# Building Enclosure Design Guide

Wood-Frame Multi-Unit Residential Buildings

**Second Edition** 



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# Contents

1	Introduction	1-1
	1.1 Background	. 1-1
	1.2 Building Enclosure as a System	. 1-2
	1.3 The Guide	. 1-3

# 2 Behaviour of Wood in Construction

#### **2-1**

3-1

2.1	Characteristics of Wood
2.2	Moisture Content and Shrinkage of Wood
2.3	Decay in Wood
2.4	Exposed Exterior Wood
2.5	Wood Shrinkage Issues

# 3 Heat, Air & Moisture Control Principles

3.1	Exterior Environment
3.2	Interior Environment
3.3	Moisture Balance
3.4	Mechanisms of Heat Flow
3.5	Heat Flow Control 3-11
3.6	Water Penetration Control
3.7	Air Flow Control
3.8	Condensation Control
3.9	Control of Construction Moisture

# Energy 4-1 4.8 National Energy Code for Buildings (NECB) ......4-5

### **5** Assemblies

5.1	Critical Barriers.	. 5-1
5.2	Assembly Fact Sheets	. 5-3
5.3	Assemblies External to Main	
	Environmental Separator	5
5.4	Crawl Spaces	. 5-5
5.5	Below-Grade Wall Assemblies	. 5-6
5.6	Above-Grade Wall Assemblies	. 5-9
5.7	Roof Assemblies	5-17
5.8	Balcony/Walkway Assemblies	5-26
5.9	Window Assemblies	5-29

#### Dotails 6

De	etails	6-1
6.1	Continuity of Critical Barriers	. 6-1
6.2	Detailing of the Water Shedding Surface	. 6-4
6.3	Too Much Membrane	. 6-5
6.4	Sample Details	. 6-7

5-1

# 7 Components and Materials

7.1 Scope	
7.2 Wood Products	
7.3 Insulation	
7.4 Sheathing Membranes	
7.5 Flashings	
7.6 Eavestroughs and Rain Water Leaders	
7.7 Cladding	
7.8 Windows	
7.9 Insulating Glass Units	
7.10 Skylights	
7.11 Doors	
7.12 Sealants	
7.13 Painting and Exterior Coatings	
7.14 Water Shedding Roofing	
7.15 Waterproof Roofing	
7.16 Balcony and Walkway Pedestrian Traffic Membranes	

# 8 Maintenance and Renewals

8.1	Overview
8.2	Why Maintain?
8.3	Maintenance Planning
8.4	Renewals Planning
8.5	Design Considerations

# Glossary G-1

Additional Resources	R-1
Appendix A	A-1

**8-1** 

7-1

# 2 Behaviour of Wood in Construction

The particularly wet climate of many areas of British Columbia, together with the limitations of wood under wet conditions, requires building designs to incorporate technology that provides a suitable environment for wood. This chapter discusses the unique properties of wood and its use in building enclosures, to assist in understanding how to construct durable buildings.

### 2.1 Characteristics of Wood

To successfully use wood building materials, some basic knowledge is needed regarding the cellular structure of wood, how it holds and reacts to moisture, how it is processed, and what factors may result in its deterioration.

Softwood lumber, the product of coniferous (needlebearing) trees, is most often used for wood-frame construction in North America. The wood from coniferous trees is used because it is economical and plentiful, more easily worked, and has a higher strength-to-weight ratio than hardwood. It is also readily available in the required



Figure 2-1 Wood-frame multi-unit residential building under construction

lengths needed for construction. Engineered wood-based members, built from multiple wood plies or strands, are available to fill the need for larger structural sections.

Softwood is comprised of tubular cells that are about 4 mm (0.16 in.) long and 0.04 mm (0.0015 in.) thick. Most of the cells are longitudinally aligned, in the lengthwise direction of lumber or timbers. Each year, trees grow a new layer of cells called a growth ring. The density and other cellular characteristics, including growth rate, account for some of the differences in strength and stiffness of different species of wood, parallel to and across the grain. The cells of normal wood shrink and expand mainly across their width as they lose or gain moisture.

### 2.2 Moisture Content and Shrinkage of Wood

Moisture is held in wood in the cell walls (bound water) and the cell cavities (free water). When timber is felled, it has a high moisture content and needs to be dried before it can be used in building construction. Moisture content is the weight of water contained in wood, expressed as a percentage of the weight of oven-dry wood. The oven-dry state does not occur under normal service conditions; it 2

Normal, cautionary, and dangerous ranges were developed from field measurements and computer modelling based on commonly accepted thresholds for wood products and decay-resistance testing. Understanding seasonal variations in wood moisture content as well as the specific properties of wood products is important when assessing the condition of building enclosure components.

The behaviour of wood building materials after manufacture is closely related to fluctuations in moisture content within the wood. This has implications for the design of wood-frame structures and the performance of the building enclosure. Wood shrinks when it loses moisture and swells when it gains moisture. Shrinking and swelling do not occur when the moisture content is above the fibre saturation point.

The change in length of wood along the grain is small and can be ignored, except:

- > Where grain irregularities occur
- > Where lumber has been sawn at an angle to the grain
- When the structure is very sensitive to any dimensional movement, such as with truss uplift
- When the overall length is too large to be neglected, such as in a tall building (>six storeys)

Shrinkage is greatest in the circumference of a log (perpendicular to grain but tangential to the growth rings) compared to the radial direction (perpendicular to the grain but radially from the growth rings). The change in dimension is almost in direct proportion to its moisture change below the fibre saturation point. See Figure 2-4, Figure 2-5, and the detailed shrinkage calculation examples in Section 2.5 on page 2-11.

The shrinkage of wood varies between and within wood species and even within the same tree. Normally, a user has no control of grain orientation or species selection, therefore, a composite estimate for transverse grain shrinkage of 0.25% per 1% change in moisture content for most softwood lumber should be used for design. Unlike other building materials such as plastic or steel, expansion and contraction of wood due to thermal conditions is relatively small and can be considered insignificant for construction purposes.



Figure 2-4 Typical shrinkage values of wood in different grain orientations



Figure 2-5 Directional shrinkage

#### **Example: Six-storey Building Shrinkage Estimate**

Case	Estimated Shrinkage at Eave	
#1 – S-GRN joists and S-GRN plates	120 mm (4.7 in.)	
#2 – S-DRY joists and S-DRY plates	73 mm (2.9 in.)	
#3 – Dried S-DRY joists and dried S DRY plates	50 mm (2 in.)	
#4 - SCL joists and S-DRY plates	41 mm (1.6 in.)	

Assumptions used in calculations:

- > Six-storey platform frame building
- Pressure treated 38 x 140 mm (2x6) dimension lumber with an initial moisture content of 26% is used between the bottom plate and the concrete foundation
- For the upper storeys, two bottom plates are assumed to accommodate concrete topping
- Floor joists are 38 x 235 mm (2x10)
- S-GRN lumber has an initial moisture content of 30%, though 26% is used as the fibre saturation point
- > S-DRY lumber has an initial moisture content of 19%
- An initial moisture content of 15% is assumed for "Dried S-DRY" to simulate the further drying of lumber under cover on construction sites
- An initial moisture content of 10% is assumed for floor joists made of SCL
- 8% final framing moisture content is assumed for all cases.

Various strategies can be used to address the floor-tofloor shrinkage in wood-frame construction. For example, modified balloon framing can be used to reduce the amount of cross-grain wood in the wall load path at the floors. See Figure 2-14 and Figure 2-15.







Figure 2-15 Modified platform framing to reduce crossgrain height in the vertical load path (note pre-strip of GWB behind joist hanger for fire stopping)

## 3.3 Moisture Balance

The design and construction of the building enclosure for moisture control is a process of balancing moistureentry mechanisms (wetting) and moisture-removal mechanisms (drying). An imbalance may result in moisture accumulation within assemblies and materials, potentially leading to deterioration of less moisturetolerant materials.

Interior finishes are subject to fungal growth and deterioration in the presence of moisture. Masonry may spall if it remains wet and is subject to freeze-thaw cycles. Steel will corrode in the presence of air and moisture. Wood changes dimension and more importantly, when exposed to sustained high moisture content in suitable temperature conditions, it can experience fungal growth and potentially decay.

As discussed in Chapter 2, wood and wood-based materials always contain some moisture; the amount varies over time with exposure to humidity and water. The equilibrium moisture content of wood exposed to humidity alone is generally below that which is conducive to growth of decay fungi. There generally needs to be liquid present from some sustained source to lead to decay conditions.

#### Wetting Mechanisms

Aside from accidental sources of water such as plumbing leaks, moisture can enter a building enclosure from any of the following:

**Exterior Moisture:** Enters from the outside environment into a completed building. It has several forms, including rain, groundwater, snow, and moisture from warm humid air from wet materials via air movement or vapour diffusion. **Interior Moisture:** Generated from inside by the unit use and occupancy, moisture migrates outward via air movement or vapour diffusion.

**Construction Moisture:** Built into the structure through the use of wet lumber or other building materials, or by precipitation during construction.



- 1. Precipitation
- 2. Water vapour transported by diffusion
- and/or air movement (outward or inward)
- 3. Built-in construction moisture
- 4. Ground water

#### Figure 3-5 Wetting sources

#### **Drying Mechanisms**

Water in an enclosure assembly can be removed by several mechanisms:

**Drainage:** Water will drain down and out of assemblies on hydrophobic materials as well as from oversaturated materials. Elements like sloped flashings use gravity to

#### **Exposure Nomograph**

The assessment of exposure can be simplified to a consideration of three factors for the design of water penetration control:

**Climate:** The Moisture Index concept represents a rational approach to characterizing climate for the purpose of rain penetration control.

**Local terrain:** Site-specific factors including local terrain (as well as adjacent buildings and trees) and orientation influence the extent to which a building and the enclosure are exposed to wind and rain.

**Overhang ratio:** The ratio of the width of a projection, divided by the height above the base of the element (wall, window, door etc.) the projection protects. This is a direct and useful measure of various building-specific features that influence wetting of the wall and its details. See Figure 3-11.

Figure 3-12 contains a nomograph to show the relationship between the Moisture Index, the building overhang, and the local terrain in determining the exposure conditions. The nomograph is used by first obtaining the Moisture Index value for the municipality (from BCBC). This value is used to determine which of the three bars (centre of nomograph) is considered when assessing exposure category.

An overhang ratio and terrain category are then determined for the building enclosure element under consideration and plotted on the nomograph. A line is drawn between the plotted overhang ratio and terrain category points to intersect the appropriate Moisture Index zone bar. Finally, the exposure category can be determined by the intersection point on the appropriate Moisture Index bar. The colour of the bar indicates high, medium or low exposure.





3

# HEAT, AIR & MOISTURE CONTROL PRINCIPLES



#### Figure 3-18 Airtight drywall approach

#### **Exterior Approaches**

There are several possible exterior approaches for achieving airtightness, as follows:

- > Mechanically-fastened sheathing membrane
- > Self-adhered sheathing membrane
- > Liquid-applied sheathing membrane
- > Sealed sheathing approach

One of the most common methods utilizes an airtight and vapour-permeable sheathing membrane, mechanically attached to the exterior sheathing. Joints, penetrations, and laps are made airtight utilizing sealant and tape.



Figure 3-19 Mechanically-fastened sheathing membrane with taped lap joints

3-24

Self-adhered sheathing membranes are also used in exterior applications and rely on adhesion to both the substrate and to itself at lap points in order to be airtight. The membrane must be installed so that it is fully adhered to the substrate upon initial installation, as its adhesion may be reduced by exposure, making repairs or readhesion difficult. The membrane must also be installed onto a suitable substrate that provides continuous backing.



Figure 3-20 Self-adhered sheathing membrane (with adhesive primer)



Figure 3-21 Liquid-applied membrane with reinforcing mesh at sheathing joints

Exterior liquid-applied membranes rely upon the exterior sheathing as the support and continuous backing in order to achieve an airtight barrier.

### 4.10 Heat Transfer and Opaque Building Enclosure Assemblies

This section discusses building enclosure assemblies in the context of thermal performance and airtightness; however, moisture control is also important. The vapour flow control strategy must consider insulation type, location, ratio of insulation inside and outside of the exterior sheathing, and vapour permeability of the various layers.

For the purpose of this guide, R-values contained within ASHRAE 90.1 are given for typical opaque enclosure assemblies. For walls using discreet cladding attachments, R-values are calculated using HEAT3 version 6.1. HEAT3 is a three-dimensional finite-element thermal analysis software tool commonly used by the building industry to analyze building assemblies in three dimensions that two-dimensional analysis tools (such as THERM) cannot accurately analyze (see Figure 4-6). R-values given and adapted from tables in ASHRAE 90.1 may be different than those found in or calculated from Section 9.36 of the BCBC due to differing assumptions for enclosure framing, material properties, air films and other variables. See Section 4.9 for further guidance on the R-value calculation requirements for each code.

Each opaque assembly on a typical wood-frame MURB will require unique considerations for controlling heat and air flow. The wood-frame walls and roof must provide the necessary structural support in the building, while still allowing insulation and air barrier installation. While the below-grade assemblies do not typically consist of wood framing as the primary structure, the same principles apply for thermal performance and airtightness.



Figure 4-6 Three-dimensional thermal modelling of discreet clips through exterior insulation

5

# 5 Assemblies

This chapter examines the performance of wall, window, roof, deck, balcony, and walkway assemblies. In addition, guidance is provided regarding two related elements of wood-frame buildings: assemblies that are external to the building enclosure (walkways, divider walls etc.) and crawl spaces. Chapter 6 considers building enclosure performance at details, either where assemblies interface or where various penetrations of the assemblies occur. Chapter 7 provides guidance for a selection of components and materials for the assemblies presented in this chapter.

The intent of this chapter is to assist in the selection of appropriate assemblies. The generic assemblies presented are representative of those likely to be considered in wood-frame residential construction and have been used to develop the details presented in Chapter 6.

It may be possible to use variations of the assemblies shown, as well as other assemblies not presented in this guide. In either case, it is important to ensure that consideration is given to each of the variables affecting heat, air and moisture control. Hygrothermal simulation or performance testing of new or alternate assemblies may be required to confirm their performance characteristics.

The assemblies are presented in sheet format, and include a description of the assembly as well as a discussion of key attributes of each assembly.

# 5.1 Critical Barriers

The guide uses the term "critical barrier" to refer to materials and components that together perform a control function within the building enclosure. It has been common to think of, and define, some critical barriers within an enclosure assembly, such as a vapour retarder or air barrier. The guide also refers to a "water shedding surface" and a "water resistive barrier" to facilitate a discussion of water penetration control strategies. The use of critical barriers to evaluate assemblies and details is consistent with the principles discussed in Chapter 3, and they are easier to assess in the context of specific assemblies and details being considered for a project. Figure 5-1 below shows the list of control functions and corresponding critical barriers in the enclosure assembly.



------- Primary Relationship ------ Se

----- Secondary Relationship

<sup>1</sup>Water is defined as precipitation (rain, snow, hail, etc.) and ground water

<sup>2</sup>Vapour is separately defined as the water vapour in the air, as well as the condensate moisture

<sup>3</sup> Building Form & Features is not strictly defined as a critical barrier, but is important for control of water

#### Figure 5-1 List of primary building enclosure control functions and critical barriers

### AGW-2: Above-Grade Wall – Rainscreen Wall Assembly, Split Insulation, Exterior Air Barrier, Masonry Veneer

Exterior

Air space

Sheathing

Polyethylene

Interior

Gypsum board

11/2" mineral wool

Cladding (masonry veneer)

Brick ties through exterior insulation

Wood framing with batt insulation

Vapour-permeable sheathing membrane



Plan View

#### Water Shedding Surface

This wall assembly anticipates control of the majority of exterior moisture at the exterior cladding while recognizing that some incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain through the cavity formed between the exterior cladding and the mineral wool exterior insulation, and out of the assembly at cross-cavity flashing locations. Further drying of the cavity is facilitated by evaporation and ventilation of the cavity.

#### Water Resistive Barrier

The water resistive barrier is the vapour-permeable sheathing membrane behind the exterior insulation. There are a variety of sheet products that could be used as well as some liquid-applied products. The sheathing membrane, as well as the exterior insulation, should be vapour permeable to allow for outward migration of vapour.

#### Air Barrier

This assembly could be easily modified to accommodate several air barrier strategies. While it may be possible to utilize the sheathing and associated tapes and sealants as the air barrier, it is more likely that the vapour-permeable sheathing membrane will be utilized as the air barrier. The air barrier must be able to accommodate the structural loads imposed by the wind. The sheathing membrane is sandwiched between the sheathing and the exterior insulation in this assembly, so structural support for the air barrier is not an issue, except during construction.

#### Vapour Retarder

Polyethylene provides the primary vapour retarder layer. Vapour retarder paint may also provide an adequate vapour flow control layer. The vapour control layer must only be present at the interior side of the insulation in order to allow drying to the outside. Therefore, it is important that the sheathing membrane and exterior insulation are vapour permeable. For further information on vapour retarder placement in wall assemblies with split insulation, see the *Illustrated Guide - R22+ Effective Walls in Wood-Frame Construction in British Columbia*, published by BC Housing.

#### Application

This assembly can be used to meet the increasing wall effective R-value requirements and energy performance targets of the various codes.

#### **Factors Limiting Performance**

- Care must be taken to install cladding connections in a way that does not significantly reduce the thermal performance of the exterior insulation.
- The system used for cladding attachment through thick layers of exterior insulation must be designed to adequately secure the insulation and transfer the structural load of the cladding through to the primary structure.
- For assemblies with strapping, care is required in strapping placement to avoid restricting drainage or cavity ventilation.
- Excessive use of adhered waterproof membranes at interfaces should be avoided as it restricts drying.

5

#### FGW-1: Fibreglass Window Assembly



#### Performance

Water penetration and airtightness performance ratings for aluminum windows vary widely. Water penetration ratings can be poor or excellent, depending on the product. Condensation resistance and U-values are not as good as other framing materials. Aluminum frames have good span capability, and depending on the system used, can be suitable for higher wind load applications. Aluminum frames typically have a factory-applied finish available in a limited range of standard colours.

#### Application

Aluminum windows are suitable for use in most wood frame building situations, subject to ability to meet energy performance and condensation resistance requirements. They may not be suitable for cold climate environments.

#### Factors Limiting Performance

Aluminum windows may be prone to relatively poor thermal performance and condensation resistance if the frame does not include a sufficient thermal break.

5-39

5

# 6 Details

The foundations, walls, roofs, doors, windows, and other elements in a building combine to form a complete and continuous enclosure that separates interior space from the exterior. Key functions such as the air barrier, water resistive barrier, water shedding surface, vapour retarder, and in most cases the thermal insulation must all be present – not only in each assembly of the enclosure, but also at the interfaces and penetrations. This is one of the most common and challenging tasks faced by designers and builders. This chapter focuses on appropriate details for building enclosure interfaces and penetrations.

Design of all building details is a complex and iterative process. Numerous and sometimes conflicting requirements must be satisfied. However, although all variables need to be considered, they are not necessarily all of equal importance, and will not affect the design of building enclosure interface and penetration details to the same degree. Certain design considerations will clearly influence others, for example, the position of the window unit within the wall. A flanged window is typically placed based on the location of the sheathing, which may vary relative to the location of the cladding material depending on the type of wall assembly, specifically if exterior insulation is used.

### 6.1 Continuity of Critical Barriers

The term "critical barrier" refers to materials and components that together perform one of the primary control functions within an enclosure assembly. These functions are described in greater detail in Chapter 5 of the guide. Continuity of these critical barriers must be maintained at interfaces between different assemblies. Challenges arise when critical barriers are located at different planes in adjoining elements, for example at a wall-to-window interface (Figure 6-1) or a roof-towall interface (Figure 6-2). It is not always clear how to effectively maintain continuity of the critical barriers through these interfaces. It is also not always clear which parties in the design and construction process are responsible for ensuring that continuity.



Figure 6-1 Detail and continuity of critical barriers at the window sill (flanged window)

**Detail Locations** 



Figure 6-8 Detail locations on a wood-frame multi-unit residential building

#### Table 6-1 List of Details

Title	Page	Air Barrier Approach	
Concrete Foundation Details			
Detail 1 – Foundation Wall at Slab Thermal Insulation	6-10	Exterior air barrier, exterior insulation	
Detail 2 – Base of Wall/Foundation	6-13	Interior air barrier, exterior air barrier, split insulation	
Detail 3 – Door Sill/Concrete Deck	6-20	Exterior air barrier	
Wall Details			
Detail 4 – Rim Joist	6-23	Interior air barrier, exterior air barrier, split insulation	
Detail 5 – Wall/Cantilevered Floor	6-28	Interior air barrier, exterior air barrier, split insulation	
Detail 6 – Exterior Corner	6-33	Interior air barrier, split insulation	
Detail 7 – Interior Corner		Exterior air barrier, split insulation	
Detail 8 – Cladding Transitions	6-37	Exterior air barrier	
Detail 9 – Fire Wall at Exterior Wall	6-39	Exterior air barrier	

Title	Page	Air Barrier Approach	
Window and Door Details			
Detail 10 – Window Sill	6-41	Flanged window & non-flanged window, interior & exterior air barrier, with sill angle, split insulation	
Detail 11 – Window Jamb	6-49	Flanged window & non-flanged window, interior & exterior air barrier, split insulation	
Detail 12 – Window Head	6-55	Flanged window & non-flanged window, interior & exterior air barrier, split insulation	
Detail 13 – 3D Window Installation Sequences	6-61	Flanged window & non-flanged window, exterior air barrier, split insulation	
Detail 14 – Window Sill – High Differential Movement	6-70	Exterior air barrier, precast sill & flashing approaches	
Detail 15 – Door Sill – Cantilevered Balcony	6-73	Exterior air barrier	
Detail 16 – Base of Wall – Cantilevered Balcony	6-75	Exterior air barrier	
Detail 17 – Door Sill – Supported Balcony		Exterior air barrier, interior air barrier, accessible door sill	
Detail 18 – Door Sill – Roof Deck		Interior air barrier	
Roof Details			
Detail 19 – Water Shedding Roof/Wall	6-82	Interior air barrier, exterior air barrier, split insulation	
Detail 20 – Water Shedding Roof/Skylight	6-88	Interior air barrier	
Detail 21 – Waterproof Membrane Roof/Wall	6-90	Interior air barrier, exterior air barrier, split insulation	
Detail 22 – Waterproof Membrane Roof/Skylight	6-95	Exterior air barrier	
Detail 23 – Waterproof Membrane Roof/Firewall	6-97	Exterior air barrier	
Detail 24 – Roof Deck Divider Wall	6-99	Exterior air barrier	
Penetration Details			
Detail 25 – Wall Duct Penetration	6-101	Exterior air barrier	
Detail 26 – Railing Attachment at Wall	6-103	Exterior air barrier, split insulation	
Detail 27 – Pipes	6-105 Exterior air barrier, split insulation		
Detail 28 – Electrical Fixtures		Exterior air barrier, split insulation	
Exterior Elements			
Detail 29 – Column Detail	6-109		
Detail 30 – Balcony Edge	6-111		
Detail 31 – Balcony Edge/Wall 3D Sequence	6-113		

Detail 12 SI includes insulation on the exterior side of the sheathing and sheathing membrane. In this instance, it is not desirable to drain sub-sill water into the insulation because it may be held against the vapour-permeable membrane and migrate inward. The sample detail indicates an additional piece of membrane that drains the water to the outside of the insulation.

Table 6-2 contains the list of the five window sillconfigurations shown in this section.

*Note: See Detail 13 for the complete 3D installation sequence of the flanged and non-flanged window.* 

#### Table 6-2 List of Window Sill Details

Detail Number	Window Type	Sill WRB/AB Approach	Air Barrier Approach
	Flanged	Backer rod	Interior air
10 IAD	window	& sealant	barrier
	Flanged	Backer rod	Exterior air
IU EAD-I	window	& sealant	barrier
10 EAB-ii	Non- flanged window	Backer rod & sealant	Exterior air barrier
10 EAB-iii	Non-flanged window	Sill angle	Exterior air barrier
10 SI	Non-flanged window	Backer rod & sealant	Exterior air barrier, split insulation

#### **Sill Drip Flashing**

Sill drip flashings are necessary in order to direct water that runs down the face of the window away from the wall surface below. Sill flashings also reduce the problem of staining of the wall directly below the weep holes in the window.

Some window assemblies use weep holes that drain from the bottom of the window frame. The sill details must accommodate the various locations of the weep holes. In each sample detail, the flashing is shown either fastened to the front face of the flange, or inserted under the nonflanged window.

#### Renewals

Consideration should be given to the possibility of window replacement prior to cladding replacement. This is particularly true for flanged windows where the flange may be located directly behind the cladding. Costeffective renewals could be facilitated through the use of a removable perimeter trim detail. Alternatively, nonflange window frame sections can generally be replaced with minimal disruption to the cladding.



Figure 6-38 Detail 10 IAB: Location of critical barriers at the flanged window sill













Figure 7-12 Signs of plasticizer migration from the self-adhered membrane through to the silicone-based liquid-applied membrane

#### **Proper Joint Design**

Sealants installed into a joint must be able to allow the substrate to expand and contract without cracking (cohesive failure) or pulling away from the substrate (adhesive failure).

The maximum extension of a sealant is generally required on a cold day when the adjoining cladding has contracted. Many sealants behave differently at different temperatures. Ensure that the sealant is able to undergo its maximum extension at the coldest temperature to which it will be exposed.

The width of the sealant joint should be designed based on the expected movement of the wall and the movement capability of the sealant. For example, if the maximum movement of a wall panel is 6 mm (1/4 in.) and the sealant movement capacity is 25%, the joint width should be 6 mm/0.25=24 mm (1 in.).

Generally, a sealant joint should be greater than 6 mm regardless of expected movement, to allow for proper application. The depth of sealant at the centre should generally be half of the width. A round foam backer rod should be used to provide the proper joint profile. Sealants should be bonded only to two surfaces on opposite sides of the joint. If a backer rod is used, this is not usually a problem. If a fillet joint is used, a bond breaker tape should be used to allow joint movement to occur. Figure 7-13 shows three sealant profiles commonly used in construction, along with an alternate bandage joint approach using a pre-cured silicone strip. Width (W) is generally four times the expected joint movement when high performance sealants are used.





PRE-CURED EXTRUSION JOINT

#### Figure 7-13 Typical sealant profiles

#### **Typical Usage**

Table 7-7 shows applications for various types of caulked joints. The performance level is based on typical longevity when the sealant is installed in accordance with the manufacturer's instructions with proper backing and

7-29

# 8 Maintenance and Renewals

### 8.1 Overview

Over the life span of a multi-unit residential building, money is spent in four fundamental ways:

- Initial Construction: This includes the initial cost of constructing the facility, including professional and permit fees and equipment that is an integral part of the building.
- Operations and Maintenance: This includes costs associated with the day-to-day operation of the facility including building maintenance, custodial services, utilities, landscape and grounds maintenance, security, and other recurring costs. Examples of routine maintenance activities for the enclosure would include cleaning debris from roof drains and inspecting exterior sealant.
- Renewals: This includes expenditures to replace worn-out components of a building and are usually for items with life-cycles in excess of one year. For example, a roof replacement is expensive but is likely to be required only every 20 to 25 years.
- Adaptation: This includes expenditures required to adapt or add to the building to meet the evolving needs of the users and to address new legislative requirements and standards. An example of this would be retrofitting to meet new fire safety requirements in a multi-unit residential building.

The first category, initial construction, represents a one-time expense which has been the primary focus of the design and construction provisions of this guide. The second category, operation and maintenance, while representing a significant part of the building owners' ongoing cash flow, should be relatively predictable and would typically not change significantly from year-to-year. (This does not mean that operations and maintenance costs should not be reviewed so that tasks and expenditures optimize the building's life-cycle costs.) Renewal and adaptation costs, on the other hand, are generally large and occur sporadically throughout the life of the building.

Figure 8-1 gives an overview of the relative size of these costs over a significant part of the life-span of a building. This graphic clearly illustrates that a much larger portion of money is spent on a building after the initial construction. Residential buildings are frequently sold to a different owner group after construction, leaving the responsibility for the costs of operations, maintenance, renewals and adaptation to the new owners. This removes most of the built-in incentives that may have been available to optimize life cycle costs of the building had the developer been long-term owner.





The building enclosure is the single most costly system requiring maintenance and renewal during the service life of a typical MURB. Building enclosure maintenance can be complicated, difficult to access, and require specialized skills that homeowners typically do not have. The high

# Glossary

Bolded words in the descriptions below can be found within this glossary.

absorption	The process of a material taking in water to the point that it adds to its volume (rather than just wets its surfaces), such as when wood soaks in water.
adhesion	The binding of two surfaces by an adhesive.
adhesive failure	The separation of two bonded surfaces from the <b>interface</b> between the adhesive and the <b>substrate</b> . See also <b>cohesive failure</b> .
advanced framing	A wood-frame construction technique where all or most framing members are spaced at up to 24" on centre and aligned directly on top of the supporting element below. This technique is intended to reduce the amount of structural framing in the wall assembly, thus reducing the <b>framing factor</b> . See also <b>standard framing</b> .
air barrier	The materials and components that together control/limit airflow through an assembly and limit the potential for heat loss and <b>condensation</b> .
anchor	Any device used to secure a building part or component to adjoining construction or to a supporting structural or framing member.
annealing	In float glass manufacturing, the process of heating followed by controlled cooling to relieve internal stress.
anodize	The process of coating metal with aluminum oxide through electrolytic action. Coatings may be clear, integral colour, or electrolytically deposited colour.
assembly	The arrangement of more than one material or component to perform specific overall functions, such as a wall assembly, which may include the structural <b>frame, sheathing</b> , <b>sheathing paper,</b> insulation, <b>vapour retarder, air barrier</b> and finish.
authority having jurisdiction (AHJ)	The provincial organization, office or individual responsible for adopting and enforcing the laws and regulations of construction.
awning window	A window with a top-hinged <b>sash</b> that swings out at the bottom. See also <b>hopper window.</b>
backer rod	A cylindrical foam <b>material</b> , either polyethylene or polyurethane, that is used to control <b>sealant</b> joint depth, provide a surface for <b>sealant tooling</b> , serve as a <b>bond breaker</b> to prevent three-sided adhesion, and provide an "hour-glass" contour of the finished <b>sealant profile</b> .

# Appendix A: Prescriptive Assembly Thermal Performance Requirements in Codes and Standards Applicable in B.C.

This Appendix A outlines the assembly prescriptive minimum R-values in building codes and energy performance standards generally applicable to the design and construction of building enclosures in multi-unit, wood-frame residential buildings in British Columbia, including:

- > BC Building Code 2018 (BCBC 2018) Part 9
- Vancouver Building By-Law (VBBL) 2014 and forthcoming VBBL 2019
- American Society of Heating, Refrigerating and Air-Conditioning Engineers standard 90.1-2016, Energy Standard for Building Except Low-Rise Residential Buildings (ASHRAE 90.1-2016)
- National Energy Code of Canada for Buildings (NECB 2015).

Both the BCBC 2018 and the forthcoming VBBL 2019 reference ASHRAE 90.1 2016 and NECB 2015 as possible compliance pathways, though various exceptions and limitations apply. Always consult with your local authority having jurisdiction to confirm which codes and standards are applicable in each jurisdiction and for each building type. In the City of Vancouver, refer to the online resources for current building energy performance requirements. Note that the BC Energy Step Code is not included in this section.

### **BC Climate Zones**

The BC climate zones are defined by the average heating degree-days below 18° C (HDD). The BC Building Code states that the authority having jurisdiction (AHJ) can establish climatic values to define climate zones, typically based on information from Environment Canada, and building designers must consult the AHJ before making any assumptions about a building's climate zone. Both the NECB 2015 and ASHRAE 90.1 also reference climate zones, though define them differently (see Chapter 4).



Figure A-1 BCBC/NECB approximate climate zones based on BCBC climate data