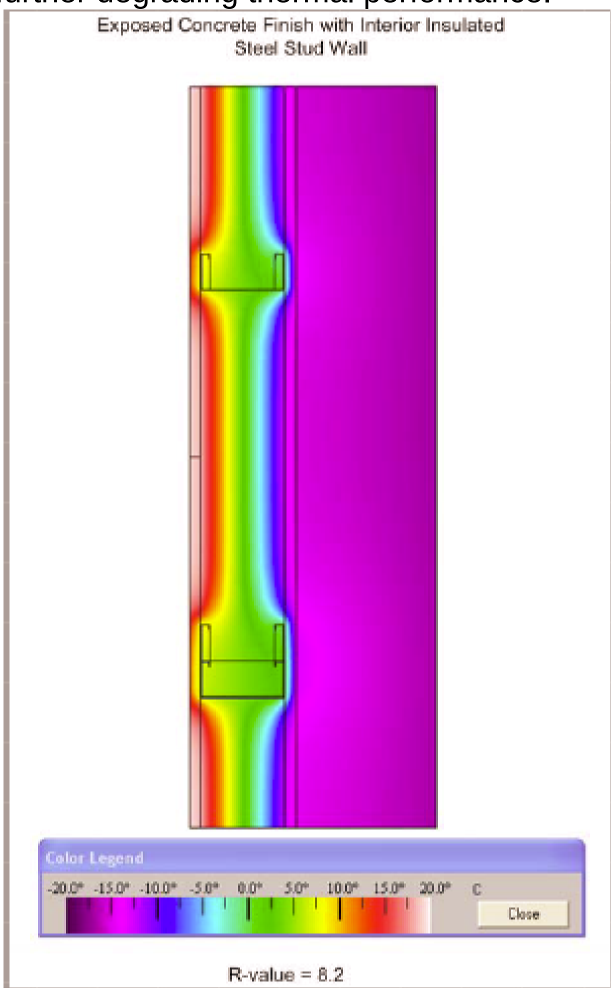


Fig 11 : Results of thermal modeling showing the temperature gradients across the type of wall assembly originally suggested for this project (Courtesy RDH Building Engineering Ltd.)

- An improvement to reduce the risk of these potential problems is to place a sheet of extruded polystyrene (XPS) foam insulation (2" or

50mm thick) between the steel stud and the inside face of the concrete. XPS has the following benefits

- Restricts air movement within the wall cavity.
- The low permeance of XPS will resist reverse vapour drive and diffusion of interior moisture vapour outward.
- The temperature at the inside fact of the foam board will be raised high enough to typically be above the dew point temperature of the indoor air, reducing the potential for condensation on the steel studs
- A greatly enhanced thermal performance with a composite wall insulating value in the range of RSI 3 (R17)

- Similar performance can be obtained if the steel studs are held back (minimum of 25mm (1”)) and closed cell urethane foam insulation is sprayed on the inside face of the concrete wall and between the steel studs.

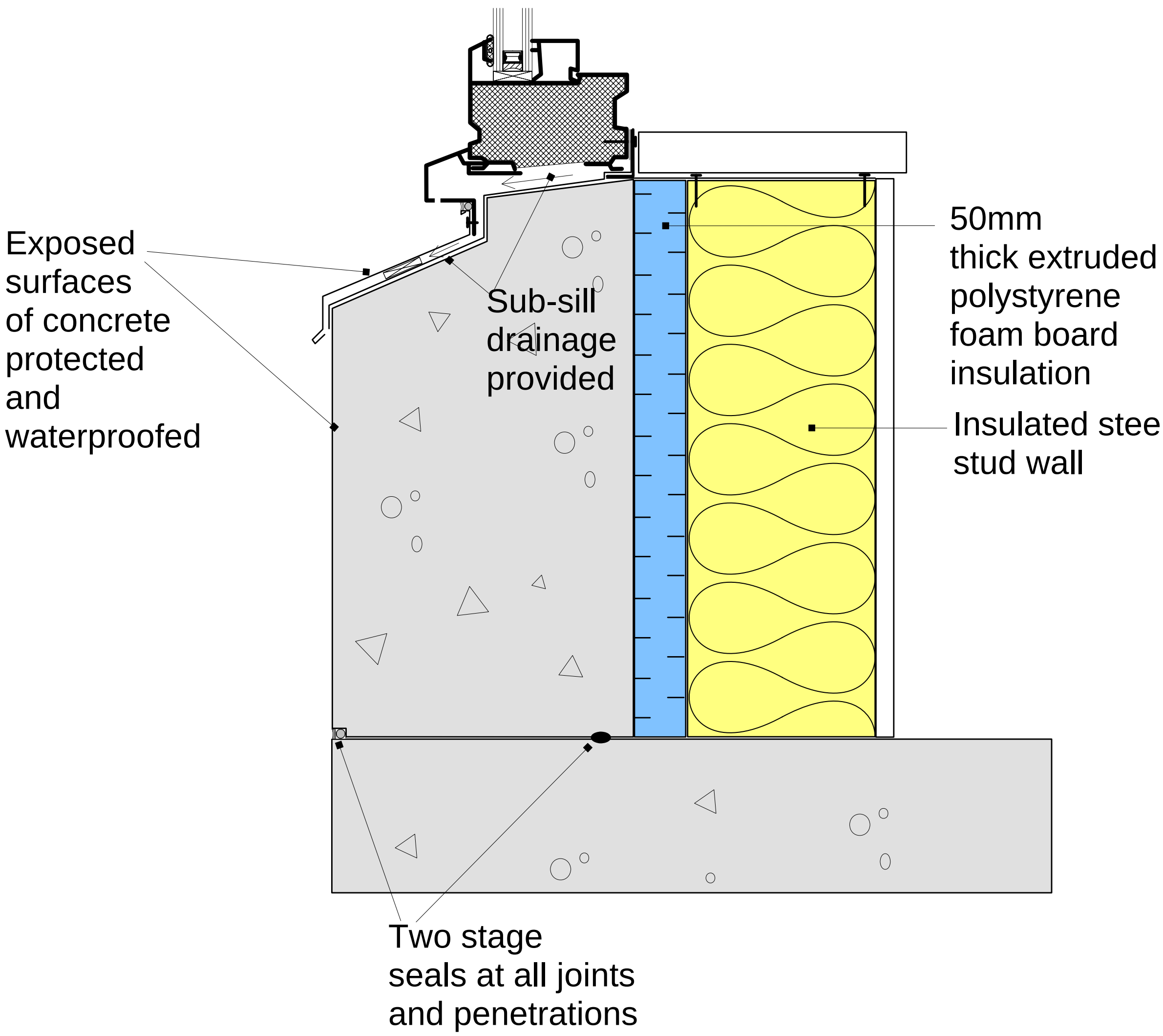


Fig 12: Glazing and wall assembly that enhances energy efficiency and durability of poured in place concrete walls

- Placement of XPS or spray urethane on the inside face of the concrete wall will not provide continuous insulation on the exterior concrete walls (per ASHRAE 90.1) and reduce thermal bridging and associated heat loss at the floor slab wall connection so the thermal performance of the wall is still compromised.
- Heat losses at the slab edge can lower the slab temperature to where the RH of indoor air adjacent to the slab is at or above 80%. Under these conditions mould growth can occur on the underside or top surface of the slab adjacent to the exterior wall.
- Computer modeling of heat flows through concrete slab / concrete exterior wall connections show that heat flow is not significantly increased when the slab extends through the wall to form a fin or balcony due to the large amount of thermal bridging that already exists.

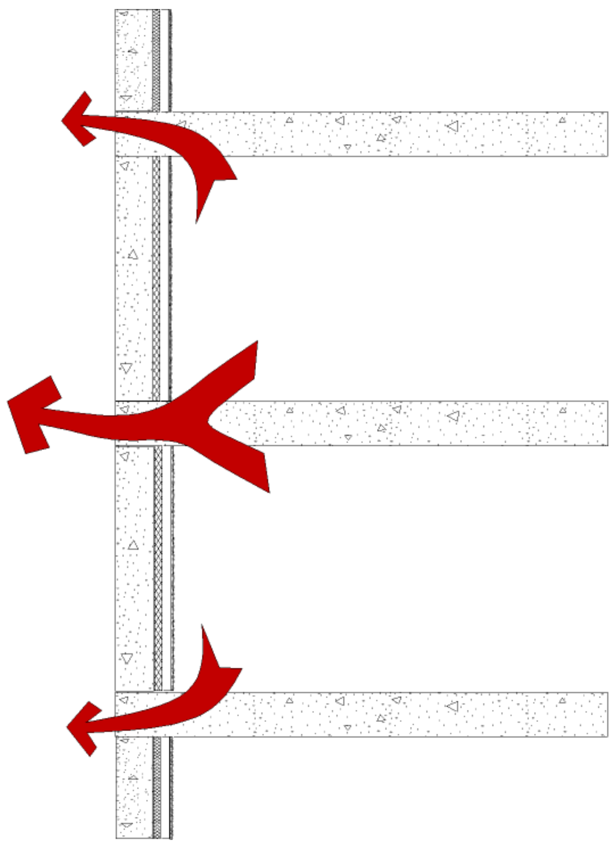


Fig 13 : Heat flow through slab edges in a building with interior insulated poured in place concrete exterior walls.

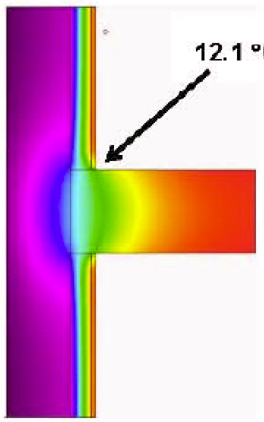
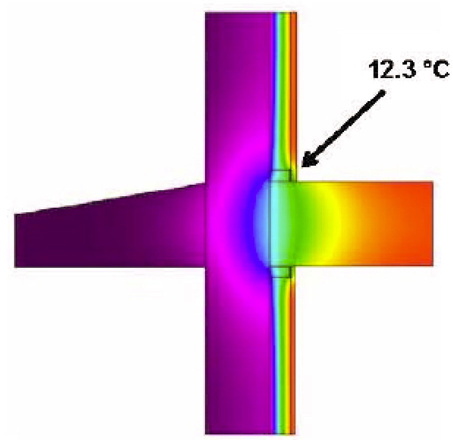
1. Floor slab to wall intersection of W2.	2. Floor slab to wall intersection or W2 incorporating a concrete eyebrow on the exterior side.
	

Fig 14: Thermal modeling of floor wall intersection shows eyebrow does not significantly change the heat loss and temperature of the edge of the floor slab (Courtesy of RDH Building Engineering Ltd.)

The envelope durability and thermal performance of a poured in place concrete wall will be most improved through the use of exterior insulation and rain screen cladding system.

- Using exterior insulation raises the temperature of the wall assembly and when carried past the slab edge significantly reduces heat losses in that area.
- The lowest cost approach for this type of assembly is to use vertical Z girts attached to the face of the concrete or a steel stud framed wall assembly with board insulation placed between the Z girts. A 12mm to 19mm (½" to ¾") gap is left between the insulation and the back side of the exterior cladding (typically stucco or metal). A 100mm (4") Z girt with R4.3/inch insulation will have a composite R value of approximately 8.8 for this particular building also accounting for losses at balconies
- Alternatively an exterior insulation system using a brick veneer cladding can be utilized. Due to the reduced thermal bridging with brick ties when using 75mm (3") of semi rigid insulation a composite insulating of R 10.2 is obtained for this particular building also accounting for losses at balconies

Presentation Title: **Balcony thermal break strategies**
Presenter: Chris Mattock, HD+C Ltd.

Chris Mattock made a presentation on the techniques for reducing heat loss through balconies or overhangs constructed by passing the floor slab through the exterior wall of the building. The strategies can be summarized as:

- Separation

- Encapsulation
- Thermal Isolation

Separation involves structurally supporting the balcony so that it is separate from the building. Encapsulation involves wrapping the balcony with a rigid insulation to reduce heat losses. The third method involves incorporating a cast in place thermal break in the slab to reduce it's conductivity.

Fig 15: Balconies separately supported from the building

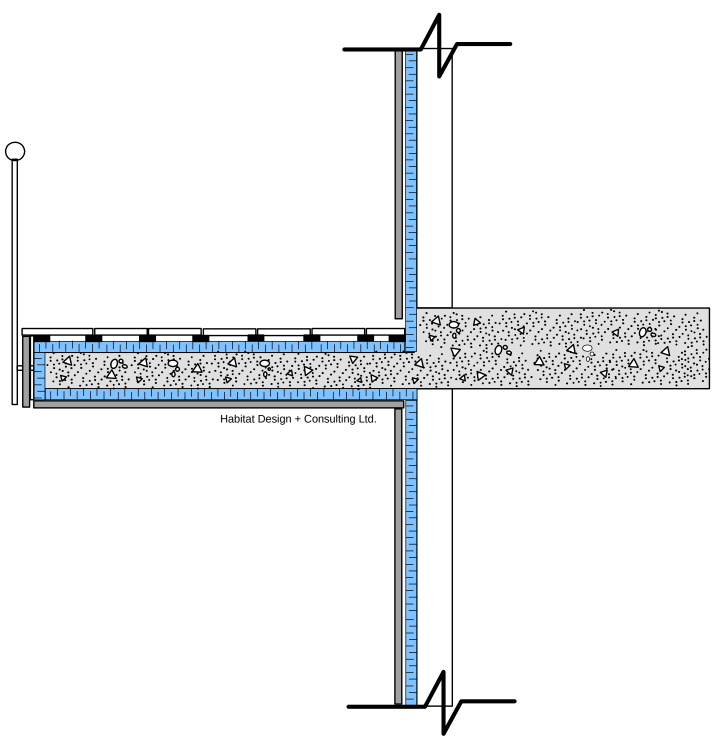


Fig 16: Balcony encapsulated in rigid insulation

Fig 17: Cast in place thermal break (Courtesy Schoeck Corporation)

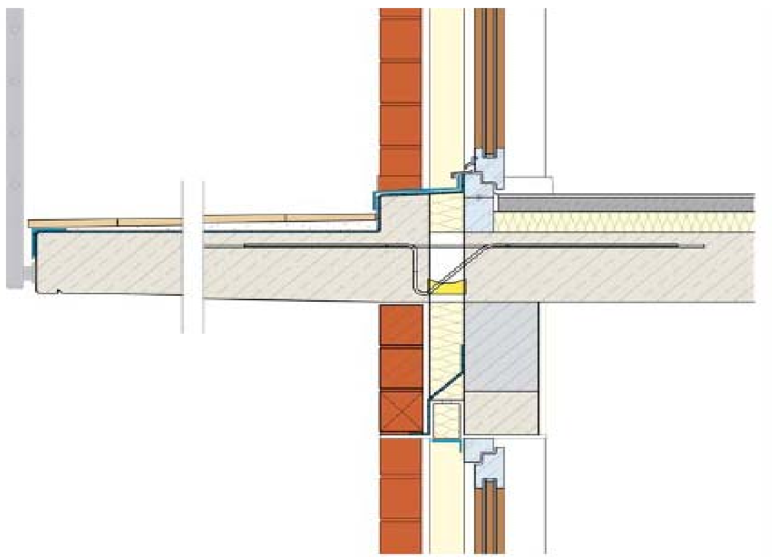


Fig 18: Balcony incorporating a cast in place thermal break (Courtesy Schoeck Corporation)

Building Envelope Brain Storming Summary

During the rest of day 1 and the part of the morning of day 2 various modifications to the building envelope were discussed and modeled using the Enersys Analytics modeling tool, the results are summarized as option A through H below

Option A			
	Description	Capital Cost Increase	Capital Cost Savings
Glazing Area	70% of wall area in glazing (same as current design)		
Glazing System	Double glazed low E fiberglass frame windows RSI 0.6 (R 3.4) $58.80/m2 ($ 5/ ft2) cheaper than aluminum window wall		$180,000
Wall system	Poured in place concrete with insulated steel stud		
Roof	Concrete with R40 foam insulation		
Eyebrows	Retained as per original design		
Horizontal shade over south facing windows	457mm (1'-6") deep eyebrow		
Compartmentalization	Building fully compartmentalized estimated cost $500 per unit	$55,000	
Ventilation System	Supply duct to the heating system return air plenum and small supply fan	$20,000	
Corridor pressurization fan and supply air heating system	Corridor pressurization fan (MAU) size decreased due to compartmentalization, with roughly 2/3rds of building outside air heating diverted to distributed suite heat pumps. Utility bill savings not included in analysis, but approximated at $6400/year (for strata, but tenant costs will increase by roughly $3200/year)	unknown, although increase in heat pump size likely would exceed decrease in MAU	
Geo exchange field	Down sized due to lower heating load		$60,000
Total energy savings over base case	3%		
Heating energy	18% energy savings in heating energy		
Cooling energy	60% increase in cooling energy, although this likely is overstated with the likely increase in opening of windows not accounted for.		
Annual savings in energy costs	$3,400		
Affect on capital cost of project	Total capital cost of the project lower than baseline due to reduction in glazing costs and down sizing of geo exchange field		$240,000
Net savings or cost to the developer	Cost savings from reduced MAU would be realized, but likely more than made up for with the increase in suite heat pump sizes.		$105,000
% under the MNECB	33%		
IAQ Implications	Compartmentalization will minimize odor transfer between units and in combination with balanced ventilation system will ensure higher indoor air quality. Higher performance windows will reduce potential for surface condensation and mould growth on inside face of glazing system. Poured concrete walls with insulated steel stud and uninsulated slab edges and balconies still present a risk of mould growth.		
Thermal comfort implications	Higher thermal comfort due to higher surface temperature of glazing system and higher level of airtightness		
Building envelope implications	Conventional cast in place concrete wall functions as a face sealed system. To provide adequate resistance or rain penetration recommendations in HPO Builder Insight # 3 "Poured in Place Concrete Residential Construction: Moisture Management Strategies" should be followed		

Option B			
	Description	Capital Cost Increase	Capital Cost Savings
Glazing Area	70% of wall area in glazing (same as current design)		
Glazing System	Double glazed low E fiberglass frame windows RSI 0.6 (R 3.4) $58.80/m2 ($ 5/ ft2) cheaper than aluminum window wall		$180,000
Wall system	Steel stud wall with RSI 2.64 (R15) exterior rigid insulation and brick veneer cladding composite wall insulating value RSI 1.8 (R10.2)	$160,000	
Roof	Concrete with R40 foam insulation		
Eyebrows	Eliminated		$210,000
Horizontal shade over south facing windows	600mm (2') aluminum fin	$60,000	
Compartmentalization	Building fully compartmentalized estimated cost $500 per unit	$55,000	
Ventilation System	Supply duct to the heating system return air plenum and small supply fan	$20,000	
Corridor pressurization fan and supply air heating system	Corridor pressurization fan (MAU) size decreased due to compartmentalization, with roughly 2/3rds of building outside air heating diverted to distributed suite heat pumps. Utility bill savings not included in analysis, but approximated at $6400/year (for strata, but tenant costs will increase by roughly $3200/year)	unknown, although increase in heat pump size likely would exceed decrease in MAU	
Geo exchange field	Down sized due to lower heating load		$78,000
Total energy savings over base case	6%		
Heating energy	28% energy savings in heating energy		
Cooling energy	80% increase in cooling energy, although this likely is overstated with the likely increase in opening of windows not accounted for.		
Annual savings in energy costs	$6,400		
Affect on capital cost of project	Total capital cost of the project lower than baseline due to reduction in glazing costs and down sizing of geo exchange field		$248,000
Net savings or cost to the developer	Cost savings from reduced MAU would be realized, but likely more than made up for with the increase in suite heat pump sizes.		$95,000
% under the MNECB	35%		
IAQ Implications	Compartmentalization will minimize odor transfer between units and in combination with balanced ventilation system will ensure higher indoor air quality. Higher performance windows will reduce potential for surface condensation and mould growth on inside face of glazing system.		
Thermal comfort implications	Higher thermal comfort due to higher surface temperature of glazing system, higher interior surface temperature of walls and higher level of airtightness		
Building envelope implications	Highly durable building envelope due to exterior insulation over steel studs and rain screen provided by brick veneer		

Option C			
	Description	Capital Cost Increase	Capital Cost Savings
Glazing Area	50% of wall area in glazing		
Glazing System	Double glazed low E aluminum window wall		$200,000
Wall system	Steel stud wall with RSI 2.27 (R12.9) exterior rigid insulation and Z girts with stucco or metal cladding, composite wall insulating value RSI 1.54 (R8.8)	$130,000	
Roof	Concrete with R40 foam insulation		
Eyebrows	Eliminated		$210,000
Horizontal shade over south facing windows	600mm (2') aluminum fin	$60,000	
Compartmentalization	Building fully compartmentalized estimated cost $500 per unit	$55,000	
Ventilation System	Supply duct to the heating system return air plenum and small supply fan	$20,000	
Corridor pressurization fan and supply air heating system	Corridor pressurization fan (MAU) size decreased due to compartmentalization, with roughly 2/3rds of building outside air heating diverted to distributed suite heat pumps. Utility bill savings not included in analysis, but approximated at $6400/year (for strata, but tenant costs will increase by roughly $3200/year)	unknown, although increase in heat pump size likely would exceed decrease in MAU	
Geo exchange field	Down sized due to lower heating load		$78,000
Total energy savings over base case	7%		
Heating energy	18% energy savings in heating energy		
Cooling energy	no significant change.		
Annual savings in energy costs	$7,800		
Affect on total capital cost of project including geo exchange field and related backup systems	Total capital cost of the project lower than baseline due to reduction in glazing costs and down sizing of geo exchange field		$298,000
Net savings or cost to the developer	Cost savings from reduced MAU would be realized, but likely more than made up for with the increase in suite heat pump sizes.		$145,000
% under the MNECB	35%		
IAQ Implications	Compartmentalization will minimize odor transfer between units and in combination with balanced ventilation system will ensure higher indoor air quality. Lower performance windows could lead to condensation and mould growth on inside face of glazing system.		
Thermal comfort implications	Higher thermal comfort due to higher surface temperature of glazing system, higher interior surface temperature of walls and higher level of airtightness		
Building envelope implications	More durable building envelope due to exterior insulation over steel studs and rain screen		

Option D			
	Description	Capital Cost Increase	Capital Cost Savings
Glazing Area	50% of wall area in glazing		
Glazing System	Double glazed low E aluminum window wall		$200,000
Wall system	Steel stud wall with RSI 2.64 (R15) exterior rigid insulation and brick veneer cladding composite wall insulating value RSI 1.8 (R10.2)	$260,000	
Roof	Concrete with R40 foam insulation		
Eyebrows	Eliminated		$210,000
Horizontal shade over south facing windows	600mm (2') aluminum fin	$60,000	
Compartmentalization	Building fully compartmentalized estimated cost $500 per unit	$55,000	
Ventilation System	Supply duct to the heating system return air plenum and small supply fan	$20,000	
Corridor pressurization fan and supply air heating system	Corridor pressurization fan (MAU) size decreased due to compartmentalization, with roughly 2/3rds of building outside air heating diverted to distributed suite heat pumps. Utility bill savings not included in analysis, but approximated at $6400/year (for strata, but tenant costs will increase by roughly $3200/year)	unknown, although increase in heat pump size likely would exceed decrease in MAU	
Geo exchange field	Down sized due to lower heating load		$78,000
Total energy savings over base case	7%		
Heating energy	20% energy savings in heating energy		
Cooling energy	5% decrease in cooling energy.		
Annual savings in energy costs	$8,300		
Affect on total capital cost of project including geo exchange field and related backup systems	Total capital cost of the project lower than baseline due to reduction in glazing costs and down sizing of geo exchange field		$174,000
Net savings or cost to the developer	Cost savings from reduced MAU would be realized, but likely more than made up for with the increase in suite heat pump sizes.		$19,000
% under the MNECB	36%		
IAQ Implications	Compartmentalization will minimize odor transfer between units and in combination with balanced ventilation system will ensure higher indoor air quality. Lower performance windows could lead to condensation and mould growth on inside face of glazing system.		
Thermal comfort implications	Higher thermal comfort due to higher surface temperature of glazing system, higher interior surface temperature of walls and higher level of airtightness		
Building envelope implications	Highly durable building envelope due to exterior insulation over steel studs and rain screen provided by brick veneer		

Option E			
	Description	Capital Cost Increase	Capital Cost Savings
Glazing Area	70% of wall area in glazing (same as current design)		
Glazing System	Quad glazed low E fiberglass frame windows RSI 0.95 (R 5.4) $21.50/m2 ($ 2/ ft2) higher than aluminum window wall	$72,000	
Wall system	Poured in place concrete with insulated steel stud		
Roof	Concrete with R40 foam insulation		
Eyebrows	Retained as per original design		
Horizontal shade over south facing windows	457mm (1'-6") deep eyebrow		
Compartmentalization	Building fully compartmentalized estimated cost $500 per unit	$55,000	
Ventilation System	Supply duct to the heating system return air plenum and small supply fan	$20,000	
Corridor pressurization fan and supply air heating system	Corridor pressurization fan (MAU) size decreased due to compartmentalization, with roughly 2/3rds of building outside air heating diverted to distributed suite heat pumps. Utility bill savings not included in analysis, but approximated at $6400/year (for strata, but tenant costs will increase by roughly $3200/year)	unknown, although increase in heat pump size likely would exceed decrease in MAU	
Geo exchange field	Down sized due to lower heating load		$126,000
Total energy savings over base case	7%		
Heating energy	37% energy savings in heating energy		
Cooling energy	120% increase in cooling energy, although this likely is overstated with the likely increase in opening of windows not accounted for.		
Annual savings in energy costs	$7,500		
Affect on capital cost of project	Total capital cost of the project lower than baseline due to reduction in glazing costs and down sizing of geo exchange field		$54,000
Net savings or cost to the developer	Cost savings from reduced MAU would be realized, but likely more than made up for with the increase in suite heat pump sizes.	$147,000	
% under the MNECB	36%		
IAQ Implications	Compartmentalization will minimize odor transfer between units and in combination with balanced ventilation system will ensure higher indoor air quality. Higher performance windows will reduce potential for surface condensation and mould growth on inside face of glazing system. Poured concrete walls with insulated steel stud and uninsulated slab edges and balconies still present a risk of mould growth.		
Thermal comfort implications	Higher thermal comfort due to higher surface temperature of glazing system and higher level of airtightness		
Building envelope implications	Conventional cast in place concrete wall functions as a face sealed system. To provide adequate resistance or rain penetration recommendations in HPO Builder Insight # 3 "Poured in Place Concrete Residential Construction: Moisture Management Strategies" should be followed		

Option F			
	Description	Capital Cost Increase	Capital Cost Savings
Glazing Area	50% of wall area in glazing		$200,000
Glazing System	Quad glazed low E fiberglass frame windows RSI 0.95 (R 5.4) $21.50/m2 ($ 2/ ft2) higher than aluminum window wall	$52,000	
Wall system	Steel stud wall with RSI 2.64 (R15) exterior rigid insulation and brick veneer cladding composite wall insulating value RSI 1.8 (R10.2)	$130,000	
Roof	Concrete with R40 foam insulation		
Eyebrows	Eliminated		$210,000
Horizontal shade over south facing windows	600mm (2') aluminum fin	$60,000	
Compartmentalization	Building fully compartmentalized estimated cost $500 per unit	$55,000	
Ventilation System	Supply duct to the heating system return air plenum and small supply fan	$20,000	
Corridor pressurization fan and supply air heating system	Corridor pressurization fan (MAU) size decreased due to compartmentalization, with roughly 2/3^{rds} of building outside air heating diverted to distributed suite heat pumps. Utility bill savings not included in analysis, but approximated at $6400/year (for strata, but tenant costs will increase by roughly $3200/year)	unknown, although increase in heat pump size likely would exceed decrease in MAU	
Geo exchange field	Down sized due to lower heating load		$162,000
Total energy savings over base case	11%		
Heating energy	45% energy savings in heating energy		
Cooling energy	110% increase in cooling energy, although this likely is overstated with the likely increase in opening of windows not accounted for.		
Annual savings in energy costs	$12,000		
Affect on total capital cost of project including geo exchange field and related backup systems	Total capital cost of the project lower than baseline due to *envelope changes* and down sizing of geo exchange field		$330,000
Net savings or cost to the developer	Cost savings from reduced MAU would be realized, but likely more than made up for with the increase in suite heat pump sizes.		$168,000
% under the MNECB	38%		
IAQ Implications	Compartmentalization will minimize odor transfer between units and in combination with balanced ventilation system will ensure higher indoor air quality. Higher performance windows will reduce potential for surface condensation and mould growth on inside face of glazing system.		
Thermal comfort implications	Higher thermal comfort due to higher surface temperature of glazing system, higher interior surface temperature of walls and higher level of airtightness		
Building envelope implications	Highly durable building envelope due to exterior insulation over steel studs and rain screen provided by brick veneer		

Option G			
	Description	Capital Cost Increase	Capital Cost Savings
Glazing Area	50% of wall area in glazing		$200,000
Glazing System	Double glazed low E fiberglass frame windows RSI 0.6 (R 3.4) $58.80/m2 ($ 5/ ft2) cheaper than aluminum window wall		$130,000
Wall system	Steel stud wall with RSI 2.27 (R12.9) exterior rigid insulation and Z girts with stucco or metal cladding, composite wall insulating value RSI 1.54 (R8.8)	$130,000	
Roof	Concrete with R40 foam insulation		
Eyebrows	Eliminated		$210,000
Horizontal shade over south facing windows	600mm (2') aluminum fin	$60,000	
Compartmentalization	Building fully compartmentalized estimated cost $500 per unit	$55,000	
Ventilation System	Supply duct to the heating system return air plenum and small supply fan	$20,000	
Corridor pressurization fan and supply air heating system	Corridor pressurization fan (MAU) size decreased due to compartmentalization, with roughly 2/3rds of building outside air heating diverted to distributed suite heat pumps. Utility bill savings not included in analysis, but approximated at $6400/year (for strata, but tenant costs will increase by roughly $3200/year)	unknown, although increase in heat pump size likely would exceed decrease in MAU	
Geo exchange field	Down sized due to lower heating load		$114,000
Total energy savings over base case	9%		
Heating energy	31% energy savings in heating energy		
Cooling energy	50% increase in cooling energy, although this likely is overstated with the likely increase in opening of windows not accounted for.		
Annual savings in energy costs	$10,000		
Affect on total capital cost of project including geo exchange field and related backup systems	Total capital cost of the project lower than baseline due to *envelope changes* and down sizing of geo exchange field		$464,000
Net savings or cost to the developer	Total capital cost of the project lower than baseline due to *envelope changes* and down sizing of geo exchange field		$350,000
% under the MNECB	37%		
IAQ Implications	Compartmentalization will minimize odor transfer between units and in combination with balanced ventilation system will ensure higher indoor air quality. Higher performance windows will reduce potential for surface condensation and mould growth on inside face of glazing system.		
Thermal comfort implications	Higher thermal comfort due to higher surface temperature of glazing system, higher interior surface temperature of walls and higher level of airtightness		
Building envelope implications	More durable building envelope due to exterior insulation over steel studs and rain screen		

It should be noted that due to the fact a GSHP system with a COP of 3 is being used all energy cost savings are only approximately only 1/3 of what they would be if electric resistance or gas fired heating were used. This means on a life cycle cost basis less can be invested in building envelope upgrades when a GSHP system is used than when conventional heating systems are used. The following tables compiled by Enersys Analytics shows the annual savings and LCC indicators for this project for various combinations of energy efficiency measures applied with the GSHP as proposed and with the more common electric resistance heating. Line 1 in both table refers to realistic behaviour – this is a reference to the fact that typically in MURBs many windows in upper floor units are opened to control overheating and humidity thereby significantly increasing air change rates.

26-August-2006 Summary for Baseline

ENERGY MANAGEMENT OPTION LISTING		ANNUAL SAVINGS		LCC INDICATORS	
	Measure	Energy (mmBtu)	Net Utility & Maintenance	NPV Difference	Payback (Years)
001	1) Baseline with "Realistic Behavior" (3x MNECB infiltration)	-351 (-6.%)	-$6,060 (-5.%)	$94,201	Never
002	2) Continuous Insulation Wall System at Ro-8.8 and 50% Glazing	408 (7.0%)	$7,782 (7.0%)	-$418,983	Instant
003	3) Continuous Insulation Brick Wall System at Ro-10.2 and 50% Glazing	435 (7.0%)	$8,256 (7.0%)	-$302,351	Instant
004	4a) Fiberglass Frame Windows at U-0.29	209 (3.0%)	$3,408 (3.0%)	-$292,980	Instant
005	4b) Brick Wall System with Fiberglass U-0.29 Windows	370 (6.0%)	$6,427 (5.0%)	-$347,914	Instant
006	5a) Quad Heat Mirror Windows at U-0.13	428 (7.0%)	$7,475 (6.0%)	-$170,208	Instant
007	5b) Quad Heat Mirror Windows at U-0.13 & R-10.2 Brick Wall System	195 (3.0%)	$3,045 (3.0%)	-$127,330	Instant
008	Baseline	0 (0.0%)	$0 (0.0%)	$0	0.0
009	Envelope Combo #2 (Combo #1 with Quad Low-e Windows)	644 (10.6%)	$12,032 (10.1%)	-$517,054	Instant
010	Envelope Combo #1	539 (9.0%)	$10,030 (8.0%)	-$619,918	Instant
011	Roof Insulation Reduced from R-40 to R-20*	-28 (0.0%)	-$452 (0.0%)	-$30,576	> 30
012	MAU Served by Heat Pump Loop	593 (10.0%)	$9,668 (8.0%)	-$130,297	2.2
013	Condensing Boilers	117 (2.0%)	$1,763 (1.0%)	$2,585	23.3

Indicates that the last R-20 of roof insulation is not cost-effective.

Follow-Up of 26-Aug-2006 Options Applied to Typical Electric Baseboard Case

ENERGY MANAGEMENT OPTION LISTING		ANNUAL SAVINGS		LCC INDICATORS	
	Measure	Energy (mmBtu)	Net Utility & Maintenance	NPV Difference	Payback (Years)
001	1) Baseline with "Realistic Behavior" (3x MNECB infiltration)	-543 (-8.%)	-$11,057 (-8.%)	$171,885	Never
002	2) Continuous Insulation Wall System at Ro-8.8 and 50% Glazing	622 (9.0%)	$12,584 (9.0%)	-$415,631	Instant
003	3) Continuous Insulation Brick Wall System at Ro-10.2 and 50% Glazing	669 (10.0%)	$13,552 (10.0%)	-$300,683	Instant
004	4a) Fiberglass Frame Windows at U-0.29	614 (9.0%)	$12,433 (9.0%)	-$373,288	Instant
005	4b) Brick Wall System with Fiberglass U-0.29 Windows	967 (13.7%)	$19,565 (14.4%)	-$474,149	Instant
006	5a) Quad Heat Mirror Windows at U-0.13	1,252 (17.8%)	$25,350 (18.7%)	-$322,087	3.0
007	5b) Quad Heat Mirror Windows at U-0.13 & R-10.2 Brick Wall System	1,526 (21.7%)	$30,888 (22.8%)	-$398,176	2.8
008	Baseline	0 (0.0%)	$0 (0.0%)	$0	0.0
009	Envelope Combo #2 (Combo #1 with Quad Low-e Windows)	1,482 (21.1%)	$30,006 (22.1%)	-$634,469	Instant
010	Envelope Combo #1	1,026 (14.6%)	$20,765 (15.3%)	-$672,811	Instant
011	Roof Insulation Reduced from R-40 to R-20*	-67 (-1.%)	-$1,115 (-1.%)	-$20,262	> 30
012	MAU Served by Air-Source Heat Pump	769 (11.0%)	$10,851 (8.0%)	-$148,687	1.9
013	Condensing Water Heater for DHW	297 (4.0%)	$4,501 (3.0%)	-$54,977	3.6

Indicates that the last R-20 of roof insulation is not cost-effective.

Figure 19: Table comparing various energy efficiency measures for the Essence of White Rock MURB tower heated with the proposed geo-exchange and distributed heat pump system and electric baseboard heating.

Presentation Title: **Heating and cooling systems to be used in Essence of White Rock and targets for performance**
Presenter: Goran Ostojic, Cobalt Engineering

Goran presented schematics of the space heating and cooling system which consists of a geo-exchange field to be supplied by Terasen Energy Services and individual packed heat pump units to be placed in each living unit. A gas fired boiler will provide additional heat when the heating capacity of the geo-exchange field is exceeded. A cooling tower will be used to provide additional cooling capacity when the cooling capacity of the geo-exchange field is exceeded. Distribution of heating and cooling within each unit will be by way of forced air ductwork requiring a dropped ceiling over part of each suite. Ventilation is provided by a low noise bath fan ducted to the exterior through an in-slab duct and an exterior vented range hood. Make up air is be supplied by the corridor pressurization fan by way of the undercut suite entry door.

Presentation Title: **MURB ventilation options and targets for performance**
Presenter: Chris Mattock, HD+C Ltd.

Chris gave a presentation on the performance of conventional MURB ventilation and how it could be improved and presented 4 possible options for higher performance MURB ventilations.

Conventional MURB Ventilation Systems Performance

- Low / unpredictable exhaust rates
- Unpredictable and poor distribution of supply air
- Transfer of odors between suites
- Inadequate ability to vent moisture
- High energy consumption
- Noise
- Possible conduit for pests and for smoke during fires
- Operation can be highly influenced by the wind and stack effect in leaky poorly compartmentalized buildings

Improving Performance of Ventilation Systems - Distribution

- Dedicated continuous supply in:
    - Bedrooms
    - Living room
    - Dining room
    - Dens
- Dedicated continuous exhaust in:
    - Kitchen
    - Bathrooms
    - Laundry
- Intermittent exhaust (range hood)

        - Kitchen
- Air seal all joints and seams in sheet metal ductwork
- Commission systems - measure air flows

Improving Performance of Ventilation Systems

- Continuous high performance air barrier in exterior envelope
- Compartmentalization of suites
    - Reduces stack effect on operation of the ventilation system
    - Prevents air flow from adjacent suites

Ventilation System Option 1 Suite-based central exhaust ventilation (CEV) system with passive inlets

Benefits	Lowest cost system Improved ventilation when installed in conjunction with compartmentalized suites and high performance continuous air barrier Quieter operation Low maintenance
Drawbacks	No tempering of outdoor air possible may lead to occupant discomfort Only minimal filtration of outdoor air possible Maybe affected by wind pressure Outdoor noise can enter through supply vents

Ventilation System Option 2: Suite based HRV / ERV system

Benefits	Excellent ventilation when installed correctly in compartmentalized suite with a high performance continuous air barrier Least affected by wind Provides filtration of incoming air Tempers incoming air enhancing comfort Reduces energy consumption Quiet operation
Drawbacks	Higher capital cost Filters require regular cleaning or replacement

Option 3: Whole building central exhaust ventilation (CEV) system with passive inlets

Benefits	Improved ventilation when installed in conjunction with compartmentalized suites and high performance continuous air barrier Centralized control and maintenance Low maintenance
Drawbacks	Higher capital cost Space required on each floor for ductwork Fire dampers required where ducts cross fire separations No tempering of outdoor air possible may lead to occupant discomfort Only minimal filtration of outdoor air possible Performance maybe affected by wind pressure Outdoor noise can enter through supply vents

Option 4: Whole building central HRV or ERV system

Benefits	Excellent ventilation when installed correctly in conjunction with compartmentalized suites and high performance continuous air barrier Least affected by wind Provides filtration of incoming air Tempers incoming air enhancing comfort Reduces energy consumption Centralized control and maintenance
Drawbacks	Higher capital cost Filters require regular cleaning or replacement Space required on each floor for ductwork Fire dampers required where ducts cross fire separations

Mechanical Ventilation Brain Storming Session Summary

It was recognized by the group that the conventional ventilation systems as proposed have resulted in poor distribution of ventilation air particularly to bed rooms and also has resulted in many cases in elevated humidity levels and condensation on windows. Suite compartmentalization was recognized as a necessity for the reasons previously stated and would not allow for the conventional make up air supply method. While balanced HRV / ERV systems have recognized energy and IAQ benefits the cost and complexity of getting ventilation ductwork installed and ensuring adequate separation of supply and exhaust hoods was also acknowledged. A balanced system without heat recovery was proposed as a solution. An in-slab duct would supply outdoor air to the return air plenum of the heat pump air handler unit, due to the pressure drop in the duct and the need for the ventilation air to be supplied continuously a small fan would be used to draw air through the duct and supply it to the return air plenum. Outdoor air would then be distributed through the living unit by way of the heating / cooling ductwork. A high quality multi speed central exhaust fan in each suite ducted to all the wet rooms and vibration and noise isolated would ensure the necessary exhaust of humidity and odours. The increased cost of the higher quality in-suite ventilation systems can be partially or fully offset by savings in the sizing of corridor pressurization fans and heating units.

With the corridors compartmentalized, smaller fans can be used to maintain required pressurization and less energy is required to temper the smaller quantity of air supplied to the corridors. A quick analysis was done of the option of replacing the gas fired furnaces that would preheat the corridor pressurization with ground source heat pump units; there would be a $10,000 year savings in energy costs and roughly a 2 to 3 year payback for the $30,000 incremental cost of the heat pump system. This also represents an energy savings of 10% over the baseline case an emerged as one of the most effective measures that could be incorporated into the project. Terasen Energy Systems will be approached about financing this component thereby eliminating this cost for the developer.

Presentation Title: **Solar water heating applications in MURBs and targets for performance**
Presenter: Joe Thwaites, Taylor Munroe Energy Systems

Joe presented information on solar water heating systems and compared solar collector technologies. Flat plate solar collectors typically have the best performance to cost ratio of all technologies for medium temperature applications such as solar water heating. Solar water heating systems in MURBs typically supply 25 to 50% of the domestic water heating an annual basis. Excess heat produced by solar water heating systems in the summer could also be used to recharge geo exchange fields with heat. Solar collectors can serve also serve as part of the building envelope, forming part of the roof or a wall or acting as a shading device over south facing windows. Flat plate solar collectors cost in the range of $300 / m^2 ($27.90/ ft^2), fully installed systems with storage, piping and controls cost about $1000 / m^2 of collector. The federal government subsidizes the cost of installation of solar water heating systems to roughly the equivalent of 25% of the cost. Terasen Energy Systems has expressed an interest in financing the installation of such systems in the past.

Solar Water Heating Brain Storming Session Summary
Solar was discussed both for it's energy contribution and the marketing benefit it would provide. Solar collectors could be used as shades over south facing windows replacing the eyebrows called for in the current design (estimated capital cost $210,000) or an aluminum fin shade for the south side (estimated

capital cost of $60,000). The total collector area would equal 180 m^2 and produce 334 GJ of heat energy annually. The collector should not extend more than 600mm (2 ft.) horizontally so as not to interfere with the window washing equipment. The solar collectors could be connected to the heat transfer loop used on each floor to move heat between units reducing total installation costs. The maximum temperature output of the ground source heat pumps is 46 C (115 F) leading to a requirement for topping up to 55C (131 F) solar could contribute to filling this need.

Electrical energy conservation in MURBs and targets for performance

Presentation Title: **Power Smart - residential initiatives**
Presenter: Greg Morandini, B.C. Hydro Power Smart

Greg presented information on the Power Smart Energy Star appliance package rebate program.

Install ENERGY STAR packages in your new multi-unit residential building and receive a rebate up to $200 per suite.

To receive a $150 rebate per suite, simply install the following ENERGY STAR labelled items in each suite:

- ENERGY STAR compact fluorescent lighting in 40 per cent of the suite
- One ENERGY STAR refrigerator
- One ENERGY STAR dishwasher
- One ENERGY STAR ventilation fan

Receive an additional $50 rebate per suite when you install:

- One ENERGY STAR clothes washer

He also presented information on cold cathode fluorescents that are dimmable, can blink and can be operated by motion detectors. They last 15 to 20,000 hours and use less mercury than conventional compact fluorescents. Their energy consumption is lower than cfls with 3, 5 and 8 watt lamps (equal illumination to 25, 40 and 60 watt incandescents)

Presentation Title: **Smart metering initiative**
Presenter: Tony Mauro, B.C. Hydro Power Smart

Tony presented on the smart metering initiative currently being undertaken by B.C. Hydro. Smart meters will allow for two way communication between the utility and electrical devices in the home. This will allow for the following:

- Load management by the utility

- Displaying of real time energy use and energy costs in the home to allow the home owner to manage their own electrical energy consumption
- Remote control of electrical appliances by the home owner
- Automatic detection by the utility of power failures
- Integrating plug in electric cars into the grid for energy storage and supply.

Hydro is presently working with 3 potential suppliers to supply the smart meters. All electrical appliances will utilize an open source protocol for communications to encourage as many appliance manufacturers to participate as possible.

Presentation Title: **Daylighting opportunities in residential construction**
Presenter: Chris Mattock, HD+C Ltd.

Chris presented on the fundamentals of daylighting design including building orientation, daylighting and view window placement, and interior reflection, use of light shelves, luminaire placement and controls.

Brain Storming on Electrical energy conservation in MURBs
The following items were identified as already being included in the project or to be considered for inclusion in the project.

Included

- All corridors and stairwell lighting to be cfls and to be switched by motion detectors
- All parking garage lighting to be fluorescent tubes
- 70% of parking garage lights to be controlled by motion detectors, the remaining 30% to be left on continuously for security reasons
- Parkade ventilation fans to be on timers to run primarily during morning and evening peak use periods

To be considered

- Solar powered exterior lighting
- Energy efficient elevators
- Exterior energy efficient lighting fixtures
- High efficiency transformers
- Central “green” switch in each suite to allow for switching off all unnecessary circuits when leaving
- Use of daylighting techniques in the credit union branch to be located in phase 1

Conclusions

- The building must be fully compartmentalized by air sealing all suites, corridors, lobbies, elevator shafts, stairwells and other spaces from each other in order to:
  - Reduce heat losses related to uncontrolled air change

- Enhance life safety by more effectively preventing smoke movement through the building during a fire
  - Enable in – suite ventilation systems to operate effectively by minimizing stack forces
  - Prevent transfer of odours between suites
  - Reduce noise transfer between suites
  - Contribute to reducing air movement through the exterior envelope thereby reducing the potential for interstitial condensation formation and envelope deterioration
  - Reduce the amount of outdoor air required for corridor pressurization
- Training of construction crews and provision of onsite airtightness testing during and after construction is absolutely necessary to ensure compartmentalization is achieved.
- Replace the conventional in-suite ventilation system with a balanced ventilation system consisting of an in-slab duct and fan providing outdoor air to the return air plenum of the forced air heating / cooling system.
- If acceptable to the market reduce the glazing area to 50% of the wall area from the current 70%
- Replace the existing aluminum curtain wall system with a fibreglass framed double low E glazing system to raise the RSI (R) value of the window and lower the capital cost.
- Enhance the thermal performance and durability of exterior wall assemblies through possible incorporation of one or more of the following options:
  - If the poured in place exposed concrete walls are retained, place 50mm (2") thick sheet of extruded polystyrene foam board insulation between concrete walls and interior insulated steel stud framing. Follow the recommendations for preventing rain penetration as outlined in HPO Builder Insight # 3 "Poured-in-place Concrete Residential Construction"
  - Reduce glazing area to 50% of wall area from the existing 70%
  - Replace the existing aluminum framed glazing system with a fibreglass framed glazing system raising the composite insulation value from RSI 0.4 (R2.3) to RSI 0.59 (R3.4) and lowering the capital cost of the windows by $\$54/m^2$ ($\$5/ft^2$)
  - Use a rain screened exterior insulated wall system, this will eliminate thermal bridging at floor slab / wall connections and reduce the walls vulnerability to wind driven rain penetration as well as enhance the overall insulating value of the wall
  - Eliminate the concrete eyebrow slab extensions, only if a rain screen wall assembly is used, and replace with a shading device over south facing windows.
- Reduce the size of corridor pressurization fans (possible due to the compartmentalization of the corridors) and replace the gas fired

furnaces used for preheating corridor air with a heat pump unit connected to the geo – exchange field. This will reduce both capital and operating costs. Based on the initial energy analysis this proved to be one of the most effective single energy efficiency measures.

- Consider the incorporation of flat plate solar collectors for marketing benefits, to contribute to space and water heating requirements, and to act as shading devices over south facing windows.
- The following electrical energy conservation measures should be considered
    - Solar powered exterior lighting
    - Energy efficient elevators
    - Exterior energy efficient lighting fixtures
    - High efficiency transformers
    - Central “green” switch in each suite to allow for switching off all unnecessary circuits when leaving
- In the case of this project the primary heating and cooling system consists of distributed heat pumps and a geo – exchange field with a COP of 3. The geo-exchange field and the backup boiler and cooling tower will be financed by Terasen Energy Services and the heat provided by those systems will be sold to the building occupants over the life of the building to recover the capital and operating costs of those systems. This arrangement removes the capital costs of the geo-exchange system and back-up heating and cooling equipment from the developer’s balance sheet. This has the following impacts on the project:
    - Due to the high efficiency of the space conditioning equipment the goal of having an annual energy consumption of 25% below MNECB can be met with a conventionally insulated building envelope.
    - Due to the high efficiency of the ground source heat pump system the purchased energy savings derived from energy efficiency measures applied to the building envelope result only 1/3 the financial benefit that would be derived with the same measures applied to a building with conventional gas or electric heating.
    - Energy efficiency measures applied to the building envelope that reduces the size of the geo – exchange field and backup equipment benefit Terasen Energy Systems. For these reasons some of the building envelope energy conservation measures investigated that lead to a downsized geo-exchange field and related equipment may prove to be attractive to Terasen Energy Services as a less expensive alternative investment.
    - Implementation of energy efficiency measures may result in capital cost savings for the developer for the in-suite heating and cooling equipment (down sizing of the heat pump and shorter supply duct runs).

- Other reasons for using the measures suggested in this report that can differentiate this project and for which marketing benefits can be derived include
  - Significantly lower heating and cooling costs for the condominium owners
  - Greater thermal comfort due to higher wall and glazing surface temperatures and reduced drafts
  - Enhanced building envelope durability due to
    - Reduced potential for condensation on interior finishes and inside insulated cavities
    - Higher resistance to wind driven rain penetration
  - Enhanced indoor air quality due to balanced ventilation and warmer interior surfaces preventing mould growth
  - Elimination of odour and smoke transfer between units
  - Enhanced life safety in the case of a fire
  - The building is greener than competitors due to it's lower greenhouse gas emissions and demonstrated use or renewable energy technologies
- At present most MURBs in south western BC use electric resistance heating and due to cost and for technical reasons ground source heat pumps will not be an option in all future MURBs. These projects will require more efficient building envelopes such as those proposed in this report to comply with the new British Columbia Building Code, which as of September 5th, 2008 references ASHRAE 90.1-2004.
- The actual performance of the building will need to be monitored for a minimum of one year post occupancy to establish the following:
  - The total energy consumption for space heating and cooling
  - The contribution of internal and passive solar gains to space heating loads
  - The purchased energy consumption for space heating and cooling and a breakout of the amount of each type of fuel used
  - The greenhouse gas impacts of the space heating and cooling energy consumption.
  - Total energy consumption for domestic water heating
  - The contribution of the solar water heating system (if any) to the space and domestic water heating loads
  - The purchased energy consumption for domestic water heating and a breakout of the amount of each type of fuel used
  - The peak heating demand and peak cooling demand
  - The total water consumption of building expressed a m3/suite
  - Levels of four indoor air quality indicators (temperature, relative humidity, formaldehyde, CO2) to be monitored in 4 suites over a two week period during mid winter.
  - The ventilation systems located in the same four suites used for indoor air quality monitoring will be measured for gross air flow and balanced. Air flows from each grill will be measured to

understand air distribution within each suite. The fan energy consumption of the ventilation system will be measured for the same 2 week period to allow for calculation of the total ventilation related space conditioning energy consumption for each suite which will then be extrapolated to the entire building.

Recommended Next Steps

- Promote and facilitate the use of higher thermal performance building envelopes through
  - Researching and demonstrating economical methods for continuous insulation at exposed slab edges (spandrels)
  - Researching and demonstrating economical methods for providing thermal breaks, encapsulation or thermal separation of balcony slabs.
    - Cast in place thermal breaks are well established in Europe but have not been accepted here to date due to concerns about cost and structural liability. If thermal isolation of balconies where mandated cast in place thermal breaks may become the most economical choice but verification of their structural performance will have to be carried out through testing to Canadian standards in a manner that will satisfy the concerns of the structural engineering community.
  - Establishing an equivalency under the BCBC for insulated fibreglass framed glazing systems that will allow their use in mid and high-rise MURBs.
    - A test project be used to establish if an Alternate Solution Approach would be appropriate for the use of fibreglass framed windows in non combustible buildings.
      Thermally broken aluminum framed windows and glazing assemblies are predominantly used, however, the incorporation of the thermal breaks compromises the load carrying characteristics of the frames during a fire. Preliminary results suggest that fibreglass frames have the potential to provide improved performance during actual fire events.
      It is understand that the code intent is to control the contribution of combustible exterior wall components towards external fire spread. However, the expected quantity and distribution of such possibly combustible material in a window frame system does not lend itself to the configurations of the corresponding standard fire test. It is therefore likely that a performance based approach making use of fire modeling technique be developed to address and demonstrate the equivalency of this system as an alternative to the code requirements will be used.
      LMDG Building Code Consultants has expertise and has

carried out previous work in this area and would appear to be a prime candidate to carry out such work. (Please see Appendix C)

        - Further research to better determine risks during fires with respect to glazing assemblies and building code revisions as appropriate.
          This further research would form the basis for building code revisions to better establish criteria for glazing assemblies in non combustible buildings based on testing and modelling results of actual assemblies, rather than test results of individual elements.
    - Research, modeling (thermal and moisture), construction and performance monitoring of demonstration projects using conventional heating systems and ground source heat pump systems that meet energy efficiency targets of the current BCBC and 25% to 50% below BCBC requirements and meet market expectations regarding areas of glazing for views by using high performance exterior wall assemblies incorporating
        - Rain screen assemblies,
        - Insulated opaque wall sections
        - Low thermal conductivity glazing systems such as triple and quad glazed, low E, insulated fibreglass framed windows in conjunction with
        - Thermally broken balconies and
        - Highly insulated slab edge (spandrel) details.
        - Site tested continuous air barriers
- Research the potential for natural cooling in MURBs through the use of shading devices, wind driven ventilation and fan forced night time free cooling.
- Promote and facilitate the adoption of exterior building envelope airtightness and full building compartmentalization in all future MURBs. As documented elsewhere in the report full building compartmentalization will provide multiple energy, building envelope durability, indoor air quality, comfort and life safety benefits. These actions could take the following forms:
    - Model the impact of higher levels of airtightness and compartmentalization and the related changes to ventilation systems on energy consumption in typical MURB projects.
    - Develop quality assurance (test) protocols and specifications for exterior envelope airtightness and compartmentalization in MURBs based on the airtightness testing standards proposed in this report. Methods for testing individual suites, corridors, lobbies, stairwells, elevator shafts and other rooms contained in the building will need to be covered.
    - Develop “tear off sheet details” and training for contractors to provide guidance on achieving an airtight exterior envelope and

compartmentalization using visual inspection and airtightness testing equipment.
    - Support and document the construction and monitoring of the performance of demonstration MURB projects that incorporate high levels of exterior envelope airtightness and compartmentalization.
    - Support the development of a publication of typical details for exterior envelope airtightness and full building compartmentalization based on field experience.
    - Produce printed and online documents similar to the HPO Builder's Insight series showing how to construct airtight exterior MURB envelopes and compartmentalized MURBs and how to verify their performance and the benefits derived from exterior envelope airtightness compartmentalization
    - Due to the life safety and building envelope durability benefits of compartmentalization, requirements for compartmentalization should be considered for inclusion in the BCBC.
- Investigate methods for sizing downsized corridor pressurization fans (make up air units) due to compartmentalization. Downsizing would have to account for the need to maintain a higher pressure in the corridor than the surrounding spaces as well as ensuring adequate ventilation to maintain acceptable indoor air quality.
- Promote and facilitate of the use of in-suite balanced ventilation systems. The performance of conventional suite ventilation systems (bath fan, range hood and makeup air under the suite entry door) is widely recognized as fraught with problems. At the same time the argument for compartmentalization of MURBs is compelling from many perspectives and when a MURB is fully compartmentalized suite make up air is no longer supplied from the pressurized corridor. This necessitates in-suite balanced and distributed mechanical ventilation systems. At this point balanced ventilation systems are not widely accepted by local developers for the following reasons
    - Higher costs (which in part can be compensated for by the lower costs of downsized corridor pressurization fans and heating equipment)
    - The difficulty sometimes encountered with providing adequate separation between intake hoods and exhaust hoods on the exterior walls of a suite
    - Limitations on air flow volume for in-slab ducts
    - The costs and design implications of using dropped ceilings to conceal ventilation system ductwork. One of the issues related to this was identified as the limitations on building height. If building heights could be increased to allow for above ceiling ductwork in the same way that building dimensions are allowed to increase to accommodate higher insulation levels or building envelope durability features then distributed ventilation systems could become a more viable option.

To deal with these barriers to the use of in-suite balanced ventilation systems in MURBs research needs to be carried out on how to overcome the technical, cost and regulatory challenges related to these systems. In addition where these systems are being incorporated into MURBs their performance needs to be measured and evaluated and guidance documents on the design and commissioning of such systems produced.

- The design charrette process must become more widely used to accelerate the changes that are needed in the MURB industry so that it can meet the challenges of the new BCBC energy requirements and future more stringent energy codes and the ultimate goal of zero fossil fuel use for space conditioning of buildings as stated in the RAIC 2030 challenge[1]. Some possible mechanisms for encouraging the use of design charrettes include:
    - Publication of articles and development of presentations documenting the success of design charrettes in reducing capital costs while increasing energy, building envelope and environmental performance and the marketability of MURB projects. These should be targeted at such organizations as BOMA, CHBABC, AIBC, APEGBC, provincial and municipal governments.
    - Provision of financial and regulatory incentives by government(s) and utilities to encourage the use of design charrettes. Some communities are mandating carbon neutrality; this is causing a considerable challenge to the local development community that could be in part alleviated by the use of design charrettes.
    - Development of an easy to use energy modeling and costing screening tool. One of the most productive and dynamic aspects of the charrette process was the use of the Energy Analytics screening tool which allowed immediate feedback on the energy and costing implications of proposed building envelope and mechanical systems measures. Training should also be made available to design professionals to ensure proficiency in the use of such a tool.
    - Development of a MURB specific charrette manual to aid in the organization, conducting and reporting aspects of a charrette. This would cover such issues as
        - How to facilitate a design charrette
        - Who should participate
        - What type of information should be provided to the participants before hand
        - Suggested agendas
        - Suggested topics for presentations
        - Suggested performance target ranges
        - Tools to analyze decisions

[1] The RAIC, in adopting the 2030 Challenge, is calling all design professionals to become actively engaged in reducing fossil fuel use in building construction and operation by a minimum 50% today, 60% in 2010, 70% by 2015, 80% by 2020, 90% in 2025 to arrive at carbon neutral by 2030.

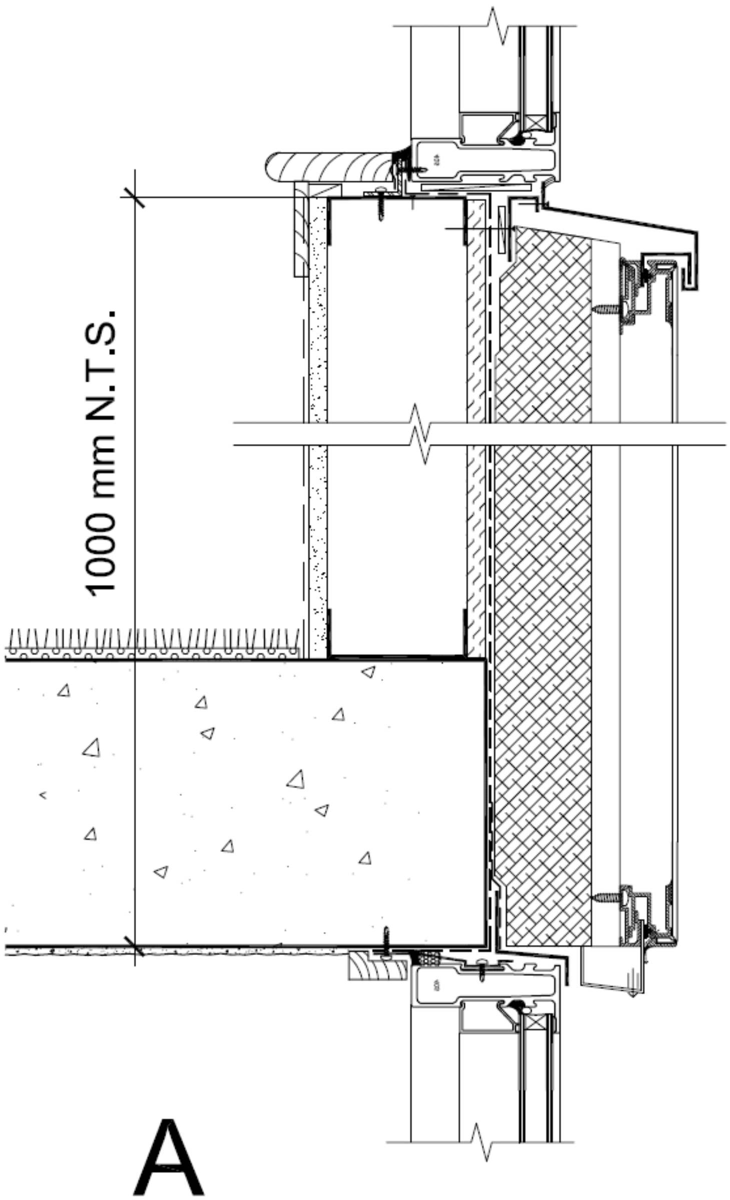
        - A framework for reporting the results of the charrette
    - One of the benefits of a design charrette is the transfer of state of the art knowledge across professional disciplines. This is typically done in the form of PowerPoint presentations. As series of such presentations on appropriate topics for high performance MURBs should be developed to bring all the participants up to speed and to aid in the brain storming process.
    - A web site devoted to MURB design charrettes
        - Documenting the results of successful charrettes,
        - Providing a document on the organization and running of a charrette
        - Providing information on state the art features of energy efficient MURB design and construction
        - Providing downloadable analytical tools to be used in conducting charrettes
        - Online training in the use of analytical tools
        - Power point presentations that could be used in charrettes
        - Links to other resources on MURBs
- Develop a course in partnership with the Architectural Institute of British Columbia on the implications of the new BCBC for MURBs and state of the art design of high performance MURBs. This course must be accredited by the AIBC so attending the course will earn participants continuing education credits.
- Develop courses in partnership with the Architecture School at UBC on the charrette design process and state of the art design of high performance MURBs.
- Develop courses in partnership with the BCIT on state of the art design of high performance MURBs.
- Design Optimization: As shown by the charrette process there are numerous possible improvements that can be made to existing MURB construction in the south-western British Columbia to improve energy, building envelope, environmental and cost performance. Options A through G shown earlier in this document outline possible combinations of energy efficiency measures (EEMs) and their estimated cost and energy savings benefits as well as building envelope durability implications. An optimization study should be undertaken using detailed thermal and moisture modeling and detailed costing to establish the bundles of EEMs that at the lowest cost will meet acceptable building envelope performance and the energy targets of the present BCBC based on ASHRAE 90-1 2004 and higher performance standards of 25% and 50% below present code requirements. This study must address buildings using ground source heat pump systems and conventional electric resistance heating as well as mid and high efficiency gas fired systems.

Appendix A: Design Charrette Agenda

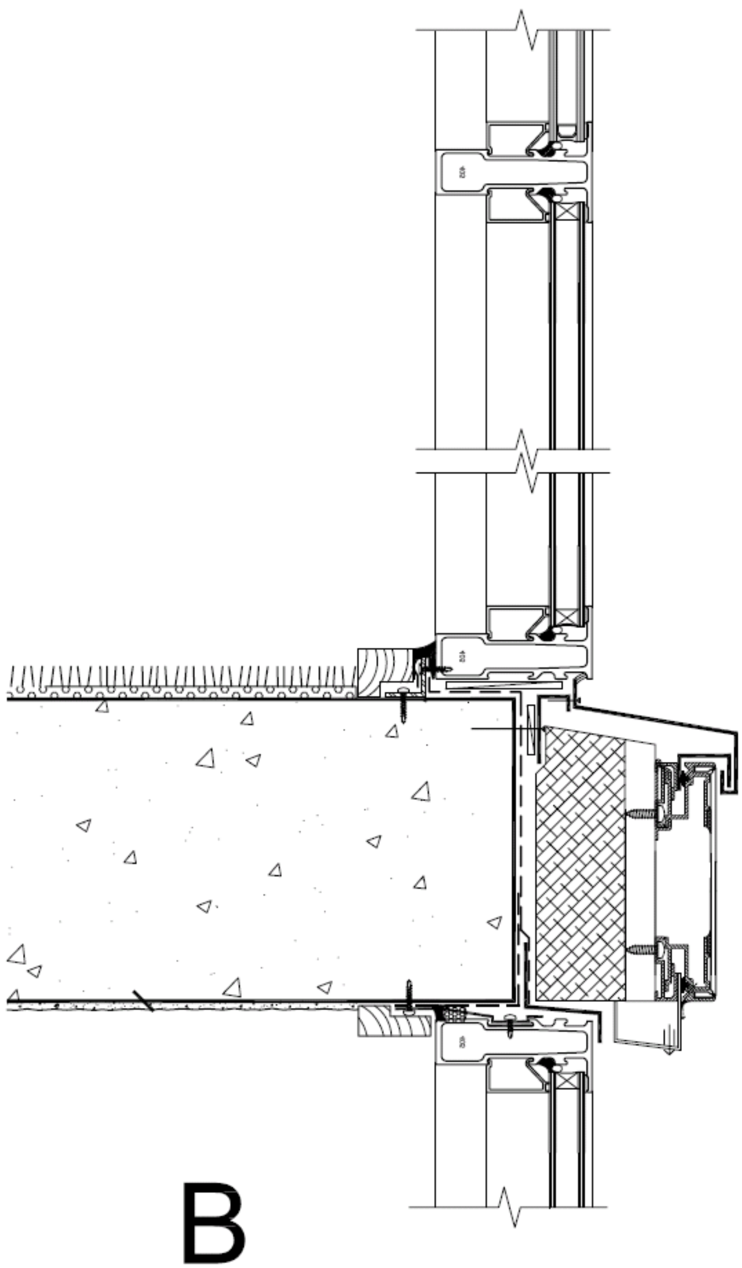
Essence of White Rock MURB Design Charrette August 25 and 26, 2008

August 25th		Location: CP 14 North B.C. Hydro Offices 4555 Kingsway, Burnaby		
		Presentations and Establishing Performance Targets	Presenter	
8:30	8:45	Welcome and self introductions	Chris Mattock	HDC
8:45	9:00	Purpose of a design charrette	Chris Mattock	HDC
9:00	9:30	Over view of the Essence of White Rock MURB project	Ken Wong	CDCL
			David O'Sheehan	Abbarch
9:30	9:45	Summary of content of the background references supplied	Chris Mattock	HDC
9:45	10:30	Review of Baseline Building Model Characteristics and Preliminary Summary Results, including Reflection on ASHRAE 90.1-2004 (BC Building Code) Requirements	Curt Hepting	Enersys Analytics
10:30	10:45	Coffee Break		
10:45	11:00	Energy simulation updated results	Curt Hepting	Enersys Analytics
11:00	11:45	Field experience with airtightness testing of MURBs and targets for air barrier performance	Colin Genge	Retrotec
11:45	12:00	Air movement and compartmentalization in MURBs and targets for compartmentalization performance	Chris Mattock	HDC
12:00	12:30	Lunch		
12:30	12:45	Recap of Morning	Chris Mattock	
12:45	2:15	**Brain Storming Session**		
		Air barrier options discussion and typical detailing at:	All	
		Floor / exterior wall connection	All	
		Window / wall connection	All	
		Door / wall connection	All	
		Mechanical penetrations	All	
		Electrical penetrations	All	
		Interior Compartmentalization	All	
		Interior wall / ceiling connection	All	
		Interior wall / floor connection	All	
		Interior wall connections	All	
		Interior wall electrical and mechanical penetrations	All	
		Controlling air flow between corridor and units	All	
		Controlling air flow between floors	All	
		Controlling air flow up elevator shafts		
2:15	2:30	Coffee Break		
		Presentations and Establishing Performance Targets		
2:30	3:15	Fenestration and cladding options for enhanced energy efficiency and targets for performance	Warren Knowles	RDH
3:15	3:30	Balcony thermal break strategies	Chris Mattock	HDC
3:30	5:00	**Brain Storming Session**		
		Fenestration and cladding options	All	
		Glazing Characteristics (U value, transmission etc.)	All	
		Passive Solar Heating	All	
		Solar control strategies	All	
		Opening windows for natural cooling	All	
		Spandrel Details	All	
		Opaque envelope components	All	
		Balcony Detailing	All	
August 26th		Location: CP 13 North B.C. Hydro Offices 4555 Kingsway, Burnaby		
8:45	9:00	Recap of Previous Day	Chris Mattock	
		Presentations and Establishing Performance Targets		
9:00	9:45	Heating and cooling system to be used in Essence of White Rock and targets for performance	Goran Ostojic	Cobalt
9:45	10:15	MURB ventilation options and targets for performance	Chris Mattock	HDC
10:15	10:30	Coffee break		
10:30	11:15	Solar water heating applications in MURBs and targets for performance	Joe Thwaites	Taylor Munroe
11:15	1:00	**Brain Storming Session**		
		Heating and cooling systems		
		Space heating	All	
		Space cooling	All	
		Domestic water heating	All	
		Ventilation	All	
		Corridor pressurization	All	
1:00	1:30	Lunch	All	
1:30	1:40	Recap of Morning	Chris Mattock	
		Electrical energy conservation in MURBs and targets for performance		
1:40	2:00	Power Smart - residential initiatives	Greg Morandini	Power Smart Engineering
2:00	2:20	Smart metering initiative	Tony Mauro	Power Smart Engineering
2:20	2:40	Daylighting opportunities in residential construction	Chris Mattock	HDC
2:40	2:55	Coffee break		
2:55	4:00	**Brain Storming Sessions**		

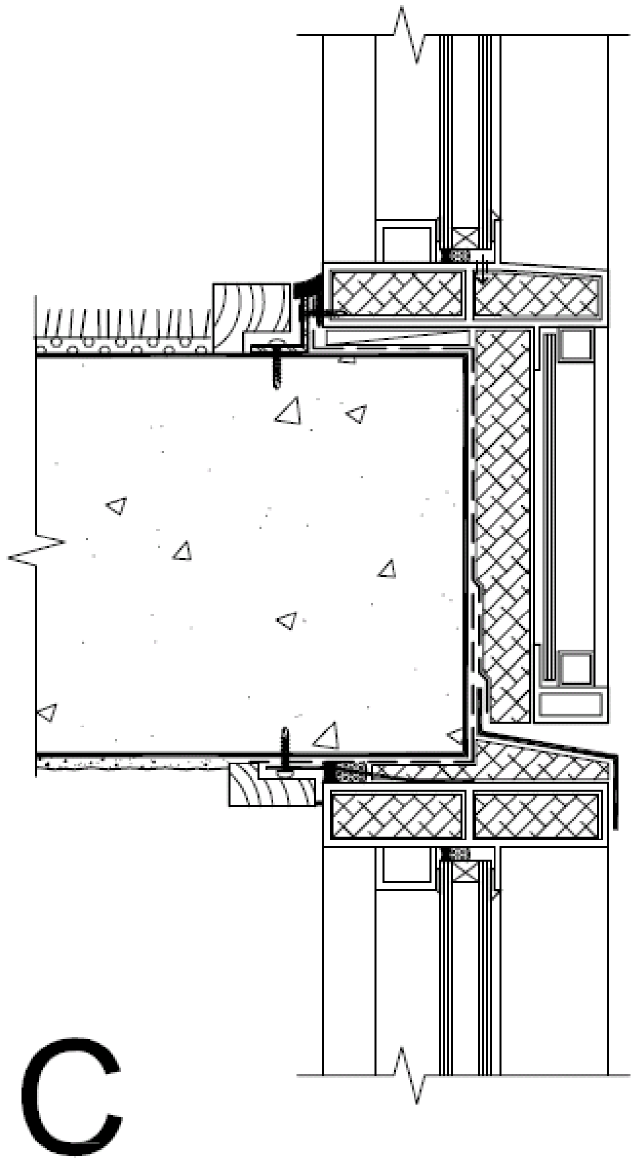
Appendix B Alternative Spandrel Details Using Fibreglass Windows



Fibreglass windows with 1 metre separation at the floor levels per the current BCBC requirements. A glazed or aluminum panel, supported off of a metal frame and steel clip supports (preferably stainless steel) could be used for the infill panels. We suggest an exterior insulated wall assembly at these panel areas. (Courtesy RDH Building Engineering Ltd.)



Fibreglass window arrangements (that are readily available) with less than 1 metre separation at the floor levels, and greater than 40% glazing area. An Alternate Solution Approach (ASA) would have to be established on a project by project basis. We understand that LMDG Building Code Consultants Ltd. have begun working on behalf of Cascadia Windows in the context of a BC Housing project. Once an acceptable ASA is established, it will simplify the process for other projects. (Courtesy RDH Building Engineering Ltd.)



The third detail shows a conceptual fibreglass window wall arrangement. Based on preliminary work, there are a number of ways which this could be accomplished. It is currently in development, and it looks like something will be available early next year. (Courtesy RDH Building Engineering Ltd.)

Appendix C: Meeting Minutes Regarding Use of Fiberglass Windows in a High Rise MURB project Located in Vancouver (Supplied courtesy of RDH Engineering Ltd.)

LMDG Building Code Consultants Ltd.

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James R. Ware, FPET

MINUTES OF MEETING
HELD JUNE 23, 2008

LICENSES & INSPECTIONS DEPARTMENT
CITY OF VANCOUVER

RE: FIBREGLASS CURTAIN WINDOW/WALL ASSEMBLIES
1338 SEYMOUR STREET, VANCOUVER

(Our File 08-186)

Attendees:

Mr. Jeff Mitchell, M.Eng., P.Eng., Deputy Chief Building Official, Licenses & Inspections Department, City of Vancouver (L&I)
Mr. Serges Desmarais, MAIBC, MRAIC, CP, RDH Building Engineering Ltd. (RDH)
Mr. David Ricketts, M.Sc., P.Eng., RDH Building Engineering Ltd (RDH)
Mr. Glenn A. Gibson, M.Eng., P.Eng., CP, LMDG Building Code Consultants Ltd. (LMDG)
Mr. Kin Man Wong, M.Sc., P.Eng., CP, LMDG Building Code Consultants Ltd. (LMDG)

Distribution:

To attendees.

The purpose of this meeting was to introduce the proposed use of a fiberglass window wall assembly in noncombustible buildings in general, and specifically as an alternative solution for use on the proposed residential highrise building at 1338 Seymour Street in Vancouver. The proposal to use fiberglass as a major component to the exterior wall assembly is motivated by environmental considerations including the thermal insulating value of this material, compared to the commonly used alternatives (e.g., aluminum or steel assemblies).

Action by:

1.0 INITIAL ASSESSMENT

LMDG proposed that as a first step to establish the adequacy of fiberglass curtain window/wall assemblies, the relevant acceptable solution and its intent should be identified. Such information would enable the design team to decide if an alternative solution would be required. INFO

LMDG summarised that, under the Vancouver Building By-law, all building components in a building of noncombustible construction are required to be noncombustible unless explicitly exempted in Subsection 3.1.5. L&I added that materials with tested performance that met the criteria specified in Sentences 3.1.5.1.(2) to (4) would be permitted for use in noncombustible construction.

It was agreed that the proposed assemblies would be tested for combustibility. LMDG proposed that additional properties and test parameters should be included if possible. A list of the

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V

Action by:

recommended tests and reference parameters is included as **Attachment No. 1** to these minutes.

RDH noted they would advise of the test schedule. RDH

2.0 ACCEPTABLE SOLUTION ANALYSIS

L&I agreed that if the test results meet the VBBL requirements for use in noncombustible construction, the proposed curtain wall/window assemblies would be a code-conforming component. Meanwhile, the proposed assemblies would be assumed to be combustible such that the concept of an alternative solution can be developed.

Furthermore, since an aluminum curtain wall/windows assembly has traditionally been accepted as a conforming exterior wall assembly in building of noncombustible construction, it will be referenced as the baseline case for the development of the alternative solution.

LMDG presented the following acceptable solution analysis:

2.1 Sprinkler Protection

Sentence 3.1.5.4.(5) defines the general construction requirements where combustible window sashes and frames are permitted in noncombustible construction. The aggregate area of openings is limited to 40% of the area of the wall face. With reference to the 1990 updates of the NBC requirements in spatial separation where credit is given to the added protection provided by sprinkler control, it is concluded that no benefit has been attributed to sprinkler protection for the use of combustible components in the exterior wall.

2.2 External Vertical Flame Spread

In addition to Sentence 3.1.5.4.(5), Article 3.1.5.5 specifies the performance criteria for combustible exterior wall assemblies in a sprinklered building. It is noted that the CAN/ULC S134 test specifies a fully developed fire where flame projected from the opening in the fire compartment is acknowledged to have leapt past the floor immediate above to affecting the exterior wall assembly on the next floor above. It is observed that under such a fire size within the room of origin, the contribution of the exterior wall components on fire spread to adjacent building by radiation, i.e., spatial separation, is insignificant.

It is therefore concluded that external flame spread along the exterior wall would be the code issue that the alternative solution should address in accordance with Article 3.1.5.5. Nevertheless, it is also noted that the test configuration specified by S134 does not depict exactly that of a curtain wall/window assembly. Corresponding excerpts from the VBBL are included as **Attachment No. 2** to these minutes.

Furthermore, the fire resistance requirement associated with the spatial separation will not be significant. This is because the proposed curtain wall/window assemblies will typically be used in situations where 100% unprotected openings are permitted. In situations where the exterior wall is required to have a fire-resistance rating, a water

Action by:

curtain system can be provided as an alternative solution similar to all approved assemblies (i.e. steel or aluminum frames).

2.3 Performance Criteria for Proposed Assemblies

As the Bylaw does not provide the safety objectives and functional statements for the above-identified acceptable solution, LMDG proposed the following performance criteria to be achieved by the alternative solution:

- the flame spread and resulting heat flux along the exposed fibreglass framing under the anticipated fire scenarios should not exceed those specified in Sentences 3.1.5.5.(2) and (3).

3.0 PROPOSED TESTS

A list of the recommended fire tests and determination of material properties for the proposed fiberglass window curtain/window assemblies is included as **Attachment No. 1** to these minutes.

4.0 PROPOSED ALTERNATIVE SOLUTION APPROACH

Fiberglass will perform as well as an aluminum curtain wall. Fires that compromise the exterior wall are expected to be post-flashover vent controlled fires. The contribution of the fiberglass components to this type of fire is insignificant.

5.0 DRAWING AND PRODUCT INFORMATION

Drawings showing the typical configurations of the assemblies proposed for use at 1338 Seymour Street are included as **Attachment No. 3** to these minutes. Product information is also included.

We trust that the above summary is an accurate reflection of the discussions that took place at this meeting. However, if your recollection differs from that recorded above, please notify the undersigned at your earliest convenience.

Prepared by:

LMDG BUILDING CODE CONSULTANTS LTD.

Kin Man Wong, M.Sc., P.Eng., CP

Reviewed by:

For/ Glenn A. Gibson, M.Eng., P.Eng., CP
June 30, 3008
KMW/dd 08186062308.min.wpd
Attachments

ATTACHMENT NO. 1

RECOMMENDED FIRE TESTS AND
DETERMINATION OF ADDITIONAL MATERIAL PROPERTIES

RECOMMENDED FIRE TESTS AND
DETERMINATION OF ADDITIONAL MATERIAL PROPERTIES

(A) Recommended fire tests:

ULC-S135-04:	Test Method for the Determination of Combustibility Parameters of Building Materials Using an Oxygen Consumption Calorimeter (Cone Calorimeter)
CAN/ULC-S134-92:	Fire Test of Exterior Wall Assemblies

Notes:

1. The corresponding noncombustibility test specified in the International Building Code (IBC) is the ASTM E-136 in which the sample is tested in a vertical tube furnace (and therefore very different from a cone calorimeter).
2. The International Building Code (IBC) specifies the requirements of "Combustible materials on the exterior side of exterior walls" under Section 1406 and requires a test protocol in accordance with NFPA 268.
3. It therefore appears that the CAN/ULC tests cannot be extended to provide the equivalent IBC ratings.

(B) Additional material properties:

The following material properties for the fibreglass framing and its substrate, respectively, are required for the development of an alternative solution:

- specific heat
- conductivity
- density
- heat of combustion
- threshold ignition surface temperature or incident flux level (TRF)

ATTACHMENT NO. 2

EXCERPTS FROM
VANCOUVER BUILDING BY-LAW

10) Wood girders and beams in *heavy timber construction* shall be closely fitted to columns, and adjoining ends shall be connected by ties or caps to transfer horizontal loads across the joints.

11) In *heavy timber construction*, intermediate wood beams used to support a floor shall be supported on top of the girders or on metal hangers into which the ends of the beams are closely fitted.

<12) Roof arches supported on the top of walls or abutments, roof trusses, roof beams and roof girders in *heavy timber construction* are permitted to be not less than 64 mm wide provided

a) where two or more spaced members are used, the intervening spaces are
   i) blocked solidly throughout, or
   ii) tightly closed by a continuous wood cover plate not less than 38 mm thick secured to the underside of the members, or

b) the underneath of the roof deck or sheathing is *sprinklered*.>

3.1.5. Noncombustible Construction

3.1.5.1. Noncombustible Materials

< 1) Except as permitted by Sentences (2) to (4)> and Articles 3.1.5.2. to 3.1.5.21., 3.1.13.4. and 3.2.2.16., a *building* or part of a *building* required to be of *noncombustible construction* shall be constructed with *noncombustible* materials. <(See also Subsection 3.1.13. for the requirements regarding the *flame-spread rating* of interior finishes.)

2) Notwithstanding the definition of *noncombustible* materials stated in Article 1.4.1.2. of Division A, a material is permitted to be used in *noncombustible construction* provided that, when tested in accordance with ULC-S135, "Test Method for the Determination of Combustibility Parameters of Building Materials Using an Oxygen Consumption Calorimeter (Cone Calorimeter)," at a heat flux of 50 kW/m^2,

a) its average total heat release is not more than 3 MJ/m^2,

b) its average total smoke extinction area is not more than 1.0 m^2, and

c) the test duration is extended beyond the time stipulated in the referenced standard until it is clear that there is no further release of heat or smoke.

3) If a material referred to in Sentence (2) consists of a number of discrete layers and testing reveals that the surface layer or layers protect the underlying layers such that complete combustion of the underlying layers does not occur, the test shall be repeated by removing the outer layers sequentially until all layers have been exposed during testing, or until complete combustion has occurred.

4) The acceptance criteria for a material tested in accordance with Sentence (3) shall be based on the cumulative emissions from all layers, which must not exceed the criteria stated in Clauses (2)(a) and (b).>

3.1.5.2. Minor Combustible Components

1) The following minor *combustible* components are permitted in a *building* required to be of *noncombustible construction*:

a) paint <(See also Sentence 3.1.5.10.(1)),>

b) mastics and caulking materials,< including foamed plastic air sealants,> applied to provide a seal between the major components of exterior wall *construction*, <(See also Article 3.6.4.3. for limits on the use of *combustible* materials in *plenum* spaces),>

c) fire stop materials conforming to Sentence 3.1.9.1.(1) and Article 3.1.11.7.,

d) tubing for pneumatic controls provided it has an outside diameter of not more than 10 mm,

e) adhesives, *vapour barriers* and sheathing papers,

f) electrical outlet and junction boxes,

g) wood blocking within wall assemblies intended for the attachment of handrails, fixtures, and similar items mounted on the surface of the wall, and

h) similar minor components.

3.1.5.3. Combustible Roofing Materials

1) *Combustible* roof covering that has an A, B, or C classification determined in conformance with Subsection 3.1.15. is permitted on a *building* required to be of *noncombustible construction*.

2) *Combustible* roof sheathing and roof sheathing supports installed above a concrete deck are permitted on a *building* required to be of *noncombustible construction* provided

a) the concrete deck is not less than 50 mm thick,

b) the height of the roof space above the deck is not more than 1 m,

c) the roof space is divided into compartments by fire stops in conformance with Article 3.1.11.5.,

d) openings through the concrete deck other than for *noncombustible* roof drains and plumbing piping are protected by masonry or concrete shafts
   i) constructed as *fire separations* having a *fire-resistance rating* not less than 1 h, and
   ii) extending from the concrete deck to not less than 150 mm above the adjacent roof sheathing,

e) the perimeter of the roof is protected by a *noncombustible* parapet extending from the concrete deck to not less than 150 mm above the adjacent sheathing, and

f) except as permitted by Clause (d), the roof space does not contain any *building* services.

3) *Combustible* cant strips, roof curbs, nailing strips and similar components used in the installation of roofing are permitted on a *building* required to be of *noncombustible construction*.

4) Wood nailer facings to parapets, not more than 600 mm high, are permitted on a *building* required to be of *noncombustible construction*, if the facings and any roof membranes covering the facings are protected by sheet metal.

3.1.5.4. Combustible Glazing and Skylights

1) *Combustible* skylight assemblies are permitted in a *building* required to be of *noncombustible construction* if the assemblies have a *flame-spread rating* not more than

a) 150 provided the assemblies
   i) have an individual area not more than 9 m^2,
   ii) have an aggregate horizontal projected area of the openings through the ceiling not more than 25% of the area of the ceiling of the room or space in which they are located, and
   iii) are spaced not less than 2.5 m from adjacent assemblies and from required *fire separations*, or

b) 75 provided the assemblies
   i) have an individual area not more than 27 m^2,
   ii) have an aggregate horizontal projected area of the openings through the ceiling not more than 33% of the area of the ceiling of the room or space in which they are located, and
   iii) are spaced not less than 1.2 m from adjacent assemblies and from required *fire separations*.

(See Appendix A.)

2) *Combustible* vertical glazing installed no higher than the second *storey* is permitted in a *building* required to be of *noncombustible construction*.

3) Except as permitted by Sentence (4), the *combustible* vertical glazing permitted by Sentence (2) shall have a *flame-spread rating* not more than 75.

4) The *flame-spread rating* of *combustible* glazing is permitted to be not more than 150 if the aggregate area of glazing is not more than 25% of the wall area of the *storey* in which it is located, and

a) the glazing is installed in a *building* not more than 1 *storey* in *building height*,

b) the glazing in the *first storey* is separated from the glazing in the second *storey* in accordance with the requirements of Article 3.2.3.17. for opening protection, or

c) the *building* is *sprinklered* throughout.

5) *Combustible* window sashes and frames are permitted in a *building* required to be of *noncombustible construction* provided

a) each window in an exterior wall face is an individual unit separated by *noncombustible* wall *construction* from every other opening in the wall,

b) windows in exterior walls in contiguous *storeys* are separated by not less than 1 m of *noncombustible construction*, and

c) the aggregate area of openings in an exterior wall face of a *fire compartment* is not more than 40% of the area of the wall face.

3.1.5.5. Combustible Components for Exterior Walls

1) Except for an *exposing building face* required to conform to Sentence 3.2.3.7.(1) or Sentence 3.2.3.7.(4), an exterior non-*loadbearing* wall assembly that includes *combustible* components is permitted to be used in a *building* required to be of *noncombustible construction* provided

a) the *building* is
   i) not more than 3 *storeys* in *building height*, or
   ii) *sprinklered* throughout,

b) the interior surfaces of the wall assembly are protected by a thermal barrier conforming to Sentence 3.1.5.12.(3), and

c) the wall assembly satisfies the criteria of Sentences (2) and (3) when subjected to testing in conformance with CAN/ULC-S134, "Fire Test of Exterior Wall Assemblies."

(See Appendix A.)

2) Flaming on or in the wall assembly shall not spread more than 5 m above the opening during or following the test procedure referenced in Sentence (1). (See Appendix A.)

3) The heat flux during the flame exposure on a wall assembly shall be not more than 35 kW/m^2 measured 3.5 m above the opening during the test procedure referenced in Sentence (1). (See Appendix A.)

4) A wall assembly permitted by Sentence (1) that includes *combustible* cladding of *fire-retardant-treated wood* shall be tested for fire exposure after the cladding has been subjected to an accelerated weathering test as specified in ASTM D 2898, "Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing."

3.1.5.6. Nailing Elements

1) Wood nailing elements attached directly to or set into a continuous *noncombustible* backing for the attachment of interior finishes are permitted in a *building* required to be of *noncombustible construction* provided the concealed space created by the wood elements is not more than 50 mm thick.

3.1.5.7. Combustible Millwork

1) *Combustible* millwork, including interior trim, doors and door frames, show windows together with their frames, aprons and backing, handrails, shelves, cabinets and counters, is permitted in a *building* required to be of *noncombustible construction*.

3.1.5.8. Combustible Flooring Elements

1) *Combustible stage* flooring supported on *noncombustible* structural members is permitted in a *building* required to be of *noncombustible construction*.

2) Wood members more than 50 mm but not more than 300 mm high applied directly to or set into a *noncombustible* floor slab are permitted for the *construction* of a raised platform in a *building* required to be of *noncombustible construction* provided the concealed spaces are fire stopped in conformance with Sentence 3.1.11.3.(2).

3) The floor system for the raised platform referred to in Sentence (2) is permitted to include a *combustible* subfloor and *combustible* finished flooring.

4) *Combustible* finished flooring is permitted in a *building* required to be of *noncombustible construction*.

3.1.5.9. Combustible Stairs in Dwelling Units

1) *Combustible* stairs are permitted in a *dwelling unit* in a *building* required to be of *noncombustible construction*.

3.1.5.10. Combustible Interior Finishes

1) *Combustible* interior finishes, including paint, wallpaper, and other interior finishes not more than 1 mm thick, are permitted in a *building* required to be of *noncombustible construction*.

2) *Combustible* interior wall finishes, other than foamed plastics, are permitted in a *building* required to be of *noncombustible construction* provided they

a) are not more than 25 mm thick, and

b) have a *flame-spread rating* not more than 150 on any exposed surface, or any surface that would be exposed by cutting through the material in any direction.

3) *Combustible* interior ceiling finishes, other than foamed plastics, are permitted in a *building* required to be of *noncombustible construction* provided they

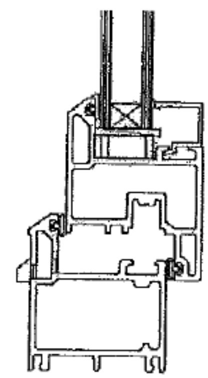
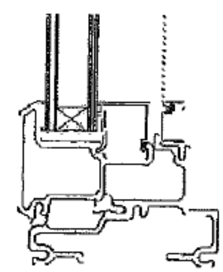
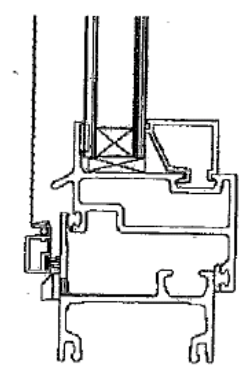
a) are not more than 25 mm thick, except for exposed *fire-retardant-treated wood* battens, and

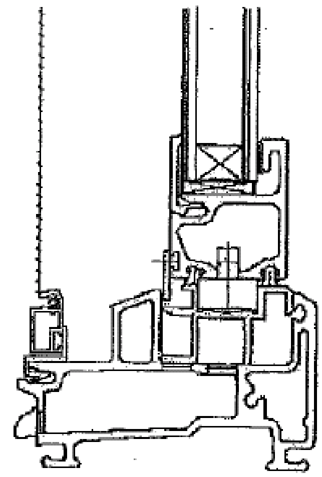
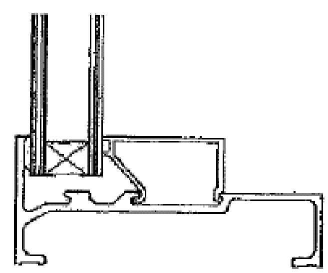
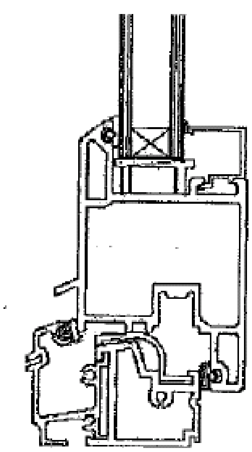
b) have a *flame-spread rating* not more than 25 on any exposed surface, or on any surface that would be exposed by cutting through the material in any direction, or are of *fire-retardant-treated wood*, except that not more than 10% of the ceiling area within each *fire compartment* is permitted to have a *flame-spread rating* not more than 150.

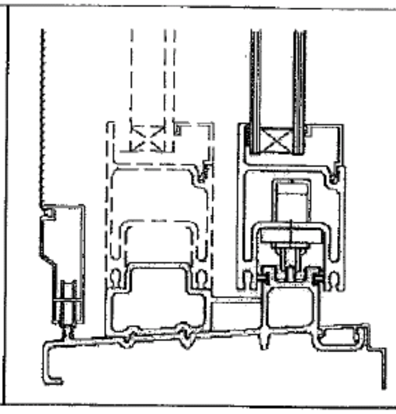
ATTACHMENT NO. 3

DRAWINGS AND PRODUCT INFORMATION

CASCADIA

SERIES	FEATURES	THUMBNAIL
Tilt n' Turn Windows (Series 300)	Inswing tilt n' turn operable vents Outswing option with casement and awning operable vents Integrates with 400 series	
Outswing Casement and Awning Windows (Series 325)	Outswing casement and awning operable vents Also used for operable vents within 400 series windows	
Inswing Casement and Hopper Windows (Series 700)	Inswing casement and hopper vents Integrates with 400 series	

Horizontal and Vertical Slider Windows (Series 800, 850 & 900)	Horizontal (800), Single Hung (850), and Double Hung (900) operable vents	
Strip Windows (Series 400)	Integrates with 300, 325 and 700 operable vents	
Inswing Tilt n' Turn Door (Series 301)	Inswing tilt n' turn	
Outswing Door (Series 301)	Outswing version of the 301 with low profile threshold detail. Can meet ADA and FHA requirements in most situations	

Sliding Patio door (Series 600)		

Appendix D: Summary of Reference Materials Supplied to Participants

Document Summary for Essence of White Rock MURB Design Charrette

Airtightness, Air Barriers and Compartmentalization

Title: **AIR LEAKAGE TESTING OF INDIVIDUAL SUITES IN MULTI-UNIT RESIDENTIAL BUILDINGS**
Source: Graham Finch RDH, John Straube University of Waterloo, Colin Genge Retrotec
Format: MS Word
Topic: Air leakage testing of six suites in four multi-unit residential buildings in Vancouver, BC was performed to quantify air leakage between adjacent suites, floors, common spaces, and through the exterior building enclosure.
Key Points:

- Testing was performed using up to four high power door-fans and an automated fan-control system that precisely controlled the test pressure across each wall sequentially in order to measure the leakage of the six sides of the suite separately.

- Air leakage and flow path test results are expressed in terms of:

    - Equivalent Leakage Area at 50 Pa (ELA50): cm2 @ 50 Pa & in2 @ 50 Pa
    - Air-Flow at 50 Pa(Q50): l/s @ 50 Pa & ft3/min @ 50 Pa (CFM50)
    - Air-Changes per Hour at 50 Pa(ACH50): m3/hr/m3 @ 50 Pa & ft3/hr/ft3 @ 50 Pa (CFM50)
    - Normalized Leakage Area, over surface area of leakage path (NLA50): cm2/m2 @ 50 Pa & in2/100 ft2 @ 50 Pa.

- This provides some baseline data for users performing similar type of testing in the future. Comparisons between different wall and floor assemblies are made using data from the six tested suites.
- Three of the buildings tested were part of a larger study which monitored the hygrothermal performance of the exterior walls over the past five years. The fourth building was recently rehabilitated and was tested for this study as a result of complaints of high interior humidity during the wintertime. The air leakage testing results combined with the previous data and observations is used to better understand past performance and make conclusions regarding the interior air quality and ventilation rates within these buildings.
- The impact of air-tightness on the existing mechanical systems and suite ventilation of the four buildings is shown. Recommendations to avoid

ventilation and humidity problems within multiunit residential buildings, particularly with air-tight exterior enclosures are discussed.

Title: **Air Leakage Control Manual Existing Multi-Unit Residential Buildings**
Source: CMHC
Format: PDF
Topic: This manual provides guidance to air leakage control (ALC) contractors on how to reduce air leakage in existing high-rise multi-unit residential buildings (MURBs).
Key Points:

- Benefits of Air Leakage Control (ALC)
- Air Leakage Principles
- Developing an Air Leakage Control Plan
- Case Studies of Air Leakage Control Projects
- Air Leakage Control Resources
- Air Leakage Control Checklist Forms

Title: **Air Pressure and the Building Envelope**
Source CMHC
Format: PDF
Topic: This publication examines the sources of pressure and pressure gradients and the characteristics of buildings, particularly envelope cavities or voids, which are subject to these five forces. It also addresses the ways design can combat the negative effects of pressure and air pressure differences. This article also explains the dynamic buffer zone (DBZ), a recent concept for control of envelope moisture.
Key Points:

- How and where pressure differences drive moisture within buildings and their envelopes
- How the main driving forces which create these pressure differences contribute to moisture problems, and their relative significance
- How to do basic calculations to determine pressure differences
- Strategies to offset the problems of pressure differences due to mechanical, thermal, barometric and stack effects.

Title: **Commissioning and Monitoring the Building Envelope for Air Leakage** (Summary)
Source CMHC Website
Format: MS Word
Topic: Steps required for commissioning an air barrier
Key Points:

- Air Barrier Specifications in the Project Brief

- Design Validation
- Tender Documents
- Air Barrier Certification during Construction and Final Commissioning
- Post Commissioning Operation, Maintenance and Repair
- Implications for the Housing Industry

Title: **Design of Durable Joints between Windows and Walls** (Research Highlight)
Source: CMHC Website
Format: PDF
Topic: Window / wall joint design to control water penetration, and air and sound movement
Key Points:

- Rain Barrier
- The Perimeter Joint
- Coefficient of Linear Thermal Expansion of Common Construction Materials
- Choosing a Mastic
- Sizing Joints
- Shims and Anchors
- Insulation

Title: **Rigid Air Barrier Assemblies** (Research Highlight)
Source: CMHC Website
Format: PDF
Topic: To familiarize designers and builders with a type of air barrier system made up of rigid panels applied to the walls
Key Points:

- New Building with Concrete Structure
- Renovated building with concrete structure
- New building with steel structure
- New building with wood structure
- Implications for the Housing
- Industry

Title: **Structural Requirements for Air Barriers**
Source: CMHC Website
Format: MS Word
Topic: To assist in the development of design guidelines for air barriers, Canada Mortgage and Housing Corporation (CMHC) commissioned a study on the requirements for structural design of air barriers.
Key Points:

- Types of Structural Failure

- Structural Design Requirements
- Possible air barrier materials identified as
    - gypsum board;
    - rigid insulation, such as extruded polystyrene;
    - polyethylene sheet;
    - membranes, including thermo-fused, trowel- or spray-applied, and mechanically—fastened systems; and
    - exterior insulation finishing systems.
- As a minimum, air barriers should be designed to resist the wind loads for cladding specified in the NBC. However, it is prudent to seriously consider requiring that air barrier materials be capable of withstanding loads higher than those required for cladding.

Title: **Part 5.4 Air Leakage**
Source: BCBC
Format: jpg
Topic: BCBC requirements for air barrier performance
Key Points:

- Required resistance to air leakage
- Air barrier system properties

Title: **Appendix A Section 5.4 Air Leakage of the BCBC - 1**
Source: BCBC
Format: jpg
Topic: Explanation of BCBC requirements for air barrier performance
Key Points:

- Resistance to air leakage
- Air leakage through the air barrier system

Title: **Appendix A Section 5.4 Air Leakage of the BCBC - 2**
Source: BCBC
Format: jpg
Topic: Explanation of BCBC requirements for air barrier performance
Key Points:

- Recommended maximum air leakage rates

Title: **Air Tightness, Air Movement and Indoor Air Quality in British Columbia High-Rise Apartment Buildings**
Source: CMHC Web site
Format: MS Word

Topic: Five high-rise buildings, ranging from seven to eleven stories, were studied. Two had been built in the early 80s and three were new. All were equipped with electric baseboard heating.

Key Points:

- The greatest sources of air leakage, from most to least, are:
    - elevator shafts;
    - floors and ceilings;
    - stairwell doors;
    - sliding glass patio doors;
    - suite fans with ineffective backdraft dampers; and various other service shafts.
- Most of the air leakage into the suites could be traced to deliberate openings in the building such as elevator shafts, stairwells, garbage chutes, exhaust fans and opening windows. The only other noticeable through-wall air leakage entered the suites through the electrical outlets on the outside walls
- Build-up of dirt, lint, grease, etc. on suite exhaust fan backdraft dampers can render them ineffective. Exhaust fans with ineffective back flow prevention become signif-icant sources of infiltration. Underground parking, garbage disposal and combustion vents present ventilation design challenges which are often overlooked.

Title: **Airtightness, Air Movement, and Indoor Air Quality in High Rise Buildings**
Source: CMHC Web site
Format: MS Word
Topic: This publication summarizes the results of a series of programs of field measurement of air leakage and air movement in existing buildings of various ages across the country. Occupants were also polled on their satisfaction with conditions in the same buildings.

Key Points:

- Air leakage rates reported greatly exceed NRC's proposed guidelines of L/s•m2, at 75 Pa. The high rates of leakage reported imply that rates of air leakage, and therefore potential rates of condensation inside building envelope assemblies, may be much higher than is desirable, particularly if occupants attempt to maintain comfortable indoor humidity. This may have adverse implications for envelope durability, although air leakage through windows is not reported separately in the research results from leakage through walls. In some cases, the leakage rates reported combine exterior wall and corridor wall leakage.
- Occupant comfort and perhaps health are as much at risk as the building envelope. Leaky buildings cannot be maintained at comfortable humidities in winter, in mid-continent. Condensation in walls may result in mold

growth, and dispersal of spores into indoor air, a risk to occupant health. If ventilation is mostly driven by stack effect in winter, occupants of lower floors are troubled by cold drafts and exhaust fumes from vehicles adjacent to the building, or in a communicating parkade, while occupants of higher floors suffer from high temperatures and resort to opening windows

Title: **Air Permeance of Building Materials**
Source: CMHC Web site
Format: MS Word
Topic: A total of 36 building materials for air leakage rates at a pressure differential of 75 Pa .
Key Points:

Material	**Air Leakage Rate (l/s-m2@75 Pa)**
Smooth Surface Roofing Membrane, 2 mm	Non-measurable
Aluminum Foil Vapour Barrier	Non-measurable
Modified Bituminous Torch-On Grade Membrane, 2.7 mm, Glass Fibre Matt	Non-measurable
Modified Bituminous Self-Adhesive Membrane, 1.3 mm	Non-measurable
Modified Bituminous Torch-On Grade Membrane, 2.7 mm, Polyester Reinforced Matt	Non-measurable
Plywood Sheathing, 9.5 mm	Non-measurable
Extruded Polystyrene, 38 mm	Non-measurable
Foil Back Urethane Insulation, 25.4 mm	Non-measurable
Phenolic Insulation Board, 24 mm	Non-measurable
Phenolic Insulation Board, 42 mm	Non-measurable
Cement Board, 12.7 mm	Non-measurable
Foil-Backed Gypsum Board, 12.7 mm	Non-measurable
Plywood Sheathing, 8 mm	0.0067
Flakewood Board, 16 mm	0.0069
Gypsum Board (M/R), 12.7 mm	0.0091
Flakewood Board, 11 mm	0.0108
Particleboard, 12.7 mm	0.0155
Reinforced Non-Perforated Polyolefin	0.0195
Gypsum Board, 12.7 mm	0.0196
Particleboard, 15.9 mm	0.0260
Tempered Hardboard, 3.2 mm	0.0274
Expanded Polystyrene, Type 2	0.1187
Roofing Felt, 30 lb.	0.1873
Non-Perforated Asphalt Felt, 15 lb.	0.3962
Rigid Glass Fibre Insulation Board with a Spun Bonded Olefin Film on One Face	0.4880
Plain Fibreboard, 11 mm	0.8223

Asphalt Impregnated Fibreboard, 11 mm	0.8285
Spun Bonded Olefin Film (1991 product)	0.9593
Perforated Polyethylene, # 1	4.0320
Perforated Polyethylene, # 2	3.2307
Expanded Polystyrene, Type 1	12.2372
Tongue and Groove Planks	19.1165
Glasswool Insulation	36.7327
Vermiculite Insulation	70.4926
Cellulose Insulation, Spray-On	86.9457

Title: **Controlling Stack Pressure In High-Rise Buildings by Compartmenting the Building**
Source: CMHC Web site
Format: MS Word
Topic: The objectives of this study were to: 1) measure the actual pressure differentials across various separations within a high-rise apartment building; 2) generate and analyze potential ways of reducing the air leakage through these separations; and 3) to draw conclusions on how reducing air leakage affects air movement in the building. The effects include changes in operation of typical current ventilation Strategies and fire and smoke control measures.
Key Points:

- In the study, compartmentalization led to smaller variations in unit ventilation rates over the height of the building. This would allow the overall rate of ventilation to be reduced to closer to the ASHRAE standard of 0.35 air changes per hour, which would translate into substantial savings in heating and cooling costs
- Greater reductions in exterior envelope pressure differentials may also be achieved by reducing make-up air fan speeds, and significant peak demand savings may be gained where staged electric resistance coils provide heat and there is central air-conditioning.
- The main benefit of the compartmentalization observed in the study was that the garage area was neutralized as a source of infiltration. Field measurements indicated that, even with the corridor make-up air fans operating, during cold weather the garage pressure was higher than that in the vertical shafts. With a significant amount of air entering the building through the garage, compartmentalization essentially eliminated airflow from the garage to the building.
- Of the three compartmentalization strategies analyzed, the best performance was obtained from the Double Compartmentalization strategy, which isolates the vertical shafts, the corridors and the units from each other.

Title: **Design Considerations for an Air Barrier System**
Source: OAA / CMHC

Format: PDF
Topic: This document examines the problems of air leakage control, the concepts of air leakage paths and air pressure differences, the design requirements of air barriers systems, the properties of air barrier materials and systems, the building code requirements, the design of air and vapour barriers. It also provides notes on the preparation of drawings and specifications and site review considerations.

Key Points:

- The types of problems caused by air leakage through a building
- envelope
- The nature of holes, openings and air leakage paths in the building
- envelope
- The concepts of air flow and pressure difference
- The structural loading effects of an air pressure difference on air
- barrier materials and systems
- Where the air barrier should be positioned or located in a wall, roof, or
- window
- How to distinguish between air barrier materials, vapour barrier
- materials and air/vapour barrier materials
- How to interpret and comply with the building code requirements
- On-site methods to test and commission air barrier

Title: **Establishing the Protocol for Measuring Air Leakage and Air Flow Patterns in High-Rise Apartment Buildings**

Source: CMHC Web site
Format: MS Word
Topic: To establish protocols for measuring air leakage and air flow patterns in high-rise residential buildings.
Key Points:

- Airtightness of the Whole Building
- Airtightness of Individual Storeys
- Airtightness of Stair Shafts
- Tracer Gas Decay Tests
- A set of test procedures was developed and verified for conducting a systematic study of air leakage and air flow patterns in high-rise residential buildings. The test procedure allows determination of the airtightness of the building envelope, of the exterior walls of individual storeys and of the interior partitions. The procedure can be used for the commissioning of the building envelope and for verification with Code requirements. However, in occupied buildings, the success of the test depends heavily on occupant cooperation.

Title: GUIDELINES FOR DELIVERING EFFECTIVE AIR BARRIER SYSTEMS
Source: OAA / CMHC
Format: PDF
Topic: This article presents a methodology to help both designers and installers deliver an air barrier system that meets the requirements and recommendations of the National Building Code of Canada and any specifications particular to that project. Common design and installation flaws will be identified, and a protocol for the inspection and testing of the system, as it is being installed, will be documented.

Key Points:

- What are we testing for?
- Why problems occur
    - Materials
    - Design
    - Installation Practice
- Specifications
- Protocol for the inspection and testing of air barriers
- The design, inspection and testing procedure
    - Visual Inspection
    - Quantitative Testing
    - Qualitative Testing
- Post Construction

Title: **Structural Requirements for Air Barriers**
Source: CMHC Web site
Format: MS Word
Topic: To be effective over the life of a building, the air barrier must resist the damaging effects of winds, stack effects, and other forces. These forces must therefore be taken into account in its design. To assist in the development of design guidelines, Canada Mortgage and Housing Corporation (CMHC) commissioned a study on the requirements for structural design of air barriers.

Key Points:

- As a minimum, air barriers should be designed to resist the wind loads for cladding specified in the NBC. However, it is prudent to seriously consider requiring that air barrier materials be capable of withstanding loads higher than those required for cladding.

Title: **The Potential Application of Compartmenting Strategies in High-Rise Residential Buildings**
Source: CMHC Web site
Format: MS Word
Topic: To analyze the potential impact of compartmenting the building by sealing interior partitions, a computerized multi-zone air flow simulation program,

(CONTAM93), was used to simulate conditions within the building under three different compartmenting strategies.
Key Points:

- Compartmenting reduces air leakage and associated space heating costs in high-rise residential buildings in cold climates.
- Compartmenting reduces interzonal air transfer within buildings. This will help to alleviate common problems in apartment buildings such a the transfer of cooking and smoking odours from apartment to apartment, the proliferation of smoke during fires, noise transmission, and the general lack of individual control over their indoor environment.
- Compartmenting is not practical for buildings where apartments are connected by common ventilation shafts which effectively bypass the sealed interior partitions. Ventilation systems in compartmented buildings would have to employ apartment-based systems.
- Compartmenting offers the potential to improve the spatial integrity between the apartments of a building. This, in turn, can resolve the problems of noise and smoke transfer associated with apartment buildings. The costs and benefits of compartmenting should be further assessed in either new or existing buildings.

Building Envelope Durability

Title: **Analysis of the Hygrothermal Behaviour of Residential High-Rise Building Components**
Source: CMHC Web site
Format: MS Word
Topic: The main objective of this joint IRC-CMHC research project was to examine the use of modelling to predict the hygrothermal performance of a few selected high-rise wall and roof systems
Key Points:

- Brick Veneer/Steel Stud Wall
- Brick Veneer/Concrete Block Backup
- EIFS Wall
- Roofs
- The simulations demonstrated the strong influence rain penetration has on the moisture regime of a building assembly. In fact, in wet conditions, liquid diffusivity is the dominant moisture transport mechanism and the importance of vapour resistance is of less significance. This issue may prove to be of particular importance, since the concept of vapour resistance is widely used by "moisture experts" as the only concept for comparing building envelope moisture performance.

Title: **Study of Poured-In-Place Concrete Wall Assemblies in Coastal British Columbia** (Research Highlight)
Source: CMHC Website
Format: PDF
Topic: To analyze and document potential performance questions associated with poured-in-place concrete wall assemblies, as well as develop a guideline for appropriate design and construction practices

Key Points:

- Identify and investigate key performance questions associated with components and materials utilized with poured-in-place concrete wall assemblies in multi-unit residential construction. In all, four existing buildings and five new projects were reviewed.
- Analyze heat, air and moisture control requirements of Part 5 of the building code for poured-in-place concrete wall assemblies, including water penetration control, air leakage, vapour diffusion, thermal performance and durability of materials.
- Examine several specific aspects of construction practices(including exterior coatings, concrete mix, crack control and joint detailing) that impact the performance characteristics of poured-in-place concrete wall assemblies.

Title: **Keeping Walls Dry Parts 1 & 2**
Source: OAA / MAA / CMHC
Format: PDF
Topic: This article examines the many considerations that must go into the design of walls that "stay dry," starting with the results of several CMHC studies that looked at the most common causes of building problems. The sources of moisture that can cause wetting of walls, including interior, exterior and construction moisture, are examined and methods of controlling each source are discussed.
Key Points:

- Deflection: Using features of the building to limit exposure of the walls to rain, such as overhangs and drips.
- Drainage Using design features that provide a means to direct water that does penetrate the wall back to the outside.
- Drying Using features that facilitate the drying of materials that get wet.
- Durability Using materials that are tolerant of moisture.

Title: Simulation of Wind-Driven Rain and Wetting Patterns on Buildings
Source: CMHC Web site
Format:
Topic: This project included the following components: 1) a demonstration of the feasibility of physically modelling wind-driven rain in a wind tunnel to show how wetting affects buildings; 2) a study, using a model that allows comparisons with

field experience, of the effects of wind direction and wind speed on wetting patterns; and 3) an exploratory investigation of the effects of building height and architectural features on wetting patterns
Key Points:

- Preliminary results showed that features such as overhangs and cornices can be effective in reducing the amount of rain which falls on a building, even on highrise buildings.

Title: **The Rainscreen Wall: A Commissioning Protocol**
Source: CMHC Web site
Format: MS Word
Topic: The project included three areas of interest:

- the measuring and monitoring of rainscreen field performance,
- on-site testing using the Cavity Excitation Method (CEM) for performance verification, and
- commissioning the design and construction of rainscreen wall and window systems.

Key Points:

1. In the normal course of design, cladding systems are selected during the development of facades. It is at this stage that the decision to use a rainscreen wall must be made. The vertical and horizontal compartments must be located and the number of rainscreen cavities determined.
2. Having chosen the rainscreen principle for the exterior walls, the performance criteria must be established, including the steady state and dynamic equalization performance and the ratio of rain penetration to rain loading.
3. The individual parts of the rainscreen wall must be designed, including an air barrier system, compartment seals, and a cladding system with vents and drains.
4. The steady state equalization and the dynamic performance must be determined using Version 2.0 of the CMHC RAIN* computer program. If the design fails to meet the established criteria, it is revised until the criteria are met. If the performance criteria are met, the design is carried to the production of working drawings.
5. The commissioning criteria should be established, which could include:
   - a maximum limit on the air barrier/compartment seal leakage,
   - a minimum cladding vent area,
   - a maximum time decay rate for the prescribed CEM tests, and
   - a maximum limit on the deflections of the cladding and air barrier system.
6. The design must be validated, ideally through laboratory testing of a full-scale mock-up, to determine if the performance requirements of the

simulation compare adequately with the mock-up performance and what quality of construction was required.

7. If the mock-up fails to meet the performance objectives, then it is progressively revised and retested until it does. On the final iteration, the CEM (Cavity Excitation Method) performance characteristics (decay curve) are defined for the field commissioning criteria.
8. If timing or budget do not permit the laboratory testing, a mock-up could be done on site. However, an allowance must be carried for modest re-design as the builder should not be expected to pay for the uncertainty of design changes. The design must be validated before the builder accepts responsibility for the eventual commissioning specifications of the rainscreen system.
9. The commissioning process would then be undertaken to determine compliance of the rainscreen. Commissioning may proceed in a progressive manner if the project is large and complex, or near the completion of construction if adequate site supervision has ensured that the quality of construction required was attained as per laboratory or mock-up requirements.
10. If the construction has met the commissioning criteria, then a certificate of compliance may be issued by the commissioning agent or architect to the builder.

While the commissioning procedure does not include a water test, it would be prudent to undertake such a test.

Title: **The Rain Screen Wall System**
Source: OAA / CMHC
Format: PDF
Topic: The rain screen principle and the process of pressure equalization are explained. Parameters are given for determining how to vent a rain screen properly. Sample details are shown for various rain screen wall and joint systems. Ten key features to look for in rain screen details are provided.
Key Points:

- Provision for water shedding at the outer cladding, away from joints, with drips under any projections to prevent water collecting at the building face.
- A cavity of appropriate width to allow pressure equalization across the cladding system and prevent capillary movement (allow for construction tolerances!).
- A continuous and effective (for example, airtight to a maximum air leakage of 0.1 L/s/m2) air barrier within the backup wall.
- Drainage of the cavity through continuous flashings and weep openings, and proper management of drained water.
- Adequate venting of the cavity provided through properly located openings in the cladding (appropriate ratio achieved between vent area and leakage of air barrier and seals).

- Additional provision for drainage at the backup wall (located on the "warm" side of the insulation to avoid condensation problems).
- Effective compartmentalization of the cavity at each building face with airtight seals, and additionally across the width of the façade as required (refer to calculations).
- Sufficient rigidity and/or structural support of the air barrier to resist wind loads and limit deflection.
- Sufficient rigidity of the cladding to limit deflection and resist wind loads as required.
- Special attention paid to water-resistance and drainage at building edges and parapets (areas subject to heaviest rain-wetting and wind pressure differences, where pressure equalization may not be achievable).

Title: **Understanding Vapour Permeance and Condensation in Wall Assemblies** (Research Highlight)
Source: CMHC
Format: PDF
Topic: CMHC initiated a research program to investigate the significance or insignificance of potential moisture problems due to the use of low permeance plastic sheeting in above-grade and below-grade wall assemblies. The research was intended to identify cases where performance could be improved, and provide information to help avoid inappropriate use.

Key Points:

- Theory and previous research have confirmed that the need for vapour barriers depends on the interior humidity levels, the exterior temperature, and the makeup of the wall assembly.
- The field testing and simulation results from this study show that low permeance interior layers are required in some situations but not necessarily in others.
- Under conditions of high interior humidity and very cold exterior temperatures, mineral-fiber-insulated walls with no insulating sheathing will require low permeance (for example, under 60 metric perms) vapour barriers.
- In applications with lower (that is, safer) relative humidity levels, warmer Canadian climates and walls with exterior insulated sheathing, ordinary latex paint may be sufficient. The addition of insulating sheathing controls both cold weather and warm weather condensation without the use of plastic sheeting, but
- the R-value of the insulation must be sufficient to control winter-time condensation for the interior humidity expected.
- The report provides more detail on what combination of climate, interior relative humidity, and insulated sheathing controls cold weather condensation.

Title: **Wind-Rain Relationships in Southwestern British Columbia** (Research Highlight)
Source: CMHC
Format: PDF
Topic: This study examines the relationship between wind and rain for all seasons of the year. Wind and rainfall data are from 12 meteorological stations on Vancouver Island and in B.C.'s Lower Mainland.
Key Points:

- The topography and ocean influence greatly affect local weather conditions in the Lower Mainland and Vancouver Island, and building design decisions based on weather information from a single location such as the Vancouver Airport may be inappropriate for the location of the building. The data show that Vancouver Airport weather data do not represent wind-rain conditions over all locations within the lower Fraser Valley. Predominant wind directions during rain, as well as maximum wind speed, vary with location.
- These results also have implications for design of new construction. Knowing the prevailing directions for wind-driven rain in a given location can provide guidance in selecting appropriate facades for entrance doors or sliding patio doors, both of which are notoriously poor at resisting wind-driven rain. The wind roses can also provide some indication about the need for wider overhangs on a given elevation. Also, if (due to an unavoidable interior configuration) an entrance door must be located on an elevation with a high exposure to wind-driven rain, the designer can anticipate the need for a canopy or deep alcove to reduce the building's vulnerability to water ingress.

Energy Consumption in High Rise Buildings

Title: **Energy Audits of High-Rise Residential Buildings**
Source: CMHC Web site
Format: MS Word
Topic: This report details actual energy consumption of high rise residential buildings and suggests means of reduction.
Key Points:

The report recommends the following general energy conservation measures:

- air sealing to reduce air leakage;
- improved window performance (including low-e films for retrofits);
- insulation upgrades for walls and roofs;
- energy-efficient lighting;
- scheduling of make-up air, central exhaust and laundry room exhaust systems;

- calibration of thermostats;
- lower thermostat set-points in garages, storage and service rooms; and
- Water conserving measures (e.g., low-flow shower heads).

Title: **Strategies for Reducing Building Energy Use Via Innovative Building Envelope Technologies** (Research Highlight)
Source: CMHC
Format: PDF
Topic: In order to better understand the opportunities to reduce, generate and recover energy at the building envelope of existing multi-unit residential buildings (MURBs), Canada Mortgage and Housing Corporation initiated a research project to document existing technologies, assess which would be most likely considered by MURB property owners and to evaluate the costs and benefits of selected technologies.
Key Points:

- The technologies identified as a part of the review were:
  - Improved Wall and Roof Insulation
  - Window Retrofits
  - Sunspaces/Atria (e.g. enclosed balconies)
  - Double-Facade Envelopes
  - Building-Integrated Photovoltaics (BIPV)
  - Solar Ventilation Air Heating (e.g. Solarwall™)
  - Solar Domestic Water Heaters
- Solar air heating was deemed to be potentially attractive to building owners as it reduces corridor ventilation system energy use, improves the indoor environment and can be easily integrated into building envelope renewal work.
- Enclosed balconies were considered viable as they can reduce space heating energy requirements, increase usable space within apartments (seasonally) and can offset balcony and railing repair and replacement costs.

<u>Fenestration</u>

Title: **Design, Selection and Commissioning of Window Installations**
Source: CMHC
Format: PDF
Topic: This article provides guidance on ways to reduce surprises involving windows delivered to the construction site. Many of these surprises are avoidable, and the discussion of proper specification language will help minimize frustration and the associated cost of not getting the desired window performance. This article discusses the performance parameters to consider in the building design stage to define desired performance levels. It also discusses how to specify those parameters in the design documents and how to specify the desired level of performance to the contractor-builder. Finally, it discusses the proper use of quality assurance through on-site testing as a means of determining whether the finished product achieves the desired performance.

Key Points:
- Performance parameters — the design stage
- Specifying the desired performance
- Achieving field performance

Title: Glass and Aluminum Curtain Wall Systems
Source: OAA / CMHC
Format: PDF
Topic: This article provides an overview of the components of modern glass and aluminum curtain walls, their design features, performance and durability characteristics. It also provides the architect or designer with knowledge of the technology of curtain wall design with respect to air leakage control, rain penetration control, heat loss (or gain) control and condensation control.
Key Points:
- THE STICK BUILT SYSTEM
- THE UNITIZED CURTAIN WALL
- THE STRUCTURAL GLAZING SYSTEM
  - AIR LEAKAGE CONTROL
  - VAPOUR DIFFUSION CONTROL
  - RAIN PENETRATION CONTROL
  - CONDENSATION CONTROL
- CURTAIN WALL DETAILS AND CONNECTIONS
- TESTING CURTAIN WALL SYSTEMS
- SOURCES OF INFORMATION

Title: **Healthy High-rise**
Source: CMHC
Format: 7 PDF Files
Topic: This document is intended to present alternative ways of thinking about design principles for highrise buildings, to provide some different approaches to design, construction, commissioning and operations and maintenance. In many cases, it presents the need for a more holistic and integrated approach to the design and construction of a high-rise residential building. This type of integration is displayed in the “Related Topics” table at the beginning of each sub-section.
Key Points:
Enhancing Envelope Design
Enhancing Performance
Enhancing Indoor Air Quality
Enhancing Environmental Performance
Enhancing Accessibility
Green Infrastructure

HVAC

Title: **Field Testing to Characterize Suite Ventilation in Recently Constructed Mid- and High-Rise Residential Buildings** (Research Highlight)
Source: CMHC
Format: PDF
Topic: A research study of 10 mid- and high-rise residential buildings was conducted to assess the performance of the mechanical ventilation systems and to identify influencing design, installation, operational, and environmental factors.
Key Points

- The results of this research project challenge the idea that conventional corridor air systems can act as a ventilation system for individual apartments. Environmental conditions and building physical and operational parameters can undermine the ability of corridor air systems to deliver outdoor air to individual apartments. The findings imply that other approaches to ventilating apartments will have to be developed in order to meet growing demands for healthy, safe, durable, and energy-efficient buildings.

Indoor Air Quality

Title: **Evaluation of Pollutant Source Strengths and Control Strategies in Innovative Residential High-Rise**
Source:
Format:
Topic: a study of the pollutant emission behaviours of common building materials and finishes and the indoor air quality in several suites of a new multi-unit residential building. The purpose of the study was to determine the relative influences of building and occupant-related pollutant emissions on indoor air quality over the initial six to eight months after construction. Recommendations regarding the effectiveness of control and dilution strategies were subsequently developed.
Key Points
To optimize indoor air quality, the following recommendations were proposed:

- Use non-polluting materials and finishes in the construction and finishing of buildings.
- When low-emission materials and finishes are used, beware of the total available surface area used, as low-emission materials that have large surface areas can be just as problematic as high-emission materials and finishes.
- Additionally, reduce surface areas of materials that can serve as potential “sinks” for indoor air pollutants.
- Finally, educate the occupants concerning their selection and use of low-emission and non-polluting furnishings, finishes and cleaning compounds so that they do not undermine the efforts made on their behalf in the design and construction of the building.

Title: **Indoor Air Quality Test Protocol for Highrise Residential Buildings**
Source: CMHC
Format: MS Word
Topic: a study of the general protocol to be followed for the assessment of indoor air quality in highrise residential buildings. The results of the investigation were compiled in the form of a manual that may be used to assist investigators in this task.
Key Points

- This manual provides a protocol for the three stages involved in the assessment of indoor air quality in highrise residential buildings. It serves to assist investigators in the identification of potential problems and in the determination of the appropriate course of action once contaminant levels are suspected.

Innovative Mid and High Rise Projects

Title: **Conde Nast Building**
Source: Advanced Building News 25
Format: PDF
Topic: Review of the design and construction of the Conde Nast Office Building 4 Times Square New York
Key Points

- Green features incorporate in:
    - Architectural
    - Structural
    - HVAC
    - Power Supply (on site fuel cells and PV)
- Review of computer simulation tools used
- IAQ considerations
    - Ventilation
    - Occupant selection of interior finish materials

Title: **Conservation Co-operative 140 Mann Ave. Ottawa, Ontario**
Source: CMHC Innovative Buildings Series
Format: PDF
Topic: The Conservation Co-operative project was Canada's residential selection for the Green Building Challenge 98.The downtown Ottawa project is an example of a community-based "green" multi-unit residential building. The development shows how sustainable advances on all fronts can be achieved on a restrained budget and without complex technology.
Key Points

- Construction waste reduction
- Highly insulated building envelope
- Separately supported balconies with thermal break

- Water conservation and reuse measures
- Recycling facilities
- Low off gassing interior finishes

Title: **District Lofts , Toronto**
Source: CMHC Innovative Buildings Series
Format: PDF
Topic: The District Lofts development is a unique mixed-use condominium project located in the heart of Toronto's urban core. It boldly establishes a number of innovative precedents that have enhanced its marketability without compromising its contribution to sustainability.
Key Points

- Advancement of urban intensification and mixed use through non-conventional design;
- Integration of public and private automobile parking;
- Promotion of natural ventilation and daylighting opportunities;
- Application of efficient structural engineering components;
- Deployment of underslung elevators to eliminate penthouse mechanical rooms;
- Innovative fire egress strategy.

Title: **Grandin Green: Pioneering Innovation in an Multi-Unit Residential Building**
Source: CMHC Innovative Buildings Series
Format: PDF
Topic: The Grandin Green is a 15 storey multi-unit residential building (MURB) constructed in 1999-2000 in Edmonton, Alberta. The building was one of the first MURBs constructed in Canada to incorporate many innovations designed to reduce energy and water consumption and to enhance the indoor environment. Additionally, it was the first MURB designed in accordance with Natural Resources Canada's innovative Commercial Building Incentive Program (CBIP) that requires buildings to have an annual energy consumption that is 25 per cent less than the Model National Building Code for Buildings.
Key Points

- Building Envelope - EIFS, RSI 1.17 Windows
- Space Conditioning – Individual gas fired fan coil units
- Ventilation – in suite HRV

Title: **Monitored Performance of an Innovative Multi-Unit Residential Building 77 Governor's Road, Dundas, Ontario** (Research Highlight)
Source: CMHC
Format: PDF
Topic: In 1998/1999, an innovative, 6-storey, 48-unit condominium was designed and constructed around the four main goals of the Canada Mortgage and Housing Corporation's IDEAS Challenge and Natural Resources Canada's C-

2000 programs. These include envelope durability, energy efficiency, indoor air quality (occupant health), and environmental and resource conservation. The building was designed to have energy consumption 35 per cent lower than a similar building designed to meet the Canadian Model National Energy Code for Buildings. The thermal comfort and indoor air quality were also designed to be better than that in typical apartment buildings.

Key Points

- The verified performance of this innovative multi-unit residential building indicates that it is possible to include many advanced and environmentally responsible features into a fairly conventional construction project. The integration of an air leakage control procedure into the construction, design and commissioning process is perhaps one of the most important aspects of this project. The in- suite and corridor ventilation strategies represent significant departures from conventional designs but demonstrate significantly improved performance.

Title: **Radiance @ Minto Gardens Multi-Residential Natural Resource** Conservation and Energy Efficiency
Source: CMHC Innovative Buildings Series
Format: PDF
Topic: Beyond the usual development objectives, the mandate for this condominium in North York was to adopt urban sustainability principles in its planning, design and construction. The ultimate goal was meeting LEED Silver Certification standards. The LEED philosophy and its five performance categories of sustainability were considered throughout all aspects of the project.

Key Points

- 55% reduction in water use
- Consumes 33% less energy than MNECB
- Central high efficiency chiller and condensing gas boiler, in suite combined fan coil / HRV units
- Low emitting interior finish materials
- Integrated design process methodology used to develop design

Title: **Innovative Buildings The Silvia**
Source: CMHC Innovative Buildings Series
Format: PDF
Topic: The Silva is a newly constructed 16-storey, 68-unit condominium tower in downtown North Vancouver. The building was designed and constructed with the principles of healthy and sustainable living in mind. It aims to deliver indoor air quality, water and energy efficiency, and enhanced liveability advantages to the residents while benefiting the local community through the conservation of materials and resources, waste management, and sustainable site planning.

Key Points

- recycling of more than 75 per cent of demolition and excavation materials (wood from a two-storey building and asphalt from a parking lot which were previously on-site);
- promotion of energy efficiency during construction, and occupancy;
- emphasis on environmentally friendly materials, including routine use of water- and energy-efficient ENERGY STAR® appliances;
- choice of regionally sourced materials, supporting local manufacturers and reducing transportation energy;
- incorporation of non-toxic paints, sealants and adhesives, and non- off gassing kitchen and bathroom cabinets to maintain interior air quality;
- use of materials with high recycled content; and
- a green roof to aid in stormwater management and to filter pollutants

Title: **Tatry-Pathway Housing Non-profit Co-operative**
Source: CMHC Innovative Buildings Series
Format:
Topic: Completed in 1994 on a Mississauga main street, the Tatry-Pathway won the 1995 World Habitat Design Award. The complex, consisting of two mixed-use (retail and apartments), sets a new standard for quality suburban intensification. The environmentally friendly design provides high indoor-air quality and reduces energy consumption by reducing loads and co-generating energy.
Key Points

- Reduced energy consumption up to 50 per cent of ASHRAE 90.1 through energy-efficiency measures.
- Fresh air is drawn into each suite through balanced heat recovery ventilator (HRV).
- Up to 80 per cent of electrical demand is supplied through a gas co-generation system.
- Envelope RSI value was improved by 70 per cent over conventional construction.
- The value of windows (triple-glazed, argon-filled) was doubled over conventional construction.
- Envelope and ventilation techniques allow smaller mechanical equipment to be used.
- Cooling loads are reduced on the south-east and west sides with selective window glazing that rejects infra-red radiation.
- Absorption and reciprocating chillers have a combined ozone depletion of 20 per cent for a conventional building.

Title: **Waterfall Building Green Roof Case Study Vancouver, British Columbia**
Source: CMHC Innovative Buildings Series
Format: PDF
Topic: The Waterfall Building is part of a new mixed-use project located in Vancouver, British Columbia developed by Hillside Development Ltd. in 2000-

2001. The ground floor is reserved for general office, retail or service use, while the remainder of the project is a mixture of commercial and "live/work" space. The green roof system was intended to meet the goals of creating an aesthetically pleasing community recreational space—which met both the social development goals of Hillside and the community revitalization goals of the city

Key Points

- The Waterfall Building green roof is both extensive and intensive. Extensive green roofs are characterized by their low weight, low capital cost and minimal maintenance requirements.
- The extensive plots on Waterfall building is comprised of *poa alpina*, blue grass. In contrast, intensive green roofs are characterized by greater weight, higher capital costs, more diverse plantings and higher maintenance requirements than extensive systems.
- Most of the system was comprised of Soprema's Sopranature green roof system
- The decision to use Soprema's system was based on excellent results that the architectural firm has had with previous projects.
- There is a 5-10 year warranty on the system on the green roof components and a one-year warranty on plants.

Title: **Minto Sustainability Projects**
Source: MintoUrban Communities Inc.
Format: PDF
Topic: Tjis document gives an overview of the recent high rise MURB projects constructed or under construction by MintoUrban Communities that incorporate sustainability features including high levels of energy efficiency.

Key Points

- Radiance at Minto Gardens.
- Minto Yorkville
- Minto Midtown
- Minto Skyy
- Minto Roehampton
- 180 Kent Street

Mechanical Ventilation

Title: **Field Testing to Characterize Suite Ventilation in Recently Constructed Mid- and High-Rise Residential Buildings**
Source: CMHC Research Highlight
Format: PDF
Topic: CMHC conducted a research study of 10 mid- and high-rise residential buildings to assess the performance of the mechanical ventilation systems and to identify influencing design, installation, operational, and environmental factors. The study provides many useful insights as to why conventional ventilation strategies are unable to meet the ventilation requirements of multi-unit residential buildings.

Key Points
Six series of field tests were conducted in each building:
1. Determination of Environmental Driving Forces
2. Determination of the Pressure and Airflow Capabilities of the Suite Exhaust Systems
3. Determination of Corridor Air System Supply Airflow Rates
4. Assessment of the Air Leakage Characteristics of Suite Access Doors
5. Determination of Suite and Room Air-change Rates
6. Estimation of Inter-suite Transfer Air Fraction.

The results of this research project challenge the idea that conventional corridor air systems can act as a ventilation system for individual apartments. Environmental conditions and building physical and operational parameters can undermine the ability of corridor air systems to deliver outdoor air to individual apartments. The findings imply that other approaches to ventilating apartments will have to be developed in order to meet growing demands for healthy, safe, durable, and energy-efficient buildings.

Renewable Energy

Title: **Solar Energy for Buildings**
Source: CMHC
Format: PDF
Topic: *Solar Energy for Buildings* presents basic information on solar building design, which includes passive solar heating, ventilation air heating, solar domestic water heating and shading. The article suggests ways to incorporate solar design into multi-unit residential buildings, and provides calculations and examples to show how early design decisions can increase the useable solar energy.
Key Points
Passive solar is best for buildings that have low internal heat gains and in which direct solar gain is directed to absorbent thermal mass. The housing market

today may object to hard floor surfaces out of concern for comfort and impact noise, but increased drywall thickness and concrete ceilings may compensate for the lack of hard flooring. Mass is most effective if it receives direct solar gains, i.e. usually on the floor. However, if this is not possible, a concrete ceiling will absorb much of the energy from air heated by the floor; this air will rise through buoyancy. Generally, about 5-10 cm of concrete—or equivalent—on the floor provides adequate mass