CHAPTER 20

BUILDING DESIGN AND CONSTRUCTION

Learning Objectives

After studying this chapter, a student should be able to:

- ☑ Identify common architectural and construction styles
- ☑ Classify residential houses by several methods
- ☑ Provide accurate physical descriptions of homes
- ☑ Distinguish between construction qualities
- ☑ Describe common problems and remedies associated with the different components of a house
- ☑ Detect common defects in building design and construction
- ☑ Recognize the components of a “greened” home and the various rating services and programs

INTRODUCTION

In order to correctly determine how buyers and sellers value the physical features of homes, real estate licensees must know how to examine a property and identify its positive and negative features. The intent of this chapter is not to make licensees into qualified building inspectors; instead, the chapter is intended to provide licensees with a working knowledge of the physical aspects of real property. The chapter begins with a general overview of some of the items to consider in identifying the physical characteristics of a building. Apartment and residential construction is discussed, followed by an overview of various components, systems, and building defects. The chapter concludes with a section on green construction.

CURRENT BUILDING STANDARDS

Building construction has changed a great deal during the past few decades. In the past, structures were assembled with more emphasis on the availability and endurance of materials, and less on other less tangible aspects. Contemporary building technology is the result of sustained experience, the systematic study of problems, and considerable research leading to the development of new materials and methods. Not only is contemporary technology concerned with strength and endurance, but also with comfort, convenience, efficiency, economy, and environmental factors.

Building Codes

Over time, building codes have been adopted to ensure that structures are safe and durable; however, building codes and municipal bylaws are often misunderstood. People sometimes object to the fact that construction or alteration of buildings requires a permit and/or an inspection. These requirements are in place to ensure not only that the structural elements are strong and durable, but also that proper methods of construction have been employed in assembling the building. Compliance with codes and regulations protects purchasers of residential buildings by ensuring that established standards have been followed.

Building code structural and envelope considerations for multi-family property design and construction are mandated to protect the safety and comfort of occupants. Building codes specify requirements for new building or the substantial renovation of existing buildings, such as:

- **Structural strength to resist forces acting on buildings:** These forces will have a combined influence on a building and may act in different ways. For example, wind places horizontal pressures on a building; dead loads (weight of materials) and live loads (weights imposed by use and occupancy) place vertical pressure on a building; and seismic activity can place torsion or twisting forces on a building.
- **Resistance to spread of fire:** For wood-frame dwellings, the resistance to spread of fire is achieved by firestopping, cladding over the wood frame, and fire-rated doors and closures in common areas. When a wood-frame building is above a certain size, masonry walls are required to divide the building into fire compartments.
- **Resistance to heat movement and vapour transmission**
- **Adequate means of egress:** In other words, the ability for occupants to vacate the building
- **Adequate light and ventilation**
- **Resistance to sound transmission:** The main complaint of inhabitants of multi-family dwellings is lack of soundproofing between suites and to the common areas. In many cases, the wall systems can be improved by the use of acousticaulk or other form of perimeter sealant, poured concrete topped floors, and sound insulation between floors.
- **Protection against smoke penetration**

Building standards have been continually improved over the years. This becomes obvious when comparing a home built during the 1950s to a contemporary home. The standards with respect to items such as electrical wiring, insulation, and draft proofing have undergone significant changes.

When determining if an older home meets current standards (e.g., in quality of insulation), the answer will depend on the year the home was built and whether the home has been renovated since that time. It is impossible to tell whether a particular house meets today's building standards unless it can be established that the home was built to a specified standard in place at the time the home was constructed. In Canada, building codes are regulated by the provinces, but all follow or have made changes to synchronize with the National Building Code of Canada. The National Building Code is updated approximately every five years, with its most recent update in 2020. The BC Building Code is based on the National Building Code and was updated in 2018. The City of Vancouver adopted the City of Vancouver Building Bylaw (VBBL) in 2019, which is based on the 2018 BC Building Code. The VBBL regulates the construction of buildings in the city.

BC Housing Licensing and Consumer Services

Canadian builders have continually supported improved housing standards. To protect new home purchasers, builders formed a National Steering Committee in 1972, which initiated actions leading to the establishment of Home Warranty programs in each province (except the Atlantic provinces, where a regional program was established). In British Columbia, Licensing and Consumer Services is a branch of the British Columbia Housing Management Commission (commonly referred to as BC Housing), a provincial Crown agency under the Minister of Municipal Affairs and Housing, and is responsible for:

- licensing residential builders and building envelope renovators province-wide;
- administering owner-builder authorizations; and
- carrying out research and education that benefits the residential construction industry and consumers.

All residential builders who engage in, arrange for, or manage all or substantially all of the construction of a new home in British Columbia must be licensed through the Licensing and Consumer Services and the new home must have a warranty insurance policy. Similar requirements apply to all building envelope renovators. Licensing and Consumer Services provides this information free of charge through the New Homes Registry and Builder Registry. Licensees may use this service to determine the licensing and warranty status of a residential development by searching using its address.

Homeowner Protection Act

Between the late 1980s and early 2000s, improper construction and insufficient waterproofing caused an estimated $4 billion in property damage to homes in British Columbia. Most of the properties affected by this damage were multi-unit residential strata properties in the Lower Mainland. This epidemic of water-related damage, known as the “leaky condo crisis”, motivated the BC government to pass the *Homeowner Protection Act* (the “HPA”) in 1998. The purpose of the HPA was to increase consumer protection and improve the quality of residential construction in BC.

The HPA introduced three new regulatory requirements:

1. All residential home builders must be licensed and registered, unless exempt;
2. All new homes must be registered in the New Homes Registry; and
3. All new homes must be covered by home warranty insurance, unless exempt.

Licensing and Registration of Residential Builders

Under the HPA, a person must not carry on the business of a residential builder unless that person has been licensed by BC Housing’s Licensing and Consumer Services division. A residential builder is defined as a person who engages in, arranges for, or manages the construction of a new home, and includes developers and general contractors. To obtain a residential home builder licence, applicants will have to satisfy the following criteria:

- provide proof of 24 months of experience managing or supervising residential construction within the previous 5 years; and
- demonstrate competency in a number of areas, including construction management and supervision, construction technology, financial planning, customer service, home warranty insurance, and legal issues.

To maintain their licence, residential builders are also required to complete continuing professional development courses in these areas.

The licensing requirement ensures that all persons or companies who build new homes in BC are qualified to do so, and it allows Licensing and Consumer Services to monitor licensee performance by maintaining a residential builder registry. Real estate salespeople should be familiar with the residential home builder registry and should use it to determine whether a builder of a new home is properly licensed and in good standing.

New Homes Registry

In addition to a registry of residential builders, Licensing and Consumer Services also maintains a New Homes Registry for both single detached homes and multi-unit homes (e.g., strata buildings). The purpose of this registry, which can be found online, is to allow new home buyers to obtain several important pieces of information, including:

- whether the home was built by a licensed residential builder or by an owner builder;
- whether or not the home is covered by home warranty insurance and the commencement date for that insurance; and
- the name and contact information of the warranty provider.

New homes cannot be built unless they are registered with Licensing and Consumer Services; therefore, the absence of a new home from this registry may be a red flag. Licensees who cannot find a new home in the New Homes Registry should contact Licensing and Consumer Services before taking any further steps because the online version of the New Homes Registry only contains homes that were registered after November 19, 2007.

Home Warranty Insurance

Mandatory Insurance Requirement

One of the key ways in which the HPA seeks to protect consumers is by requiring all new homes to be covered by home warranty insurance (unless the home qualifies for an exemption). Without proper insurance in place, a new home must not be built or sold. Section 22(1.1) of the HPA, which is directly relevant for licensees, states that a person must not sell or offer to sell a new home:

- while the new home is being constructed; or
- within 10 years from the date an occupancy permit was issued;

unless

- the new home is covered by home warranty insurance; or
- the home is exempt from the requirement for insurance.

The warranty requirement applies for the first 10 years after an occupancy permit was issued, regardless of the number of people that have owned the house. This is an important point for licensees to keep in mind, as subsequent purchasers may not know that the home is still considered a "new home".

In the HPA, the definition of "new home" also includes homes that have been "substantially reconstructed." In order to be considered a "substantial reconstruction," one of two situations usually has to be present:

- more than 75% of the home's structure above its foundation has been removed or replaced; or
- when a new foundation has been laid and the total amount of new structural components, including the foundation, makes up 50% of the completed structure.

One of the most common areas in which licensees fail to comply with the HPA is in the sale of substantially reconstructed homes without proper warranty insurance in place. If a licensee in doubt as to whether a reconstructed home meets the definition of a "new home" under the HPA, they should contact Licensing and Consumer Services or seek legal advice.

! ALERT

In a decision of the former Real Estate Council, a listing licensee was fined $1,200 after a re-built home in Vancouver was listed without home warranty insurance in place. The home was entirely re-built, with only 1% of the previous home remaining. The licensee was unaware that substantially rebuilt homes are considered "new homes" under the HPA.

Source: 2015 CanLII 45732

Minimum Coverage Levels

The HPA sets out minimum coverage levels regarding both the duration and the value of warranty coverage. The minimum period of coverage that must be offered by a home warranty insurance policy varies according to the type of defect:

- 2 years for materials and labour;
- 5 years for the building envelope, including water penetration; and
- 10 years for any structural defects.

In the industry, this staggered warranty insurance program is often referred to as "2-5-10" insurance.

The HPA also prevents insurers from unduly limiting claims. For a property held in fee simple, claim limits must not be less than $200,000 or the value of the property, whichever is lesser. In the strata context, claim limits on strata units must not be less than $100,000 or the value of the property, whichever is lesser. There are also minimum coverage levels for the common property of a strata development.

As a Licensee...

Even though home warranty insurance is now a legal requirement, it is good practice to include a term in the contract of purchase and sale that makes it clear that the provision of mandatory warranty insurance coverage is a fundamental term of the contract that, if breached, will give the buyer the right to terminate the contract. In the *Knowledge Base*, the following clause is suggested in all contracts respecting new homes:

Receipt and Satisfaction Regarding Warranty Insurance

Subject to the Buyer receiving a copy of the home warranty insurance policy for the Property from the Seller and being satisfied, on or before __(date)__, with the terms of that policy (including commencement and expiry dates and any exclusions for coverage). This condition is for the sole benefit of the buyer.

Source: "Clauses" section in the BC Financial Service's Authority's Knowledge Base, found online.

Owner-Builder Exemption

Under the HPA, a person who intends to build a home for personal use may apply for an "owner-builder authorization," which must be secured before construction begins. Once authorized, owner-builders are exempt from the licensing and warranty insurance requirements discussed earlier. To qualify for an owner-builder exemption, the applicant must meet several requirements, including:

- the person must be an individual (rather than a corporation);
- the person must intend to personally use the home for at least one year from the date of occupancy and may not rent it during that period; and
- the person must intend to engage in, arrange for, or manage all or substantially all of the construction of the new home.

The owner-builder exemption was designed to allow people who want to construct their own homes to avoid the costs that the HPA imposes on professional home builders. In order to prevent the exemption from being misused, the HPA imposes restrictions on the resale of owner-built homes. First, an owner-builder must not sell or offer to sell a new home while that home is being constructed or within 12 months after the house has been built. Second, if an owner-builder (or subsequent owner) decides to sell the home within 10 years of initial occupancy, they must provide disclosure to the prospective purchaser that indicates whether or not the home is covered by home warranty insurance. This is known as an "owner-builder disclosure notice", which the owner-builder must obtain from Licensing and Consumer Services. Third, if the home is not covered by home warranty insurance, the owner-builder is personally liable to cover the cost of any defects that would have been covered by the standard 2-5-10 insurance policy.

ALERT

In the process of negotiating the purchase of a new home, the buyers' licensee failed to inquire about whether mandatory home warranty insurance was in place and failed to include a reference to warranty insurance in the contract of purchase and sale. Following completion, when the buyers asked the seller for the warranty documents, they were informed that the house had no such coverage. The licensee was found to have committed professional misconduct. She was suspended for 7 days and ordered to pay $1,250 in enforcement expenses.

Source: 2013 CanLII 58277

Technical Safety BC

Construction in British Columbia is also subject to Technical Safety BC (formerly BC Safety Authority), which is responsible for licensing contractors, making sure they are qualified to do regulated work, and issuing permits for electrical and gas installations in most municipalities in British Columbia.

Licensees should be aware that there are regulations that describe the technical obligations and requirements for contractors, individuals, and equipment used in working in the electrical, gas, boiler, and elevating technologies. These regulations also describe specific obligations regarding qualifications and permits. For example, the province requires that regulated electrical and gas work is done properly by licensed contractors who take out permits. Regulated work includes all work where electrical wiring or gas piping is extended or modified in any way, or where new or replacement gas fireplaces, water heaters, furnaces, ranges, or cook tops are installed; such work requires a permit issued by Technical Safety BC. Connecting gas barbecues to existing gas outlets and replacement of receptacles, dimmer switches, residential furnace thermostats, lamps, and lighting fixtures do not require a permit. Where permits must be taken out for the work, these are separate permits to municipal building permits and, in most cases, are obtained through Technical Safety BC.

Prospective new homeowners should always be encouraged to check that appropriate permits are in place, especially if there are indications that recent electrical or gas work was done in the home.

Key Points: Homeowner Protection Act

The HPA imposes numerous requirements on persons who construct and sell new homes, and licensees can be held responsible for failing to comply with the requirements of the HPA or for failing to adequately protect their clients' interests. Some of the most important points for licensees to remember include the following:

- A new home cannot be listed or sold (or even built) unless the licensing and warranty requirements in the HPA are met. Whenever you encounter a home that is less than 10 years old or that has been substantially reconstructed, you should take steps to ensure that all of the insurance, licensing, and disclosure obligations under the HPA have been met and properly incorporated into the contract of purchase and sale.
- Make use of the Registered Builder Registry and the New Home Registry. These registries contain important information, including:
  - whether the builder is properly licensed;
  - whether the home is properly registered;
  - whether warranty insurance is in place; and
  - whether an owner-built home can be offered for sale.
- When you are dealing with subsequent buyers of a new home, you must ensure that they are aware of the warranty coverage that still remains and whether any claims have been made on the policy. You must also ensure that the warranty documents are properly transferred.
- When representing owner-builders (or purchasers of owner-built homes), you must take extra care to ensure that all disclosure obligations have been met and that, if warranty insurance is not in place, the buyer(s) understand that if there is a defect, their only recourse is against the builder personally.

ALERT

Reminder About Property Inspections

Pre-purchase property inspections are common in the marketplace. This is a positive development in that a property inspection will assist the buyer in understanding, prior to the purchase, the condition of the property and what repairs may be necessary.

For this reason, a buyer's agent should always advise a buyer to have an independent inspection of a property. The licensee should explain the importance of why such an inspection is necessary and that licensees are typically not qualified to provide home inspection advice. If a buyer chooses not to have an inspection, the agent's advice to do so should be documented.

In some cases, in addition to a buyer wanting to have the property inspected, a seller may also want such an inspection before listing the property for sale so that the seller is aware of what issues the property inspection report may identify.

If a licensee intends to refer clients to a property inspector, the safest way to do so is to provide a list of at least three professionals with whom the licensee, or others they know, has dealt and have the client call, interview, and select them independently. It is recommended that licensees avoid "steering" buyers towards particular service providers or communicating information about their fees.

Anyone providing a property inspection for a fee requires a licence to do so. Consumer Protection BC is the agency responsible for property inspector licensing. For further information, visit *www.consumerprotectionbc.ca*.

Licensees should exercise care in selecting those to be included in this list of service providers. Before making a referral, licensees should ensure the individual is properly licensed. They should also consider the inspector's experience, credentials, and insurance coverage (e.g., errors and omissions insurance, liability insurance, and worker's compensation coverage).

Once a buyer has determined which property inspector is to be used, licensees must respect the client relationship between the buyer and the property inspector. The buyer is paying the property inspector for professional advice with respect to the condition of the property they are considering purchasing. Licensees should not attempt to thwart that relationship either by downplaying the importance of deficiencies noted by property inspectors or by making disparaging comments about the buyer's choice of property inspector.

As with any subject clause, the length of time allowed for its removal should be reasonable while not being unnecessarily long. In the case of property inspections, sufficient time is required to arrange and conduct the inspection, prepare the report, and have the report reviewed by the buyer. The goal is to ensure the buyer has full knowledge of the results of the inspection and, if necessary, clarification from the inspector or any other qualified person as required.

In order to avoid the possibility or even the appearance of a conflict of interest, licensees are advised not to pay the cost of the inspection report on behalf of a buyer. If the licensee were to pay, the inspector could be suspected of not wanting to jeopardize the transaction of the person paying them, who might or might not ask for their services in the future, depending on the conclusions of the inspection report.

Finally, as with any referral, section 56 of the *Real Estate Services Rules* (the "Rules") requires that if a licensee is to receive a referral fee or other consideration from a property inspector, this must be disclosed in writing to the licensee's client.

A question often arises whether the seller's agent should be present during the inspection. It is recommended that the seller's agent either be present or obtain permission from the seller that the seller's agent is not required to be present during the inspection. In making this decision, the seller should be advised whether the buyer and/or the buyer's agent intend to be present when the property inspector views the property. If the seller agrees that the seller's agent does not need to be present, the seller's agent should obtain the full name and address of the inspector as well as information on whether the inspector is bonded.

Source: RECBC. Report from Council. Volume 45, No.4. February 2010.

METRIC CONSTRUCTION MODULES

The introduction of the metric system to the building industry has not come without some confusion. Part of the misunderstanding surrounds the use of both soft changes and hard changes. Although all codes and standards now use metric measurements as the official numbers, most low rise residential construction today is still built following imperial measurements.

Soft changes involve the use of existing physical sizes now specified in metric measurement. For example, the old faithful 2" × 4" (which is really the rough sawn imperial measurement for a planed piece of structural lumber 1½" thick and 3½" wide) is now specified 38 mm thick and 89 mm wide, though the size remains unchanged.

Hard changes involve the establishment of metric standards. For example, the metric building module is now 100 mm. Multiples of this module are used by designers in planning room sizes and specifying distances between structural members; for example, common spacing between floor joists is 300 mm or 400 mm, and the common ceiling height in a metric home is 2400 mm. Another hard change involves the dimensions of sheet products. Metric measurements for plywood, waferboard, gypsumboard, and other such products becomes 1200 mm × 2400 mm rather than 4' × 8' (Imperial). However, few materials are sold in hard metric dimensions.

ARCHITECTURAL INFORMATION

Evaluating a building's design and construction requires an understanding of its architectural features. This requires consideration of the site plan and the building plan.

Site Plan

The best building design is the one that develops a site to its maximum potential. A well designed site sustains its value and is less likely to become obsolete as design standards increase or change. Property owners place great importance on the quality of their environment, particularly the visual quality of a site. Preservation of natural features creates a harmonious development, ensuring that the value potential of the site is realized.

The following are considerations of a good *site plan*:

site plan
a drawing of the plan for the development and intended use of a particular piece of land, including the building outline, landscape elements, work areas, and property boundaries

- **Siting of the building:** The siting of the structure should relate with the design and grouping of the surrounding buildings, abiding by set-backs and other building bylaws.
- **Visual aspects:** The building should be sited to preserve privacy of ground floor residential windows and ensure the overlooking of upper windows is minimized. Natural lighting should not be impaired by other buildings.
- **Orientation:** The siting of the building should take advantage of pleasant views and consider sun, wind, and snow drifting.
- **Access:** Routes for public access should be convenient without creating a nuisance or detracting from the living environment of the site.
- **Physical characteristics:** Attention should be given to the topography of the site, particularly its drainage, soil, and natural features. These physical characteristics may affect the form and cost of the site development.

The blending of building and site design is fundamental to good architectural practice. Suitable combined characteristics create and sustain the market value of the property.

Building Plan

The first consideration in judging building design is its suitability to meet present and future space requirements at a marketable price. A building that is built to the specifications of a particular owner may suffer a loss in value because it exhibits specific tastes and requirements. On the other hand, a *building plan* that is designed to meet the most typical requirements of the market will get the maximum price. A good residential plan will have the layout of the sleeping, working, and living zones arranged in relationship to one another. These areas are connected with traffic zones, which allow passage from one zone to another without passing through a third zone. This traffic zone should be of a minimum area and designed to reduce foot traffic at any one place.

building plan
a drawing of the intended arrangement of rooms and zones within a building

The building site will have a strong influence on the type of building design. Some designs lend themselves better to lots with certain characteristics (e.g., split level homes are well suited to sloping lots). A building design should be in harmony with the neighbourhood style in light of social factors, aesthetic characteristics, climate conditions, and local trends.

As a Licensee...

Measuring Floor Area

As a licensee, it is important to know how to measure and calculate the floor area of various types of dwellings. The standard of the American National Standards Institute (ANSI) for calculating finished floor area of all detached and attached single-family houses (sharing common walls), such as townhouses and duplexes,[1] will be followed for the purposes of instruction. Various methods are used throughout the province of British Columbia; licensees are recommended to follow the standard measurement practices that are common to the given market where their business is being conducted.

ANSI standards require that floor area reporting distinguish between above and below grade space. Grade is defined as "the ground level at the perimeter of the exterior finished surface of a house."[2] For the floor level to be classified as above grade, it must be entirely above ground level.

Additionally, ANSI standards require a distinction to be made between finished and unfinished space. Finished floor area is defined as "an enclosed area in the house that is suitable for year-round use, embodying walls, floors, and ceilings that are similar to the rest of the house."[3] The following areas/features are not included as finished area:

- garages;
- porches, balconies, or decks that are not within the definition of "finished floor area";
- unfinished floor areas;
- openings to floors below (e.g., a vaulted ceiling on the main level that is two storeys in height);
- "finished areas that protrude beyond the exterior finished surface of the outside walls and do not have a floor on the same level",[4] such as chimneys or protruding windows that do not extend to the floor; and
- finished areas that are not connected to the main body of the house by other finished areas such as hallways or stairways. For example, a finished loft connected by a stairway would be included in a measurement, but a finished loft accessible by a ladder would not be included.

Features not included in finished floor area may be described separately.

For detached houses, measurements are taken from the outside surfaces of exterior walls. For row and semi-detached houses, measurements are taken from the centre line of party walls and the outside surfaces of exterior walls. Measurements can be made in metres (m) or feet (ft) and areas calculated in square metres (m^2) or square feet (sq. ft.). Imperial measurement (square feet) can be calculated by multiplying the number of square metres by 10.76.[5]

City planning and zoning calculations are done differently; these will not be the same as measurements taken for market valuation.

When taking measurements, the licensee must be consistent with how they are typically done in the local market and for the given property type. The examples in Appendix 20.1 illustrate common residential building types by number of floors and demonstrate square metre calculations of living areas. Note that the examples shown follow the ANSI standards. When taking measurements, the licensee must be consistent with how they are typically done in the local market and for the given property type. See Appendix 20.2 for more information.

[1] The ANSI standard is a voluntary guide (not required by law) and is intended to be applied as a whole. Note that the standard does not apply to room dimensions or to apartment/multiple family buildings.
[2] ANSI Standard, page 1.
[3] ANSI Standard, page 1.
[4] ANSI Standard, page 7.
[5] 1 metre = 39.37 inches; therefore, a more accurate multiplier is 10.763867, but for the purposes of this course a multiplier of 10.76 is sufficient.

MULTI-FAMILY BUILDING CONSTRUCTION

Building design and construction is governed by the applicable building bylaw or code. The four top-level objectives of the National Building Code or BC Building Code are:

1. Structural safety
2. Public health (sanitary conditions)

3. Accessibility
4. Fire and structural protection of buildings

For multi-family buildings, the principal limitations as to height and size of building are governed by local zoning and planning regulations. The degree of fire protection of various types of construction is defined in the National Building Code. The building or planning department of the local authority can provide information on applicable height and area limitations of any type of construction.

The National Building Code regulates the construction requirements of apartment buildings by indicating the type of fire protection required for buildings based on building area, number of stories, and the number of streets that the building faces. As the building area and number of stories increase, there are more stringent fire protection measures that have to be built into the construction. These measures include the use of sprinklers, the requirement of non-combustible construction for larger buildings, and the requirement that the floor assemblies and mezzanines and their supports be fire rated. The building's facing streets is of concern; this determines the ease in which firefighters can approach each face of the building. It is easier to fight a fire if the firefighters can easily approach three faces of the building rather than one face; if this is the case, then the fire protection measures for the construction of the building may be relaxed.

Heavy timber construction is an older form of construction that was used to address fire protection. This form of construction waives the requirement for fire-resistance ratings for floor assemblies and their supporting structure, as long as combustible construction is allowed and the required rating is not more than 45 minutes. This type of exposed wood construction can sometimes be seen in lodges, meeting halls, and alpine buildings. Heavy timber construction is rarely used today in new structures due to cost of materials. It can be seen in older buildings or in commercial buildings (e.g., warehouses) that have been converted to residential and commercial uses.

Materials Used

The choice of materials used in the construction of residential buildings depends on factors such as cost, quality, ease of application, durability, and maintenance requirements.

The quality of contemporary building materials is controlled by regulations that specify minimum acceptable standards. In Canada, most of these standards are set by Canadian Standards Association (CSA Group) or the Underwriters Laboratories of Canada (ULC). Some material standards are established by agreement within an industry; for example, the grading regulations for dimension lumber are established by the National Lumber Grades Authority (NLGA).

Standards cover a range of issues; some standards apply to manufacturing processes, while others affect performance standards. Typically, users are interested in performance, but not all standards apply to this area. Another reference for materials use are product evaluations by the Canadian Construction Materials Centre (CCMC), which offers a national evaluation service for all types of innovative construction materials, products, systems, and services. The CCMC is a part of the National Research Council's Institute for Research in Construction (IRC). CCMC ensures that its evaluations are based on the latest technical research and expertise.

Durability is dependent not only on the chemical, mechanical, and physical properties of a material, but also on the harshness of the environment, how it is integrated into the construction details, and the standard of personal use and care. Modern building technology continues to produce new materials that are more durable and less demanding in terms of maintenance.

Multi-Family Dwelling Substructures

The *foundation* for any building is the most important element on which the building sits. Building foundations are carefully designed and engineered to carry the load imposed by the building sitting on it, as well as soil loads on the walls and seismic loading. The foundation is usually the most overlooked portion of a building, even though it supports the entire structure above it. The materials used in foundations can consist of everything from pressure-treated wood to stone to concrete. Each of these products possess different capabilities to perform under varying environmental conditions. If produced correctly and installed properly, each product can provide a solid foundation for houses that will last many years.

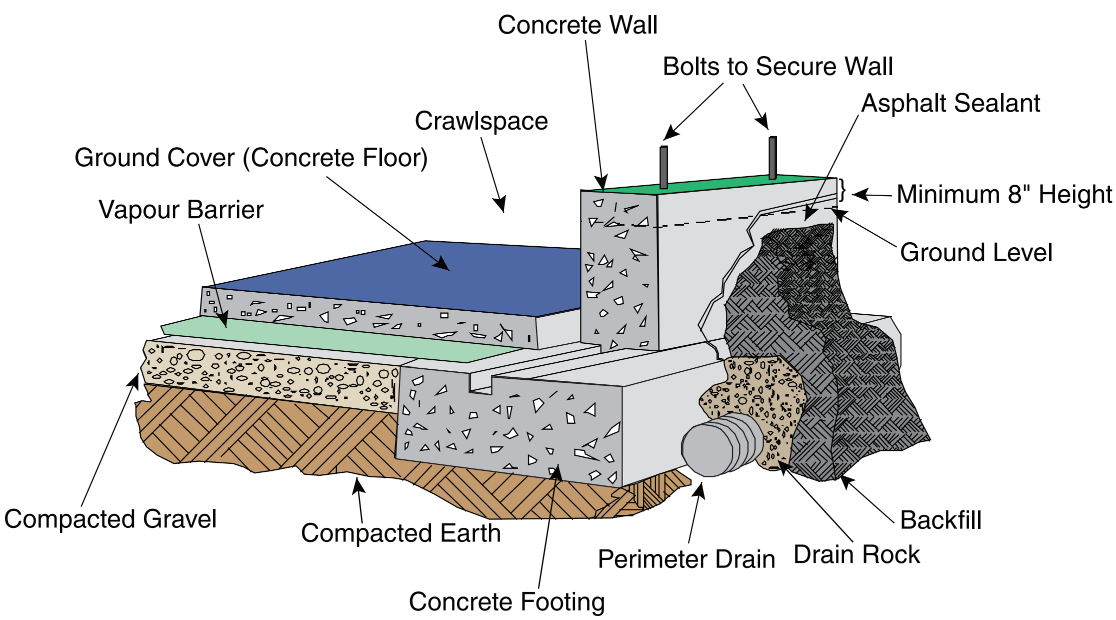
foundation
the lowest part of a building or structure, serving as support for the building or structure as a whole and typically placed below ground level

Foundation design, especially for larger multi-storey buildings, is done by specialists. Geotechnical engineers must analyze the soil conditions on the property where the building is situated because the bearing capacity varies considerably according to soil type. Virtually all foundations are built with reinforced concrete. Some smaller, older buildings may have been built on a foundation made from stones and mortar or masonry blocks. This type of foundation is not suited to higher loads or to typical soil conditions found in British Columbia; therefore, they are rarely used. Retrofitting or repairing older substandard foundations can be done to bring them up to current standards. However, this can be very expensive and requires the participation of specialists.

Common types of foundations include concrete wall, concrete block, preserved wood, pillar and post, and concrete slab.

The soundness of a foundation cannot be determined without an understanding of how foundations are built. Since the foundation is supporting the structure, it is always necessary to ensure that the structure rests on soil that is capable of supporting the weight of the building. The builder must excavate to a depth where the soil is undisturbed, thus ensuring that the footing can evenly distribute the weight to solid bearing soil. The thickness and the width of the footing is determined by the bearing capacity of the soil it is resting on. On top of the footing, a wall is constructed to reach at least eight inches above final grade. The required thickness of this wall is determined by the height of backfill that is placed against the outside of the wall.

FIGURE 20.1: Typical Concrete Footing and Foundation Wall



Notes:
1. Preserved wood foundations require a special gravel footing.
2. A continuous polyethylene vapour barrier is required under concrete floor to prevent moisture transmission.
3. Rigid insulation (foam type) is now required around the perimeter of basement walls in many jurisdictions.
4. Foundation wall must be a minimum of 8 inches above grade (ground level).

Moisture management is one of the greatest challenges with foundations. Drain tile and drain rock are placed around the outside of the foundation to ensure proper drainage of water away from the foundation. In most cases, the drain pipe terminates on a sump (a large concrete cylinder), which has an inspection lid. From here, the storm water can be directed to a municipal storm system. Should the perimeter drain system become plugged, it can usually be cleared with pressure or using mechanical means.

Damproofing (the black coating applied to foundation walls) is not the same as waterproofing. It is applied to seal minor capillary pores in the concrete that would otherwise suck in ground moisture. That is why free draining backfill is required against foundation walls. Moisture protection membranes and boards are increasingly used in new construction. These can consist of semi rigid fibreboards or dimpled sheets that are applied against the foundation. They allow any ground moisture to be deflected away from the

damproofing
a black coating applied to the outside of a foundation below grade to prevent the entry of water by sealing minor capillary pores that would otherwise suck in ground moisture

foundation wall. In most urban areas, water collection is performed by a double system. A solid pipe collects rain water from roof downspouts, while a perforated pipe collects ground water from around the house; this pipe is placed around the house at the lowest level of the excavation below the basement floor.

Knowing the level of the underground water table is important in order to keep any basement areas under the building dry. Most buildings have underground parking and service areas, which are part of the foundation. Making use of the space below grade requires that the site have a low water table. A high water table is why buildings in areas such as Richmond and Delta do not have any basements, and the entire structure is built above ground.

Although it is possible to build waterproof underground structures in areas with a higher water table, the extra effort and costs required to ensure that the structure remains dry is not usually worth the effort, and is generally discouraged.

A risk with any building is soil subsidence (i.e., downward shift) or settlement of the foundation, which may result in corresponding deformation and failure of superstructure elements. In most cases, any structural issues are identified during construction or within the first year of occupancy of the building. Moisture problems are another area of concern with foundations. Poorly designed water management on the site when the building was built or poor maintenance of drainage systems can cause excessive water pressure on the foundation floor and walls, which can lead to water leaks into the building. Concrete is not a waterproof material; if observed under a microscope, concrete has an appearance that is similar to that of a very rigid sponge – it has small pores that will always absorb moisture. Concrete is a brittle material, with many small cracks that will allow moisture to pass through. If the bottom of the foundation sits in water, the water will be absorbed by the concrete and will wick upward through the concrete, evaporating into the building. The salt crystals and dank smell in basements and parkades are tell-tale signs of moisture movement from the ground through the foundation.

High humidity and moisture in foundations is a concern because it may also affect building services in multi-family buildings. Although parking is typically placed in the basement, so are building utility areas, electric and communications controls, and mechanical and plumbing systems. These can all be affected by moisture. Moisture problems in underground structures are expensive to fix, so extra effort needs to be given at the design and construction stage. Moisture movement through the foundation can also be the major source of moisture throughout the building itself, especially the lower levels of the building.

In foundation areas that are also used for services and parking, good indoor air quality must be maintained. This typically means continuous ventilation of parking areas to remove contaminants, with motion and gas sensors to increase airflows when increased levels of contaminants are noted. These areas require regular maintenance to ensure that the equipment is functioning as intended.

Multi-Family Dwelling Superstructures

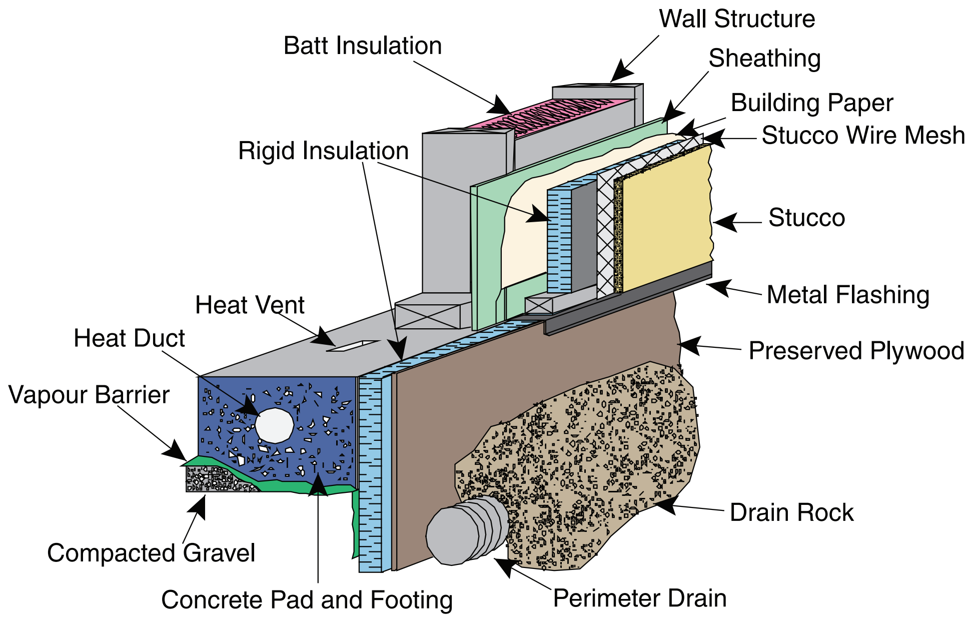
The *superstructure* of a house is built upon the foundation to form the walls, floors, and roof of the building. There are many different structural methods of construction, including post and beam, masonry, and platform framing. Of these, platform framing is the most common residential construction method and will be emphasized in the following discussion.

superstructure
the walls, floors, and roof of a building

Once the foundation and backfill are completed, the frame is ready to be placed on the foundation walls. The joists for the first floor are leveled on top of plates that will rest either on the foundation wall or a pony wall (a wall of partial height). Where openings exist, beams are laminated or prefabricated in accordance with the engineered specifications. When the joists and beams are all installed, the floor deck, which is usually plywood or oriented strand, is secured to the top of the joists. On this platform, the walls (interior and exterior) are built and stood in place. The same process is repeated if there is a second floor. Over the frame, there must be sheathing to tie the studs together to form a rigid wall unit.

The buildup (components included) in exterior walls varies according to structural method used, but always includes some form of protection for the house structure, maintenance of the internal environment of the house, and interior finish. For example, a wood-frame exterior wall buildup, from the inside outwards, includes an interior finish (i.e., wallpaper or paint on drywall or plaster), a vapour barrier to control moisture diffusion (usually polyethylene), insulation to control interior temperature, the wood frame, plywood sheathing to increase rigidity, building paper to shed any water that may leak in, and exterior siding to protect the house from the weather (see Figure 20.2).

FIGURE 20.2: Typical Concrete Slab on Grade Foundation with Wood Exterior Wall Outside Buildup



The next sections of this chapter briefly outline four principal construction types for multi-family developments:

- Wood stud frame
- Steel studs and concrete topping
- Concrete framing
- Masonry walls and wood floors

Superstructure Terminology

Following are some key terms used in superstructure design and construction:

- **Joist:** a horizontal framing member used to support a floor
- **Stud:** the vertical framing member used to construct walls
- **Beam:** laminated, built-up lumber or steel used to support vertical loads in the absence of a vertical wall under the load
- **Column:** a solid or built-up post under a beam or point load
- **Header:** the supporting structure over an interior opening
- **Lintel:** the supporting structure over an exterior opening
- **Truss:** an engineered, prefabricated roof or floor support structure
- **Rafter:** the structural member that supports the roof deck
- **Ceiling joist:** the structural member that supports the ceiling finish
- **Sheathing:** the plywood or dimensional lumber that covers the walls under the siding
- **Plate:** the horizontal lumber that the studs rest on at the bottom and the top of all framed walls
- **Engineered wood products:** include the full range of new wood products such as wood-I joists, paralam and micro-lam beams, and finger jointed studs

Wood Stud Frame

In general, wood frame is the least costly method of construction. Wood stud frame construction in multi-family properties is similar to that used for single-family houses. The principal differences between single and multi-family wood-frame construction is space separation and the methods for heating, ventilation, and air conditioning (HVAC). HVAC will be covered under a separate heading later in this chapter. Space separation means the walls and floors dividing the units from each other and from the common space (e.g., corridors, stairs, and hallways), largely for fire protection. This is normally provided by gypsum board covering to the ceiling and walls. In larger projects, firewalls may be constructed from reinforced block to divide the floor plan into smaller parts. A two-inch concrete topping is often placed on the floors to produce a stronger floor and improve the acoustic protection between floors.

Framing consists of plywood sheathing on joists spanning between wood stud bearing walls. Wood stud walls sheathed with plywood provide lateral resistance. A common problem with wood frame construction is shrinkage of the wood framing as the wood dries out. This problem can be mitigated by the use of engineered wood products, such as manufactured truss joists and beams made from wood products (e.g., Parallam).

Stud walls for external walls of upper floors in one- or two-storey apartments may be of 2" × 4" studs. In most cases, the basement is also formed partly with stud walls; in this case, it is more usual to use 2" × 6" except for the top floor. Internal stud partitions supporting two storeys should be either 2" × 4" at 12" o.c. (oncentre) or 2" × 6" at 16" o.c.; the top floor can be 2" × 4" stud. Apart from the design of beams, the remainder of the framing of floors, ceiling joists, and roofs is similar to that for houses.

The National Building Code includes Span Tables for wood joist rafters and beams. These tables are based on the following assumptions:

- The allowable spans are measured from the face or edge of support.
- In the case of a sloping roof framing member (rafters, etc.), the spans are expressed in terms of the horizontal distance between supports rather than the length of the sloping member.
- Snow loads are also expressed in terms of the horizontal projection of the sloping roof.
- Seismic design requirements are taken into account.

For stairways, it is normal to enclose the stairwell with 2" × 4" or 2" × 6" stud walls sheathed with plywood as required for lateral loading; in addition, these walls must be made fire resistant. This also applies to ducts and garbage chute housings and to elevators, where used.

Steel Frame

Steel frame construction was commonly used in the past and there are still many existing buildings with this type of construction. The floors are constructed from metal decking with concrete topping spanning between load bearing metal stud walls. The lateral resistance is provided by cast-in-place concrete walls, which are usually located at the elevator core and the stair shafts. The advantages of this type of construction are that it is non-combustible, there are none of the shrinkage problems inherent with wood construction, and the fire resistance can be provided by drywall for the floors and walls. However, unless certain design features require steel frame or make steel frame more economical, then reinforced concrete is generally a cheaper form of construction for an apartment building. Unprotected steel frame is the preferred type of construction for economy and speed.

Steel framing is common in central Canada, but is rarely seen in low rise construction in British Columbia. Steel is used in cases where non-combustible construction is required for fire safety and code requirements, such as high rise construction.

Masonry and Timber

Masonry and wood buildings have exterior load-bearing masonry walls and protected wood frame interior construction. Staircase and corridor walls are often of block and, in some instances, reinforced concrete spandrels are incorporated.

Masonry and wood is an older construction style and many locations will still have these buildings in the housing stock. However, this construction style has become less common with the more stringent fire bylaws. Masonry structural walls are still commonly used where a wall is tight to a property line, to provide appropriate fire separation between the properties.

Concrete Framing

Concrete framing is the most common type of construction today for mid- to high-rise multi-family buildings. Concrete framing can be altered on the fly to accommodate design changes and decisions during construction. In contrast, steel framing elements must be carefully designed and pre-ordered well before construction begins, meaning there is little room for changes in design.

Building and fire codes typically require a two-hour fire rating for floors and columns – concrete will give this rating without any additional protection for most applications. Steel framing requires additional fireproofing because exposed joists will distort rapidly under intense heat, leading to structural collapse.

There are several building systems choices for reinforced concrete construction:

- Flat plate
- Flat slab
- One-way or two-way joist

The most common structural concrete systems multi-family buildings today are the flat slab, which has drop panel at the columns (thickened slab), or the flat plate, which is flat between the columns (see Figure 20.3). These systems have the advantage of being simple to form, simple to reinforce with straight bar column mats, and simple to finish. The concrete floors are poured flat between concrete columns and walls. A sprayed ceiling finish and carpet completes the floor.

In British Columbia, there is a perception that wood frame construction is poorer quality than concrete and therefore more difficult to sell. Many buyers prefer concrete construction because of the bad press from the leaky condo situation.

FIGURE 20.3: Flat Slab vs. Flat Plate Structural Concrete Systems

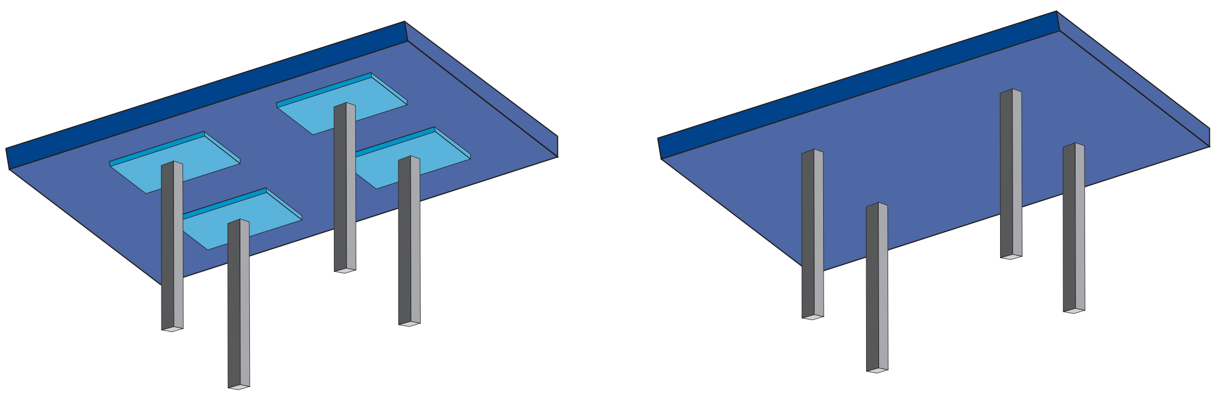
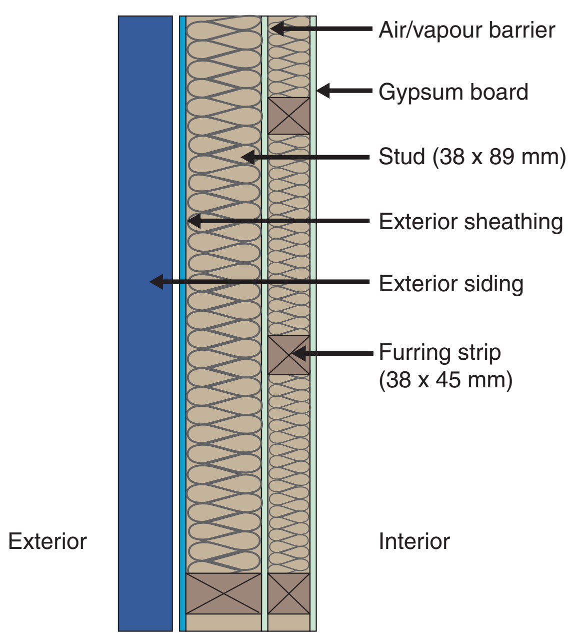


FIGURE 20.4: Materials in a Building Envelope



Source: NRCan, Office of Energy Efficiency, NRCan. "Low-Permeance Materials in Building Envelopes". Construction Technology Update. No. 41, March 2002.

Weather Barriers

The building envelope must be designed to be weather resistant. Moisture in any form must be repelled by the envelope and led away from the building using proper drainage techniques.

A structure's first weather barrier is its siding (i.e., the exterior covering of a house). Siding – usually wood, vinyl, stucco, hardboard, or fibre cement – acts as the weather barrier against the elements. A structure's second weather barrier is a thin layer of water-resistant tar paper or house wrap, below the siding, attached to the outside of the sheathing. If any moisture penetrates the siding, this layer leads liquid moisture away from the sheathing and structural components, protecting the integrity of these important building components. The exterior sheathing beneath this layer can consist of plywood, oriented strand board (OSB), waferboard, or exterior gypsum board. Each of these barriers protects the structural components from water outside the home. The wall frame or studs sits inside this sheathing. Insulation, vapour and air barriers, drywall, and paints make up the final layers of a typical wall.

Air and Vapour Barriers

In cool climates as are found Canada, air and vapour barriers protect the structural components of the building envelope from water produced inside the home. These barriers slow both vapour diffusion and air transported moisture. If the warm, moist air in the home finds an access point into the wall and roof assembly, the concern is that the moisture vapour it holds will condense as the air cools on its way outwards. The exact placement of these barriers within the building assembly will depend on the climate and choice of building assembly combination.

Products are considered air impermeable when they have an air leakage rate of below 0.021 litres per second per metres squared when tested at a pressure of 75 pascals. According to the Canadian Home Builder Association Home Builders Manual, choices include (but are not limited to) polyethylene housewrap, plywood sheathing, cement board, and aluminium foil.

The most common type of vapour barrier is a clear, flexible polyethylene sheet of plastic that has a thickness of at least 6 "mil" (6 micrometres, 0.006 inches, or 0.15 millimetres). This material is inexpensive and easy to work with, though care must be taken to create a seamless seal around doorframes, windows, electrical boxes, and over joints. Separate sheets should overlap widely, be stapled to the framing, and then joined with acoustic sealant. Holes for electrical wiring or plumbing fixtures should be as small as possible and, again, sealed with acoustic sealant.

Other types of vapour barriers include speciality paints, treated paper, Kraft paper, aluminium foils, or black polyethylene. Foils should be taped with adhesive-backed foil tape to create a continuous barrier. All vapour barriers should have a minimum permeability rating of 1.0 perms, which stands for the minimum amount of moisture movement through a material (measured as grains per square foot per hour per inch of mercury difference in vapour pressure) – the smaller the perm number, the less moisture can penetrate. Low Volatile Organic Compound (VOC), non-toxic vapour barrier products are available to minimize the negative effects of off-gassing on the home's indoor air quality.

The challenge with air and vapour barrier comes in sealing each of these components together with house wrap tape, caulking, sealant, gaskets, or foam to control air leakage in those gaps. Extra care should be taken to reseal entry points around electrical wiring, plumbing fixtures, and lighting fixtures. The air barrier must be continuous, but less precision is required of the vapour barrier connectivity.

Roofing

The roof assembly will resemble that of exterior walls, with the exception of interior finish, which is commonly omitted to allow interior inspection of the roof structure. From the inside out, a typical roof buildup includes a paint and drywall or textured ceiling finish on drywall, a polyethylene vapour barrier, insulation, rafters or trusses, plywood or oriented strand board sheathing, and a weather barrier (e.g., tar and gravel, asphalt shingles, cedar shakes, or tiles).

Tar and gravel roofing is used only for low-slope applications. The roof deck generally consists of solid plywood or other sheet material applied on top of roof joists, with a layer of insulation sometimes applied on top of the plywood under the first layer of tar and tar paper. The remainder of the roof consists of layers of tar paper and hot, mopped-on tar. The roofer will build up the layers, with the number of layers directly corresponding to the roof's lifespan. The roofer will spread a layer of gravel over the top layer. The layer of gravel protects the tar and paper from damage caused by the ultraviolet rays of the sun.

Most membrane roofing used in new construction on low slopes or flat roofs is factory manufactured in rolls and installed on site by adhering to the roof deck, either with a torch (also referred to as torch-on roofing) or by adhesion with special adhesives. Some older, low-rise buildings will have built-up tar and gravel roofing (BUR). Torch-on roofing is a more popular option now. Flashing is installed around all roof penetrations such as plumbing, ventilation, and furnace vents. Flashing is also installed along the roof perimeter over fascia boards or corner trim. The purpose of the flashing is to direct rain-driven moisture away from the sealant around the vertical penetrations, which is the weakest element of any roof. Roof flashings are mainly of galvanized sheet metal with some copper used on the better quality buildings.

Figure 20.5 shows some examples of roof designs. When a roof design is being selected, factors that must be considered include the design's suitability to the building site and the overall aesthetic appearance. The roof design and the complexity of the structure will have some bearing on the cost of construction, with the more complex roof shapes being more costly to build.

The roof structure consists of a ceiling joist and rafter (for homes built before the 1960s) or an engineered truss (homes built in the 1960s and later). Figure 20.6 shows an example of both of these types of roof structures. A ceiling joist and rafter roof consists of rafters angled upwards to form a peaked roof, with joists running horizontally to support the ceiling and tie together the exterior walls. Truss systems are prefabricated and are more structurally efficient. Trusses also use rafters and joists (called top and bottom chords), but include diagonal supporting braces (webs) as well. The rafters, joists, and chords are connected to each other by metal plates (gangplates). The roof surface can be formed by sheathing the chords or rafters with sheathing material such as plywood (used if the surface required for the type of roof has to be solid or for structural reasons). If tiles, shakes, or shingles are used, roof sheathing may also consist of 1" × 4" or 1" × 6" lumber spaced to allow the roof to breathe.

FIGURE 20.5: Roof Designs

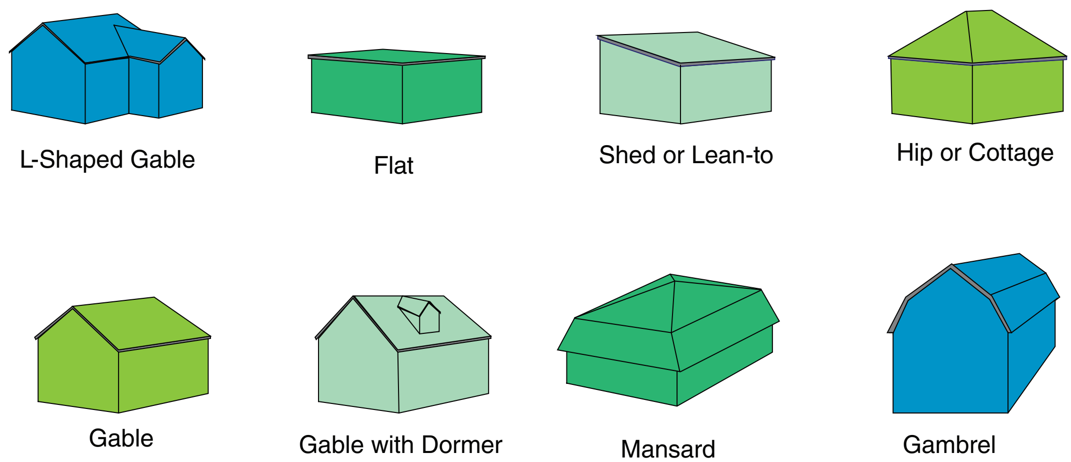
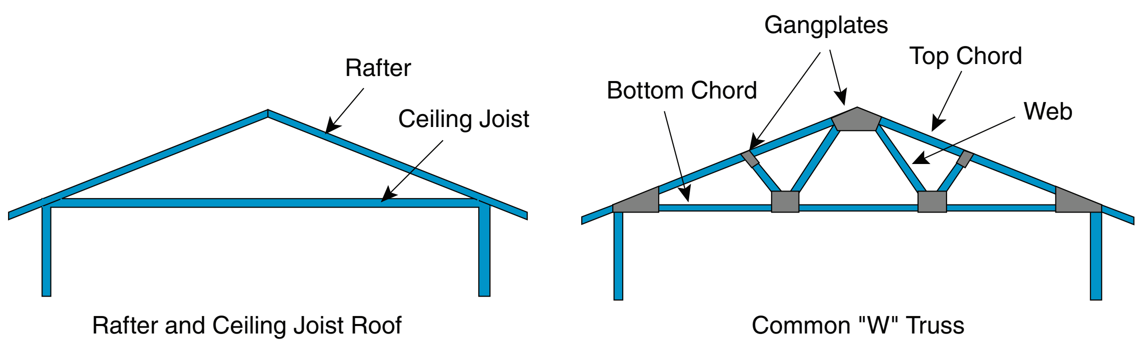


FIGURE 20.6: Roof Structures



Asphalt shingles could be described as a premanufactured tar and gravel roof. The shingle itself consists of a matt material covered first in tar, then with fine gravel. While the grit or gravel is usually coloured for aesthetic reasons, the principle is the same. The gravel layer on top protects the tar and matt material underneath from the effects of the sun. Shingles are purchased in bundles and applied individually according to the manufacturer's specifications. Some shingles are referred to as "self-tabbing" because they have rows of tar on their underside that, when heated by the sun, stick the bottom of the shingle down to the one below it. Others are interlocking: they lock into each other during application and hold each other down. Increasingly, shingles are manufactured on a fibreglass matt (hence referred to as fibreglass shingles), which is more durable.

Most shakes and shingles are made of cedar. Shakes are split and have a rough, rustic, grooved surface, while shingles are sawn and have a smoother, more uniform profile. To identify whether shakes or shingles have been used, the profile of the edge of the roof can be inspected. A shingle will taper from a thick end at the bottom to a fine point at the top, whereas a shake will not taper to such a fine point, if it tapers at all. Shakes and shingles can be fire-proofed and pressure-treated to prevent decay. A roof that is silver to black in colour is untreated, while a roof that is greenish in tint is treated. Installation of shakes and shingles is quite different than the installation of asphalt shingles. In order for the wood to breathe, the shakes or shingles are installed on top of layers of tar paper that have been laid on evenly spaced one by fours or one by sixes. However, the first four or five feet from the lower edge of the roof are not spaced so as to prevent water infiltration from ice build-up at the gutter and roof edge.

Most cedar roofing products are cut from second growth timber, which is not as durable as old growth cedar; these products should be treated to enhance their durability. Even old growth cedar should be treated, because despite its natural decay resistance, it will still decay in the presence of enough moisture. This is often the case in many homes on the West Coast, which are in the shadow of mature trees meaning that portions of the roof seldom see the sun.

Concrete tiles are installed in a similar fashion to shakes with one essential difference: instead of layers of paper under the tile, there is a uniform membrane forming a secondary roof. This material is usually a reflective foil or four by eight foot thermal sheathing. This membrane is designed to direct moisture and condensation to the roof edge for drainage. Because of the extra weight of concrete and stone tiles, the roof structure must be capable of carrying the weight. This is taken into account in new construction, but could be a problem in older homes that are undergoing renovations.

The decision on any specific roofing product is made based on durability, suitability for the application, and aesthetic considerations. A variety of new roofing products, such as sheet metal roofing, metal tiles, or new synthetic tiles, are available for use. They all perform similarly to the other roofing products and can be considered either as shingles, which require a minimum roof slope of 4" rise for each 12" in run, or as a membrane sheet, which is used on shallow (or flat) slopes.

Building Envelope Systems

Relating building design to human anatomy, if the superstructure is the skeleton of the house, the *building envelope system* is the skin; the superstructure is designed to hold the house up, while the building envelope system is used to protect the house's internal environment from moisture, dust, wind, and extreme temperatures. The components that will be examined in this section include siding, windows, doors, and insulation. The leaky condo events of the late 1980s to mid 1990s have highlighted the importance that must be given to the design and construction of the building envelope. The envelope failures were not limited to multi-family condominium construction; many single-family houses faced the same issues and required the same remedial work.

building envelope system
the elements that protect a structure's internal environment from moisture, dust, wind, and extreme temperatures; includes components such as siding, windows, doors, and insulation

The building envelope encompasses several barriers; together, they work as a system. The exterior cladding is like the umbrella, which deflects most of the rain, but behind the cladding there is a moisture barrier that keeps the water and wind out of the wall assembly. In the wall, the sheathing membrane (i.e., the building paper) that is installed behind the exterior cladding is the most important part of the moisture barrier, as it stops any moisture that will have penetrated through the exterior cladding.

No amount of sealant on the exterior of the building will keep water out. The caulking and sealants have a relatively short life span and will eventually deteriorate, allowing exterior moisture to penetrate. That is why the BC Building Code requires that the details used in all coastal locations incorporate a rain screen, which is a gap behind the cladding. The rain screen allows any moisture that might penetrate to drain out and dry out, rather than being absorbed into the wall assembly where it can lead to deterioration.

Many of the building envelope failures on the West Coast were the result of poor detailing (allowing exterior moisture to penetrate the exterior) and a mistaken belief that a well-sealed exterior would keep the water out. The products and details used to keep water out of the wall assemblies also prevented the moisture that did penetrate from drying out, so there was moisture build up within the walls, until deterioration set in. Face-sealing a building from the exterior is not feasible in practice.

Although older buildings often experienced moisture penetration, they were built differently – with uninsulated walls, for example – which allowed the moisture to dry out before deterioration could set in.

External Cladding

The weather tightness of a building is dependent on the integrity of the exterior siding. Common external *cladding* options include the following:

cladding
a covering or coating on a structure or material intended to protect against weather infiltration

- **Wood:** Wood siding is available in a wide variety of shapes, sizes, and types. Wood siding is usually applied over a layer of tar paper or other water-impervious sheet material. The siding is applied overtop of the paper layer using nails to secure the wood. Wood must be cut to fit tightly around window and door openings. Wood is very susceptible to the effects of weather, which can cause the wood to move and change shape. Heat and ultraviolet light from the sun, along with wind and rain, do their part to break down exposed coatings. Therefore, the joints between the siding and the opening must either be covered with a piece of wood trim or be caulked with exterior caulking. Cracks and holes in the siding can usually be fixed by recaulking the affected area. If the wood is damaged to a point where it has to be removed, cost is directly related to the style of the siding. Removal of a lapped-type siding is much simpler and less expensive than an interlocked style, such as tongue and groove. With regard to siding finish (painted or stained), areas that are blistered or water-stained indicate there is moisture in the wood. The source of the moisture must be discovered before the problem can be fully resolved.

- **Aluminium or vinyl siding:** Manufactured vinyl siding has become very popular over the past few decades because of its low cost and ability to maintain its finish, giving a lasting appearance to the home. Aluminum or vinyl siding should be installed very loosely because of high thermal expansion of the material when heated by the sun. Aluminum or vinyl siding is usually applied over a paper or water-repellent sheeting (as is done with wood siding), and the siding must be carefully secured. Elongated nailing holes are provided in the siding; the nail should be located in the centre of the hole, hammered in loosely. This type of application allows the siding to expand and contract as the temperature changes. If the siding is nailed too tightly, the change in temperature will cause it to buckle. The main advantage of aluminum or vinyl siding is that repairs are usually inexpensive. With the proper tools, a damaged piece can be unlocked and easily replaced.
- **Stucco:** Stucco provides a more continuous exterior cover than wood or aluminum vinyl siding. It is available in a wide variety of styles and finish textures, but can generally be categorized as either regular cement-based stucco or synthetic stucco. With traditional cement stucco, a coat of cement material called a scratch coat is installed over a layer of wire mesh and tar paper. The wire mesh and tar paper are nailed to the sheathing that is applied to the studs. On top of the scratch coat, a second "brown" coat is applied, then the finish coat is applied in the colour and texture desired.
    - Regular stucco is susceptible to cracking and water seepage. Minor shrinkage cracks are to be expected because it is a cement-based product. Any major damage or cracks can be repaired by a qualified tradesperson; however, matching the existing stucco is difficult (if not impossible). The other main problem with traditional stucco is water seepage; it is a porous surface and can allow wind-driven rain to penetrate the surface, causing unsightly stains. If there are stains, the affected surface can be power-washed or cleaned with mild soap and water to remove the stains. The surface should then be protected on a regular basis with a water repellant.
    - Synthetic stucco is a popular newer alternative. The wall is coated with an insulating board called expanded polystyrene, which is coated with a fibreglass mesh and a very thin epoxy cement scratch coat. On top of this coat, the finish coat of very flexible acrylic stucco is applied to a thickness of about three millimetres. While more expensive than traditional stucco, synthetic stucco is also generally of higher quality and not as susceptible to cracking – it provides an easy way to incorporate architectural features on the building. Synthetic stucco systems are seamless, as they are meant to be airtight for added insulation. However, it is nearly impossible to make these systems completely waterproof, as moisture can enter through improperly caulked windows and doors or through dryer vents, decking, or phone and cable TV line entries. This moisture is deposited between the stucco and the inner walls, and because the system is airtight, it cannot get out. Over time, this can cause rotting of the structural wood frame. Inspecting for these problems with synthetic stucco involves looking for signs of moisture damage, such as rotting window or door frames, mould or mildew, and swelling or bulges in interior walls.
- **Face brick:** There are very few homes with solid brick walls (containing no lumber products); therefore, this discussion is focused on brick veneer. Brick veneer refers to the application of a layer of brick to a standard frame wall system. The brick is supported either directly on the concrete foundation or on angle iron bolted to the foundation. The brick veneer wall is tied to the wood wall by special ties, which are installed during the bricklaying process. Three main areas of concern with brick are cracks,

weepholes, and settlement. Hairline cracks in brick should be left alone; however, large cracks could be a sign of structural damage to the brick veneer or the supporting wall and an inspector should be consulted. At the bottom of a brick veneer wall, there should be holes through the mortar joint every two feet to allow water to drain out from behind the brick. If these holes are plugged, they should be opened up. This is why traditional brick veneer buildings seldom had any moisture penetration problems. The main area to check for settlement is directly under a window that intersects the brick – if there has been any major settlement, the brick will exert pressure on the window. This pressure can be relieved by chipping away the brick and caulking the gap that is created.

- **Cement board siding:** Cement board siding has increased in popularity due to its durability and reliability. Cement board is extremely strong and resistant to fires, insects, and rot. In many cases, cement board is made with a simulated grain appearance and is coated with a paint that does not typically chip or peel. This type of siding is generally installed with nails or screws on a wood frame.
- **Glazing systems**
- **Exposed concrete (either painted, sandblasted, or with patterns formed into the concrete itself)**
- **A mix of the above in various areas throughout the building's exterior**

The type of siding will depend on the location of the building and its design. Specific requirements may be set by building code requirements for fire safety, requiring the use of fire-resistant materials on the exterior. Wood and vinyl are combustible materials, therefore they are not suited for use in locations where fire safety issues are important.

For wood-frame multi-family dwellings, common finishing materials that are typically used include stucco with some brick veneer or wood siding as relief, aluminium siding, vinyl siding, or fibre-cement lap siding, which often has a wood-like finish.

For reinforced concrete multi-family dwellings, the exterior walls can be stuccoed or the concrete walls can form their own finish if left smooth from the forms or bagged to form a smooth finish – but this finish is not very attractive and is usually painted. The least expensive form of finish is a good cement-based paint; this often forms the sole finish to a building. The plastic-based coatings normally give a longer life and better appearance, but they are much more expensive. Today, bush hammering of concrete and special form treatment is more common; sandblasting is also used.

Brick veneer, which is applied directly to the concrete, is one of the most durable finishes available. The downside of brick veneer is that it often increases the load on the building frame but does not contribute to the structural strength of the wall.

Faience tile (glazed earthenware) is a low maintenance cladding material, but is rarely used today due to cost and change of fashion. When clay masonry is used, it is usually in the form of "giant" face brick. In the 1960s and 1970s, ceramic mosaic tile and glass mosaic were popular facing materials.

Windows

Older window frames may be made of wood, but most modern windows will be aluminium or vinyl. In newer low-rise condominium unit construction, vinyl clad window glazing is common since this option is generally less expensive than commercial grade aluminium windows. For opening windows, casement or sliders tend to be the most common styles. Apartments with a balcony will most often have a horizontal sliding aluminium door.

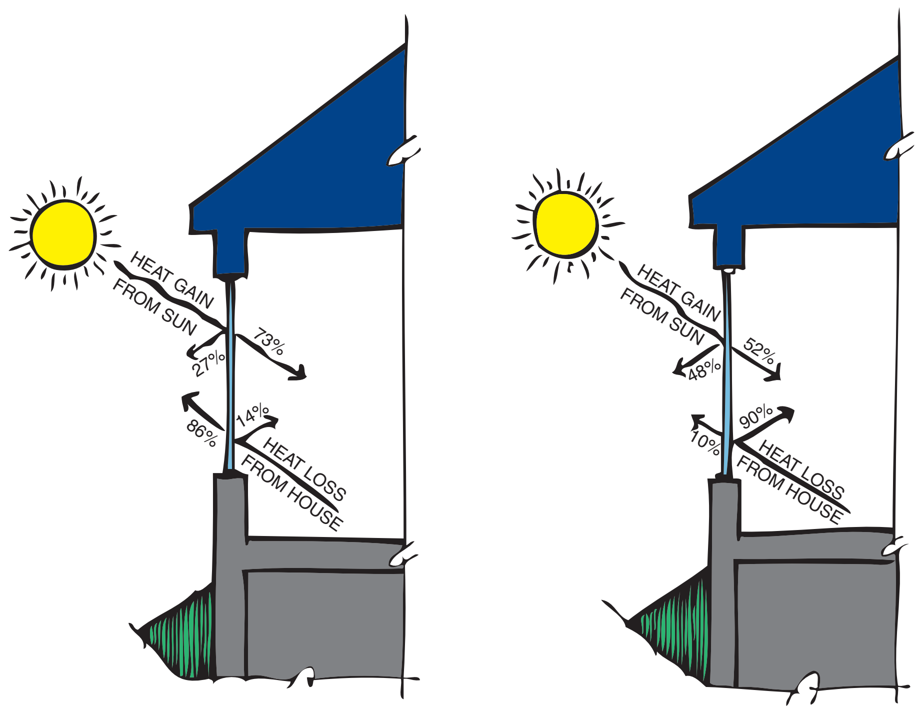
Single-glazing was popular in the past, but modern code requirements require sealed double-glazed units, offering both thermal protection and a sound barrier. Triple glazing or additional window glazing treatments may be found in extremely cold climates where the additional cost is justified.

It is common to use windows with low-E coated glass and gas fills in the sealed spaces. This helps reduce heat loss from the building, while also improving comfort. Some coatings can also reduce solar heat gains into the building, which is an important consideration in buildings with large window areas, especially on the southwest and west sides of the building. Reducing solar heat gains will help reduce overheating of the apartments, which has become a concern with some of the new glass towers being built today. Window types can be strategically installed based on their location in the building. For example, a large west facing glass area can use glass that reduces the amount of solar radiation penetrating the window, thus reducing the overheating in the house. Similarly, homes with large glass areas will benefit from high performance insulating glass to improve the thermal comfort and reduce heat loss from the house. Key features of high efficiency windows include:

- double or triple panes of glass;
- low emissivity (low-E) coatings on the window;
- gas fill in the sealed unit (typically argon, krypton, or another non-toxic gas instead of air);
- insulated spacers (the bar that keeps the panes of glass apart); and
- insulated window frame.

Windows are the lowest insulating element in the house, so any improvement in their thermal performance will have a significant impact on the energy use in the home.

FIGURE 20.6: Low-E Window Glazing



Standard Glazing Low-E Glazing

Window Terminology

Follow are some key terms used pertaining to windows:

- **Single-glazed:** one layer of glass in the window
- **Double-glazed:** two layers of glass separated by air space and sealed for greater insulating value
- **Non-thermal broken:** the frame of the window is one continuous unit from the inside to the outside
- **Thermal broken:** the frame of the window is split into two parts from the inside to the outside to reduce the conduction of heat from the home to the outside and vice-versa
- **Vertical pivoted:** horizontally opening window that pivots on a central axis
- **Vertical single hung:** opening portion of the window slides vertically
- **Horizontal slider:** opening portion of the window slides horizontally
- **Hopper:** opening portion of the window is hinged on the bottom and opens inwards
- **Awning:** opening portion of the window is hinged on the top and opens outward
- **Casement:** opening portion of the window is hinged on the side and opens outward
- **Tilt and turn:** a combination operating mechanism that allows the window to open like a hopper or like a regular casement; this window type is commonly seen in Europe

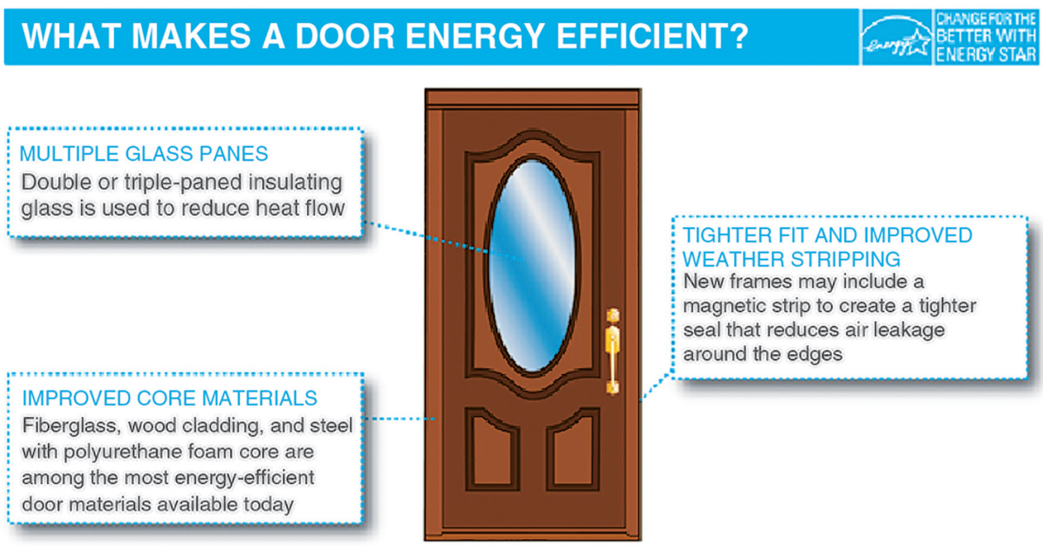
Doors

As with windows, door types are selected for design, energy efficiency, and security. There are six main parts to a door unit:

- **Frame:** the material between the rough opening in the frame wall and the actual door
- **Hinges:** the hardware on which the door swings
- **Door slab:** the actual door that swings
- **Hardware:** the mechanism to open and lock the door
- **Threshold:** the bottom of the doorframe that is subject to the most wear and tear
- **Weatherstripping:** the seal around the outside edge of the door to prevent entry of weather

The use of insulated doors instead of hollow core doors greatly improves the energy efficiency and the durability of the door unit. Heat loss can be further mitigated by reducing the glass area or using multiple panes and glazing in doors.

FIGURE 20.7: Energy Efficient Doors



Most modern multi-family dwellings have a full-height storefront type entrance, which can be formed of wood but is usually plate glass glazing in aluminum sections. Depending on the type of building and the price range available, the entrance door may vary from painted fir to solid hardwood to wrapped aluminum on a fir core. In many parts of a building, a cheaper material has little effect on the finished appearance; however, the quality of the front door is very important.

Suite entrance doors must be solid core to comply with fire regulations; the most common type is a flush ply-faced solid core door. When using a paint finish, birch ply is suitable but fir ply should never be used as it is impossible to hide the grain swirls. Entrance doors are often fitted with higher quality hardware than in-suite doors. Metal and fibreglass insulated entry doors are commonly used in row houses.

Internal suite doors are used to close off space, as space dividers, and for closets. Internal suite doors to separate rooms are normally hollow core flush ply doors with fir, birch, or mahogany ply facing. They are set in plain stops, linings, and trim latch sets. Sliding pocket doors can be used if space is at a premium.

There are several types of space dividers, including:

- **Flush Sliding Pocket Doors:** popular for hall to kitchen division, consisting of a normal hollow core flush door hung in a sliding pocket, which is set in the frame wall. The opening for the door and sliding pocket are often framed up. The sliding pocket is set in, then the door is hung to slide in the pocket and the door linings are fitted. The distance between the door and wall face is often minimal and sometimes, when either the drywall finish or the trim is nailed around the door, a nail point will project and mark the door as it slides into the pocket. Thus, extra care must be taken in this process.

- **Folding Doors:** An older type of door is the modernfold type, which consists of a metal expanding frame covered with either fabric or plastic. The fitting is simple: it requires a plain lining set with trim only and the door track is screwed to the head. Another type of folding door consists of wood battens fixed together with vinyl plastic hinge strips. Fixing is somewhat similar to the modernfold type and jalousie (with angled slats) or half-jalousie doors are popular.

Most closet doors use a multi-panel sliding or folding door. Panel or jalousie doors are also used, but tend to warp.

Fire doors must be provided in multi-family buildings, principally in the following locations:

- at each entrance to the fire escape staircases;
- to all boiler and incinerator rooms;
- to all electrical switch rooms;
- to all entrances from inside the building to a garage; and
- where corridors are divided into sections and are kept open, they must be fitted with a fusible link heat activated device.

Insulation

In most of North America, insulation is used primarily to keep heat in; however, insulation is also integral to keeping unwanted heat out during the summer. Insulation slows conduction, blocks airflow, and minimizes radiation by creating small, stagnant air pockets that are surrounded by thermal resistant materials. The combined resistance to the flow of heat is called an "R-value"; the greater the R-value, the greater the resistance to heat flow.

For flat roofs, thermal insulation can be provided by use of rigid fibreglass insulation, impregnated fibreboard, or polyethylene or polymethane materials. The minimum thickness for rigid foam insulation as part of a torched-on roof system is two inches. In colder regions, double layers of insulation may be installed with up to five inches of rigid insulation. In older rental apartments with BUR roofing, there may be minimal to no insulation. External wall thermal insulation can be provided by use of foamglass, rigid fibreglass, and other materials. Fibreglass batt insulation is common in low-rise multi-family wood frame buildings with sloped roofs.

Wall insulation is most often found on the inside of the wall sheathing, between the studs and behind the vapour barrier. However, rigid foam insulation that is placed to the outside of the frame is becoming more common.

Selecting the type of insulation used depends on:

- the difficulty of applying or installing the insulation;
- its associated cost;
- its required function;
- where it is to be installed; and
- environmental benefits.

For example, loose-fill insulation is often used in attic rafters and wall cavities, while rigid foam boards are often used between interior walls and the siding. Foam is used to seal air leaks and can be sprayed into wall cavities, while batts and blanket rolls are used in attics, unfinished walls, and wall cavities. The following are types of insulation:

- **Glassfibre batt:** This is the most common type of wall insulation; it usually pink or yellow in colour and resembles cotton candy. The batts are premanufactured to friction fit the wall cavity and are rated according to R-value (the higher the "R", the higher the thermal resistance). For example, R-12 is a 3.5" thick batt, while R-20 is a 5.5" thick batt.
- **Blown glassfibre:** This consists of glassfibre batts that have been chopped up by a machine on site and blown through a hose into a space (e.g., an attic). The R-value depends on the thickness and density of the blown insulation.

- **Cellulose fibre:** This is made from shredded recycled newsprint with chemicals added to prevent fungi and fire. This is a loose fill insulation that must be blown into place.
- **Polystyrene insulation:** This is a high-density rigid sheet material mainly used for sheathing insulation on wall and floor surfaces.
- **Rigid glassfibre:** This is a rigid sheet material made of glassfibre for sheathing applications.
- **Spray in place foam insulation:** This is a foamed polyurethane insulation that is used to air seal and insulate buildings. Its use has gained prominence in recent years. It is also used in older building renovations.

Although the primary function of insulation is to slow the flow of heat, these products also control the flow of air, moisture, and sound. Acoustic separation means minimizing sound transmission from suite to suite and between suites and the common areas. This is accomplished by installing materials that can reduce or resist the transmission of sound. The Sound Transmission Class (STC) rating system measures the sound insulating performance of construction assemblies. The National Building Code sets a minimum STC rating of not less than 50 decibels.

BUILDING SYSTEMS

A building's appearance and use are largely defined by its superstructure, but the mechanical and electrical systems are equally important to the success of the overall design. A mechanical system involves machinery or the movement of air or fluids through the structure. An electrical system involves electricity, lighting, control systems, and communications.

The size and age of multi-family buildings will often provide clues for the type and design of building systems. For example, in low-rise multi-family buildings, elevators are usually medium- or slow-speed, passenger-operated with a simple control system, while mid- to high-rise multi-family buildings will tend to have higher speed, cable-driven elevators. The following sections discuss these considerations.

Heating, Ventilation, and Air Conditioning (HVAC)

The specifics of heating, ventilating, and air conditioning systems go beyond the scope of this chapter; the following is not intended to provide a comprehensive explanation of these systems, but rather to summarize and identify the types commonly used.

The National Building Code specifies space heating requirements for multi-family buildings, requiring HVAC systems to be able to maintain a minimum temperature of 22 degrees Celsius (72 degrees Fahrenheit). There is a great diversity in HVAC systems found in multi-family buildings, including the following:

- Forced hot air
- Central hot water
- Steam heating (common in old buildings but rarely used in modern construction)
- Electrical

Many apartments were historically heated by a steam heating system, but this practice has fallen out of favour. In older buildings, which are typically low-rise rental apartments, it is common to find a central hot water heating system. The hot water heating system consists of a gas- or oil-fired furnace housed in a boiler room together with a hot water boiler. Central hot water systems are normally heated by means of a gas or oil-fired furnace with water jacket leading to a hot water tank, from which the hot water is pumped in a closed circuit. The furnace is operated by thermostatic control in certain control areas of the building. Although these systems are more economical for the resident in terms of operating costs, they are more expensive to install, so they are less common today in new developments. The heat in this system is usually distributed by wall convectors. Historically, these consisted of somewhat unsightly cast iron radiator units set under windows; these were later replaced by wall convector units with sill height casings. Today, the wall fin unit or baseboard convector is used, consisting of standard black or copper pipe, which has fixed fins of aluminum or other material affixed. The addition of the fins increases the heating surface and eliminates the necessity for the conventional convector. The finned pipe is inserted in the pipe run wherever heating is required and is covered by a sheet metal baseboard convector casing. Where large expanses of full height windows make this system impractical, ceiling radiant panels are used to blanket the window area.

Radiant hot water or steam heating systems are no longer commonly used in modern multi-family construction, given high cost and inefficiency. Modern central heating systems typically use hot water boilers that do not reach temperatures that create steam.

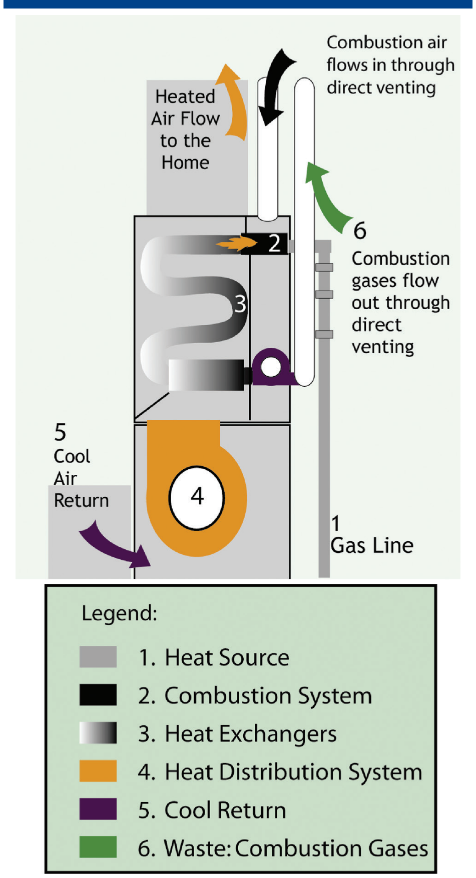
New small-scale multi-family buildings, such as row houses, can often be successfully heated by forced hot air alone. The system is similar to that in a single-family house with a thermostat control. The furnace is typically located in certain control areas of the building. In the summer months, the furnace can be designed to circulate cool air (though this is not an air conditioning system). Ventilation is usually provided in the kitchens and bathrooms by individual exhaust fans carried to the open air by a separate duct system. Some of the smaller packaged gas units can be used successfully with a bank of three or four units in line, coming into use as the demand increases.

Central heating systems have generally fallen out of favour in modern multi-family construction, in large part because developers and building owners prefer HVAC systems that allow usage metering so that costs can be charged to individual unit occupants.

Many modern low-rise apartment buildings are designed with electric baseboard units as the only heat source. This allows maximum flexibility for occupants and avoids the need for mechanical rooms and additional space between floors and in common areas devoted to mechanical ventilation ducting. Each unit can be metered separately, which is important for allocation of hydro expense to residents. The downside of electric heat is that electricity costs have escalated faster than natural gas over recent decades. The long-term heating cost with electrical is generally higher than natural gas in most parts of Canada. With the population growth in BC, electrical capacity in the system is strained, so the electric utilities often discourage the use of electricity for space heating.

The main faults in heating systems arise from their design, such as uneven distribution of heat through the building or insufficient control points. A problem with hot water systems is circulation from suite to suite of cooking odours; a slightly pressurized lobby and corridor system can prevent this. Central forced air systems typically have only one thermostat, making it difficult to regulate in-suite temperature for multi-family buildings.

FIGURE 20.8: High Efficiency Gas Furnace



Domestic Heating Systems

The type of heating system for a house will depend on the age of the home and the most prevalent fuel in the area. Heating systems can be categorized by three main methods of distribution: forced air, convective, and radiant. The fuels for each distribution system can be either wood, electricity, gas (natural or propane), or fuel oil. Coal was a common heating fuel in the past.

Forced Warm Air

The principle of forced warm air heating is quite straightforward. A heat source, the furnace, is burned in the combustion chamber of the furnace. A heat exchange chamber above the combustion chamber warms the air pushed through by the furnace fan, then distributes it through the house. Ideally the furnace should be located centrally in the house, so that the ductwork layout can be kept as simple as possible. Usually the furnace will be placed in the basement or crawlspace.

The furnace fan creates the air movement necessary to distribute the heat throughout the home. The main items to check in forced air systems are damaged fan belts, cracked heat exchangers, plugged air filters, and plugged hot and cold air registers. With annual servicing, forced air systems will provide many years of service.

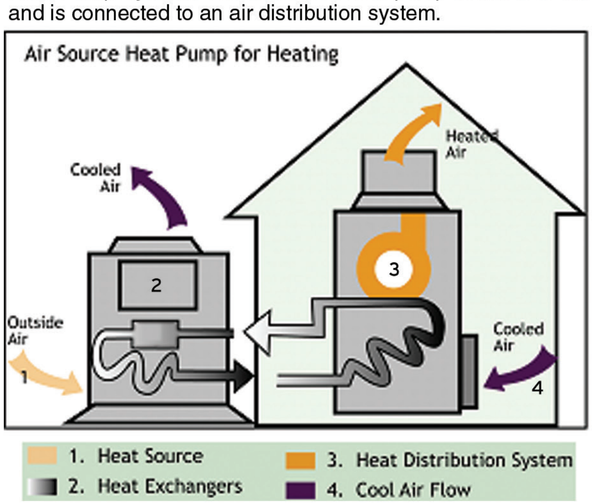
The main difference among forced air systems (besides the fuel) is the efficiency with which they can burn the fuel. Most older units will burn fuels at an efficiency level of 50-60%, while current minimum energy efficiency regulations require that natural gas fired furnace be mid efficiency (an annual efficiency of 80%). The highest efficiency for natural gas furnaces or boilers is about 95%.

Combustion gases from the furnace or boiler are commonly exhausted from the home via a conventional chimney or metal vent. Combustion of a fuel requires a continuous supply of oxygen, so it is always advisable to have a combustion air supply pipe from outside the home to the area where the furnace is located. Since the pipe will bring in cold air, it should be insulated to prevent condensation. High efficiency appliances do not require a conventional chimney. The higher combustion efficiency means that the venting can be done through a plastic flue pipe, often through the side wall of the house rather than through the roof. These units also have dedicated pipes to bring combustion air directly into the firebox.

In contrast to the combustion process in furnaces, a heat pump does not burn fuel to generate heat. Rather, a heat pump moves pre-existing heat from one place to another by collecting and compressing the heat energy in a refrigerant fluid. This heat may be collected from the air (i.e., air source heat pump), ground (i.e., geothermal heat pump), or a body of water (i.e., water source heat pump).

FIGURE 20.9: Heat Pump System

Heat Pump System: The air source heat pump consists of two coil systems, one that sits outside the home and one that sits inside and is connected to an air distribution system.



Typical duct air source heat pumps: External and internal units

Source: City Green Solutions

Increasingly, heating systems are combined with the hot water heater, so that the hot water heater provides all the home's hot water as well as the space heating. These combination systems can provide heat through forced warm air systems – the furnace is replaced with a fan coil that is similar to a radiator on a car – or through low temperature in-floor radiant heating systems.

Forced warm air heating systems are also combined with the ventilation system, so that the furnace fan is set up to run continuously in order to distribute fresh incoming air. When the furnace fan runs continuously, it should be an energy efficient blower motor. This is a typical standard with newer furnaces (or it may be available as an option). These energy efficient fans are also very quiet so the air is gently circulated through the house. Multi-speed settings allow more control; the fan switches to high speed only when heat is called for.

Continuous operation of the fan also makes it effective to add air filtration to the house, since the filter requires that air be passing through it. If a house has a high quality filter installed but the fan is not running, then the filter is not doing what it is supposed to.

Convective

Convective systems rely on fuel or heated liquid to heat an element, usually a baseboard unit, which in turn heats the air in the home. There is no system of air circulation associated with the convective heating system other than the convection currents that are generated by the unit itself. The most common types of convection heating are electric baseboard heaters and hot water wall unit systems. These systems are quiet and do not require ducts. Each of the rooms or zones in the home can be individually controlled by thermostats to allow a greater variety of heat levels.

Due to escalating fuel costs, independently functioning space heaters are often used to supplement the central heating system. Although other fuels can be used, most units are wood-fired and may either be located in fireplaces or as standalone units with a separate chimney. Although thermostats and fans are available for space heaters, most units do not have a distribution system and depend on convection and natural circulation to move the hot air.

When inspecting a convection system, each thermostat should be turned on to see if all of the elements are working. If the system is hot water, the condition and service record of the boiler that heats the water should be checked. If the water system is noisy when it is working, there is probably air trapped in the pipes. Air can be bled off either at the register or at the expansion tank, if one exists.

Comparing Heating Systems

The comfort, convenience, economy, and efficiency of various heating systems can be challenging to assess. Factors such as insulation values and draft proofing are directly related to a system's performance. Personal preference is an additional consideration; for example, some people prefer the steady consistent temperature of hot water heating, while others prefer the rapid response and level of control available with forced hot air systems.

Following is a chart identifying some of the advantages and disadvantages of a few common systems. These comments exclude the cost of installation and the cost of fuel, both of which are subject to change.

Advantages	Disadvantages
1. Electrical Baseboard Heating	
• No heat ducts or pipe • No central furnace system • Very clean • Each unit is independently controlled • Moderately rapid response to extreme changes in outside temperature • Provides mostly convection heat transfer with some radiation	• Lack of air filtration • Baseboard occupies wall space
2. Central Gas-Fired Forced Hot Air	
• Rapid response to extreme changes in outside temperatures • Air filtration included • Compact furnace • Fully automated • Clean • Humidifier may be added • Electrostatic dust collector may be added	• Requires ductwork under main floor • Sometimes criticized for being drafty • Air ducts require cleaning
3. Central Gas-Fired Forced Hot Water with Room Baseboard Units	
• Steady consistent heat • Convenient • Fully automated • Clean • Provides mostly convection heat transfer with some radiation	• Baseboard unit occupies wall space • Lack of air filtration to remove dust • Slow response to extreme changes in outside temperature • System will freeze if not in operation or not protected
4. Wood-Fired Space Heater in Living or Family Room	
• Reduced heating expense because fewer rooms are heated • Thermostatic controls for temperature and circulation fans available • Provides both radiant and convection heat transfer, which can add to comfort	• Rooms other than space heated room remain cool • Inconvenience in adding fuel, removing ashes • Careful check must be kept on creosote build up • Fuel storage space required • Hard to prevent smoke and ash dust from entering room

Fireplaces

Although fireplaces were once used as a principal heating unit in homes, they are not very energy efficient. Most traditional wood-burning fireplaces can actually contribute to total heat loss of the house. Wood-burning fireplaces, which are commonly seen in older homes, are very inefficient, especially if the chimney flue is on the outside of the house. A chimney or flue on the outside of the house can compromise the indoor air quality and health of the residents. A flue in a cold environment will quickly lose its draft, which allows cold air to overcome the draft when the fire is dying down. This is a concern, especially with combustion appliances on the lowest level of multi-storey houses, as toxic gases may be pushed into the house. Airtight wood stoves and pellet stoves that are properly installed and operated can be reasonably efficient. Many traditional wood-burning fireplaces have been converted to burn natural gas or have had a wood burning insert installed in them to increase the overall efficiency.

Fireplaces have aesthetic appeal and are often used as a dominant design feature. Although traditional fireplaces are not very cost or energy efficient, refinements such as glass doors, heating ducts, fans, and thermostatic controls have increased their efficiency and convenience. Fireplaces in new construction are natural gas burning units (or propane in areas not serviced by natural gas). The highest efficiency units have a sealed glass pane in front of the firebox and are directly vented through a double walled pipe that exhausts combustion gases and brings in outside air for the fire. The most efficient units will also have an electronic ignition instead of a standing pilot light.

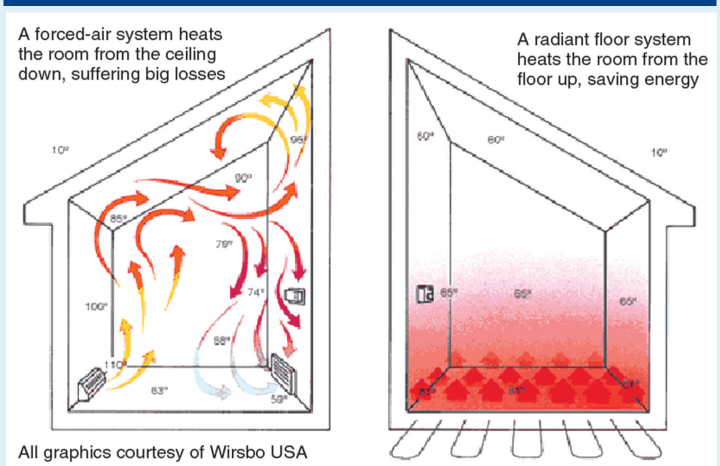
Fireplaces require exhaust of combustion gases. Considerable care must be taken to examine the chimney. In an older home with a brick chimney, the condition of the brick should be checked. If the bricks and the mortar joints are in poor condition because of age and weather or if cracks in the chimney are evident, there could be a danger of collapse of part or all of the chimney. The condition can be checked by standing back from the chimney and observing its straightness compared to some reference point in the distance. The chimney should be at least three feet above any structure within ten feet and not too close to tree branches, which can affect how well the chimney removes smoke.

With respect to metal fireplaces or wood stoves, it is most important that the correct metal chimney has been installed (if a metal chimney is used) and the fireplace or wood stove is approved. These records can usually be accessed at the building inspection department for newer homes. If the unit is a retrofit, a local fireplace dealer or fire department may provide assistance.

In-Floor Radiant Heat

In hot water radiant floor heating systems, hot water tubes run through loops that switchback horizontally within the floor construction. Radiant hot water heat tubing is most effective when embedded in concrete at the time of construction, as the concrete then acts as a heat sink to provide stable temperatures. However, tubes can also be retrofitted above a pre-existing concrete slab if this area can be insulated under and along the sides of the heated floor space; the goal is to ensure the heat rises into the living space and is not lost via conduction or radiation below the flooring. Electrical wires are an alternative for the hot water tubes to garner the same in-floor radiant heating effect.

FIGURE 20.10: Radiant Floor Heat



Source: Pro Plumbing, Hydronic Heat: *www.infloor.com*

In contrast to furnaces that heat the air around a building's occupants, radiant in-floor systems heat the solid flooring beneath the occupants. This solid mass holds steady temperatures longer, more consistently, and without the draft or air movement required to distribute the air source heat. The heat originates at a person's feet and moves slowly, so it is less likely to sit up near the ceiling. In addition, air pressures in the home do not fluctuate as rapidly, so there is less heat loss through the building envelope. Radiant in-floor heat should be coupled with a heat recovery ventilator or a similarly effective ventilation system to ensure high quality indoor air. Radiant in-floor heating systems can also be heated by a boiler.

The mechanics are usually quite complex, ensuring that balancing dampers have been installed and are accessible. If there is a concern with regard to the actual operation, a heating trade specialist in hot water systems should be consulted. Electric radiant systems are hard to inspect as they are hidden behind the drywall. To inspect, each thermostat should be turned on to ensure it is working. If a problem is suspected, an electrician should be consulted.

Ventilation

Ventilating the air in a building is crucial to diluting odours, moisture, and other pollutants in the air. An effective ventilation system expels stale indoor air. Fresh air is then drawn in, either passively by creating a low-pressure area to fill or mechanically through intake vents. Unfortunately, natural ventilation from opening windows and vents does not suffice for ventilating a building because it often provides too much or too little ventilation; no fan is present to overcome air pressure differences. An automatically controlled ventilation system is the only way to ensure a home is properly ventilated. This is especially true in energy-efficient "tight" houses in which measures have been taken to prevent air leaks and drafts, as these homes may not get enough fresh air intake otherwise. The benefits of mechanical ventilation include:

- **Better indoor air quality:** Indoor air is often far more polluted than outdoor air. This is worrisome, considering that, according to the Canadian Lung Association, the average Canadian spends 90% of their time indoors.[1] Ventilation systems can markedly improve indoor air quality by ensuring a constant flow of fresh, outdoor air.
- **More control:** Without mechanical ventilation, a home's air intake can come from undesirable locations, such as the garage or attic. Mechanical ventilation systems ensure appropriate locations for fresh air intake.
- **Improved comfort:** Mechanical ventilation can provide occupants with a constant flow of fresh, outdoor air. Some ventilation systems also filter and condition the air to remove allergens, pollutants, and moisture that can lead to mould.

Examples of mechanical ventilation include range hoods, bathroom fans, ventilation fans, and heat recovery ventilators.

The effectiveness of the fans can be checked by holding a piece of tissue paper up to the exhaust duct during operation to detect air movement. A good fan will hold the tissue firmly to the grill. It is also crucial to ensure that the fan is venting outside and not into the attic.

If there are filters on the mechanical ventilation system, they should be cleaned and periodically replaced so that they do not restrict the air flow.

Plumbing

Plumbing systems are focused on:

- Fresh water supply
- Hot water supply
- Hot water heating
- Waste water or sewage disposal
- Storm water drainage

Plumbing is regulated under the BC Plumbing Code, which adopts the core concepts of the National Plumbing Code. City, municipal, or provincial inspectors must approve all plumbing installations. Permits are required for both original and additional installations. In a multi-family building, plumbing facilities are required in each housing unit, with minimum fixtures including a kitchen sink, water closet (toilet), wash basin, and shower/bath tub. Units need a source of domestic hot water, with the heating system either in the suite or shared. Laundry facilities are commonly included in each unit in modern multi-family designs. However, older multi-family buildings (generally rental apartments) often include a shared laundry room.

Water systems function either by a gravity feed system (often from a reservoir) or by a pressure feed system (usually from an electrically operated pump). Problems with water systems can range from lack of water during drought seasons to inadequate maintenance leading to deterioration of the system.

[1] *www.lung.ca/lung-health/air-quality*

Testing for Radon

Radon is a naturally occurring, invisible, odourless, colourless, and radioactive gas produced by the decay of radium, thorium, and uranium-bearing bedrock and soil. Radon can be found throughout Canada, but concentrations vary greatly due to regional differences in bedrock and sediment composition. High concentrations of radon are typically found where there are higher levels of uranium in the underlying rock and soil.

Testing has revealed that a significant number of buildings in British Columbia are affected by radon. The Kootenays, the Okanagan, and the Prince George areas are known to have a high proportion of buildings with elevated radon concentrations. Information detailing the prevalence of radon in British Columbia by region is available from Health Canada, the BC Centre for Disease Control, and other sources.

Radon gas is generally harmless when released outdoors, where it can quickly disperse, but exposure to high levels of radon inside a building can pose a significant health risk. Radon gas can seep upwards through the ground and into buildings through cracks in foundation walls or floor slabs, construction joints, dirt floors, floor drains, window casements, gaps around service pipes, sumps or cavities inside walls, or support posts. The gas is then released into the air, where it can remain trapped inside for an extended period of time.

Generally speaking, radon is a bigger issue in single family houses, townhouses, and up to four- storey apartment buildings, with the highest radon levels being in the ground and basement floors. The upper floors in these buildings tend to have lower radon levels; however, in some apartment and commercial buildings, it is the upper units that experience higher levels of radon. This is known as the stack effect. Because warm air rises, it can draw air up through elevator shafts and stairwells, allowing radon gas to accumulate on the higher floors.

Radon emits radioactive alpha particles that can enter the lungs and lead to the development of lung cancer. In fact, radiation emitted by radon is the second leading cause of lung cancer in Canadians after cigarettes. Studies suggest that radon can be linked to approximately 3,360 deaths per year, a little over 1 in 100 deaths in Canada.

Radon concentration levels are measured in becquerels per cubic metre (Bq/m^3). The Government of Canada's Radon Guideline advises that remedial measures be undertaken whenever the average annual radon concentration in a building exceeds 200 Bq/m^3. A study performed by Health Canada's National Radon Program concluded that 3.9% of homes in British Columbia have radon levels of above 200 Bq/m^3. While the risks from radon below the 200 Bq/m^3 threshold are considered low, Health Canada says that there is no safe level of radon and that the lower the levels, the better.

While the British Columbia courts have yet to decide on the matter, it is likely that the presence of radon over the 200 Bq/m^3 threshold is a latent defect that must be disclosed by a seller, as it renders the property dangerous. Furthermore, the presence of radon over the 200 Bq/m^3 threshold to be a material latent defect under the Rules, meaning that a licensee representing a seller (or landlord) must disclose this fact to potential buyers (or tenants). To facilitate this, the BC Real Estate Association has added questions to the Property Disclosure Statement for sellers to make the necessary disclosures regarding radon.

While radon risk varies with location, no building is risk-free, and the only way to know if a building has problematic radon levels is to perform a measurement test. Health Canada recommends that all buildings be tested. Because radon levels can fluctuate over short periods of time and change from one season to the next, long-term detectors are the recommended form of testing. The standard method is to purchase a radon testing device. The test is simple to perform, requiring the user to place a small plastic "puck" in a specified area on the lowest level of the building that is occupied for four or more hours a day. Once the testing period had ended, the user mails the device back to the manufacturer, who provides a radon level report. Alternatively, testing can be done by a Canadian National Radon Proficiency Program (C-NRPP) certified testing professional. Health Canada recommends that buildings with levels over 200 Bq/m^3 be remediated within two years, while buildings with levels over 600 Bq/m^3 be remediated within a year.

Fortunately, radon remediation is not complicated; a C-NRPP certified remediation professional can generally perform remediation that reduces radon levels by up to 90%. The professional will undertake a diagnostic test to determine the most appropriate radon-reduction system for the building. The most common, effective, and reliable mitigation method is sub-slab depressurization, which involves installing a pipe through the foundation floor and attaching a fan that runs continuously to draw the radon gas from below the building and release it through the pipe to the outside of the building. Since 2014, the BC Building Code requires new homes to include a rough-in for a subfloor depressurization system.

Hot water must be provided to supply all fixtures (except the toilet), which must be automatically maintained to a temperature of 60°C (140°F). Hot water may be provided by a central supply or by individual units. Water can be heated by:

- an electric water heating tank;
- a natural/propane gas-fired or oil-fired water heating tank;
- an instant point-of-use gas or electric heating unit turned on or off as determined by demand;
- a hot water jacket (piping) installed in space heater, cook stove, or fireplace; or
- a solar collector and storage tank.

The piping for a hot water heating system distributes heated water from the central furnace to radiant units, wall or baseboard mounted air convection units, or to heated floor piping located in concrete floors. Normally, hot water heating systems are low maintenance, provided they have been correctly installed and have not been allowed to freeze; however, the distribution pipes for the system are normally located inside walls or behind panels, so leaks in the system may not be easily observed.

Most houses will have an electric or gas water heating tank providing a continuous hot water supply. Tank capacity is normally indicated on a tag or sticker located on the water tank. Gas heating tanks are normally a little smaller than electric heating tanks because gas units have a faster recovery time.

Homeowners concerned with energy costs of water heating may have supplementary heating units added to their hot water system. These involve the use of water heating units in space heaters, cook stoves, or fireplaces or the use of a solar collector. Occasionally, these two heating methods combined may constitute the complete hot water heating system.

Electrical

Electrical service and wiring must provide sufficient capacity, without overloading, for required illumination and efficient operation of appliances and equipment demanded by occupiers. The Canadian Electrical Code regulates electrical installations and service requirements in residential, commercial, and industrial buildings. The occupants of a suite must be able to access the breaker panel for that suite.

Electric Vehicle Charging

According to a BC Hydro report, there will be an estimated 300,000 electric vehicles in British Columbia by 2030. In anticipation of the future need for EV charging, developers are now installing these facilities in new buildings, sometimes voluntarily and other times by municipal requirement.

Strata corporations for existing condominiums can also install EV charging infrastructure for their residents and are often able to take advantage of grants and incentives. Since 2016, PlugInBC's Charging Solutions and Incentives Program has provided rebates of 75% of the infrastructure costs for EV charging facilities in multi-unit residential buildings and workplaces. EV Advisors from the program also provide services such as onsite presentations and site consultations to facilitate the installation process. Strata corporations can participate in these or similar programs to ensure that their buildings remain competitive with newer developments.

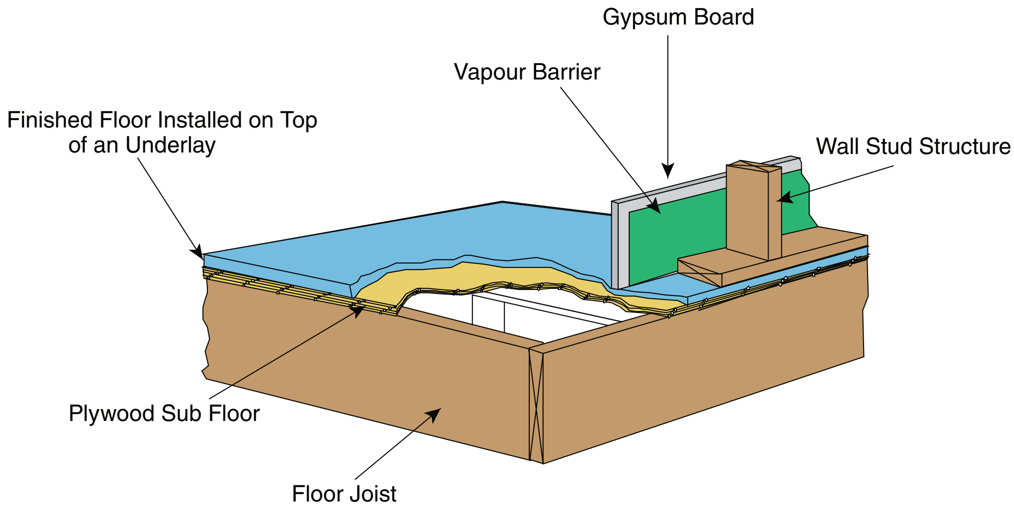
INTERIOR FINISHES

A building's finishes can highlight a building's quality and also demonstrate its condition and age. Market demand for these features can change considerably over time and finishes can quickly become outdated. In older buildings, an examination of these components can help identify the construction period – although when a building is remodelled, these components will often receive first attention as a prominent sales feature.

Walls and Ceilings

Interior walls do not typically provide structural support, acting only as partitions between rooms. The buildup for interior walls is less extensive than that required for exterior walls, generally including only the wall structure (usually wood frame) and the wall finish (see Figure 20.11).

FIGURE 20.11: Typical Floor Structure Showing Wood Frame and Inside Wall Build Up



Notes: 1. Batt insulation is installed between wall studs.
2. Exterior materials are applied to the exterior of wall stud structure.

The type, quality, and colour schemes for wall and ceiling finishes will often be associated with the era of construction or renovation. Modern finishes often consist of durable painted drywall. Entrance halls in multi-family properties may have a vinyl fabric or tiled finish and sometimes use stone or brick walls as an entrance treatment. Modern lobbies in multi-family buildings often have floor to ceiling glass entrance walls for maximum daylight penetration.

Floors

Floor coverings in old and new multi-family buildings vary depending on the price of materials and prevailing design trends. Older multi-family buildings may have solid oak flooring, sometimes overlaid with wall-to-wall carpet. Oak was a relatively inexpensive and durable material in the 1930s to 1960s and, with low labour costs, was a popular material for multi-family buildings, particularly rental apartments. In that era, linoleum was commonly installed in the kitchen and bathroom with sheet vinyl, ceramic tile, or porcelain tile found in higher quality buildings.

For projects completed in the 1960s to 1980s, consumer preference leaned to wall-to-wall carpeting for living-dining areas and bedrooms. The carpet and underlay on the floor provide the sound insulation.

With new engineered wood products becoming widely available, laminate hardwood floors and engineered hardwood have become the norm for living-dining space. Hardwood floors are usually installed with one-inch thick fibreboard insulation underneath, with the finished hardwood laid over spacer strips and fixing battens. A sandwich floor is sometimes laid using insulating material covered with a cement screed to which the floor is fixed. A screed is a thin layer of concrete that serves as a rough finish.

Bathroom floors can also be finished with sheet vinyl, laminate flooring, or ceramic or mosaic tile on a cement bed of sufficient thickness to bring the level of the finished tile up to the level of the adjoining finished hardwood floors. Better quality condominium units will have heated bathroom floors.

Kitchens can be finished with a sheet vinyl flooring, slate, tile, hardwood, or laminate flooring. Depending on the quality of finish in the building, the flooring is laid on smooth trowelled cement topping. As a result, for most multi-family buildings, it is only necessary to have a smooth trowel finish on the structural slab.

The common areas in multi-family buildings, including the lobby, corridors, and other public spaces, are typically carpeted over top of cushion underlay for comfort and sound absorption. In a large apartment building, the carpet may be designed and woven for the one job, which adds distinction to the building but is apt to cause a problem in later years when only certain parts need replacement. The cost trade-off for high quality commercial carpet installation is the expected longer carpet lifecycle and lower maintenance costs.

Some concrete structure buildings may also have reinforced concrete or concrete-topped floors. One advantage of this is the rigidity of the floor system, which provides for easy application of tile or slate flooring.

Cabinets and Countertops

Cabinet and countertop materials can vary depending on price and style. Cabinets can be made from materials such as wood, wood veneer, laminates, melamine, PVC, and stainless steel. Cabinetwork in apartments typically uses pre-finished plywood or composite board (e.g., particleboard) and plastic laminate finishes for tops and splashes. Countertops can also be constructed from a variety of materials such as granite, solid composites (e.g., Corian or artificial stone), wood, laminate, patterned formica, or stainless steel.

INSPECTING MULTI-FAMILY PROPERTIES

The following section goes into considerable detail regarding the inspection of multi-family building elements. The inspection procedures presented may be more exhaustive than would be expected of a licensee in a typical sale situation. However, this detailed information is provided in case a licensee should wish to, or need to, carry out a thorough building examination in their services to their client.

Many of the faults and defects in multi-family residential construction can be blamed directly on poor design, inadequate specification of materials and workmanship, and lack of proper supervision during construction. The use of competent professional services minimizes the risk of such faults.

Substructure and Superstructure Inspection

An inspection of the foundation begins with an exterior analysis. Signs of degradation or distress on the exterior of structure foundations include cracks, areas with sunken ground, and water ponding. The location of any signs of distress should be noted in order to check the corresponding location inside the foundation. Cracks, gaps, slippage, or bulges that show up on the siding or around any opening, such as windows and doors, can indicate structural movement. Cracks in the foundation are usually the result of settling, but can also result from:

- penetration of frost under the foundation. This should not occur if the structure was constructed according to code, but can result from excavation or alteration of the original ground line;
- improper installation of footings during original construction, such as footings on non-compacted fill;
- lack of or improperly operating perimeter drainage system; or
- earthquake.

It is necessary to understand what is causing a crack in the foundation. If the edges of a crack are very sharp, it indicates that the distress is recent and is most likely still occurring. Rounded and smooth edges usually indicate the distress is old and progress has long since stopped. A crack that is uneven in width over its length is an indication of uneven settlement. While most concrete stone or block walls will develop minor cracks due to shrinkage, it must be determined whether or not the crack is allowing water seepage or is causing the building to settle unevenly. The best way to check for uneven settlement is to stand far back from the building and try to line up the vertical edges of the building with a reference point of a structure behind the home being inspected.

Once the exterior inspection of the foundation has been completed, the interior can be checked. The smell of the air in below-ground levels will indicate if the space is dry or wet with mildew. The feel of the walls and lumber overhead will indicate the presence of moisture or cold drafts. Using a flashlight, the areas that were previously identified as problems from the outside should be examined from the inside to determine whether or not there are any additional signs of distress on the inside. Not all signs indicate a major problem, but serious settlement or water penetration is the major concern.

Dry rot or insect infestation can indicate serious problems with a foundation. Decay in the form of dry rot can cause structural members to lose their strength. Although dry rot is invisible in its initial stages, it becomes increasingly visible as the rot advances, especially if a structural member fails. Signs of insect infestation (e.g., carpenter ants or termites) include fine powdery sawdust or mud tubes from the ground to the wood. As the insects penetrate the wood with their tunnels, they weaken the house structurally. If either dry rot or insect infestation is discovered, a structural engineer should be consulted to survey the situation.

If cracks are allowing water to enter the basement, it is usually a simple process to seal them. If there are indications of settlement that is beginning to cause distress to the structure above, an engineer should be consulted.

Ventilation is another concern in basements and crawlspaces. When the space is heated, dampness will build up if new air is not able to enter the space. Where a crawlspace is not heated, it should be well-ventilated to the outside air. There is a lot of misunderstanding regarding the amount and type of ventilation required in a crawlspace. The building code definition of a heated crawlspace is that it is heated if there are heating ducts or hot water lines running in the crawlspace. In other words, a heated crawlspace must be treated as a shallow basement, and sealed and insulated accordingly. If there is no heat introduced into the crawlspace, then the floor over must be properly sealed and insulated, and the space must also be well vented to the outside. In most cases, it is much simpler and easier to treat the crawlspace as interior conditioned space.

In the basement or crawlspace, the groundcover can consist of uncovered dirt or a two-inch concrete skim coat. A floor consisting of uncovered dirt is of concern, as ground moisture and soil gases will move up and enter the house, compromising the indoor air quality. The dirt should always be covered with a plastic vapour barrier that is weighted down and sealed at the joints to prevent movement. If a smell of mildew is present, it is a tell-tale sign of the presence of ground water in sufficient quantities to affect the indoor air quality of the house. If the ground cover is concrete, minor cracks are to be expected. However, if cracks are allowing water to enter the space, they should be sealed.

Special care and attention is usually devoted to building envelope construction. A third-party special consultant may be involved to provide careful design and on site reviews during construction. This level of attention has evolved as a result of the building envelope failures in the past (the leaky condo situation).

Sloping floors may occur due to an inadequate foundation, which allowed the floor to settle, or from improper installation. Small changes in the elevation of level floors should only occur at doorway thresholds – not in the centre of a room. Doors that repeatedly swing open to the same position indicate that either the door was improperly installed or the wall is not vertical.

Every attic space has an access allowing a view of the underside of the roof structure. The person inspecting should note the type of structure (truss or rafter) and examine the roof structure for sagging or broken roof framing members. A discoloured, water-stained ceiling may indicate a roof leak; if not repaired quickly, such leaks can result in extensive damage to both insulation and ceiling materials. Water stains inside the attic on the underside of the roof may be an indication of a roof leak. However, they can also be an indication of air leakage from inside the house; warm, moist air from the interior leaks outward through air leaks in the ceiling would be taking interior moisture, which would be condensing on the cold surfaces in the attic. Excessive moisture build-up would be a cause of concern, as it could lead to deterioration of the structure.

Older homes may not meet the current structure standards. An uneven or sagging roof is a clear sign of an undersized roof structure that may require structural upgrading.

Remedial Work and Multi-Family Properties

Licensing and Consumer Services (BC Housing) regulations require that building envelope consultants be involved on remedial work for multi-family properties, so that any repairs worth more than $2,000 per suite will be covered by third party insurance coverage and will meet current standards.

Defects and concerns that are commonly present in multi-family buildings include the following:

1. **Concrete frame:** fins from forms may not be ground off and holes from reinforcing ties may not be filled.
2. **Blockwork cracks appearing:** confirm whether this is due to settlement or shrinkage.
3. **Roofing:** see if a guarantee has been issued and obtain inspection certificate. Check flashings to ensure proper laps and fastenings and that they cover the danger spots. Check to ensure that drainage flow is to the roof drains and that the drains do not form a high spot. The best warranty is offered through the Roofing Contractors Association of BC (RCABC). Although there is no mandatory requirement to take out this policy, it does provide the building owner with a certainty that the roof has been properly installed, as one condition for provision of the coverage is an inspection by RCABC.

Roof Inspection

Roofing can also be inspected for wear. On tar and gravel roofs, the layer of gravel should cover the roof uniformly; bare spots allow damage to the tar and paper layers. A flat roof should also drain properly so that large volumes of water do not build up (the extra weight of water can create structural problems and contribute to leaks). Metal flashings should be used to prevent water from entering any openings in the roof (e.g., skylights or roof vents).

edge curl
when asphalt shingles have curved up at each edge

fishmouth
when an asphalt shingle has lifted in the middle

Asphalt shingles can be inspected by standing back from the roof and looking across the roof, using binoculars to watch for evenness of application and wear. Curving up at each edge is referred to as *edge curl* and can be very detrimental to the roof's performance. This problem can sometimes be corrected by simply tarring the edges down. If the problem is widespread, a roofer should be consulted regarding possible replacement. If the shingle has lifted in the middle, this is called *fishmouth*; if widespread, this can be serious. Climatic conditions in the attic space have probably caused movement of the roof deck, causing the shingles to bow up in the middle. To alleviate this problem, ventilation of the attic space and re-roofing should be considered as courses of action. Any areas that appear to be of a different colour may be evidence of past fix-ups. The inspector should note their location relative to the inside of the home and check for corresponding water damage on the inside. Moss is another common problem that can usually be prevented by installing a zinc strip along the peak of the roof.

The service period for cedar shakes and shingles depends on the quality of the product, the installation, and the environmental conditions. When inspecting shake or shingle roofs, the inspector should look for missing, cracked, and rotten product; these are symptoms that can cause water leakage. Should the roof in general be in good shape, any minor problem areas can be spot repaired by having a tune-up done by a qualified roofing company. As with asphalt roofs, moss can be prevented by installing a zinc strip at the peak. Older roofs on steeper slopes that are able to dry quickly are more likely to last longer than newer or shallower sloped roofs and those that are in a shady location.

The biggest problem with tile roofs is their susceptibility to cracking. However, an advantage to tiled roofs is that an individual tile can be easily replaced. Tile roofs are quite heavy; if a new tile roof has been installed on an old home, it should be verified that the home can bear the weight of the new roof. In a new home, the two by four top chord of the truss can be changed to a two by six to accommodate the weight of a tile roof.

There are many other roofing products on the market that can range from sheet metal to plastic shingles. These man-made products generally have a very long lifespan. Any problems that occur are usually the result of improper installation. Important areas to inspect are those that are susceptible to leaks (e.g., around joists and seams; around dormers and changes in direction or slope of the roof) or those vulnerable to wind damage.

Soffits

soffit
the area on the underside of the roof overhang that extends from the gutter back to the wall surface

The *soffit* is the area on the underside of the roof overhang that extends from the gutter back to the wall surface. The soffit provides the aesthetic bridge between the angled roof and the vertical wall, as well as ventilation for the attic space. Soffits are usually made of either wood, metal, vinyl, or stucco. Because they are generally not exposed to the elements (with the exception of wind), soffits are not subject to any significant degree of degradation. The main concern with soffits is the access they can provide for birds or small animals into the attic space. Holes should be examined carefully to ensure the vent screens are in good condition and that no pieces are missing as a result of wind damage.

The other area related to the soffits is the "barge" board (or fascia), which trims the ends of the roof from the roof apex down to the roof edge and along the roof edges behind the gutters. Consisting mainly of wood products, these boards are open to the effects of the weather. Warped or cracked boards can misdirect water into the soffit area and cause damage. Damaged areas can be replaced with new trim and a minimum of three coats of exterior paint.

Window Inspection

Window frames typically consist of four different materials: wood, aluminum, vinyl, and fibreglass. The latter three require little more than semi-annual cleaning, while wooden window frames may require more maintenance (e.g., annual repainting) depending on environmental conditions. The selection of a particular size of window is usually related to the design of the home and energy efficiency considerations. The main items to check are the integrity of the seal, whether windows are single or double glazed, and the ease of operation of the hardware and opening units.

Windows and their installation are the principal problem in building envelope failures. Improper installation can create details where water can enter into the wall assembly, thus compromising the performance of the wall assembly. The window sill is the most vulnerable portion; this is where water that runs down the window collects. Caulking around the window cannot be relied on to keep the water out because water can find its way behind the caulking. Therefore, proper flashings, which help divert water away from the wall, are necessary.

A common problem with windows is drafts, which can be alleviated by sealing the joint between the window and the wall with caulking. For double-glazed windows, the space between the layers of glass increases the insulating value. However, a larger space does not necessarily mean greater insulation because the increase in insulating value decreases if the space is greater than seven-eighths of an inch.

Aluminum frames may be stained by mortar or plaster; the contractor should correct this. Check caulking around windows, especially under sills, as this may cause leaks. This is important at corners where windows meet at an aluminum post or corner mullion. Ensure windows and glass are strong enough and meet the design or specification.

Floor and Wall Inspection

To inspect flooring, examine for nail pops (from plywood) that could damage the finished surface of the floor. Check the edge of the flooring where it intersects with the wall to see if it is lifting. Marbles can be used to check the floor for humps and depressions.

Hardwood floors should be checked to ensure that they have been properly fixed and are level, that the nail heads have been pushed down and the joints and nail heads are properly filled with matching filler, and that the polish is undamaged. Uneven floors can sometimes be detected by uneven gaps at the baseboard.

Composition floors should be checked to ensure that the joints are straight in both directions and that full adhesion has taken place and no ridging is apparent. Ceramic mosaic floors should be examined to ensure that patterns have been placed correctly, no slippage has occurred, cutting around pipes and fixtures has been neatly done, and there are no cracks or loss of bond. With linoleum floors, the inspector should locate the seam and check for separation. In carpet areas, the inspector should check for badly matched seams and note the general condition of the carpet.

There are many different types of wall and ceiling finishes. The inspector should note the condition of the surfaces relative to the age of the home. Paints, varnishes, and wallpapers are all subject to a service period depending on the quality of personal care and use, the quality of the products used, and the proper installation of such products. The quality of skill and care demanded by a particular builder can be detected by examining how well mouldings are cut, fitted, and installed. Similarly, the degree to which walls are flat and even is an indication of how much care and craftsmanship went into the structural assembly and drywall (gypsum board) installation. Drywall should be examined to see that all joints have been properly filled, that nail heads are covered, that the drywall has been installed plumb and true, and that all corners have corner beads. The finished surfaces around windows should be smooth and even, with no discernable space between the window frame and the sill, sides, and top surfacing materials.

Special attention should be paid to signs of moisture damage and cracks that are in excess of three-sixteenths-of-an-inch in width. The existence of cracks in a wood structure is not uncommon due to the flexible nature of the structure; however, large cracks warrant further investigation for structural damage.

Painting defects are relatively common – most will be minor touch-up items. When painting defects affect an entire surface, it is often due to the painting sub-contractor's poor work. Such a defect can be attributed to many causes (e.g., improper mixing of paint, painting surfaces improperly prepared, dilution of paint, insufficient number of coats, and painting over damp surfaces).

Insulation Inspection

Insulation is very difficult to inspect because it is usually covered by the wall finish and siding. The only way to inspect the quality of the insulation in the walls is to survey the wall surface for signs of dampness or mould. This is an indication that the insulation behind that spot may be missing or be depressed, reducing its R-value and causing a cold spot.

Urea formaldehyde foam insulation (UFFI) is a foamed-in-place insulation that is sprayed into wall cavities and attics through small drilled holes. In December 1980, the use of UFFI was banned in Canada, but it is still used in other parts of the world, including Europe (it has not been officially determined whether or not UFFI is a direct risk to health). To check for the existence of UFFI, the inspector should look under windows to locate any evidence of the holes made to spray it in. Electrical outlet covers can be removed to examine the surrounding area. UFFI can also be detected near pipe locations that could be susceptible to freezing. Aside from tearing the walls apart, there is no conclusive way to ensure the existence of UFFI, but close scrutiny will improve the odds of detecting it.

The BC Building Code specifies minimum insulation requirements. Specified minimum insulation levels vary across the province based on the severity of the climate.

Decks and Railings

Exterior decks and railings that are exposed to the elements and subject to heavy use may require frequent repair. Deck coating protects the supporting structure of the deck from moisture. If the deck is painted or stained, it must be continually redone to avoid rot. If the deck has a fibreglass or vinyl coating, the underside of the deck must be free of water damage. Many old decks have had outdoor carpet placed on them. To inspect this product, the underside of the carpet must be examined closely; if installed incorrectly, outdoor carpet can cause excessive moisture build-up between the underside of the carpet and the supporting deck surface.

The main concern with deck rails is that they support lateral pressure to prevent a person from falling off the deck. Rails can be inspected by pushing or shaking to check for rigidity. Repairs may be a simple matter of re-securing the rail, but if the support area is rotted, the affected area will have to be replaced before the rail is reinstalled. Exterior deck rails should be 42" high with no holes or gaps greater than 4". Rails should not be climbable.

Exterior Site Work

Stairs

The main concern with steps is safety. Stairs are controlled very tightly by local and provincial building codes. The local building inspector can be consulted to determine compliance with the code.

The flooring on the stairs should be firmly secured so that it does not constitute a hazard. The rise and run of the staircase (i.e., height and depth of the stairs) should be uniform; this can be tested by simply walking up and down the stairs. Check the securement of the handrails and guardrails by pushing on them and determining if there is excessive movement. The main consideration with regard to interior stairs is the safety of those who use them. Any stairs that are wider than 44" should have handrails installed on both sides, and handrails should run continuously from the bottom to the top of the stairs.

While most stairs and steps are concrete, wood is also a popular material; however, wood is more susceptible to physical wear. To inspect wood stairs, check closely for rot. The supporting posts or pier blocks should be checked for signs of settlement.

An inspector can also look for signs of settlement and cracking in concrete steps. As concrete stairs are built separately from the foundation, they may lack the support of a proper footing. Foundations that extend below the frost line are essential for stairs, porches, and sundecks. If there is substantial movement, expensive re-supporting or replacement may be required.

Sidewalks

Sidewalks generally consist of poured-in-place concrete located on top of native soils and exposed to the weather. Sidewalks suffer from mainly aesthetic problems such as chipping, scaling, and cracking. None of the foregoing seriously affect the safety of the sidewalk – replacement typically only occurs when there is dissatisfaction with the appearance. However, if settlement has taken place, replacement should be considered in order to ensure the safety of the user – and to reduce the possibility of liability to the owner – and to avoid weakening of the structure. If the sidewalk is adjacent to the foundation wall, the depression can introduce excess water to that area of the foundation and cause structural damage. Sidewalks can also consist of paving stones, which are available in a variety of shapes and colours.

Drainage

Water that is unintentionally directed to an area can cause serious damage. The site around the structure should be graded and landscaped to direct all surface water away from the foundation. When water collects adjacent to the foundation, it causes the soil in that area to consolidate and settle, worsening the situation. When winter freezing conditions exist, the excess water can damage the foundation, creating very expensive repairs.

Driveways

Driveways mainly consist of three products: gravel, concrete, or asphalt. Regardless of the product that is used, the driveway should provide good drainage away from the building. If the driveway slopes towards the building, a water interceptor should be installed to collect run-off and direct it to the storm drainage system. While settlement and cracking will frequently occur, the main problem is maintenance of the surface to protect it from highway salts and oils. The surface can be pressure washed and sealed with a variety of sealers, available at most building supply stores.

Door Inspection

For exterior doors, the main items to check on a door are the integrity of the weatherstripping, the proper operation of the locking system, and the condition of the painted surface on the outside. Wood doors in exposed locations are subject to warping, which will affect their performance. Loose or worn weatherstripping causes drafts and should be replaced. If a door or its hardware is defective, it is usually easy to repair.

With the exception of the weatherstripping and the threshold, interior doors have the same parts as exterior doors. However, most interior doors are hollow core; hollow core door slabs can be damaged if care is not taken. The door and its opening mechanisms should operate smoothly. Replacing an interior door is usually a simple procedure – the only difficulty arises from having to match the paint or finish. In older properties, it may be necessary to reframe the door.

Garage Doors

The most common problem with garage doors is a failure of the opening system due to age. Installation companies can repair most failures relatively easily. Degradation of the exterior finish can cause damage to the door itself; repair may simply require repainting.

Cabinet Inspection

Kitchen and bathroom cabinets used to be built on-site; however, most of the cabinets in contemporary homes are manufactured by cabinet companies. There is a wide range of quality, durability, and finish in premanufactured cabinets. Good quality cabinets will display the following characteristics:

- Both exterior and interior surfaces of cabinets will be smooth and finish coated to enable the user to properly clean surfaces.
- Joinery at corners and around doors and drawers will fit tightly.
- Drawers will easily slide in or out on mechanical drawer slides. These should not be exceptionally loose. The insides of the drawers will be finish coated to allow for easy cleaning.
- Doors will open and close smoothly and fit flatly against door frames.
- Counter surfaces will be impervious to moisture and have good resistance to physical abrasion.
- Counter surfaces will have a back splash surface that extends up the wall.

The use of hardwood exterior face materials in the construction of cabinets has become popular in contemporary homes. The use of such materials, carefully fitted, assembled, and finish coated, is generally accepted as a mark of quality. Similarly, the use of melamine coated sheet materials for interior surfaces is preferred because it is durable and easy to clean.

The most frequent problem with cabinets is movement, causing the cabinet to pull away from the wall. This can be repaired by caulking the gap and shimmying the cabinet back into position. As cabinet doors are subject to a lot of use, the hinges are subject to excessive wear.

To inspect door surfaces, check for cracks and gouges. Countertops should be examined for chips and stains that may necessitate their replacement. If cabinets are mounted on a vertical wall surface, ensure the screws that are holding them on are tightly secured. Cabinets that are well looked after will require little in the way of repairs.

Electrical Systems Inspection

voltage
a measure of electrical potential or pressure of current flow

amperage
a measure of the rate of current flow or quantity of electricity per unit of time; the service capacity of a house is measured in amperes (amps)

wattage
a measure of power or consumption; electrical usage is measured in watts

When inspecting a building's electrical service, it is important to distinguish between voltage, amperage, and wattage. *Voltage* is a measure of electrical potential or pressure of current flow. *Amperage* is a measure of the rate of current flow or quantity of electricity per unit of time. The service capacity of a house is measured in amperes (amps). *Wattage* is a measure of power or consumption. Electrical usage is measured in watts (e.g., an electricity bill is typically measured in kilowatts, which are units of one thousand watts). The relationship between these measures is expressed by the following formula:

Watts = Volts × Amps

This formula can also be expressed as:

Amps = Watts ÷ Volts

For example, a 100 watt light bulb operating at 120 volts requires a current of .83 amps (100 watts ÷ 120 volts).

The wires to most homes carry 120/240 volt, 3-wire electrical service. The electrical service box (sometimes referred to as the service panel) provides both 120 volt service for lights and duplex receptacle circuits (standard household plugs), and 240 volts for major appliance circuits (e.g., range, dryer, hot water, and electrical heaters). The Canadian Electrical Code, as amended by the Government of British Columbia, regulates electrical installations and service requirements in residential, commercial, and industrial buildings. The Canadian Electrical Code requires that new or substantially renovated houses of more than 80 square metres have a service capacity of not less than 100 amps; however, it is common to find capacities of 125, 150, or 200 amps, especially if electric heating is used.

On farms or properties where workshops exist or where significant industrial electrical demands exist, 240, 480, or 600 Volt, 3-phase electrical service may be installed. Regulations for this type of service are covered by the appropriate sections of the Canadian Electrical Code.

In evaluating service size, the amount of power for the lifestyle of typical occupants is important. The size of the service will dictate the appliances the home can support. Most homes have a 100 or 200 amp service, which is adequate to service most modern appliances and consumer needs. However, older homes that have not been substantially renovated may have a 30 or 60 amp service. This is sufficient to supply power to basic appliances, but is not enough to add electric heat or an electric stove. These low amperage systems are not illegal, but they are inadequate for the electrical capacity often expected by contemporary society.

Electrical service systems are normally designed to allow additional circuits for increased future demand. The actual rating of the electrical service in a residential dwelling is printed on the handle of the main circuit breaker inside the service box. However, it is possible that the capacity of the service will be less than that stated on the manufacturer's nameplate on the electrical service box (i.e., the service box could read "120/240 Volt, 200 Amp, 40 circuits," but the customer's service wires installed to the panel and the main circuit breaker may be rated at only 150 Amps).

The size of the service is probably the most questioned item where electrical systems are concerned; however, distribution of available electricity throughout the home is generally more important. The service capacity can be expanded with a relatively small degree of damage to the home. If the distribution system (i.e., the number of plugs and circuits) is inadequate, improvement costs are very high because removal of drywall is generally required.

Technical questions on the electrical service of a house are best referred to the office of the local electrical inspector.

Electrical Safety

As with other areas of building technology, electrical codes have been amended to improve safety and to cover new electrical applications. Permits are required prior to undertaking any electrical installations or modifications. A provincial or municipal electrical inspector will normally visit the site and inspect the electrical installation prior to approving it. For connection or reconnection of an electrical service to BC Hydro lines, an inspector's authorization is required.

Electrical systems are protected from overload by fuses or circuit breakers. Wires that have too much current flowing through them can overheat and cause fires. Fuses and breaker switches are installed to break overloaded circuits, shutting off the current before it reaches dangerous levels. While breakers are more convenient, they are not necessarily safer.

The suitability and safety of the system will vary with the size and type of wire used. The three most common types of wire are as follows:

- **Knob and Tube Wiring:** Found in homes built prior to 1950, knob and tube wiring looks dangerous to the amateur electrician. However, if properly installed, it can be just as safe as modern wiring systems. Knob and tube wiring uses copper wire (like today's wiring systems), but with only two wires and without a ground. Each time the wire passes through a joist, a tube is installed and each time the wire changes direction, a knob is installed. The joints in the wire do not have a junction box, but are simply twisted together, soldered, and taped. Knob and tube wiring ceased being used because it became too expensive with three-wire systems. If a home's electrical outlets only have two holes in them, the wiring is probably knob and tube. A shortcoming of this system is that it does not support electrical equipment that requires grounding.
- **Aluminum Wiring:** If installed property, aluminum wire is just as safe as copper wire. The problem with aluminum is that it oxidizes and expands more than copper. Because of this, the joints between the wires can overheat and separate, forming a gap that can cause an electrical arc. To alleviate this problem, only equipment marked with the letters "CO/ALR" can be used with aluminum wire and an anti-oxidant must be used on all joints. The little caps used to connect the wires together are too small to be marked; therefore, if there is any doubt regarding the safety of the connectors, they should all be replaced.
- **Copper Wiring:** Copper wire is available in a wide variety of sizes to accommodate different electrical loads. The modern three wire insulated copper wire is by far the most common product. With joints and outlets housed in metal or plastic junction boxes, and with close scrutiny by electrical inspectors, these systems can be very safe.

After the review of the service size, distribution, and wiring type is complete, all switches should be turned on and off and all plugs tested with a circuit tester to ensure proper operation.

Plumbing Inspection

When inspecting plumbing systems, it is important to note the types of materials used, the existence of any leaks or potential for leaks, and the water flow or pressure.

Fresh water for homes is obtained from either an individual or regional water supply system. Individual sources may be from a shallow or deep well, a spring, an artesian well, or a reservoir on a creek for which a water right is obtained. The installation and maintenance expenses are the responsibility of the individual owner. The water for regional supply systems comes from similar sources, but the installation and maintenance of components in the system is shared by all members of the system, usually through a water tax or meter charge. In either case, each home should be provided with a clean, healthy supply of usable water available continuously throughout each season.

Water systems function either by a gravity feed system (often from a reservoir) or by a pressure feed system (usually from an electrically operated pump). Problems with water systems range from lack of water during drought seasons to inadequate maintenance leading to deterioration of the system. If the home is using a private well for the domestic supply, the well pump should be kept in good condition, as should the pressure or storage tank. The pump, tanks, and related piping should not be in a location where they may freeze in the winter.

Caution should be used when making representations to buyers about a well water supply. Many buyers do not know the right questions to ask in order to make an informed purchase of rural properties and may not be aware of the importance of water quality and quantity. In order to comply with the *Real Estate Services Act*, licensees must take reasonable steps to discover facts that a prudent licensee would take to fulfill the obligation to avoid error, misrepresentation, or concealment of pertinent facts. If a buyer requests water quality or quantity tests, the licensee should assist the buyer in determining their personal needs and requesting the appropriate tests. A licensee must keep in mind that what constituted enough water for the seller will not necessarily meet the needs of the buyer. At a minimum, a licensee should secure any representations by the seller about the well in writing, only include representations based on a well report in the contract for sale, and if there is no well report, recommend as a condition of sale that the well be tested and approved by the buyer. The licensee must not make representations to their client about the sufficiency of the water supply.

Large regional systems normally require little maintenance or inspection. The main shut-off valve is located where the supply enters the home and can be checked to ensure that it is working. Occasionally, individual systems in rural areas have problems concerning the quality and continuity of the water supply. Where serious concerns exist, the matter should be referred to a technical specialist who can evaluate the system and test the water quality. The offices of regional, district, municipality, or city plumbing inspectors can usually recommend places where water quality tests can be obtained.

Piping for the water supply may be one (or a combination) of the following types:

- **Copper:** The most commonly used material in modern construction consists of one-half-inch copper pipe with soldered joints connected to a three-quarter-inch or, in some cases, a one-inch building supply line from the municipal system or a well. The only situation where copper might wear out prematurely is where the copper pipes carried acidic water or, where a joint was soldered, the acidic flux used in the process was not cleaned off. If a pipe joint was not cleaned, the joint will begin to corrode and will exhibit a blue/green colour. Water or surfaces that come into contact with it may also have a blue/green discolouration. In rare cases, the close proximity of an electrical wire can induce electrolytic action, causing corrosion.
- **Plastic:** Some newer homes use one-half-inch plastic pipe for the domestic water supply lines. To check this type of system for corrosion, simply check the joints for leaks and the lines for damage from nails or building movement.
- **Galvanized:** Prior to 1955, galvanized steel pipe was the most popular method of water supply piping. The average life expectancy of a galvanized system is 30 to 50 years, depending on the size of the pipe, the acidity of the water, and the amount of use. Galvanized pipe corrodes from the inside out, gradually reducing the inside diameter of the pipe and plugging the system. The deterioration of galvanized pipe joints and fittings can cause tap water to have a rusty taste and be brown-coloured. To inspect a galvanized system, check the pressure at each of the outlets to see if it is substantially reduced. In many older homes, parts of the system will have been replaced due to corrosion. When this is evident, the inspector should check the joints between the new material and the old pipe, as chances of a leak are high (about 80%). If repairs to galvanized systems are necessary, it may be advisable to consider complete replacement.

Once the type of materials used in the plumbing system and their condition have been examined, taps can be inspected for level of flow and leaks. Leaks in taps and fixtures are generally the result of worn-out gaskets and washers, which can easily be replaced.

Waste Water or Sewage

Building waste is disposed of by one of two main methods: municipal systems and septic systems. If the home is connected to a municipal system, there is very little to do besides check its operation. All toilets should be flushed and examined for any problems. The rural septic system, shown in Figure 20.12, requires much more scrutiny.

A septic tank must be connected to the main plumbing waste drain at least ten feet away from the home. The size of this tank depends on the occupant load of the home. If elevations allow, the tank drains by gravity to the distribution box, which directs the waste to a series of pipes. These pipes make up what is called the septic field and the total length of pipe depends on the occupant load of the home and the porosity of the soil. The septic field pipe is full of holes and is surrounded by material called drain rock and covered with natural soils. The disposal field must be designed to suit the geography of the particular location. The field should be well above the local water table so as not to allow it to flood and back up the system. If the field has to be built up to get above the water table, the waste may have to be pumped to the distribution box by means of an electric septic pump.

The main tank and pump location of septic systems requires servicing every few years and should be exposed for easy access. If the grass is a darker green above each of the trench locations, the system has been properly installed and is working effectively. If there is no evidence of trench locations in the grass, the system may be operating ineffectively. In addition, if there is a foul odour and grey water in ditches or puddles near the disposal field, the septic system may be malfunctioning. The local health inspector should be consulted to survey the situation.

Considerable technical development has gone into the design of septic systems to make them safe and dependable. However, occasional maintenance may be required in septic systems to periodically remove sludge.

Older septic installations may have two separate systems: one for kitchen water, which ends in a soap box, and another for all other waste water disposal. This type of system is no longer recommended.

Home buyers should be alert to the kind of waste disposal system used and, if a septic system is used, to the location of the septic tank and field distribution box (and soap box, if necessary). Technical questions concerning the sewage system can be answered by plumbing inspectors or plumbing contractors who are licensed for installations.

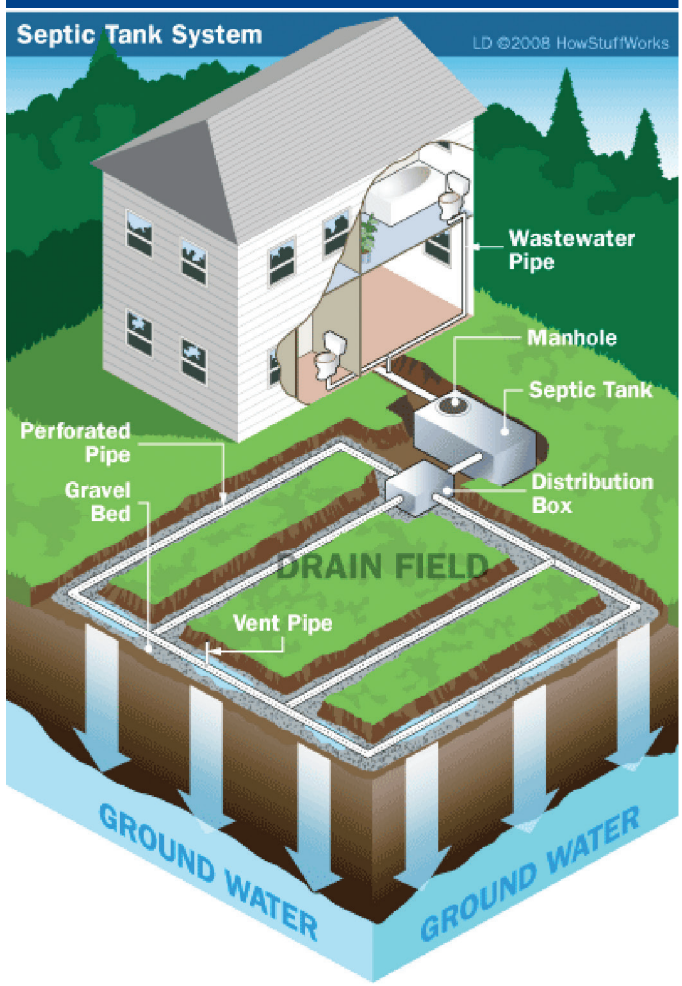
Because they are buried underground, septic tanks systems can be difficult to detect without thorough investigation. To ensure that all parties are properly informed, licensees should verify the method of sewage disposal with the vendor. It is also important to note that the BCREA's standard form Property Disclosure Statement includes several questions about sewage disposal and septic tanks. Therefore, if the Property Disclosure Statement is to be incorporated into the contract of purchase and sale, potential problems with the system need to be investigated.

The operation of septic systems is governed by British Columbia's *Public Health Act* (and its relevant regulations, including the *Sewerage System Regulation*). The *Public Health Act* stipulates that septic systems installed after May 31, 2005 must have been installed by an authorized professional and that records be filed with the local health authority; licensees should verify that this is the case. If the system was installed prior to May 31, 2005, licensees should verify that an appropriate permit was issued for the system and that the local health authority approved its construction.

Septic systems are not generally used in urban areas because disposal fields require significant land area and because of the danger of pollution. However, many homes are still connected to septic systems in older municipalities, even though the municipality has installed sewers. The drain waste and vent system carries waste to the septic or municipal system. While not subject to many problems, a variety of materials will be observed:

- **Cast Iron:** This product, popular prior to the 1960s, is a very effective material and is not subject to any form of degradation. The main area to observe is the joint between the waste pipe and the fixture. As cast iron is inflexible, movement may cause this connection to leak. Cast pipe is not used today because of cost and inflexibility of installation.

FIGURE 20.12: Septic Waste Water System



Source: Urban Contractors Ltd., *urbancontractors.ca/services/general-excavating/septic-systems*

- **Plastic (ABS):** Plastic is the most popular product for waste systems. This material has not displayed any major problems for the last several decades. To inspect, simply examine the joints for evidence of leaks.
- **Lead:** This is one of the only materials that has been used in waste systems that can cause problems. It was commonly used prior to 1955 to plumb difficult areas because it is highly flexible. This pipe will definitely leak with age. If lead pipe is detected, it should be replaced before it causes a problem.

Storm Water Drainage

The storm water drainage system is separate from the sewage disposal system. Water from the roof gutters, perimeter drains, driveway, and landscape drains is handled in one of three ways:

- The site is sloped such that water is directed away from the foundation (if no underground system exists).
- The water is collected and distributed to an underground municipal system through a series of catchbasins and sumps.
- The water is directed to an on-site rock pit to allow water to seep into the surrounding earth through a series of catchbasins and sumps.

For the latter two systems to be effective, the catchbasins and sumps must be cleaned and operational. When operating properly, the bottom of the sump should be clear of sediment and the pipes should show evidence of running water. If there is no evidence of running water, the system can be tested by removing the downspout from the gutter farthest from the sump and placing a running garden hose in the hole. Within a few minutes, water should be running out of the pipe. If the drainage system is plugged, a drain cleaning company can usually unplug the system relatively inexpensively. However, if this does not solve the problem, the alternative is to dig up the system, which is not only costly but also very damaging to the landscaping.

Gutters

Most houses have gutters on the horizontal edges of the roof to collect rain water, though winter conditions in some areas prohibit their use because of ice build-up. The water is drained to downspouts, which direct it to the building's storm drainage or surface run-off system. There are two main types of gutters: fascia type (mounted on the outside face of a trim board at the edge of the roof) and hidden gutters (concealed behind the trim board at the edge of the roof).

Fascia gutters can be made with a variety of materials including wood, aluminum, vinyl, or galvanized metal. In older homes, the gutters are wood and are subject to degradation from weather. With expansion and contraction, the caulked seams where the gutters are joined will separate and the gutter will leak. If the gutters are in a reasonable condition, then simple recaulking is all that is required. If rot has set in, the only solution is to replace the wooden gutters.

The most commonly used gutter product is now continuous aluminium, which has relatively few problems. Areas to examine are the joints where the gutter is caulked together and general securement to the building.

Hidden gutters have also displayed few problems. To check hidden gutters for holes, examine the soffits for signs of water seepage. Any holes that are found should be caulked. In general, gutters should be kept clean with screens placed over the downspout outlets to prevent residue from entering the storm system.

Elevator Inspection

Elevators are standard in modern apartment buildings. Elevators should be self-levelling with a minimum speed of 200 f.p.m. (feet per minute), or no slower than twice the elevator rise from top to bottom landing (e.g., for a rise of 150 feet, the speed of the elevator should be 300 f.p.m). In better quality apartments, 500 f.p.m. elevators are common. In low-rise three and four storey buildings, the elevators are hydraulic lifts that operate on a piston.

The size and speed of the elevation systems will typically depend on the age and size of the building. The following elements should be documented:

- **Number of elevators:** larger multi-family buildings may have separate elevators for freight and/or moving tenant furniture
- **Rated capacity of the elevator:** i.e., maximum number of passengers
- **Type of elevator:** cable or hydraulic

Residential Housing Defects

Deficiencies in housing may be categorized as design, visible, or invisible defects. These may result from improper care and maintenance or from the design and construction of the original structure or succeeding additions.

Design Defects

Design defects are uncommon in new single-family residences because of contemporary building technology; however, what is acceptable today may be considered a design defect in the future. Because of their complexity, multi-unit buildings are more likely to suffer from design defects.

Some examples of items currently considered as design defects include the following:

- main entrance directly through a bedroom or utility room;
- main bathroom directly off living room providing a view of the toilet when the door is open;
- bathroom access through bedrooms only;
- a room area that is exceptionally small;
- doors that interfere when opened;
- head room clearance in stairwells and basements that are too low;
- entrance doors that are too small;
- odd window placement and windows that are too small;
- inadequate lighting;
- inadequate electrical or plumbing systems;
- inadequate materials specifications; and
- improper mixing of public and private spaces.

Visible Defects

Most design defects are visible, but there are other types of defects that fit into the visible category. Defects of these type usually result from the following:

- Defects from improper installation:
  - cracks in the foundation from footings installed on non-compacted fill
  - space between window frames and sills, sides, and top surfacing materials
- Defects from installation of low quality products:
  - cabinets have loose drawers that do not slide in and out smoothly
  - peeling wallpaper or paint
- Defects from improper use and treatment:
  - use of asphalt or tar roofing materials as a deck surface
  - smoke damage from installing the wrong metal chimney on a wood stove
- Defects from lack of adequate maintenance:
  - a sagging porch, decaying as a result of not regularly repainting the porch structure
  - foul odours and grey water in ditches near the septic field as a result of not periodically removing sludge

Invisible Defects

Many defects may be hidden behind wall and floor surfaces in a home. Defects of this type usually fall into the following categories:

- Defects of omission:
  - lack of moisture barrier
  - lack of insulation
  - lack of sufficient electrical circuits
  - lack of proper roof ventilation
  - inadequate attention to air sealing

- Defects of improper installation:
    - non-continuous vapour barrier
    - electrical or plumbing defects
    - inadequate foundations for patio, porch, sidewalks
    - warped or wrinkled aluminum or vinyl siding
- Defects of improper materials:
    - utility rather than construction grade structural lumber
    - use of materials not allowed by code
    - improper concrete mix
- Defects due to improper maintenance:
    - plugged drain or vent resulting in excess moisture content in wood structure that may produce decay
    - insect attack on wood structural elements

Most invisible defects are covered by building, electrical, or plumbing codes. Codes were adopted to provide some guidelines as to quality in terms of material selection and installation. The permit and inspection service of municipal and regional jurisdictions is intended to ensure a uniform application of the various codes, but codes only represent minimum standards, not ideal or optimal standards.

RESIDENTIAL HOUSING CLASSIFICATIONS

House plans may be classified in several ways:

- by measuring floor area and/or number of floors;
- by external style; or
- by structural method.

Classification by External Style

Architectural style is a composite term made up of many elements including scale, proportion, massing, colour, materials, shades and shadows, contextual appropriateness, and symbolism of parts. The primary elements of architectural style are scale and proportion. Scale is the relationship of the parts of the building to the whole building and to the human observer; it has nothing to do with the size of the structure itself. Scale may be shaped by the configuration of the roof, the size and proportions of windows, the texture and colour of the elevation materials, the width and proportions of stairs and railings, and many other factors. Proportion relates partly to the way that the dimensions are mathematically orchestrated for aesthetic effect. For example, a design with too many details, materials, textures, or variations may appear too "busy", with each component vying for attention. Generally speaking, simplicity is the telling technique of good design.

House styles can generally be categorized by the interaction of three major elements:

- The mass, shape, and geometry of the structure (i.e., the three-dimensional expression of the plan)
- The use of exterior materials, details, and colour
- The patterning of the exterior, such as the location, size, and detail of doors, windows, canopies, porches, and dormers

Housing styles can generally be grouped into three main categories: traditional, architectural, and ranch. Each category contains specific sub-styles.

Traditional Styles


Classical Style

Traditional styles evolved from historic European domestic building expressions and techniques, which were brought to North America by immigrants who were forced by climate, economics, and materials to accommodate their traditional styles to suit. Traditional styles include the following:

- **Classical** (i.e., neo-classical or southern colonial) is influenced by Greco-Roman tradition. The Classical house has a flat or low slope roof, two or three storeys, a symmetrical façade, fluted white columns, triangular pediments, and open porches. There is an attempt to create a palazzo or Palladian villa look.

- **Victorian** is from England and dates to the 1800s. The Victorian house has a steep shingled roof, peaked turrets, heavy chimneys, an asymmetrical façade, porches, brick cladding, and cookie cutter trim.
- **Georgian** is from early England and dates to the late 1700s. The Georgian house has a medium sloped roof, two or three storeys, a symmetrical façade, red brick/white trim, regular window spacing, multi-paned windows, dominant chimney(s), and an entry porch.
- **Elizabethan** (i.e., Tudor) is from England and dates to the 1600s. The Tudor style evolved from using post and beam construction, with plaster or other masonry materials in between posts. Contemporary Tudor is usually decorative and not structural. Dark stained boards are secured to the building, with stucco used to surface the walls between the boards. This style usually has a steep shingled roof, two or three storeys, and regular spaced small windows.
- **Cape Cod** is from the eastern coast of the US. It is a one, one-and-a-half, or two-storey building that has a steep shingled roof, a central chimney, horizontal clapboard or shingled siding, regular spaced windows, and dormers. This style of home was originally designed to withstand the harsh climate of the Atlantic coast.
- **French**, from historic Paris, has three storeys – the first two of masonry and the top with a shingled or metal mansard roof and windows. It has a symmetrical façade and regular window spacing.
- **Chalet** (i.e., Swiss) has a very steep wood shingled roof, large overhangs, one or two floors plus an attic, wood walls with a masonry or stone base, regular small windows, and detailed wood balconies.


Victorian Style


Elizabethan/Tudor Style


Arts and Crafts Style

- **Arts and Crafts** features very fine woods, joinery, massiveness, and strength. This style often uses a solid stonework base and massive framing members. It evokes a sense of quality, durability, warmth, and old world craftsmanship.

Architectural Design

Architectural design generally refers to types of houses that were originally instigated by a strong design, but may since have been modified or simplified to reduce the unusual visual impact. Some prevalent styles include the following:

- **Bauhaus** (i.e., modern or modernist) is from the European school of architecture in the 1920s and 1930s. This style has a flat roof, one or two storeys, irregular or asymmetrical mass, little or no detail on flat walls, irregular grouped windows, and some large windows to create transparency. It is typically designed with environmental considerations taken into account (e.g., it may accommodate and accentuate the topography of a site). The square or rectangular lines of the structure are sometimes relieved by cylindrical additions to the house, such as a staircase or a sunroom. The modern style was also referred to as the "international style" and was a reaction to the conservatism and stuffiness of past styles; it was an attempt to free designers of the rigidity of the beaux arts neo-classical training and to encourage designers to embrace technological changes in construction and industry.
- **Shingle** evolved from New England on the east coast of the United States. This style has long, sloping shingled roofs, irregular massing, shingled walls (occasionally clapboard), and grouped and irregular windows.
- **West Coast**, evolved from marine climates, has a low sloped shingled roof in separate components, one or two storeys, irregular mass, angular roofs with large overhangs, and large glass areas. It is ground oriented and has an exterior finish of preserved or stained wood. It is most often associated with the style used in ski resort condominium construction in the 1980s. One trend with this style is to blend it with modern architecture, resulting in a "West Coast


Bauhaus Style


Shingle Style


West Coast Style

Modernism" (i.e., West Coast Contemporary) style with common features including strong horizontal lines with clean, uncluttered, minimalist, flowing spaces that attempt to blend the interior and exterior with much less formalism and symmetry. The milder, less harsh climate of the West Coast is one of the factors that facilitated this style of design.

Prairie Style

Narrow Lot Style

- **Prairie**, influenced from the architecture of Frank Lloyd Wright, is typically one storey with a low, sloped shingled roof, horizontal lines, irregular mass, grouped and irregular windows that start at or are close to the floor level, and a "ground hugging" mass. Larger windows are often a feature of this style, which serve to increase transparency and blend interior and exterior spaces.
- **Narrow Lot** or **"Vancouver Special"**, which emerged as a style during the 1970s and maximizes utility on a narrow site according to city zoning criteria. It is a two-storey structure with a low sloping roof. It usually includes a shallow balcony that spans the entire width of the house, with veneer cladding (e.g., brick) on the front of the first storey. One or more self-contained suites are often constructed on the first floor.
- **Po-Mo**, developed from the 1970s post-moderism movement, has one, two, or more storeys, very irregular massing, a flat or sloped roof, and patterning from windows. This style often includes stucco and may be brightly coloured with added detail echoing historical antecedent such as columns, pediments, and arches. This style was a reaction to the starkness, lack of ornamentation, and severity of modernism and its lack of connection to traditional trappings.
- **Environmentally conscious** design is evidenced in one or two storey buildings with a flat or sloped roof, glazed areas, a closed north façade, and solar panels. It is often oriented to the sun. There are some challenges with these types of developments including risk, market demand, regulatory prohibitions, and a lack of affordable support technologies. Mechanical, plumbing, and electrical codes often contain wording, conformance standards, and prescriptive requirements that make it difficult to innovate without having to negotiate for approval of alternatives to the codes.

Ranch Styles

Ranch homes are usually located on a larger lot or acreage because they occupy considerable surface area. This style evolved from a blending of the southern California low, rambling outdoors-oriented dwelling, which was often built in the Prairie style. A ranch house is typically one strorey, usually incorporating a garage, under a continuous sloping roof. It often has an irregular plan relating to outdoor patios and decks with irregular window groupings (which are generally not oriented to the sun). It is typically sheathed in brick or stucco. If a ranch style home has a basement, it is below grade at the front (i.e., not visible because it is underground). This housing type is appropriate in warm climates, but the large roof results in significant heat loss in northern climates.

Ranch Style

An additional style of home is the manufactured home, defined by Section 1 of the *Manufactured Home Act* ("the Act") as a structure that is designed to be moved from one place to another, whether equipped with wheels or not, and to be used as a dwelling house, a business office (unless exempted under the Act), or as any other accommodation. This is an extremely broad category, but transactions involving floating homes, campers, travel trailers, mobiles homes in transit to a destination outside the province, bunkhouses, and manufactured homes used solely for non-residential purposes are exempt from the Act.

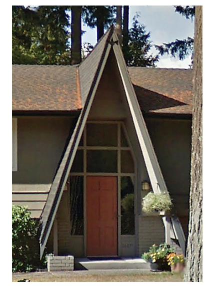
A rising trend is the use of manufactured modules for conventional houses. As several modules are assembled, the characteristic "modular home" shape disappears. Manufactured homes provide superior quality assurance during construction, since most tasks are done in factory conditions with total climate control.

Variations on External Style

Some architectural variations may occur in any housing style. Terms like bay window, dormer, cathedral entrance, or vaulted ceiling are often encountered in home descriptions.

Bay Window

Dormer Window



Cathedral Entrance

- **Bay Window:** A bay window is an extension of the floor and walls to increase the size of a room, often without extending the roof. However, it has become increasingly popular to cover the bay area with a separate roof. Besides design and aesthetic considerations, bay windows are often used because they are not considered additional floor area in the development application – they can typically be excluded from the aggregate floor space total requirement under the development bylaws, yet they result in an enlarged volume for the house.
- **Dormer:** In one-and-one-half storey buildings, it is common to find dormers mounted on roofs. These are mini-roof extensions constructed into the main roof. They are used to provide extra floor area, head room, and light in the upper level.
- **Cathedral Entrance:** This term refers to an entrance area where the ceiling of the entrance is mounted higher up, on the next storey above, on the underside of the roof, creating a high entrance hall. An A-Frame roof design is often used in this context.
- **Vaulted Ceiling:** A vaulted ceiling is similar to a cathedral entrance in that the ceiling of the rooms follows the roof line of the building and is actually the bottom surface of the roof joists. This is often encountered in post and beam homes but may occur in other structures.

Classification by Structural Method

Housing styles classified by structural method include:

- Log
- A-Frame
- Brick
- Stone
- Concrete Block (this can be block or total poured in place)
- Post, Beam, and Plank (this was most common in 1950s/1960s modernist homes)
- Western Platform Wood-Frame

Identification of these styles is primarily determined by the materials used in the structure. Log, A-Frame, Brick, Stone, and Concrete Block buildings are easily identified from their external construction material or style.

In Post and Beam construction, the roof is formed of planks that are secured to beams, which are supported by posts. This imparts a certain external aesthetic appearance where the vertical posts visibly support the room beams. Floor to roof windows with necessary framing are often placed between posts.

Although each of these styles exist in British Columbia, the most common structural style is Western Platform Wood-Frame. Typically, the first floor is built on top of the foundation walls like a platform, then the walls are built and raised on the platform and the second floor is built on the raised walls. Depending on the number of floors, this process may be repeated.

GREEN HOUSING: ENERGY EFFICIENCY AND SUSTAINABLE REAL ESTATE

The final section in this chapter touches on green issues for multi-family dwellings, reflecting on the growing interest in energy efficiency and sustainability. Describing a property as green can mean different things to different people. For some, it implies environmentally friendly, while for others it means sustainable, high performance, or energy-efficient. Green real estate involves more than the design and operation of the physical improvements. Sustainable building practices extend from site selection, building envelope siting, and drainage management to building design, construction practices, materials, finishes, and building operations.

A more comprehensive definition of a model green building is one that is energy-efficient, water-efficient, designed for healthy living, constructed of low-impact materials that do not compromise the building's durability or performance, is accessible to amenities, and is protective of the local ecosystems. A green building:

- provides a healthy indoor living environment;
- allows ample fresh air and natural light;
- is designed to take advantage of renewable resources such as solar or geothermal heat, natural airflow patterns, or rainwater;
- uses significantly less energy and water than typical buildings; and
- requires minimal care and maintenance.

Green construction practices and building features aim for a residence that is built with fewer non-renewable resources, disrupts fewer natural systems, and uses less energy and water in its final operations.

Green Building Features and Components

The most common green technologies focus on the:

- building envelope;
- heating system;
- ventilation system;
- hot water heating system;
- water fixtures; and
- appliances.

Figure 20.13 summarizes green features and components, with a brief explanation of the associated building science and benefits to owners and residents.

FIGURE 20.13: Benefits and Characteristics of Key Energy Efficient Products

Energy Efficient Component	Characteristics	Building Science	Owner Benefits
Mechanical ventilation • Heat Recovery Ventilators (HRVs)	• Stale air vented outside • Coils that remove indoor heat before expelling air outside • Fresh air delivered into the furnace return system	• Mechanical airflow minimizes stack effect, circulating air to all rooms • Air is refreshed every three hours • HRVs recover 70% of the waste heat • HVAC heats and cools air as needed	• No odours or excess moisture • Fresh, clean, dry air • Adjustable with a range of speeds and times • Convenient, reliable, durable technology
Exhaust only ventilation • Bathroom fans • Central vacuum • Range hoods	• Vented outside • Variable speed motors • Connected to humidistats • Auto controls • ENERGY STAR® Rated	• Creates a low-pressure area that other air moves in to fill • Mechanical airflow minimizes stack effect, circulating air near the fans	• No odours or excess moisture • Variable settings according to lifestyle needs • Convenient automatic settings • Cost effective to operate
Circulation only	• Ceiling fans	• Attempt to minimize the stack effect by moving heated air down from the higher levels	• Lower heating/cooling bills • Steady room temperatures • Variable settings according to lifestyle needs

continued next page

FIGURE 20.13: The Benefits and Characteristics of Key Energy Efficient Products, *continued*

Energy Efficient Component	Characteristic	Building Science	Owner Benefits
High-efficiency furnaces	• 90% AFUE (annual fuel utilization efficiency) or higher • Direct vent • Variable speed motors • Sealed combustion • Properly sized, room to room • ENERGY STAR® rated	• More efficient conversion rate of energy to heat • Have their own air source, from outside so no low-pressure zones are created inside	• Lower heating/cooling bills • Steady room temperatures • Variable settings according to lifestyle needs • No risk of carbon monoxide poisoning • Produce fewer GHG (greenhouse gas) emissions
Weather barriers • Tar paper • Stucco • Sidings	• Coverings that stop moisture outside the building from reaching the building materials	• Blocks moisture in gas form from travelling by diffusion – from high-pressure to low-pressure areas • Blocks moisture in liquid form from travelling by capillary action into the building envelope	• Prevents mould • Greater building material durability • Lower maintenance costs
Vapour barriers • Polyethylene • Some paints • Gypsum drywall	• Coverings that stop moisture inside the building from reaching the building materials	• Blocks moisture in gas form from travelling by diffusion – from high-pressure to low-pressure areas • Prevents moisture from travelling from warm to colder zones in the building envelope	• Prevents mould • Greater building material durability • Lower maintenance costs
Continuous air barrier	• Gaskets • Weather-stripping • Draft proofing/air sealing • Caulking • Double pane glass • Storm windows	• Heated air is trapped inside the building • Internal walls and windows surfaces are warmer • Internal temperature and dew point levels can be higher, minimizing condensation	• Lower heating/cooling bills • Steady room temperatures • No drafts • Outside noises are muffled
Heat barriers/stabilizers	• Insulation • Convection barriers • See air barriers listed above • Conduction barriers • Insulated window spacers • Wood, not metal • Radiant heat barriers • Low-E window coatings • Awnings • Window orientation	• Create small air pockets where convection cannot occur • Divide internal temperature zones from outside temperature zones with non-heat transferring products • Control the amount of radiant heat entering and leaving the room	• Lower heating/cooling bills • Steady room temperatures • No drafts • Outside noises are muffled

continued next page

FIGURE 20.13: The Benefits and Characteristics of Key Energy Efficient Products, *continued*

Energy Efficient Component	Characteristic	Building Science	Owner Benefits
ENERGY STAR® Windows	• Two panes or more • Panes only 12mm apart • Low-E coating • Argon gas fill • Frames air sealed to the framing with caulking • Insulated spacers	• Warm inner pane and insulated spacers minimize conduction heat loss • Narrow, argon filled space minimizes convection currents • Low-E coating minimizes radiant heat from the sun • Warm inner pane increases the dew point so moisture does not condense on the surface	• Stops airflow • Warm inside pane – no moisture condenses • Protect furniture from sun damage • Quieter • Cleaner

Source: City Green Solutions, *www.citygreen.ca*

Building performance is the sum of the components, but there can also be synergies achieved from systematic design. In a building system, the performance of each individual component affects the performance of the system as a whole, where each part interacts with the other to control the flow of air, heat, and moisture. In colder seasons, the goal is typically to keep the heat in while expelling the stale air and moisture. In warmer seasons, the goal is to keep the heat out while still drawing in fresh air and maintaining stable humidity ranges in the living space. Designing buildings with this interactivity of components in mind can improve overall performance.

An integrated design process involves the building owner, architect, contractors, mechanical engineers, and ideally the occupants during the design phase of the project to jointly outline the long-term energy and sustainability goals for the building. Working together at the start of the project helps prevent miscommunication once the linear development phases of the project begin. Joint decisions are made regarding building orientation, interior layout, mechanical ventilation, heating system type and sizing, etc. Collaborative problem solving at the start prevents troubleshooting mid-project. As well, a holistic approach prevents upgrades to one part of the building that inadvertently create problems in other parts of the building. For example, increased air sealing can lead to moisture concerns (e.g., mould and condensation) if mechanical ventilation is not added.

Existing buildings may have energy efficient elements retrofitted. The conversion of existing buildings to more sustainable design (to the extent practical) provides tangible and intangible payback in the form of reduced energy costs and increased tenant satisfaction. HVAC systems are a common example of this cost-benefit analysis. Modern HVAC systems are expensive to install but can produce immediate savings in energy costs for heating and cooling in relation to legacy HVAC systems. The other advantage of an HVAC upgrade is improved thermal comfort for building occupants.

Benefits of Building Green

Building green can offer multiple benefits, including economic benefits for owners and satisfying social and environmental goals. The following sections describe some of these benefits in greater detail.

Improved Indoor Environmental Quality

Green buildings are designed to take full advantage of the natural resources in their local environment. Windows should capture available sunlight, natural ventilation, and optimal views. Window glazing can protect furniture and flooring against fading as well as maximize the passive solar gain (i.e., heat from the sun) in the winter and minimize it in the summer. Seasonal window shading, such as deciduous trees, roof overhangs, awnings, or blinds, can also accomplish this task. Tubular skylights and high, narrow windows can draw natural lighting deep into the building.

Building envelope construction that maintains a high R-value throughout the building envelope, where R stands for the resistance to heat transfer, will be able to resist heat loss and reduce temperature fluctuations. High-efficient heating and ventilation systems help to ensure that fresh, clean, warm air is circulated evenly throughout the building. Tight air seals throughout the building envelope minimize cold patches and drafts.

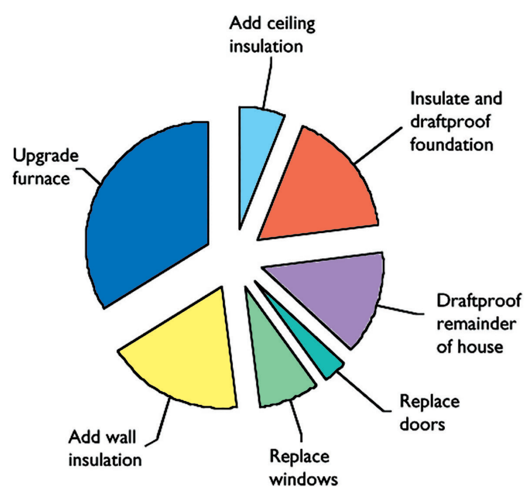
A side benefit of higher insulation values is increased soundproofing of the exterior building envelope. A well-built, well-insulated building blocks outside noises.

Energy Efficiency

Rising utility costs are a major driver of green building construction. Property owners feel the impact of high energy bills and need to control energy consumption. The energy savings potential for older buildings is substantial. Newer technologies use significantly fewer resources to fulfil the same function as older technologies. Figure 20.13 illustrates the impact of upgrades to a typical 1940s home. In this example, upgrades to the heating system and insulation have the largest impact on improving energy efficiency. However, a building is comprised of multiple interactive components. This pie chart seems to imply that all 1940s homes should start with upgrades to their furnace for the greatest impact, but this assumption is incorrect. The greatest impact in most older buildings would be to complete inexpensive air sealing and insulation upgrades to minimize heat loss. Mechanical ventilation should be added next to ensure that moisture and other pollutants are properly expelled. Then, after air sealing and insulating, furnace upgrades should be considered. These preliminary upgrades will also reduce overall heating requirements.

FIGURE 20.13: Average Energy Savings by Improvement

Based on computer simulations, the pie chart below indicates an ***average percentage of potential total energy savings*** that can be expected for each type of improvement: insulation and draftproofing 34%; door and window replacement 11%; exterior wall insulation 18%; furnace upgrade 34%.



Energy-efficient building design considers the interactions of all building components, including the building envelope, HVAC, and lighting. In order to maximize energy efficiency, these building systems must work together to control the flow of air, heat, and moisture in the building. This holistic approach to renovations prevents against well-intentioned upgrades to one part of the building that can inadvertently create problems in other parts of the building. For example, increased air sealing can lead to moisture concerns, such as mould and condensation, if mechanical ventilation is not added.

The business case for building green involves comparing the upfront investment with long-term savings and financial gain. One goal of building green is to reduce the direct operating costs of the building, including energy and water utility bills, property taxes, insurance rates, tenant services, and mechanical systems maintenance. In addition, grant and rebate programs can help minimize the initial capital costs, shortening the immediate payback on residential construction and allowing owners to benefit faster from long-term energy savings. Reducing the initial capital costs shortens the payback period and helps owners to benefit faster from long-term energy savings.

Challenges of Building Green

There are several challenges to realizing the potential benefits arising from energy efficient and sustainable design. For example:

- New buildings with sustainable design comprise a relatively small percentage of the overall market. As a result, there is little market data to conclusively prove that sustainable design results in higher sales prices and rental rates.
- Existing buildings with sustainable design upgrades, such as new lighting or improved HVAC, may not be sufficiently distinct from competing buildings to command a premium price. The building upgrades may simply reflect market norms where obsolete building systems are periodically replaced with current technology.

- During economic downturns, tenants will have greater leverage in the local market. When vacancy rates are high, the increased competition from other buildings may hamper landlords from securing higher rents in buildings with sustainable design features.
- While it is relatively straightforward to document direct cost savings from reduced energy and water consumption, it is challenging to document intangibles such as increased occupant satisfaction.

Consider, too, the various limitations in retrofitting green options in existing construction:

- A building's siting is fixed, so its orientation and exposure cannot be improved in the same way a new building can be optimized.
- There may be serious structural or code issues that preclude extensive renovation, such as the need to meet contemporary seismic standards.
- The presence of hazardous materials, such as asbestos and other unforeseen contaminants, may be cost issues that prevent the application of extensive sustainable design.
- There may be limited availability of project and construction staff with expertise in rehabilitation of heritage buildings, or limited availability of capital funds generally.

Green Certification for Multi-Unit Residential Buildings

Performance-based residential energy modelling programs, such as the EnerGuide label that describes the energy efficiency of key consumer items (e.g., houses, light-duty vehicles, and certain energy-using products), are becoming integral to the process of the energy efficiency of both new construction and existing housing. Other rating systems, such as Built Green Canada and Leadership in Energy and Environmental Design (LEED®), move beyond energy efficiency and water efficiency by incorporating a selection of other green initiatives such as recycled content and non-toxic building products, waste management processes, or site restoration. The challenge for real estate professionals is to recognize the components of a green or greened home and to translate the value of those components into clear benefits for the buyer.

EnerGuide

EnerGuide ratings are based on energy efficiency, measured by a number between 1 and 100, which describes the building's cumulative energy efficiency; the higher the number, the more efficient the building in question. For existing buildings, this data includes the building envelope measurements (i.e., windows, doors, ceiling heights, and floor plan geometry), heating and ventilation system efficiencies, as well as the results from a series of blower door fan test readings that quantify the total air leakage. For new buildings, this data is taken from the blueprints and then the Certified Energy Advisor will provide recommendations to the builder or owner on how to adjust the plans to gain an increased EnerGuide rating.

Built Green Canada

Built Green Canada is a non-profit organization that promotes green building practices in the residential building sector through energy efficiency and sustainable building practices. The program is industry driven and aims to reduce the impact of building on the environment. The BUILT GREEN® rating program provides a checklist of standards that builders must follow to obtain certification as a high performance building.

LEED®

The Leadership in Energy and Environmental Design is a third-party certification program that encourages sustainable green building and development practices. The LEED® program involves the review of documentation, on-site visitations, and the allocation of various credits to different building components to achieve certification. The LEED® rating system consists of four levels of certification (certified, silver, gold, and platinum) to reflect different green building strategies. The rating system provides points for various building components; the more points that are earned, the higher the level of certification that will be achieved.

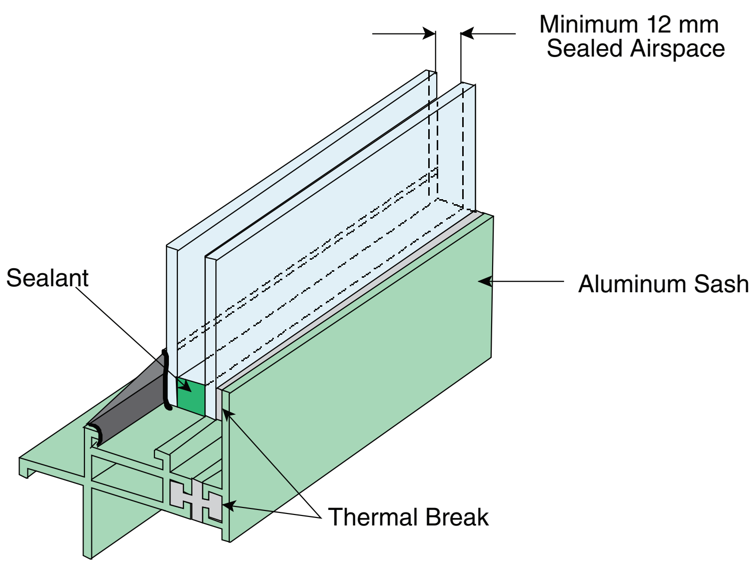
R-2000 Homes

Rising energy costs, concerns about climate change, and the need to conserve fuel have brought about the design of a new higher standard in energy efficiency. An energy efficient home standard called R-2000, which was introduced in the early 1980s, involves greatly increased insulation values and improved draft control and sealing measures. The R-2000 standard has been updated over the years. It is an energy efficient home standard that is climate sensitive, so that the requirements for an R-2000 home on the mild West Coast are different than for a similar house in a very cold environment.

Builders must follow a checklist of mandatory standards to obtain the R-2000 certification for their high performance homes, including a tight air seal test once the home is built. One of the features of an energy efficient home is that it is well air sealed to achieve a draft-free building envelope. The importance of an airtight envelope is not only to reduce heat loss, but also to enhance building durability, as a building that is airtight will have less potential for moisture movement into the construction assemblies, thus compromising the structure.

Much of the air leakage in buildings occurs around doors, windows, and where the polyethylene vapour barrier is broken to allow installation of electrical and plumbing fittings. Energy efficient homes may have double entrance doors that are insulated and weather sealed around the edges. Windows will consist of double or triple glazed thermal windows, with the opening sections properly weather sealed to prevent air leakage. The windows will be carefully sealed when installed. Metal window frames will have a thermal break incorporated into their design to reduce conduction of heat to the outside, as shown in Figure 20.14.

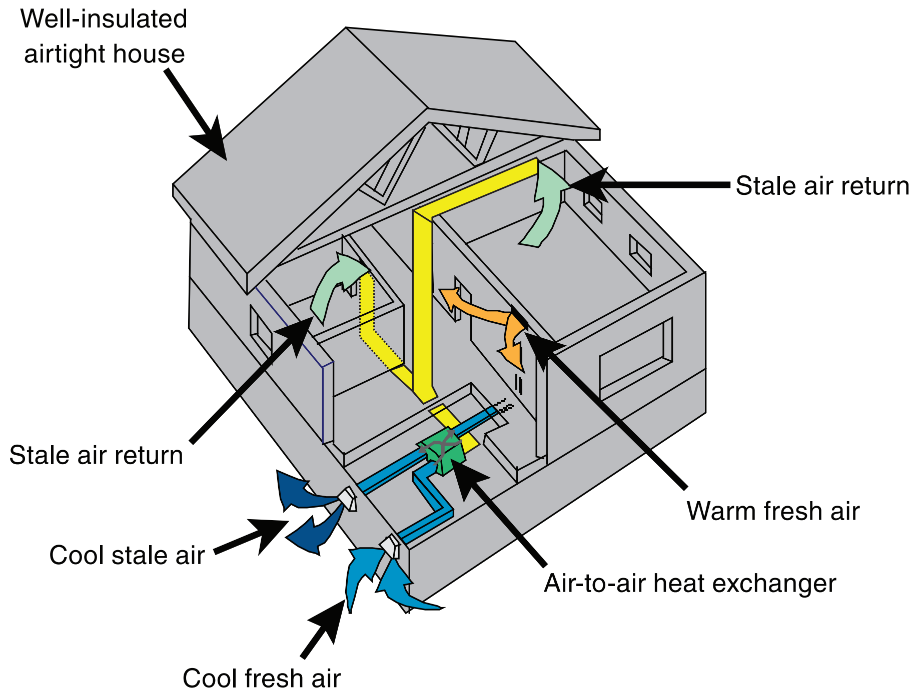
FIGURE 20.14: Typical Double Glazed Aluminum Window Sash with Thermal Break



The orientation of the building on the lot, as well as the placement and size of windows, is a key factor for energy efficient homes. To maximize the benefits of solar heat gains, buildings should be oriented so that their largest windows are facing south. This enables the window to absorb passive solar energy (heat) thereby reducing heating expenses. Reasonable overhangs (e.g., 3' on an 8' high wall) will protect the south side windows from overheating. Windows on the north side of the home are net losers of energy and these windows should be small and limited in number. Windows on the east side can assist in morning solar gain, while windows on the west side must be shaded or the house may overheat. This is where special attention to selection of window glass type is important.

From the outset of the development of the R-2000 standard, it was recognized that proper ventilation and air change is required in a home. That is why the standard requires a properly designed and installed ventilation system. This is typically done with a heat recovery ventilation system (i.e., air-to-air heat exchanger) that provides a continuous air exchange. The system must be able to provide a distribution system to guarantee a supply of fresh dry air.

FIGURE 20.15: Air-to-Air Heat Exchanger



Green Checklist

Figure 20.16 summarizes how the previously described programs compare in various categories of green.

FIGURE 20.16: Categories of Green in Each Rating System

Category	Goal	EnerGuide	ENERGY STAR® (Sask/Ont)	Power Smart (BC/ Manitoba)	R-2000	BUILT GREEN®	LEED® for Homes
EnerGuide Energy Efficiency Targets	Low energy bills	✓	✓	✓	✓	✓	✓
Appliances and Lights	Low electrical bills	✓	✓	✓		✓	✓
Indoor Air Quality	No toxins				✓	✓	✓
Environmental Impact	Reduce, reuse, recycle				✓	✓	✓
Resource Use/Waste Management	Regional, renewable, rated materials					✓	✓
Sustainable Sites	Less irrigation, less pavement					✓	✓
Location and Linkages	Bus, walk, shop local					✓	✓
Education and Awareness	Signs, logos, marketing					✓	✓

CONCLUSION

The information contained in this chapter is designed to acquaint the licensee with the process of construction and increase their sense of awareness when examining a home. Given the usual time constraints, it would be difficult for a licensee to complete an examination at the level of detail suggested in this chapter. While nothing can replace the benefit of a professional inspection or an engineer's report, the chapter should have alerted licensees to some potential problems and issues associated with correcting problems with property.

A number of claims against the Professional Liability Insurance Program have arisen, at least partially, as a result of measurement-related errors. These claims include a lack of care in taking on-site measurements resulting in incorrect dimensions and areas, simply not taking measurements and relying on best guess dimensions, using outdated building plans, not verifying the accuracy of plans, and incorrectly employing accepted industry measurement standards. Clearly, incorrect measurements leading to overstated or understated floor areas will have a significant effect on resulting value indications based on construction cost rates per square foot, direct comparison estimates based on price per square foot, floor area adjustments to comparable sales and rental income, or expenses based on rates per square foot. Furthermore, when two or more appraisals of the same property, brought together for legal or other reasons, have variances in the reported areas and dimensions, the reliability and credibility of each report is called into question and, in the broader picture, the perceived professionalism of all appraisers is tarnished.

APPENDIX 20.1

Building Measurement Guidelines

Example 1: One Storey

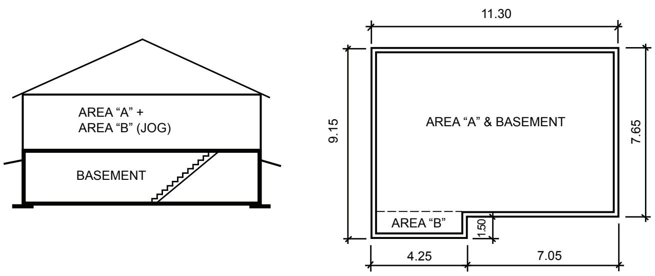
Basically self-explanatory. Exterior length times width of base of dwelling, and exterior length times width of projections and cantilevered areas. Finished basement has same dimensions as Area A.

ABOVE GRADE FINISHED FLOOR AREA:

Area A: 11.30 x 7.65 = 86.5m^2
Area B: 4.25 x 1.50 = 6.4m^2
Total = 92.9m^2

BELOW GRADE FINISHED FLOOR AREA:

Basement: 11.30 x 7.65 = 86.5m^2
Total = 86.5m^2



Example 2: One and One-Half Storey without Dormers

Area A is calculated as exterior length times width of base of dwelling, and exterior length times width of projections and cantilevered areas. Finished basement has same dimensions as Area A.

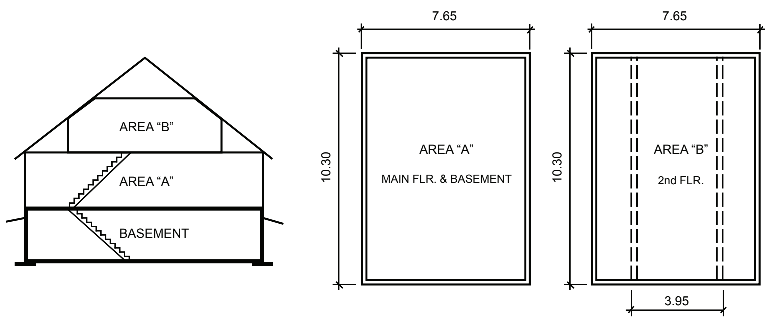
For Area B measurement, consider floor area as interior length times width to knee wall (angle where wall meets ceiling; ceiling height must be greater than 5 feet; at least 50% of space must have height greater than 7 feet). An additional 15 to 20 centimetres may be included to account for the exterior wall.

ABOVE GRADE FINISHED FLOOR AREA:

Area A: 10.30 x 7.65 = 78.8m^2
Area B: 10.30 x 3.95 = 40.7m^2
Total = 119.5m^2

BELOW GRADE FINISHED FLOOR AREA:

Basement: 10.30 x 7.65 = 78.8m^2
Total = 78.8m^2



Example 3: One and One-Half Storey with Dormers

Area A is calculated as exterior length times width of base of dwelling, and exterior length times width of projections and cantilevered areas.

For Area B measurement, consider floor area as interior length times width to knee wall (angle where wall meets ceiling; ceiling height must be greater than 5 feet; at least 50% of space must have height greater than 7 feet), plus length times width of dormers. An additional 15 to 20 centimetres may be included to account for the exterior wall.

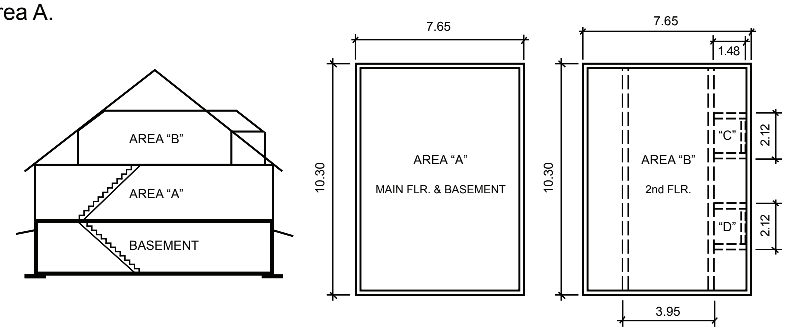
Finished basement has same dimensions as Area A.

ABOVE GRADE FINISHED FLOOR AREA:

Area A: 10.30 x 7.65 = 78.8m^2
Area B: 10.30 x 3.95 = 40.7m^2
Area C & D: 2(2.12 x 1.48) = 6.3m^2
Total = 125.8m^2

BELOW GRADE FINISHED FLOOR AREA:

Basement: 10.30 x 7.65 = 78.8m^2
Total = 78.8m^2



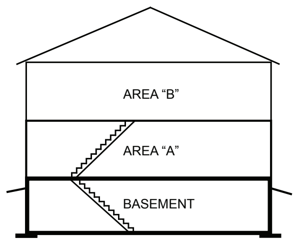
APPENDIX 20.1, *continued*
Building Measurement Guidelines

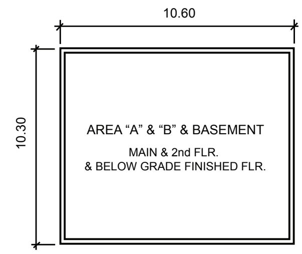
Example 4: Basic Two Storey

Exterior length times width multiplied by two. Finished basement has same dimensions as Area A.

ABOVE GRADE FINISHED FLOOR AREA:
Area A: 10.30 x 10.60 = 109.2m^2
Area B: 10.30 x 10.60 = 109.2m^2
Total = 218.4m^2

BELOW GRADE FINISHED FLOOR AREA:
Basement: 10.30 x 10.60 = 109.2m^2
Total = 109.2m^2





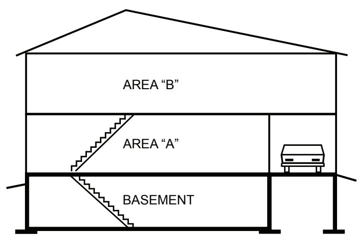
Example 5: Two Storey with Built-In Garage

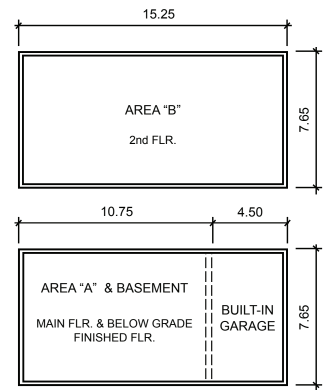
Area A is the exterior length times width, excluding the garage. Area B is the exterior length times width. Finished basement has same dimensions as Area A.

ABOVE GRADE FINISHED FLOOR AREA:
Area A: 7.65 x 10.75 = 82.2m^2
Area B: 7.65 x 15.25 = 116.7m^2
Total = 198.9m^2

BELOW GRADE FINISHED FLOOR AREA:
Basement: 7.65 x 10.75 = 82.2m^2
Total = 82.2m^2

PLUS BUILT-IN GARAGE
Built-in Garage: 7.65 x 4.50 = 34.4m^2
Total = 34.4m^2



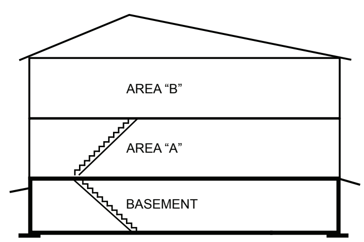


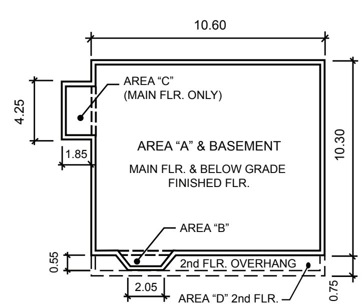
Example 6: Two Storey with Bay Window; 2nd Floor Overhang and Side Addition on Main Floor

Area A is the exterior length times width. Area D is the exterior length times width, including overhang. Exterior dimensions of addition and bay window (bay window extends to grade). Finished basement has same dimensions as Area A.

ABOVE GRADE FINISHED FLOOR AREA:
Area A: 10.30 x 10.60 = 109.2m^2
Area B: 0.55 x 2.05 = 1.1m^2
Area C: 4.25 x 1.85 = 7.9m^2
Area D: 11.05 x 10.60 = 117.1m^2
Total = 235.3m^2

BELOW GRADE FINISHED FLOOR AREA:
Basement: 10.30 x 10.60 = 109.2m^2
Total = 109.2m^2





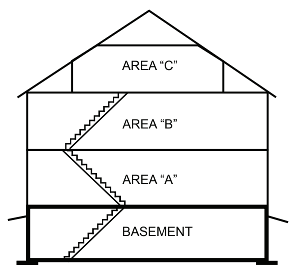
APPENDIX 20.1, *continued*

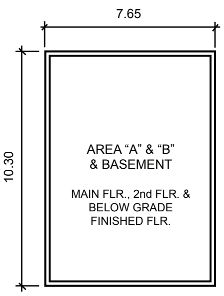
Building Measurement Guidelines

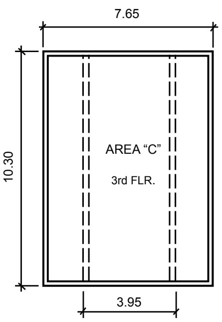
Example 7: Two and One-Half Storey without Dormers

Exterior length times width multiplied by two (Area A and B), plus length times width to knee wall (angle where wall meets ceiling; ceiling height must be greater than 5 feet; at least 50% of space must have height greater than 7 feet) and again account for width of exterior walls. Finished basement has same dimensions as Area A.

Consider full second, third, etc., levels where ceiling height is acceptable.







ABOVE GRADE FINISHED FLOOR AREA:

Area A: 10.30 x 7.65 = 78.8m^2
Area B: 10.30 x 7.65 = 78.8m^2
Area C: 10.30 x 3.95 = 40.7m^2
Total = 198.3m^2

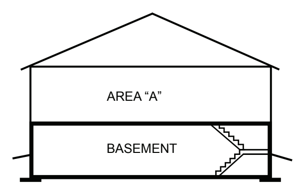
BELOW GRADE FINISHED FLOOR AREA:

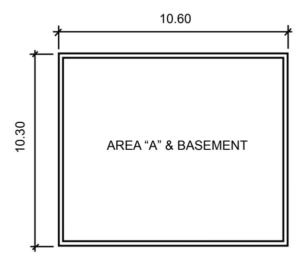
Basement: 10.30 x 7.65 = 78.8m^2
Total = 78.8m^2

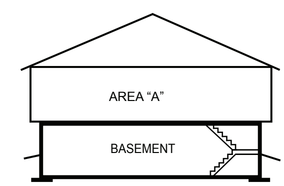
Example 8: Bi-Levels, Raised Bungalows, or Split Entries

Two elevation drawings are shown. The first drawing is without an overhang and the second drawing includes an overhang. The calculations assume the former; finished basement has same dimensions as Area A.

Basement in bi-levels are usually fully developed and quite often finished below grade floor area.







ABOVE GRADE FINISHED FLOOR AREA:

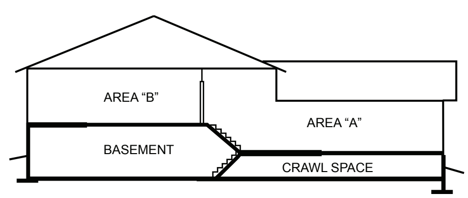
Area A: 10.30 x 10.60 = 109.2m^2
Total = 109.2m^2

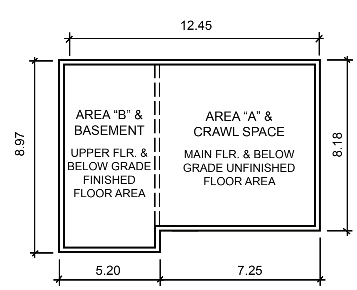
BELOW GRADE FINISHED FLOOR AREA:

Basement: 10.30 x 10.60 = 109.2m^2
Total = 109.2m^2

Example 9: Split Level or Three Level Side Split

Consider Areas A and B above grade. Area under right side of diagram is a crawl space, approximately 60 cm to 1.2 m (two to four feet) in height. Finished basement has same dimensions as Area B and crawlspace has same dimensions as Area A.





ABOVE GRADE FINISHED FLOOR AREA:

Area A: 7.25 x 8.18 = 59.3m^2
Area B: 5.20 x 8.97 = 46.6m^2
Total = 105.9m^2

BELOW GRADE FINISHED FLOOR AREA:

Basement: 5.20 x 8.97 = 46.6m^2
Total = 46.6m^2

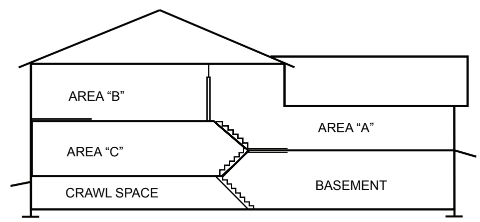
BELOW GRADE UNFINISHED FLOOR AREA:

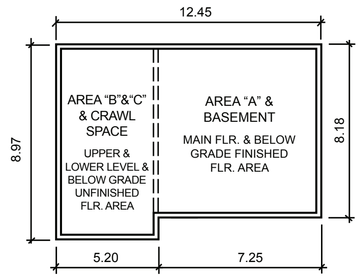
Crawl Space: 7.25 x 8.18 = 59.3m^2
Total = 59.3m^2

APPENDIX 20.1, *continued*
Building Measurement Guidelines

Example 10: Three Level Split without Built-In Garage (Four-Level Split)

Measure exterior length times width of Areas A, B, and C. Finished basement has same dimensions as Area A and crawlspace has same dimensions as Area B.





ABOVE GRADE FINISHED FLOOR AREA:
Area A: 7.25 x 8.18 = 59.3m^2
Area B: 5.20 x 8.97 = 46.6m^2
Area C: 5.20 x 8.97 = 46.6m^2
Total = 152.5m^2

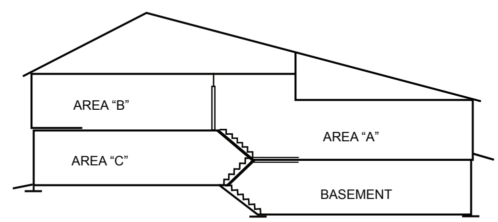
BELOW GRADE FINISHED FLOOR AREA:
Basement: 7.25 x 8.18 = 59.3m^2
Total = 59.3m^2

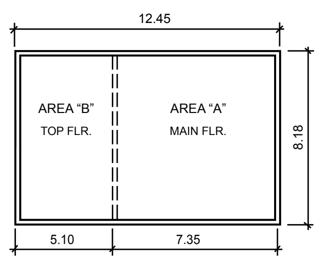
BELOW GRADE UNFINISHED FLOOR AREA:
Basement: 5.20 x 8.97 = 46.6m^2
Total = 46.6m^2

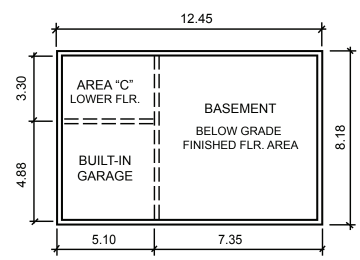
Example 11: Three Level Split with Built-In Garage

Area C, living space beside the garage, does not have a crawl space area or basement beneath but is considered above grade finished floor area. Above ground finished floor area includes Areas A, B, and C.

Finished basement has same dimensions as Area A.







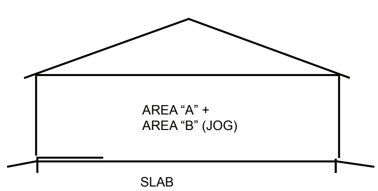
ABOVE GRADE FINISHED FLOOR AREA:
Area A: 8.18 x 7.35 = 60.1m^2
Area B: 8.18 x 5.10 = 41.7m^2
Area C: 3.30 x 5.10 = 16.8m^2
Total = 118.6m^2

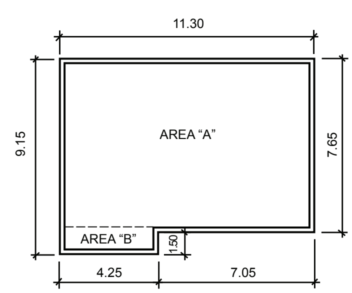
BELOW GRADE FINISHED FLOOR AREA:
Basement: 8.18 x 7.35 = 60.1m^2
Total = 60.1m^2

PLUS BUILT-IN GARAGE:
Built-In Garage: 4.88 x 5.10 = 24.9m^2
Total = 24.9m^2

Example 12: One Storey with Concrete Slab Foundation

There is no basement in this design. Measure exterior length times width. All finished floor area is above grade.





ABOVE GRADE FINISHED FLOOR AREA:
Area A: 11.30 x 7.65 = 86.5m^2
Area B: 4.25 x 1.50 = 6.4m^2
Total = 92.9m^2

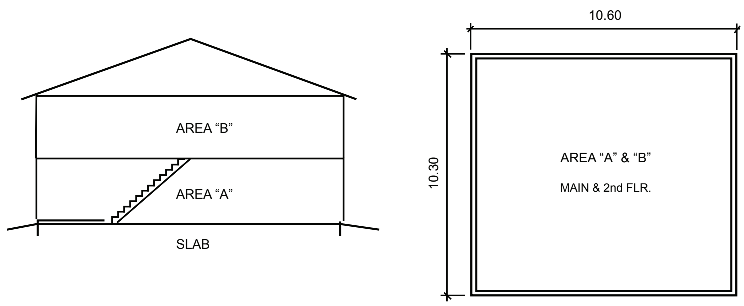
APPENDIX 20.1, *continued*
Building Measurement Guidelines

Example 13: Bi-Level or Two Storey on Slab Foundation (Maritime Style)

In the Maritimes, bi-levels are the same as two stories built on slab. Hence both levels have above grade finished floor areas. There is no basement in this design. Measure exterior length times width. All finished floor area is above grade.

ABOVE GRADE FINISHED FLOOR AREA:

Area A: 10.30 x 10.60 = 109.2m^2
Area B: 10.30 x 10.60 = 109.2m^2
Total = 218.4m^2



Example 14: One, One and One-Half Storey, and Two Storey with Part Basement

Measure all finished floor area above grade. See Examples 1, 2, and 7.

Example 15: Two Storey with Open Foyer to Second Level

Measure length times width of Area A foyer only. Open space on Area B is not considered finished floor area. Finished basement has same dimensions as Area A.

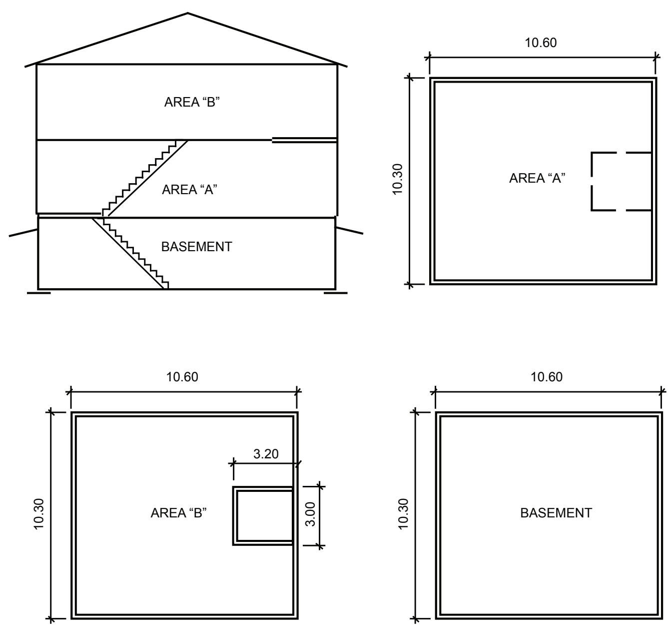
However, should Area B have a loft area extending into open air space, length times width of loft should be calculated and considered in overall finished floor area.

ABOVE GRADE FINISHED FLOOR AREA:

Area A: 10.30 x 10.60 = 109.2m^2
Area B: 10.30 x 10.60 = 109.2m^2
Subtotal = 218.4m^2
Less Foyer: 3.00 x 3.20 = 9.6m^2
Total = 208.8m^2

BELOW GRADE FINISHED FLOOR AREA:

Basement: 10.30 x 10.60 = 109.2m^2
Total = 109.2m^2



APPENDIX 20.2

Measurement Practices Bulletin CP-15

SOURCES OF MEASUREMENTS

Whether dimensions and related areas have come from personal on-site measurements, from plans, or from some other reliable and verifiable source should be clearly explained in an appraisal report. When employing third party measurements, serious consideration should be given to the reliability of this source. Spot checks of some key areas or dimensions cited in the third party source may help to establish a comfort level in relying on these numbers or may indicate a need to independently verify all measurements. Furthermore, when employing measurements made by other parties, a consistency of measurement standard should be ensured. The basis for measuring the subject property, whether it be an AIC, CREA, BOMA, or other such standard, should also be the basis employed for the comparable sales to ensure consistency in the units of comparison or value indications applied to the subject. If plans have been employed, either for existing or proposed developments, the date, drawing number, or other identifying characteristics should be identified.

MEASURING DEVICES

The most commonly used device is the tape measure, which is available in a wide variety of lengths and materials suitable for most applications. When using a tape, the appraiser must be careful to avoid inaccurate measurements resulting from running the tape around obstacles. A small amount of patience and planning can help in determining a method for measuring an awkward area with an acceptable degree of accuracy. Enlisting the help of the client, property manager, or other person on site can facilitate the process, but be alert to the fact that such an assistant may not be as diligent as you when it comes to placing the end of the tape or reading out measurements. The use of measuring wheels presents problems arising from irregular surfaces and/or not running the wheel in a consistent straight line. However, such a device can be of assistance when unusual angles or unavoidable obstacles are encountered in the measurement process. Electronic measuring devices are also employed in some circumstances and an accuracy in the order of 99.5% is reported, but caution must be employed when relying on these readings, particularly when a device is being used for the first few times. Comparative measurements by measuring tape and an electronic device can assist in determining the suitability of the device for a given size or type of measurement. The appraiser should be aware of the typical method of measurement for a given class of property in a given market area. When using methods that differ from the local industry standard, this fact should be identified and, where they are known, tolerances can be noted.

INDUSTRY STANDARDS

There are a number of organizations that have promulgated measurement standards for various classes of real estate in various regional, national, and international markets. These include CREA, which has guidelines for measuring 11 basic types of residential buildings, as well as condominiums and 4 categories of commercial space, and BOMA, which has guidelines primarily oriented to office space, which is the standard for office space leases in most areas. The Appraisal Institute of Canada has published residential and commercial measurement guidelines, which would be employed by members and other real estate professionals in the absence of an overriding standard. Local real estate boards may employ variations on the theme and individual developments may have measurement standards that are unique to that project. An appraiser's library would be incomplete without copies of the measurement standards for the classes of properties being appraised in a given market area. The appraiser should be aware of the local measurement standard for a given class of property and the standard (or any deviation from it) could be cited in the report to ensure clarity and consistency. The presence of such information could also assist in determining any reasons for variations in numbers cited in other reports or published information on that property.

APPENDIX 20.2, *continued*

Measurement Practices Bulletin CP-15

LAND MEASUREMENTS

The foregoing discussion has dealt with measuring buildings and other improvements, but many of the same principles apply to measurements involving land. This may include verification of areas, dimensions, setbacks, parking areas, or other considerations. Although the scale is typically larger, accuracy and reliability of information are no less important. Current legal descriptions and site plans prepared by professional surveyors typically form the benchmark for land-related measurements.

SKETCHES

The inclusion of sketches (or copies of relevant building and site plans) in all appraisal reports serves to enhance the clarity of the report as well as to assist the reader in visualizing the subject and understanding any measurement-related discussion in the report. As with a picture, a sketch can do more in explaining the subject property than can pages of narrative. Therefore, a neat sketch citing sources and other relevant information can effectively save time in the preparation of a report that can be clearly understood.

CONCLUSIONS

As with most aspects of appraisal reporting, the emphasis for measuring is on accuracy, with strong consideration towards clarity and consistency. Therefore it is vital that a maximum degree of accuracy be ensured when taking measurements, and that the reliability of third party measurement sources be determined to a reasonable degree of certainty.

Additionally, identifying sources and standards applied will assist users of a report in understanding and interpreting the contents, while consistent application of these standards (to a subject and comparables) will ensure consistency in the interpretation of size-based units of comparison, thereby enhancing the reliability of a resulting value conclusion.