Fire and Life Safety Fundamentals Guide

BC HOUSING
RESEARCH CENTRE

Acknowledgements

This guide was funded and commissioned by BC Housing and was prepared by Senez Consulting Ltd.

Acknowledgement is extended to all those who participated in this project as part of the project team or as external reviewers.

BC HOUSING
RESEARCH CENTRE

Visit BC Housing's Research Centre at www.bchousing.org to find the latest workshops, research and publications on building and operating affordable, sustainable housing.

Main entry under title:
Fire and Life Safety Fundamentals Guide
ISBN 978-0-7726-8036-5

BC Housing
1701 - 4555 Kingsway
Burnaby, British Columbia
V5H 4V8 Canada

To purchase printed copies of this guide, order online at crownpub.bc.ca
Product/Materials No: 7630002084
For more information contact:
Crown Publications, Queen's Printer
Toll Free: 1-800-663-6105
Email: crownpub@gov.bc.ca

BRITISH COLUMBIA
QUEEN'S PRINTER
PUBLISHING SERVICES
A BRANCH of SHARED SERVICES BC

Contents

Executive Summary

This guide has been developed to provide building authorities, designers, architects, engineers and building code consultants (Stakeholders) with an understanding of some of the key fundamental concepts underlying the fire and life safety requirements of the BC Building Code. The traditional BC Housing guide provides detailed guidance on compliance with specific Building Code requirements, but typically where the fundamental concepts underlying those requirements are well understood.

Where the fundamental concepts underlying Building Code Requirements are not well understood, as is the case for many of the fire and life safety requirements, their practical application is challenging and can result in misinterpretation and misapplication. Therefore, this guide is intended to address the fundamental concepts for fire and life safety, and form the basis upon which more practical guidelines can eventually be developed.

Building Code fire and life safety requirements have been developed to limit the negative impact of fire on people and property, and have been developed upon basic fire behaviour concepts associated with fire initiation, growth and spread. The high-level objective of the fire and life safety requirements is to contain fire and smoke while facilitating egress and emergency response. However, the prescriptive nature of the fire and life safety requirements and their long history of development complicates their application to specific building designs.

This guide specifically addresses the following key concepts and how they relate to the development of the fire and life safety requirements of the BC Building Code:

- **Fire and Life Safety Risk Quantification:** occupancy classification, major and subsidiary occupancy differentiation, prohibited combinations and major occupancy separation.
- **Fire Containment:** building size, fire separations, fire-resistance rating, continuity, concealed spaces, suite (and similar) separations, protection of egress facilities.
- **External Fire Spread:** concepts and definitions to quantify degree of exposure, determination of appropriate separation, exterior wall construction.

The fire and life safety risk of a building is directly linked to the use of the building and is measured in terms of potential fire development and occupant egress, awareness and ability to evacuate respectively. The growth and spread of fire associated with occupancy has been addressed by fire compartmentation intended to contain fire to burn-out. Where construction is not sufficient to contain a fire to burn-out, the building size is regulated corresponding with an assumed fire department ability to limit fire spread to adjacent structures (spatial separation). Occupants' ability to egress is similarly addressed through the provision of fire compartmentation to protect occupants from the effects of fire for a period of time corresponding with their awareness of their surroundings and ability to egress.

1 | Introduction

This guide addresses the foundational concepts upon which the fire and life safety requirements of the British Columbia Building Code (BCBC) have been developed, and responds to Stakeholder concerns in applying these requirements with limited guidance on their origins and intent.

The scope of subject matter underlying the fundamentals of the fire and life safety requirements of the BCBC is significant and requires a great deal of effort to adequately cover all aspects of the subject matter. Therefore, this guide focusses on basic concepts and definitions that underly the detailed application of the BCBC, and in this regard is not a traditional practical designer/builder guidance document. It does however provide the foundational information necessary to facilitate the appropriate application of the fire and life safety requirements, and the basis upon which more practical guidelines can be developed.

The objective of the fire and life safety requirements is to limit the probability of the occurrence, growth and spread of fire and its impact on life and property. These requirements have been developed based on the fundamentals of heat transfer, compartment fire dynamics and external fire spread. An understanding of these fundamentals is important to applying the requirements.

This guide introduces these fundamentals and their significance in the history of the development of these concepts to represent and lessen fire risk. These concepts are implicit to the fire and life safety requirements and embodied in the defined terms upon which these requirements are based. Therefore, the focus of this guide is an examination of key fire and life safety requirements and associated defined terms of the BCBC with respect to the fundamental concepts and facilitate a broader understanding of their application.

This guide specifically examines the fundamental concepts associated with the following key fire and life safety requirements and associated definitions:

- **Building Characteristics:** explanation of the terms that describe building characteristics enabling the application of fire and life safety requirements.
- **Occupancy Classification:** quantification of the fire and life safety risks as a function of the use of a building.
- **Fire Compartmentation:** explanation of the degree of compartmentation required to limit fire spread or protect occupants from fire as a function of the fire risk (occupancy).
- **Spatial Separation:** explanation of the concepts intended to limit the spread of fire from one building to another over a distance.

This guide references rulings by the British Columbia Building Code Appeal Board (BCAB), accepting that these rulings are specific to each matter at hand, to illustrate the interpretation of defined terms and application of requirements in complex matters respecting the fundamental concepts underlying the BCBC.

2 | Fundamentals

The following sections of this guide provide information foundational to the development of the Building Codes we use today.

2.1 A Short History of the National Building Code of Canada

The British North America Act (previously the Constitution Act) delegates the responsibility of building regulation to the provinces and territories in Canada. The Province of British Columbia (BC) currently enacts building regulations through the Building Act, which grants municipalities and regional districts the authority to enforce these building regulations. The City of Vancouver has its own Charter, which grants the City different powers than other communities under the Building Act, such as building regulation.

The British Columbia Building Code, under the responsibility of the Building and Safety Standards Branch and Vancouver Building By-law (under the responsibility of the City of Vancouver), are substantially based on the National Building Code of Canada (NBCC), which is Canada's model building code.

The first National Building Code of Canada was published in 1941. This first model code was substantially based on model codes developed in the United States, which had a 20-year lead time on the Canadian efforts.

An Associate Committee on the National Building Code of Canada was formed by the National Research Council of Canada in 1948 to continue the work of the Administrative Committee that had developed the 1941 NBCC. The 1953 NBCC was issued in 1954, and was a complete overhaul of the 1941 Code in terms of arrangement and scientific principles underlying the fire and life safety requirements.

The third edition of the NBCC was published in 1960 and subsequent editions were published every five years. The exceptions to the five-year cycle are an edition published in 1977 incorporating metric conversions of previous imperial values and the move to objective-based format in 2005. The 2005 NBCC necessitated a ten-year cycle due to the amount of work required to develop the new format.

The fire and life safety principles of the NBC have remained relatively unchanged from the 1960 NBCC to today; however, the Code provisions have evolved incrementally in reaction to events of significance to building design, and advances in knowledge.

The 2015 NBCC is the current version of the national model code, upon which the current edition (2018) of the BCBC is substantially based. The 2018 BCBC is composed of three divisions [1]:

- **Division A:** defines the scope of the 2018 BCBC and presents the objectives that the Code addresses and the functions the building must perform to help to satisfy those objectives.
- **Division B:** contains the acceptable solutions of the Code in 10 parts, deemed to achieve the objectives included in Division A.
- **Division C:** contains administrative provisions relating to the application of the Code.

As noted earlier, this guide is specific to the fundamentals of the fire and life safety requirements of the Code which are located in Part 3, "Fire Protection, Occupant Safety and Accessibility" and Section 9.10., "Fire Protection". The differences between Part 3 and Part 9 of the Code will be discussed in more detail in **Section 3.4** of this guide.

2.2 Fire Dynamics Fundamentals

Building code requirements have been developed to limit the negative impact of fire on people and property and have been founded upon basic fire dynamics concepts associated with fire initiation, growth and spread. At a high level, the objective of the fire and life safety requirements is to contain fire and smoke while facilitating egress and emergency response[1]. The following sections of this guide introduce some of these fire dynamics concepts[2].

2.2.1 Heat Transfer

An understanding of modes of heat transfer is important to the fire dynamics, and the growth and spread of fire in compartments.

Heat transfer occurs through three modes:

Conductive heat transfer occurs through a stationary material or from one material to another by direct contact. An example of conduction is heat transferred from a stove heating element to a pot.

Convective heat transfer occurs through the bulk movement of a material or between materials. An example of convective heat transfer is the heating of water in a pot on a heating element.

Radiative heat transfer occurs without material contact over a distance through electromagnetic waves. An example of radiative heat transfer is the heat you feel from the sun, or while sitting a distance from a fire.

The different modes of heat transfer (see **Figure 1**) play an important part in the ignition, growth and spread of fire, which will be discussed in more detail in the following sections of this guide.

---

[1] See the Objectives and Functional Statements in Parts 2 and 3 of Division A of the 2018 BCBC.

[2] A more detailed explanation of these concepts can be found in the following:
a) Drysdale, Dougal. An Introduction to Fire Dynamics. 3rd ed. Hoboken, N.J: Wiley, 2011.
b) Karlsson, Björn., and James G. Quintiere. Enclosure Fire Dynamics. Boca Raton, FL: CRC Press, 2000. Print.

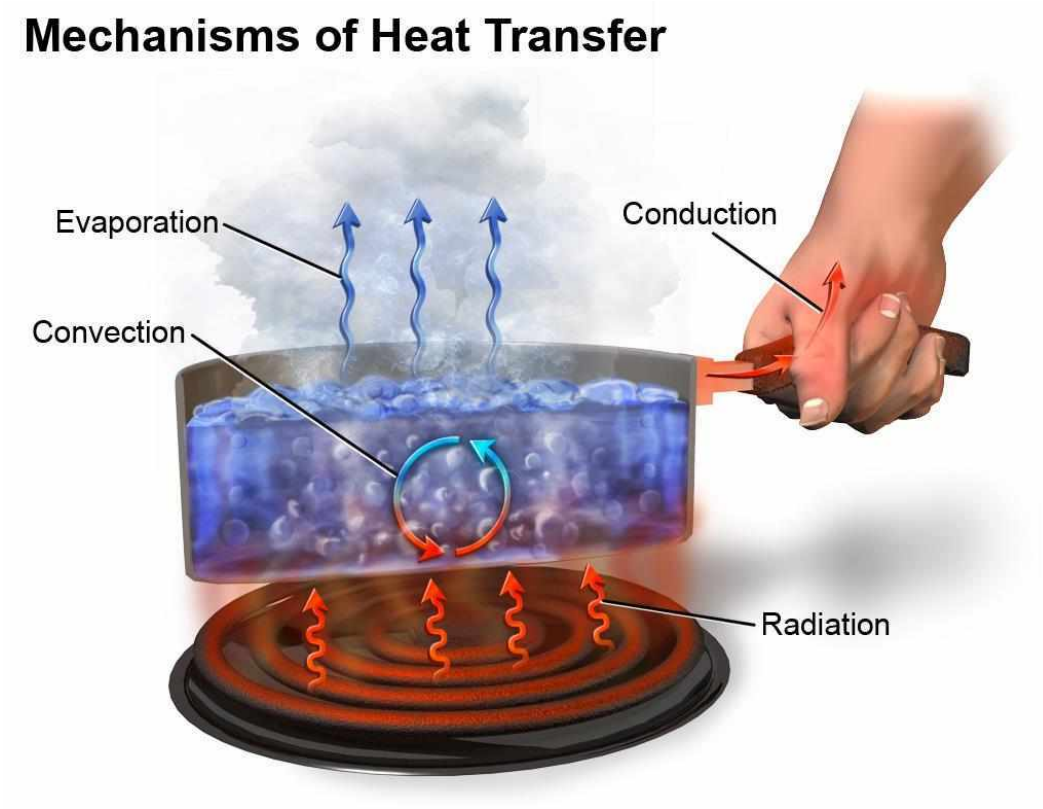


Figure 1: Heat transfer

2.2.2 Compartment Fires

A fire that develops in a room is considered a compartment fire. Compartment[3] fires develop through stages of increasing severity from ignition to full room involvement. The role of fire and safety requirements in building codes is to limit fire from occurring and transiting through these stages, which are described in more detail in the following sections of this guide.

2.2.2.1 Ignition

Ignition occurs where sufficient heat is transferred to a fuel source in the presence of adequate oxygen, represented by the fire triangle[4] shown in **Figure 2**. Elimination of any one of these three components will limit ignition from occurring. Oxygen is an important element for life safety, and therefore difficult to control in a building. However, ignition is commonly mitigated by limiting the exposure of combustible material to heat exposure. The heat exposure could be any one of the modes identified in **Section 2.2.1** of this guide.

[3] Fire compartment is a defined term in the BCBC, which will be discussed in more detail in Section 5 | of this Guide.

[4] A fourth dimension is sometimes added to the fire triangle, called the fire tetrahedron and represents unimpeded chemical reaction.

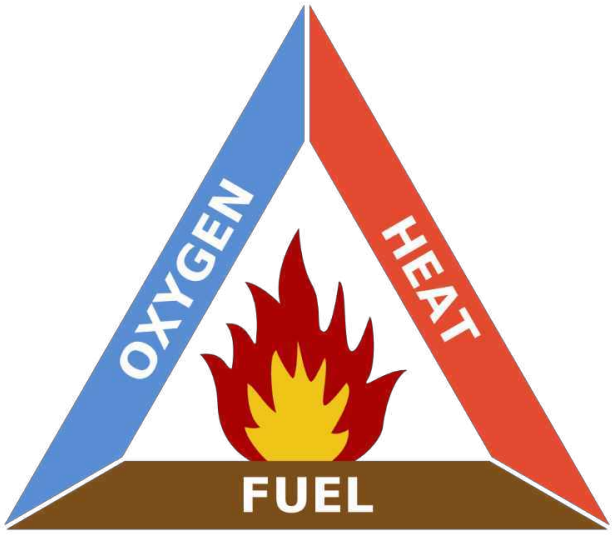


Figure 2: The fire triangle.

2.2.2.2 Fire Growth and Spread (Localized Burning)

Fire growth occurs through the continued provision of oxygen, heat feedback from flames and availability of combustible fuel (fire load). Early fire growth is localized involving the material first ignited but can spread to other combustible materials located in close proximity, primarily through convective heat transfer (see **Figure 3**). Combustible lining materials can exacerbate this fire spread.

Early fire growth and spread can be mitigated by limiting combustible materials (more specifically combustible interior finish) and provision of suppression (such as sprinklers). Fire growth can also be mitigated by limiting ventilation (low oxygen supply). However, as noted above for ignition, limiting oxygen can have an impact on life safety.

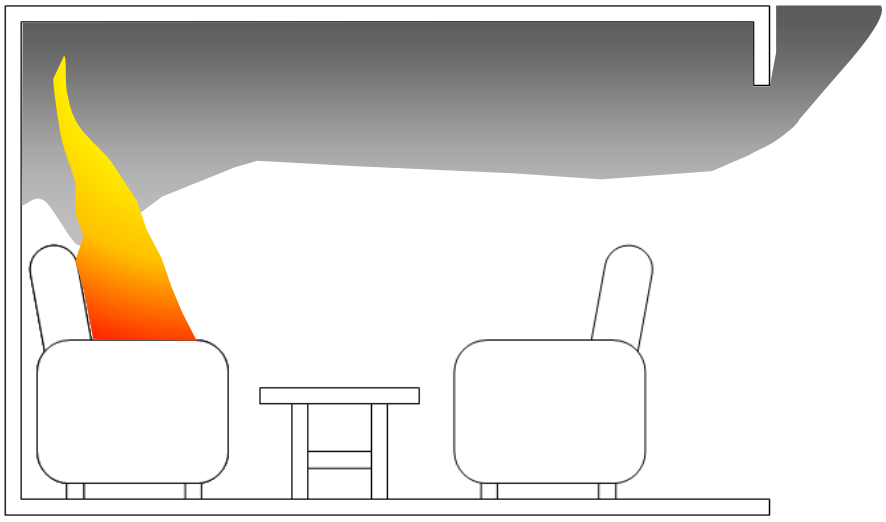


Figure 3: Localized fire growth.

As fire grows and spreads it can become constrained by compartment boundaries, resulting in the elongation of flames and development of a hot upper layer, which can be exacerbated by combustible compartment linings. The hot upper layer radiates heat to other combustible materials within the compartment, which can result in flashover.

2.2.2.3 Flashover

Flashover is a transition from localized burning to full room involvement and occurs where the heat radiated from the hot upper layer causes the progressive ignition of all combustibles within a compartment (see **Figure 4**). Thus, flashover is primarily driven by radiant heat transfer. The transition through flashover requires sufficiently distributed fuel load and adequate ventilation to progress to full room involvement in fire. Once flashover has occurred, a compartment is not survivable. The transition through flashover is intended to be limited from occurring by the provision of sprinklers. Where sprinklers are not provided or are not effective, a fire may transition through flashover to fully involve the burning of all combustibles in a room.

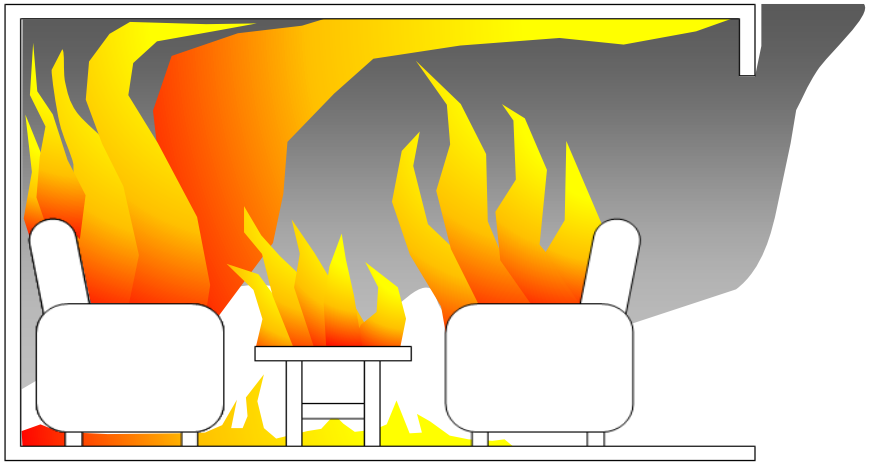


Figure 4: Flashover.

2.2.2.4 Full Room Involvement

Full room involvement is the near-steady and continued burning of all combustibles within a compartment until substantial depletion of those combustible materials has occurred (see **Figure 5**). Full room involvement is characterized by high temperature relatively uniform within the compartment and flame extension out of compartment openings. As noted in the previous section, where sprinklers are not provided or are not successful in limiting flashover, full room involvement is controlled through containment to limit fire spread to other compartments.

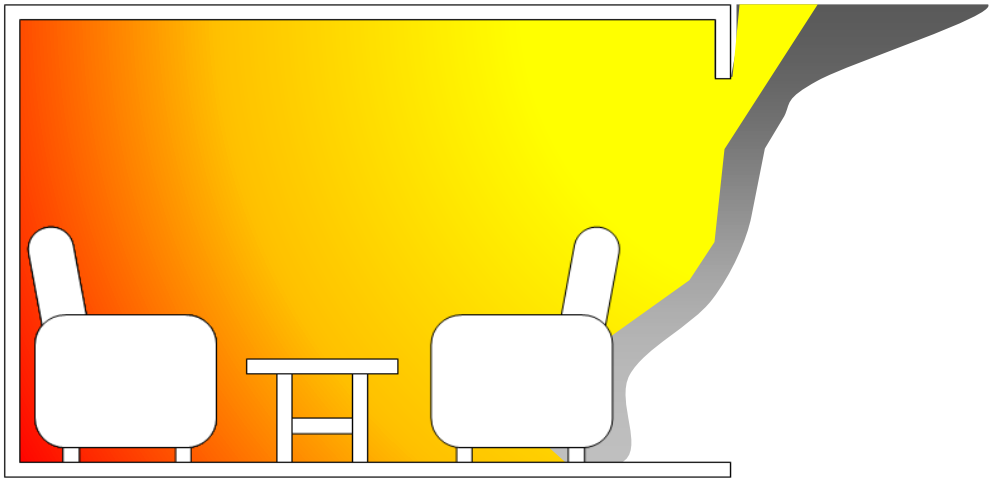


Figure 5: Full room involvement.

2.2.2.5 Decay

Compartment fire decay typically occurs when approximately 80% of the combustibles within the compartment have been consumed. This will result in a reduction in compartment temperature.

2.3 Building Code Fundamentals

Building codes are often specific requirements that respond to a specific risk or circumstance, such as a historical fire event. As time goes on, the specifics get lost, and we just have the words of the code. We then have to apply the words, without the original context and specifics, and it doesn't always make sense. Thisleads to interpretation/misinterpretation.

The fundamental conditions upon which the fire and life safety requirements of the Building Code have been based are specific to limiting the impact of fire through building design and construction.

2.3.1 Fire and Life Safety Risk

Fires have plagued cities for millennia, resulting in significant loss of life and damage due to uncontrolled growth and spread. Building regulations were developed to limit these fires from occurring and spreading, and often followed incidents of significant scale or impact that drew attention to specific city planning and building design issues. Investigation and analysis followed such events, to establish the conditions that led to the incident (exposure/risk), and solutions were developed to limit the occurrence or impact of such events in the future. These solutions were based on contemporaneous contemporary knowledge, capability (primarily related to the fire service), materials and methods, which were distilled to a concise written regulatory format resulting in the existing requirements in the Code of today ("acceptable solutions").

As noted in **Section 2.1** of this guide, the NBCC was substantially updated in the 2005 edition to improve clarity of the requirements, reduce complexity and be more responsive to innovation. The updated "objective-based" format was developed through a bottom-up analysis of the existing requirements to define high level, qualitative code objectives attributed to the legacy "acceptable solution" requirements. In addition to the objectives, functional and intent statements were developed to describe the conditions in the building that help satisfy the objectives, and what each acceptable solution requirement is intended to achieve.

While the reduction of risk has been implicit to the application of the Code requirements to building design/construction, the term "risk" was purposely introduced as a fundamental concept to the application of the Code in the objective-based format. The preface of the NBCC notes the following [2]:

> *The wording of most of the definitions of the objectives includes two key phrases: "limit the probability" and "unacceptable risk." The phrase "limit the probability" is used to acknowledge that the NBC cannot entirely prevent those undesirable situations from happening. The phrase "unacceptable risk" acknowledges that the NBC cannot eliminate all risk: the "acceptable risk" is the risk remaining once compliance with the Code has been achieved.*

The specific fire and life safety risks the Code intends to limit are embodied in the Objectives. Specifically, the objectives of the Code with respect to fire and life safety (corresponding stages of compartment fire development in brackets) are intended to limit the probability of [1,2]:

- fire or explosion occurring (ignition)
- fire or explosion impacting areas beyond its point of origin (localized fire growth and spread to full room involvement)

- collapse of physical elements due to a fire or explosion (full room involvement)
- fire safety systems failing to function as expected (all stages)
- persons being delayed in or impeded from moving to a safe place during a fire emergency (all stages)
- fire or explosion impacting areas beyond the building of origin (full room involvement)

The risk of fire spread, embodied in the Objectives outlined above, has shifted over time with improved building regulations from city-level conflagrations to primarily single building or compartment incidents today. This has occurred through the incorporation of basic principles and assumptions in these regulations that are intended to characterize fire risk (occupancy classification), contain fire (fire compartmentation), and limit building-to-building spread (spatial separation) assuming some degree of firefighting intervention. These principles are discussed in more detail in the following sections of this guide.

2.3.2 Occupancy Classification

Occupancy classification is intended to quantify the fire and life safety risk associated with certain uses within a building, which has historically attributed this risk to fuel load.

Occupancy classifications have their origin in insurance grading and were developed for the purpose of quantifying the risk inherent to the use of buildings (risk profiles) [3] and were primarily based on industry experience. The insurance grading guidelines were translated into building regulations in the early 1900s, including the associated risk profiles. The insurance-based occupancy classifications were numerous and were greatly simplified for purposes of regulatory application. Early regulatory classifications included public (assembly), institutional, residential and business (commercial and industrial) buildings [4,5]. The 1941 NBCC provided additional descriptions for uses corresponding with each type of occupancy.

As noted in **Section 2.1** of this guide, the 1953 NBCC had been completely overhauled in terms of arrangement and scientific principles underlying the fire and life safety requirements. One such principle quantified the fire growth and spread risk associated with occupancies as a function of the quantity of combustible contents.

Statistical surveys of combustible content as a function of occupancy classification were conducted between the 1920s and 1940s [6]. These surveys were used to identify a fire load on a floor area basis (combustible content) for each occupancy, summarized in **Table 1** below.

Table 1: Occupancy Fuel Load Densities [7].

Major Occupancy	Fire Load (lbs/ft^2)
Group A: Assembly, Group B: Institutional, Group C: Residential, Group D: Business, Group G: Commercial and Industrial Division 3	10
Group E: Mercantile and Group G: Commercial and Industrial Division 2	20
Group F: Hazardous and Group G: Commercial and Industrial Division 1	30

The life safety considerations associated with occupancy classification have been developed qualitatively and are not as quantitative as those for fire protection. The key considerations associated with differentiating life safety risk in terms of occupancy classification are the occupants:

- familiarity of egress facilities,
- ability to respond to an incident, and

- ability to evacuate.

A summary of the key life safety considerations as a function of occupancy are detailed in **Table 2** and include the life safety significance in determining the degree of protection required to accommodate occupant characteristics.

Table 2: Key life safety factors.

Group	Description	Life Safety Considerations	Risk Significance
A	Assembly	High occupant load. Occupants assumed to have the ability to transit the egress facilities, but likely to have limited familiarity with those facilities.	Medium
B	Institutional	Occupants may be restrained or unconscious and assumed to be significantly limited from transiting egress facilities.	High
C	Residential	Occupants may be asleep but assumed to be fully familiar with egress facilities.	Medium
D	Office	Occupants assumed to be aware, awake and fully familiar with the egress facilities.	Low
E	Retail	Occupants assumed to be aware, awake and have some familiarity with egress facilities.	Low
F	Industrial	Occupants assumed to be aware, awake and fully familiar with the egress facilities.	Low

The fire load values and life safety significance for the major occupancies were used to determine appropriate containment measures discussed in more detail in the following section of this guide.

2.3.3 Fire Compartmentation

Fire compartmentation is intended to limit the spread of fire once it has transitioned to full room involvement, as discussed in **Section 2.2.2** of this guide.

Fire compartmentation is composed of barriers intended to limit the spread of fire beyond the compartment of origin. The performance of these barriers is based on standard testing having its origins in the late 1800s and formalized as an ASTM test standard in 1918 [8]. The test involves exposing a barrier to increasingly severe fire exposure represented by a prescribed time-temperature curve. The original time-temperature curve from the 1918 ASTM Standard is included in **Figure 6** below. The corresponding standard used in the BCBC today is CAN/ULC-S101, “Standard Methods of Fire Endurance Tests of Building Construction and Materials,” which has the same time-temperature curve as the 1918 ASTM test.

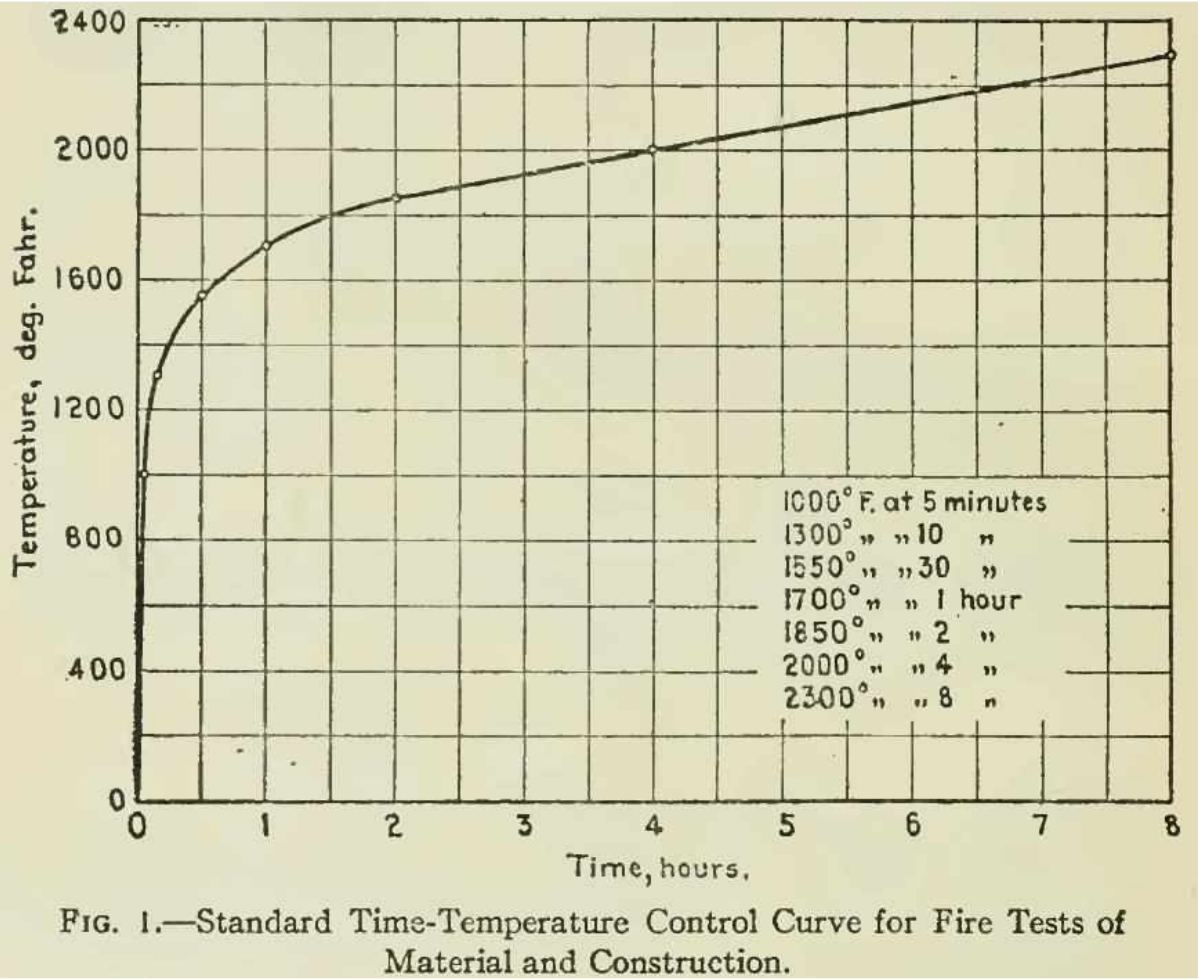


Figure 6: Time-temperature curve from 1918 ASTM C-19 [8].

The performance of the barrier is considered successful if it withstands fire exposure for a certain period of time without passage of flame or gases hot enough to ignite combustibles [9].

The period of time of exposure is based on the "burn-out" concept developed by Ingberg [10] in the 1920s to correlate the fire risk associated with combustible building contents to barrier fire performance. Ingberg conducted numerous complete burn-out fire tests of varying fire load quantities, and correlated the results of those tests with the standard time-temperature curve. Ingberg's results are summarized in **Table 3** below.

Table 3: Complete Burn-out Correlation Results [7].

Fire Load (lbs/ft^2)	Equivalent Fire Endurance Test Time (hr:min)
10	1:00
20	2:00
30	3:00

These values were used in the development of the 1953 NBCC fire compartment requirements such that appropriate fire barriers could be provided to contain a fire resulting from the fire load attributed to certain

major occupancies (See **Table 1** in **Section 2.3.2** of this guide). The resulting fire barrier requirements as a function of major occupancy are summarized in **Table 4**.

Table 4: Minimum Fire Resistance of Construction for Major Occupancies [7].

Major Occupancy	Fire Load (lbs/ft^2)	Minimum Fire Resistance of Construction
Group A: Assembly, Group B: Institutional, Group C: Residential, Group D: Business, Group G: Commercial and Industrial Division 3	10	1-hour
Group E: Mercantile and Group G: Commercial and Industrial Division 2	20	2-hours
Group F: Hazardous and Group G: Commercial and Industrial Division 1	30	3-hours

The degree of fire protection that has historically been associated with life safety is summarized here:

Table 5: Life safety fire protection

Group	Description	Significance	Minimum Fire Resistance of Construction
A	Assembly	Medium	1-hour
B	Institutional	High	2-hour
C (B3)	Residential (Care)	Medium	1-hour
D	Office	Low	3/4-hour
E	Retail	Low	3/4-hour
F	Industrial	Low	3/4-hour

The fire compartmentation fundamentals outlined above form the basis of the major occupancy separations and the construction requirements in the 2018 BCBC.

2.3.4 Type of Construction and Building Size Limits

Similar to occupancy classification, as far back as the mid-1800s, insurance companies differentiated fire hazard as a function of type of construction and characterized buildings as either fireproof or non-fireproof. Fireproof was characterized by building materials such as stone, plaster, brick, metal and glass that are implicitly noncombustible. Non-fireproof included combustible building materials such as wood. The combustible materials in non-fireproof buildings were considered to contribute to the growth and spread of fire, which at that time could result in conflagrations in densely built city districts.

The original two construction types evolved into a broader range of construction types recognizing a gradient of fire performance within those types of construction that better aligned with construction practices in the 1940s and 1950s. The new range of construction types, summarized below, could still be dichotomized into combustible and noncombustible types [6]:

1. **Fully Protected:** This type of construction was both noncombustible and with a fire-resistance more than sufficient to allow for complete burn-out as a function of the building occupancy, and typically included masonry, reinforced concrete and protected steel.
2. **Protected:** This type of construction was noncombustible with a lesser degree of fire-resistance than provided for fully protected construction, and also typically included masonry, reinforced concrete and protected steel.
3. **Heavy Timber:** This type of construction typically included noncombustible exterior walls (masonry or reinforced concrete) with interior heavy timber framing having inherent fire-resistive properties due to the large wood member sizes.
4. **Masonry Wall and Joist:** This type of construction is similar to heavy timber with masonry wall exterior construction, but with wood frame interior construction (or unprotected metal) not as dimensionally substantial as heavy timber.
5. **Wood Frame:** This type of construction included structural parts and materials of wood dependent upon a wood frame for support, including construction having a combustible exterior cladding.
6. **Unprotected Metal:** This type of construction is that in which the imposed loads are carried by an unprotected metal frame and in which the exterior walls and roof are of sheet metal or other noncombustible material.

The assumption at the time with fire development in buildings, was that combustible building elements would contribute to the growth and development of fire, regardless of any protection that may be provided to those elements. This was highlighted in the same study from which the occupancy fuel loads were derived [REF], and noted the following relative to the fire-resistance of structural elements [6]:

> *Whereas buildings of the Fireproof type can be constructed to have a high degree of fire resistance, that of the other types is necessarily limited from the standpoint of practicability with the types of materials available.*

This implies that there were no practical means (at that time) to adequately protect combustible construction from becoming involved in fire. Therefore, it was assumed that buildings constructed of primarily combustible materials or "unprotected metal" could not contain a fire (contain burn-out), and would become completely involved in fire. This then assumes, due to potential structural failure, that a fire department response would primarily be external. Contrary to this, the consideration relative to fully protected construction at the time was as follows [6]:

> *Assuming that Fireproof buildings are designed to withstand a complete burning-out of contents and combustible trim without collapse, there should in effect be no limitations imposed on the score of degree of fire resistance other than in its relation to the expected fire severity for the given building.*

This assumes, due to fire protected structural elements, that a fire department response could primarily be internal.

Therefore, building height and area for buildings of protected-type construction was generally not limited assuming inherent control over ultimate fire size through containing burn-out, and that a responding fire service could reach and address the fire from the interior. Building height and area was limited for combustible-type construction assuming burn-out would not be contained, resulting in full building involvement, as no appropriate material or assembly was available at the time to provide adequate protection to limit the involvement of combustible building components in fire. Thus, fire department response for a fully involved building would be from the exterior, and building size and the associated ultimate fire size, would need to align with fire service capability (at that time).

The types of construction were simplified into the combustible and noncombustible types in the Code today, and retained the underlying assumptions associated with building size limits.

2.3.5 Spatial Separation

Conflagrations were the driving force in the development of early building regulations following disastrous city-wide conflagrations in Rome in 64 AD, London in 1189 and 1666, Canada and the US in the late 1800s. These fires were characterized by significant building-to-building fire spread primarily driven by radiant heat transfer and ignition by brand spotting (airborne embers). Early regulations required division of a city into “fire limits” and exterior wall construction in certain areas to be of substantial noncombustible construction and firewalls to separate adjoining buildings. However, these regulations impeded development and were difficult to enforce and maintain.

Figure 7: St. Lawrence Burn No. 5.

Joint efforts by the UK and Canada in the 1950s, supported by large-scale fire testing, facilitated the development of regulations for the separation of buildings based on the fundamentals of radiant heat transfer. One key test programme was conducted in 1958 in Aultsville, Ontario in a town being flooded as part of the St. Lawrence Seaway Project [11]. The “St. Lawrence” burns involved 6 residential dwellings and two larger assembly occupancies. The results from one burn in particular (Burn No. 5 shown in **Figure 7**) were used to develop the spatial separation requirements in the NBCC. Even though these requirements have changed, the principles remain the same.

The spatial separation requirements are based on the following test data, observations and associated assumptions from the St. Lawrence burns [11,12,13,14]:

1. **Fire Department Intervention:** The radiant heat results from later in the fires in St. Lawrence burn tests resulted in "safe" distances that were considered impractical. Therefore, it was assumed that fire department response would occur within the first 10-16 minutes from the start of the fire, and limit the high radiant heat measured during the tests. Thus, lower emissive energy values could be used (See Item 2 below).
2. **Emissive Energy:** The radiant heat was measured at several locations away from the burns and back calculated as a function of configuration factor (relative location of the recording locations to the fire source) to determine the emissive energy, which is the energy being emitted from each opening in the dwelling. The emissive energy was calculated to be 178 kW/m^2 for low hazard occupancies, and 356 kW/m^2 for high hazard occupancies.
3. **Grey Radiator:** The formula for determining the amount of energy leaving the openings in a building (fire compartment) face and reaching a target was considered to be too complicated to be calculated for each opening. To address this, the spatial separation requirements were based on the assumption of the entire building (fire compartment) face as the radiating source. The actual openings were based on a percentage of the area of the building (fire compartment) face. Thus, the emissive energy is assumed to be emitted from the entire building (fire compartment) face as opposed to the individual openings. This assumption breaks down where building faces are located in close proximity and is the reason why localized clusters of openings are regulated for limiting distances of 2 m or less.
4. **Flame Front:** Within the early stages of the St. Lawrence burns, the flames were observed to extent approximately 5 to 7 feet from the openings in the buildings. This range was simplified to 6 feet (1.8288 m) for purposes of determining the "absolute" distance between the flame front and a neighbouring building.
5. **Target Criteria:** It was assumed at the time of development of the spatial separation requirements, that the predominant combustible building material would be wood, which has a piloted[5] ignition heat flux of 12.5 kW/m^2. Note that this value can be considered as a quantitative performance criteria that can be used in the development of an alternative solution.
6. **Mirror Boundary Condition:** The actual "absolute" distance between buildings is not practical for purposes of regulation. Therefore, it was assumed that "the exposing building faces of adjacent buildings are of similar size and configuration, and are equidistant from the shared property line" [Explanatory note to Subsection 3.2.3.]. This assumptions allowed the characterization of the "limiting distance", which is approximately half of the "absolute" distance required between buildings and could be applied such that the design and construction of a building on one property does not affect the design and construction of a building on an adjacent property.

The test data, observations, and associated assumptions above were used to determine the spatial separation tables in the 2018 BCBC.

[5] Requires an ignition source such as an open flame or burning ember.

2.3.6 Firefighting Intervention

Several key requirements in the 2018 BCBC such as building size and spatial separation (as outlined in previous sections of this guide) assume firefighting capability will be available in the event of a fire[6]. However, the extent to which firefighting capability has been considered in the development of the Code has not been defined quantitatively for any particular Code requirement, with the exception of the spatial separation requirements[7].

As discussed in **Section 2.3.4** of this guide, building size has been limited as a function of type of construction, assumed extent of fire spread and fire service capability to fight such a fire. More specifically, the following has been assumed:

- **Combustible Construction:** Fire is assumed to spread to involve the entire building and a responding fire service will be required to fight the fire from the exterior of the building. Therefore, building height is limited corresponding to fire service capability (i.e., hose stream reach) to fight a fire from the exterior.
- **Noncombustible Construction:** Where the floor assembly fire-resistance rating corresponds to that required for burn-out, fire is assumed to be contained to the storey of fire origin and a responding fire service can enter the building, move near the fire floor and utilize the fixed fire protection services such as standpipes and hose reels. Therefore, building height is not necessarily limited for buildings of noncombustible construction with appropriately fire-rated floor assemblies.

The assumptions above are supported by the 1953 NBCC with respect to both fire-resistance of fire separations and types of construction. More specifically, the 1953 NBCC provided the following guidance information [7]:

> *Because the potential fire severity of occupancies vary, and because of the limitations of fire resistance in some types of construction, four grades of separation of varying fire-resistance have been set up. The grade of separation required for complete containment of fire in any one storey is dependent on the degree of the fire hazard of the occupancy. It is not always practical to require complete containment under burn-out conditions. In many circumstances the fire is contained for a limited time consistent with the capabilities of the type of construction. In these cases the heights and areas are limited to dimensions that facilitate fire fighting by outside forces.*

[6] See the explanatory note to Part 3 of the 2018 BCBC

[7] Sentences 3.2.3.1.(8), 9.10.14.3.(1) and 9.10.15.3.(1) requiring a 10-minute response time 90% of the time.

3 | What is a Building?

By nature of its title, a building code is intended to apply to buildings. This makes it important to define the term 'building' such that those who use a building code know to what it applies, and how to apply it. This is clarified in Article 1.1.1.1. of Division A of the 2018 BCBC, which identifies what the Code does and does not apply to. However, Article 1.1.1.1. only clarifies the application of the Code with respect to activities associated with a 'building', and not the term itself.

3.1 Definition of "Building"

Sentence 1.4.1.2.(1) of the 2018 BCBC defines a building to mean:

> *any structure used or intended for supporting or sheltering any use or occupancy.*

The Code does not define the term 'structure', but occupancy is defined to mean:

> *the use or intended use of a building or part thereof for the shelter or support of persons, animals or property.*

The 1941 NBCC did not define the term 'building' but defined structure to mean "a building or construction of any kind," and included an interpretation that[8]:

> *the provisions of this Code shall also apply to structures other than buildings and the term "buildings" shall be understood to include such other structures.*

The 1953 NBCC provided a definition of the term building to mean[9] "any structure used or intended for supporting or sheltering any use or occupancy as set forth in this By-law," but did not define the meaning of the term 'structure'. The 1970 NBCC editorially revised the definition of building to mean "any structure used or intended for supporting or sheltering any use or occupancy," which corresponds with the current definition.

The definition for 'building' is purposely vague to be broadly applicable to structures that are clearly buildings, and those that may not normally be considered a building but may be a danger to the public. Some delineation is provided in the 2018 BCFC distinguishes between a building and facilities by noting that [Explanatory Note to Sentence 1.1.1.1.(1)]:

> *the term "facilities" is used in its broadest sense to include all premises that are not included in the definition of "building" in this Code, such as outdoor and underground areas, structures and equipment. Such "facilities" are often associated with storage, distribution and manufacturing activities.*

This explanatory note suggests that some structures are not considered to be buildings. Additional examples are provided in the Guide to Part 3 of the 1995 NBCC [15], which notes that a transmission tower, service tunnel, pedestrian bridge, walkway, dam or retaining wall may not be considered a building.

A Technical Note prepared by the NRC Associate Committee on the National Building Code [16] on the subject of "What Constitutes a Building?" reviewed a Tariff Board ruling relative to sales tax on steel used in an addition to an existing stadium that involved an extension of a grandstand seating area. Sales tax was required to be applied to "structural steel for buildings" and the Tariff Board was tasked with determining whether the

[8] Article 1.1.2 of the 1941 NBCC

[9] Section 1.9 of the 1953 NBCC, "Interpretation of Words and Phrases"

grandstand addition is a building. The Tariff Board's decision noted that [16] the building addition provided a roof and enclosed portions to shelter human beings and therefore is considered a "building".

NRC's review of this decision provides some additional insight into the intent of defining "building" relative to the application of the Code [16] and specifically notes that the Tariff Board did not consider a building to be enclosed. This was considered important to occupancies such as lumber yards or open parking garages. As a result, the philosophy relative to the definition of "building" in the 1953 NBCC was as follows [16]:

a) any construction is required to conform to the National Building Code,

b) construction is required to shield the occupants from the natural climatic and earthquake forces,

c) construction is required to shield neighbouring properties and the community in general from hazards created by an individual owner, and

d) other than for (b) and (c) no construction is required to be built.

Similar interpretations have been made by the BCAB in the following rulings:

- BCAB #1335 - Definition of Building, Water Storage Reservoir, Article 1.1.3
- BCAB #1418 - Definition of "Building", Covered Storage Bins, Article 1.1.3.2
- BCAB #1455 - Definition of Building, Drywall Storage Facility, Article 1.1.3.2
- BCAB #1640 - Article 1.1.3.2. Definition of Building ("umbrella" structure) Sentence 4.1.1.3
- BCAB #1717 - Guard on Retaining Wall, Sentence 9.8.8.1
- BCAB #1751 - Run-of-River Hydro Electric Facility, Clause 1.1.1.1.(2)(d) of Division A

The term "building" is used by the Code to define the "unit of control" upon which the application of regulations is delineated, and assumes adequate separation of adjacent buildings either spatially or by means of a firewall which is defined to mean [1]:

> *a type of fire separation of noncombustible construction that subdivides a building or separates adjoining buildings to resist the spread of fire and that has a fire-resistance rating as prescribed in this Code and has structural stability to remain intact under fire conditions for the required fire-rated time.*

The fire and life safety hazard associated with buildings is further characterized as a function of height and area.

3.2 Building Height

As discussed in **Sections 2.3.4** and **2.3.6** of this guide, the fire hazard associated with type of construction has been directly linked to the capability of a responding fire service, and their ability to fight a fire internally versus externally, as well as their external reach. The hazard of delayed occupant egress has also been linked to building height. Therefore, building height has been quantified in the Code primarily to delineate hazard. Building height is defined in the Code to mean [1]:

> *the number of storeys contained between the roof and the floor of the first storey.*

Building height is quantified in absolute terms in the Code as well, but has historically been defined on a storey basis to better correlate with use in terms of both life safety (i.e., number of occupants and egress) and property protection.

Due to the complexities associated with site grading, and the correlation with fire service capability and egress, building height is also linked to the first storey, which is determined as a function of grade. The first storey is defined in the Code to mean [1]:

> *the uppermost storey having its floor level not more than 2 m above grade.*

Grade[10] is defined in the Code to mean [1]:

> *the lowest of the average levels of finished ground adjoining each exterior wall of a building, except that localized depressions need not be considered in the determination of average levels of finished ground.*

Determination of grade is further clarified with respect to "localized depressions" and at the same time linked to firefighting capability and evacuation as noted earlier [1]:

> *Localized depressions that need not be considered in the determination of the elevation of grade include such features as vehicle and pedestrian entrances and other minor depressions that do not affect accessibility for firefighting or evacuation.*

3.2.1 Determination of Grade

The Guide to Part 3 of the 1995 NBCC [15] illustrates the determination of grade based on a site that is not completely flat. A similar example is included in **Figure 8** below, which shows the "average levels" (h_A, h_B, h_C and h_D) of finished ground adjoining the exterior walls (A, B, C and D) of the building. The grade is the lowest of these average levels, which in the example case is h_C.

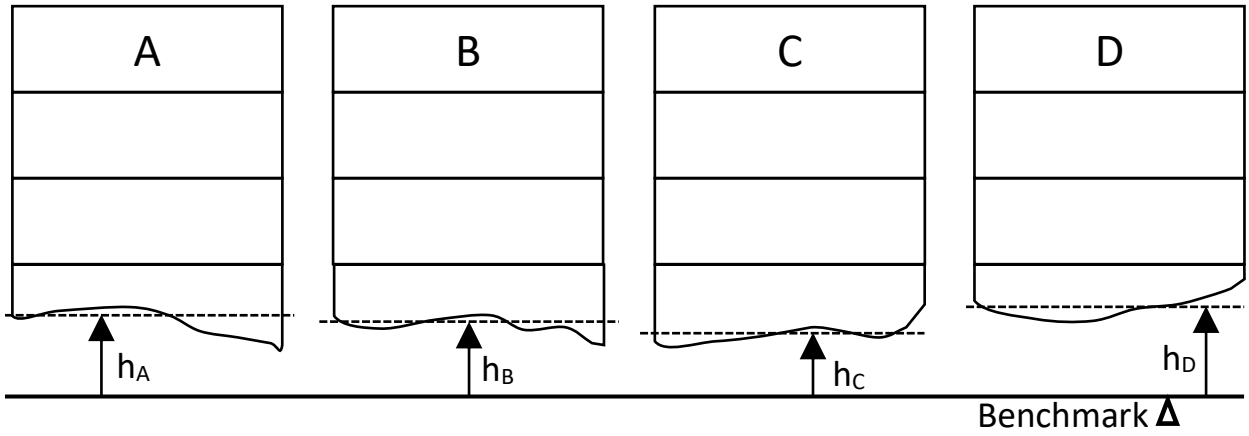


Figure 8: Determination of grade

The determination of grade as outlined in **Figure 8** is based on the assumption that the measurement represents the level of the adjacent ground that would be required to facilitate egress from the building and firefighting operations with respect to that side of the building. The grade can be artificially raised, provided it still facilitates egress from the building and firefighting operations.

Some additional clarification relative to the determination of grade can be found in the following BCAB rulings:

- BCAB #1291 - Building Height, First Storey and Grade, Subsection 1.3.2.
- BCAB #1329 - Building Height of Dwelling, Location of Grade, Article 1.1.3
- BCAB #1846 – Definition of Grade, Sentence 1.4.1.2.(1)

[10] Note that this definition is often different than grade defined in local bylaws.

In addition to the rulings noted above, BCAB 1848, “Re: Establishing Finished Ground for the Determination of Grade for a Storage Garage” provided some guidance on the interpretation of grade with respect to an Article 3.2.1.2. parking garage. This ruling recognizes the provision of adequate access for firefighting in the determination that an artificially raised grade can be considered in the establishment of the grade of a building. This ruling also suggests that the roof of an Article 3.2.1.2. parking garage may be considered appropriate for purposes of facilitating firefighting access to buildings located above the parking garage.

The definition of grade is established as a function of the exterior walls of a building; therefore, the grade can be artificially altered by berming as shown in green in **Figure 9**. However, artificially altering the grade in such a fashion defeats the intent of the definition, which relates to building height and challenges associated with firefighting response.

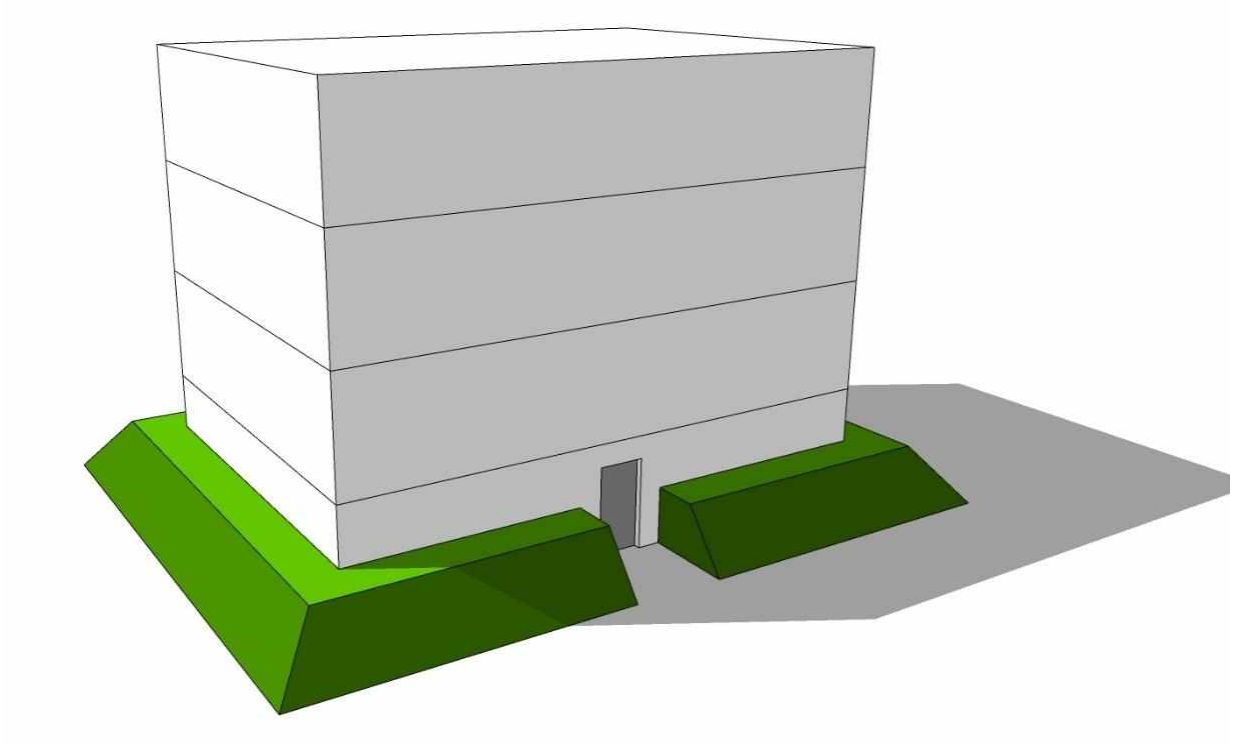


Figure 9: Illustration of an example of an artificial grade.

3.2.2 Sloped Sites

The definition of grade was established based on the assumption of a relatively flat building site, which resulted in challenges for sloped sites (see **Figure 10**). This challenge was identified following a change to the definition of grade in the 1980 NBCC and a code change request from the Province of British Columbia based on an appeal for a residential building (Group C) on a sloped site. As noted earlier in this guide, the intent of defining building height relates to fire hazard associated with fire service capability and egress.

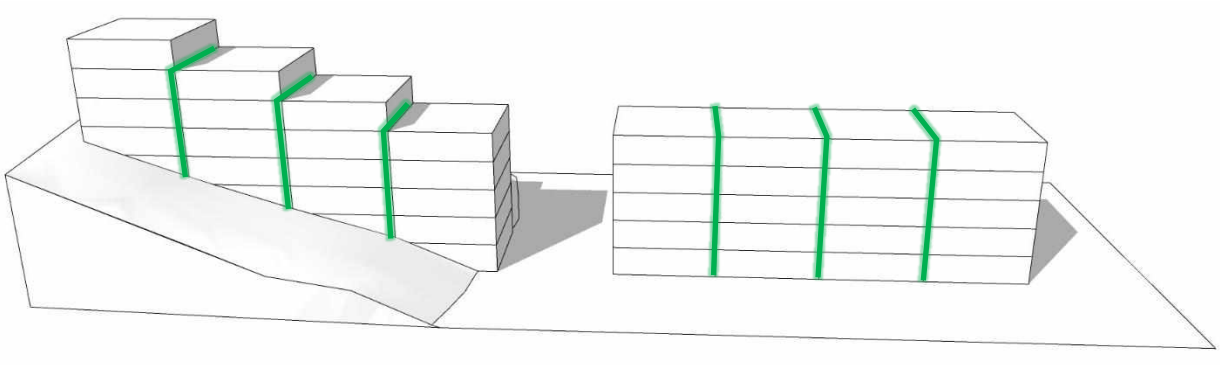


Figure 10: Illustration of an example of a sloped site, and a comparable standard site.

A solution was developed to demonstrate that the intent of the Code could be achieved on a sloped site where access, for purposes of firefighting and facilitation of egress, equating to that of a lower building. The approach was to establish building height as a function of portions of the building with the added safety measure that each portion be separated from the next adjacent portion by a continuous fire separation, with a 1-hour fire-resistance rating. The approach was further enhanced by facilitating firefighting access to each portion by limiting distance and providing each portion with an entrance.

This permission was introduced in the 1985 NBCC and was originally intended to apply only to Part 9 residential buildings. It was later expanded to include Part 3 residential buildings up to three storeys in building height. A more recent change to the 2018 BCBC expanded the application of the permission to assembly occupancies (Group A), and business and personal services occupancies (Group D), and for buildings up to four storeys in building height.

This permission has recognized an alternative means to achieving the objectives of the Code, i.e., facilitating emergency response and egress, but by means that depart from the traditional building height determination.

3.3 Building Area

Building area is the footprint area of the structure projected at grade and is specifically defined in the Code to mean [1]:

> *the greatest horizontal area of a building above grade within the outside surface of exterior walls or within the outside surface of exterior walls and the centre line of firewalls.*

This definition is illustrated in **Figure 11**, where the area of the third storey is the area of the building.

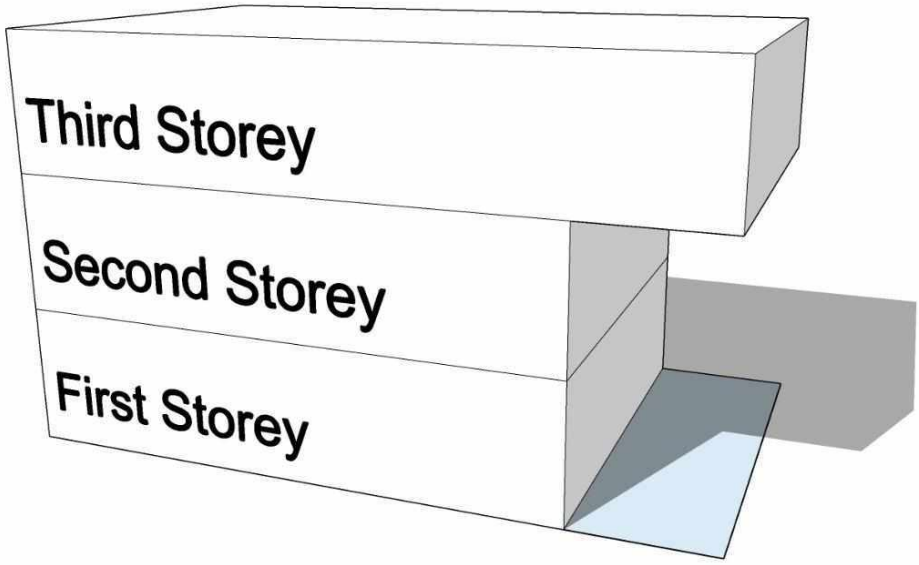


Figure 11: Illustration of building area.

Similar to building height, building area has been quantified in the Code primarily to delineate fire hazard. However, as noted by Ferguson [17]:

> *hazards of buildings having different numbers of storeys are different in kind whereas the hazards of buildings of different areas are largely different in degree.*

This statement highlights that the increase of fire risk with building height is not gradual but is assumed to increase significantly where the height is beyond the external reach of a responding fire service, whereas the fire risk associated with building area is gradual. This primarily relates to the concepts of fire load, type of construction and firefighting intervention outlined in **Section 2.3** of this guide, and to a lesser extent on occupants' ability to evacuate. More specifically, where a building is constructed of noncombustible construction with floor assembly fire separations having a rating adequate to allow for burn-out of the contents, the building area is generally not limited, except in cases where occupant evacuation may be limited (i.e., some institutional and residential occupancies). However, where a building is permitted to be of combustible construction, the size of the building (height and area) is limited primarily as a function of fire service capability [18], based on the assumption that the building is likely to become completely involved in fire.

The building areas are predominantly formulaic, based on the "wedding cake" approach which limits building area as a function of building height such that the total area of the building and correspondingly the total fuel load, and to a lesser extent total occupant load, is preserved. As an example, consider Article 3.2.2.53., "Group C, up to 3 Storeys" which permits the areas detailed in **Table 6**.

Table 6: Article 3.2.2.53. building areas [1].

No. of Storeys	Maximum Area (m^2)		
	Facing 1 Street	Facing 2 Streets	Facing 3 Streets
1	1800	2250	2700
2	900	1125	1350
3	600	750	900

The base area in **Table 6** is 1800 m^2 for a 1 storey building. This total area is preserved for each additional storey such that the area as a function of building height is as follows:

$$Building\ Area = \frac{Base\ Area}{Building\ Height}$$

Note that the Code also permits increases in building area as a function of streets facing and provision of sprinklers. Two and three streets facing allows an increase of 1.25x and 1.5x the building area respectively. Provision of sprinklers (without an increase associated with streets facing) allows an increase of 3x the building area of an unsprinklered building.

As noted earlier in this section, the key elements to determine building area are grade, exterior walls and firewalls. Grade and firewall were discussed earlier in this guide and are defined in the Code. However, "exterior wall" is not defined in the Code, which has caused some challenges when determining building area. Two specific examples are covered in the following BCAB rulings:

- BCAB 1608: Bridging roof and walls
- BCAB 1768: Patio area and "floor area"

Having defined "building" and quantified building size as a function of height and area, the next section of this guide discusses the difference between Parts 3 and 9 of the Code with respect to the fire and life safety requirements.

3.4 Part 3 vs. Part 9

Parts 1, 7, 8 and 10 of the Code apply to all buildings. Parts 3, 4, 5 and 6 apply to all buildings, except those covered by Part 9. Part 9 is intended to cover all design aspects of housing and small buildings.

The fire and life safety requirements of the 2018 BCBC are included in Part 3 and Section 9.10. of the Code. The following sections of this guide provide some context relative to differentiating between Parts 3 and 9 of the Code and the history of providing differing requirements.

3.4.1 Differentiation

The Code differentiates between Part 3 and Part 9 as a function of building height, building area and major occupancy [Sentence 1.3.3.3.(1) of Division A of the 2018 BCBC]. More specifically, Part 9 of the Code governs the design and construction of a building that is:

- less than or equal to 600 m^2 in building area,
- less than or equal to 3 storeys in building height,
- used for Group C, D, E and Group F, Division 2 and 3 major occupancies, and
- not a post-disaster building.

3.4.2 Brief History of Part 9

Part 9 was first included in the 1960 NBCC but limited to houses, defined as [19]:

> *a building that contains one or more dwelling units provided that*
>
> *i) there is not more than one dwelling unit above another, and*

ii) there are not more than 2 stories above the top of a foundation where the building contains more than one dwelling unit.

dwelling unit was defined as [19]:

> *(c) dwelling unit means two or more rooms used or intended for the domestic use of one or more individuals living as a single housekeeping unit, with cooking, living, sleeping and sanitary facilities*

Up until the 1970 NBCC, the design and construction of housing was primarily addressed by reference to Residential Standards published as a supplement to the NBCC [19]. However, the legal standing of the Residential Standards were questioned by some municipalities in Canada [20]. Therefore, a new arrangement of the NBCC in the 1970 edition, under "Part 9", incorporated most of the prescriptive requirements of the Residential Standards along with requirements from a "Short Form" of the NBCC relating to "non-engineered" commercial type buildings not covered elsewhere in the NBCC [20]. The fire protection fundamentals of Part 9 are the same as Part 3.

4 | Occupancy Classification and Separation

As noted in **Section 3.1** of this guide, the 2018 BCBC defines occupancy to mean [1]:

> *the use or intended use of a building or part thereof for the shelter or support of persons, animals or property.*

This is a general definition primarily intended to enable the determination of whether a structure is a building. Once it is determined that a structure shelters or supports an occupancy and is therefore a building, the type of occupancy becomes important in characterizing the fire and life safety risk and application of the appropriate requirements of the NBCC to address such risk, as was discussed in **Sections 2.3.2** and **2.3.3**. of this guide.

The key occupancy classifications and associated descriptions are detailed in the following section of this guide.

4.1 Major Occupancy Separations

Specific occupancy types are identified relative to "major occupancy" classifications where major occupancy is defined in the Code to mean [1]:

the principal occupancy for which a building or part thereof is used or intended to be used, and shall be deemed to include the subsidiary occupancies that are an integral part of the principal occupancy.

The major occupancy classifications used in the 2018 BCBC are detailed in **Table 7**.

Table 7: Major occupancy classifications and descriptions [1].

Group	Division	Description	Definition [Sentence 1.4.1.2.(1) of Division A]
A	1	Assembly occupancies intended for the production and viewing of the performing arts	**Assembly occupancy** means the occupancy or the use of a building, or part thereof, by a gathering of persons for civic, political, travel, religious, social, educational, recreational or like purposes, or for the consumption of food or drink
	2	Assembly occupancies not elsewhere classified in Group A	
	3	Assembly occupancies of the arena type	
	4	Assembly occupancies in which occupants are gathered in the open air	
B	1	Detention occupancies in which persons are under restraint or are incapable of self-preservation because of security measures not under their control	**Detention occupancy** means the occupancy by persons who are restrained from or are incapable of evacuating to a safe location without the assistance of another person because of security measures not under their control.

Group	Division	Description	Definition [Sentence 1.4.1.2.(1) of Division A]
B	2	Treatment occupancies	**Treatment occupancy** means the occupancy or use of a building or part thereof for the provision of treatment, and where overnight accommodation is available to facilitate the treatment.
B	3	Care occupancies	**Care occupancy** means the occupancy or use of a building or part thereof where care is provided to residents.
C		Residential occupancies	**Residential occupancy** means the occupancy or use of a building or part thereof by persons for whom sleeping accommodation is provided but who are not harboured for the purpose of receiving care or treatment and are not involuntarily detained.
D		Business and personal services occupancies	**Business and personal services occupancy** means the occupancy or use of a building or part thereof for the transaction of business or the rendering or receiving of professional or personal services.
E		Mercantile occupancies	**Mercantile occupancy** means the occupancy or use of a building or part thereof for the displaying or selling of retail goods, wares or merchandise.
F	1	High-hazard industrial occupancies	**High-hazard industrial occupancy** (Group F, Division 1) means an industrial occupancy containing sufficient quantities of highly combustible and flammable or explosive materials which, because of their inherent characteristics, constitute a special fire hazard.
F	2	Medium-hazard industrial occupancies	**Medium-hazard industrial occupancy** (Group F, Division 2) means an industrial occupancy in which the combustible content is more than 50 kg/m^2 or 1 200 MJ/m^2 of floor area and not classified as a high-hazard industrial occupancy.
F	3	Low-hazard industrial occupancies	**Low-hazard industrial occupancy** (Group F, Division 3) means an industrial occupancy in which the combustible content is not more than 50 kg/m^2 or 1 200 MJ/m^2 of floor area.

Consolidating the fire and life safety risk considerations detailed in **Sections 2.3.2** and **2.3.3**, and based on the occupancy classifications identified in **Table 7**, **Table 8** identifies the fire-resistance rating required to contain the assumed fuel load or protect the occupants during egress. The governing factor, fuel load or egress, is highlighted in blue in **Table 8**.

Table 8: Major occupancy fire containment/protection quantification [1].

Group	Division	Fuel Load (kg/m²)	Egress	Governing Factor
A	1,2,3,4	50 (1-hour)	M (1-hour)	Both
B	1,2	50 (1-hour)	H (2-hour)	Egress
B	3	50 (1-hour)	M (1-hour)	Both
C		50 (1-hour)	M (1-hour)	Both
D		50 (1-hour)	L (3/4-hour)	Fire Load
E		100 (2-hour)	L (3/4-hour)	Fire Load
F	1	150 (3-hour)	L (3/4-hour)	Fire Load
F	2	100 (2-hour)	L (3/4-hour)	Fire Load
F	3	50 (1-hour)	L (3/4-hour)	Fire Load

The major occupancy separation table from the 2018 BCBC is included in **Table 9**.

Table 9: Major occupancy fire separations [Table 3.1.3.1.].

Major Occupancy	Minimum Fire-Resistance Rating of Fire Separation, h												
	Adjoining Major Occupancy												
	A-1	A-2	A-3	A-4	B-1	B-2	B-3	C	D	E	F-1	F-2	F-3
A-1	-	1	1	1	2	2	2	1	1	2	NP	2	1
A-2	1	-	1	1	2	2	2	1	1	2	NP	2	1
A-3	1	1	-	1	2	2	2	1	1	2	NP	2	1
A-4	1	1	1	-	2	2	2	1	1	2	NP	2	1
B-1	2	2	2	2	-	2	2	2	2	2	NP	2	2
B-2	2	2	2	2	2	-	1	2	2	2	NP	2	2
B-3	2	2	2	2	2	1	-	1	2	2	NP	2	2
C	1	1	1	1	2	2	1	-	1	2	NP	2	1
D	1	1	1	1	2	2	2	1	-	-	3	-	-
E	2	2	2	2	2	2	2	2	-	-	3	-	-
F-1	NP	NP	NP	NP	NP	NP	NP	NP	3	3	-	2	2
F-2	2	2	2	2	2	2	2	2	-	-	2	-	-
F-3	1	1	1	1	2	2	2	1	-	-	2	-	-

"NP": Not permitted by the 2018 BCBC
"-": No major occupancy fire separation

The difference between the values in this table and those linked to the underlying risk considerations have been highlighted in red and green in **Table 9**. The cells highlighted in red are specific to Group F, Division 1, "High Hazard Industrial" occupancies, which will be discussed in more detail in the following section of this guide. The cells highlighted in green have a lesser than expected fire resistance-rating as the adjoining occupancies have similar fuel loads. Further, the building size limits and associated structural fire protection

associated with occupancy classifications and the separation of suites11 are additional and likely require a separation of these major occupancies. See **Figure 12** below for an illustration of major occupancy separations in a building. Note that the rating of structural members/assemblies supporting fire separations is addressed in **Section 5.1** of this guide and the separation of the parking garage (1.5-h highlighted in orange) from the Group E occupancy above is a superseding floor area separation requirement.

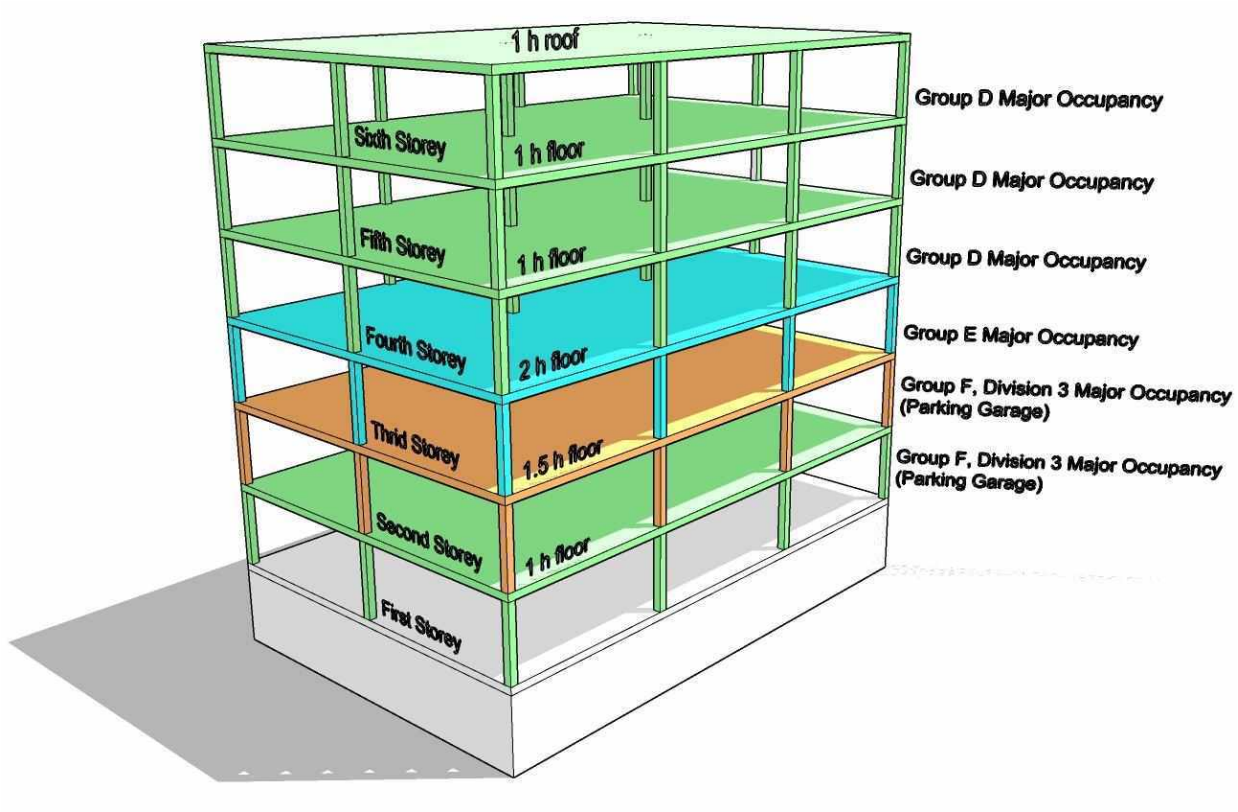


Figure 12: Major occupancy separation requirements.

4.2 Prohibited Combinations

The 2018 BCBC prohibits the following occupancy combinations [Article 3.1.3.2.]:

- A Group F, Division 1 major occupancy in the same building with any occupancy classified as Group A, B or C.
- More than one suite of residential occupancy in the same building classified as a Group F, Division 2 major occupancy.

The reason for the prohibition is identified in the corresponding intent statements attributed to the same requirements in the NBCC, which notes that the intent of the prohibition is to limit the probability that an explosion or rapidly developing fire originating in a:

- high hazard industrial major occupancy will lead to harm to persons in an assembly occupancy, residential occupancy, or care or detention occupancy due to the nature of these occupancies which require extended evacuation time, and

11 Note that the term “suite” will be defined in Section 5.4.1 of this Guide and the associated separation requirements discussed.

- a medium hazard industrial major occupancy will lead to harm to persons in a residential suite.

Therefore, the prohibition of occupancy combinations is specific to life safety and the potential for rapid fire development or explosion to impact the egress facilities required for occupancies that require longer egress times.

The prohibition identified above is relatively straight-forward in terms of its application; however, becomes complicated to apply in buildings of mixed occupancy where a Group F, Division 1 or 2 occupancy is not a major occupancy. This is discussed in more detail in the following section of this guide with specific examples associated with these divisions of industrial occupancy.

4.3 Major vs. Subsidiary

The BCBC does not define "subsidiary" occupancy, which is generally understood to mean a use that is secondary to the major occupancy and would not exist but for the major occupancy. In addition, a subsidiary occupancy is typically directly connected with the major occupancy it serves and is not independent. A restaurant is classified as a Group A, Division 2 major occupancy but contains a kitchen component that could be classified as an industrial occupancy. However, the restaurant would not exist without the kitchen and the kitchen typically only serves the restaurant, which would include dining in and take-away. Another example is a meeting room in an office (Group D major occupancy). A meeting room is generally classified as a Group A, Division 2 occupancy; however, is secondary to the primary use of the space and would not exist without the primary use. Therefore, the meeting room (in this example) is a subsidiary occupancy.

Similar interpretations have been made by the BCAB in the following rulings:

- BCAB #1793 - Determination of Subsidiary or Major Occupancy, February 16, 2017
- BCAB #1698 - Storage Lockers for Bicycle Gear in a Storage Garage, Sentence 3.3.5.6.(1), August 18, 2011
- BCAB #1675 - NFPA 13R Sprinkler System, Sentence 3.2.5.13.(2), September 23, 2010
- BCAB #1644 - Major Occupancy Classifications, Winery, Restaurant, Grappa Production, Sentence 3.1.2.1(1), March 19, 2008
- BCAB #1362 - Occupancy Classification, Spray Finishing in Woodworking Shop, Article 3.1.3.5., August 16, 1994

The City of Calgary issued a bulletin, updated 2015 Dec 3, providing criteria to differentiate subsidiary from major occupancy as follows:

a) the subsidiary occupancy serves only that major occupancy and no other, and it would cease to exist in the absence of the major occupancy,

b) the major occupancy would cease to function effectively if the subsidiary occupancy is deleted or even physically removed to another location,

c) the major and subsidiary occupancies are under the control of the same management and usually open and close for business at the same time, and

d) there is free accessibility at all times between the subsidiary occupancy and its major occupancy.

While not applicable in BC, the criteria above provides some clear rational that can be used to establish whether an occupancy is subsidiary and is not required to be separated from the major occupancy in which it is located.

The differentiation between major and subsidiary occupancy is important to the application of key requirements of the NBCC that apply holistically to a building such as the Subsection 3.2.2., “Building Size and Construction Relative to Occupancy”. As identified in the Explanatory Note A-3.3., “Safety Within Floor Areas,” other requirements of the NBCC apply to floor areas, rooms and spaces regardless of whether the use is considered major or subsidiary.

5 | Fire Compartmentation

The fundamentals of fire compartmentation (**Section 2.3.3)** are intended to limit the risk of fire growth and spread (**Section 2.2.2**) and provide protection during occupant egress as a function of occupancy (**Section 2.3.2**). The magnitude of protection required is quantitatively linked to fire load and qualitatively linked to occupants' ability to evacuate. The primary purpose of compartmentation is to protect lower risk areas from higher risk areas.

The BCBC includes requirements for physical barriers (fire compartment) intended to limit the growth and spread of fire. The BCBC defines a fire compartment as:

> *an enclosed space in a building that is separated from all other parts of the building by enclosing construction providing a fire separation having a required fire-resistance rating.*

Fire separation and fire-resistance rating are discussed in more detail in the following sections of this guide including the provisions necessary to maintain continuity of these separations while also providing interconnectivity for occupant movement and building services.

5.1 Fire Separations and Fire-Resistance Rating

A fire separation is "a construction assembly that acts as a barrier against the spread of fire" where fire-resistance rating means "the time in minutes or hours that a material or assembly of materials will withstand the passage of flame and the transmission of heat when exposed to fire under specified conditions of test and performance criteria, or as determined by extension or interpretation of information derived therefrom as prescribed in this Code". Fire-resistance ratings can be determined in the 2018 BCBC based on three methods [Article 3.1.7.1.]:

1. By subjecting a material, assembly of materials or a structural member (building element) to tests conducted in conformance with CAN/ULC-S101, "Fire Endurance Tests of Building Construction and Materials" (S-101 Test). As detailed in **Section 2.3.3** of this guide, the S-101 test is over 100 years old and is intended to expose a building element to increasingly severe fire exposure represented by a prescribed time-temperature curve.
2. Using the rule-of-thumb methods prescribed in Appendix D, which allow flexibility of design by permitting variations of components using a "component additive method".
3. Assigning a fire-resistance using the "Fire and Sound Resistance Tables" of assemblies in Part 9. These tables provide fire-resistance ratings for interior/exterior walls, floors and roofs.

The exposure conditions for fire-resistance ratings are based on the fundamentals of fire growth and development, considering the tendency of hot fire gases to rise through buoyant forces. This means that the dominant heat exposure in a compartment in full room fire involvement (**Section 2.2.2.4** of this guide) is to the ceiling/floor assembly above and the containing walls, with limited exposure at floor level. Therefore, fire-resistance ratings of building elements are determined as follows [Article 3.1.7.3.]:

- **Underside:** floors, ceiling and roofs
- **Both sides:** firewalls, interior vertical fire separations
- **Inside:** exterior walls

In order to maintain the integrity of fire separations, all loadbearing walls, columns and arches in the storey immediately below a floor or roof assembly required to have a fire-resistance rating are required to have a fire-resistance rating not less than that required for the supported floor or roof assembly [Sentence 3.1.7.5.(1)].

Note that the temperature exposure used to establish the fire-resistance rating for a fire separation does not represent actual fire exposure and is intended to provide a means to compare the general fire performance of building assemblies and structural elements. Therefore, a 1-hour fire separation could last less than 1-hour in a real fire, or, more likely much longer than 1-hour where the fire exposure is less than the high thermal exposure furnace test.

5.2 Continuity

It is not practical to construct a building without openings between fire compartments to permit the movement of occupants and facilitate the interconnection and routing of building services. Article 3.1.8.3. of the 2018 BCBC requires that fire separations be continuous to limit the spread of fire from one fire compartment to another. The approaches to maintain continuity are discussed in the following sections of this guide.

5.2.1 Closures and Shafts

The continuity of a fire separation is required to be maintained where it abuts another fire separation, a floor, a ceiling, a roof, or an exterior wall assembly [Sentence 3.1.8.3.(4)]. Where a fire separation is not continuous in order to incorporate an opening, a closure is required. A closure can be a door, window, damper or similar component, and is required to have a "fire-protection rating" coinciding with the fire-resistance rating. The fire-protection rating is defined to mean:

> *the time in minutes or hours that a closure will withstand the passage of flame when exposed to fire under specified conditions of test and performance criteria, or as otherwise prescribed in this Code*

The fire-protection ratings for closures are identified in Table 3.1.8.4. of the 2018 BCBC aligned with the associated fire-resistance rating of the fire separation in which it is located. The fire-protection rating is generally lower than the associated fire-resistance rating, with the exception of the 45-minute rating. The lower rating is based on an assumption of limited combustibles adjacent to doors and for purposes of practicality, supported as follows [7,28]:

> *For practical reasons the fire resistance of closures differs from that of the main assembly because of area, affect on stability, etc. The value of the fire resistance of the various elements has been determined by experience and is intended generally to provide a uniform resistance to the spread of fire.*

Doors are less because it was assumed unlikely that furniture or goods would be piled against a door; hence, higher temperature on the unexposed face of a door could be permitted.

Similarly, with the exception of elevator shafts, where a shaft (vertical or horizontal service space) penetrates a fire separation, the fire-resistance of the walls of the shaft are consistent with those required for the fire-protection rating of a closure [Table and 3.6.3.1.]. The rationale for the lower rating is noted as follows [28] and illustrated in **Figure 13**:

> *The fire requirements of shafts are less than those of construction separations because a fire must first break into the shaft and then break out to get to the next floor. In essence, there are two barriers to resist the fire and therefore, it was agreed that the sum of the fire resistance of the barriers should equal the required grade of separation.*

Figure 13 shows the pathway required for a fire to spread from a storey, separated from other storeys by a 2-hour fire-resistance rating (highlighted in blue), by way of a shaft separated from the remainder of the building by a 1-hour fire-resistance rating (highlighted in green). The fire in **Figure 13** would be required to move through two 1-hour rated fire separations to spread from one storey to another, which is equal to the 2-hour fire-resistance of the floor assembly the shaft penetrates.

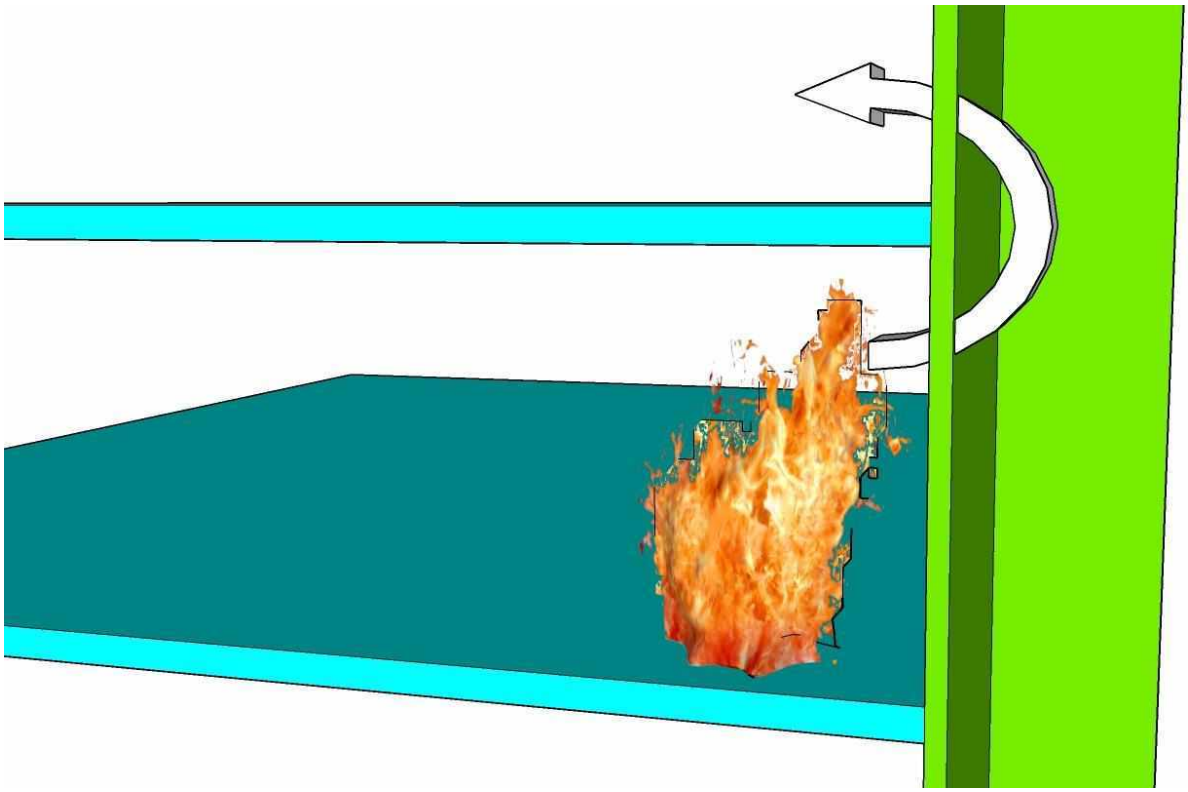


Figure 13: Shaft penetrating floor assemblies.

5.2.2 Fire Stopping

Penetrations of a fire separation or a membrane forming part of an assembly required to have a fire-resistance rating are required to be adequately sealed [Article 3.1.9.1.]. Penetrations are required to be [Sentence 3.1.9.1.(1)]:

- sealed by a fire stop that, when subjected to the fire test method in CAN/ULC-S115, "Fire Tests of Firestop Systems," has an F rating not less than the fire-protection rating required for closures in the fire separation in conformance with Table 3.1.8.4.,
- cast in place, or
- tightly fitted.

The rating required for a fire stop system is consistent with that required for a fire-protection rating for a closure (i.e., generally less than for a fire-separation) and for the same reasons as a closure[12].

[12] Note that this is intended to change in the next edition of the BCBC and align with the fire-resistance rating of the assembly in which it is located.

5.3 Concealed Spaces and Fire Blocking

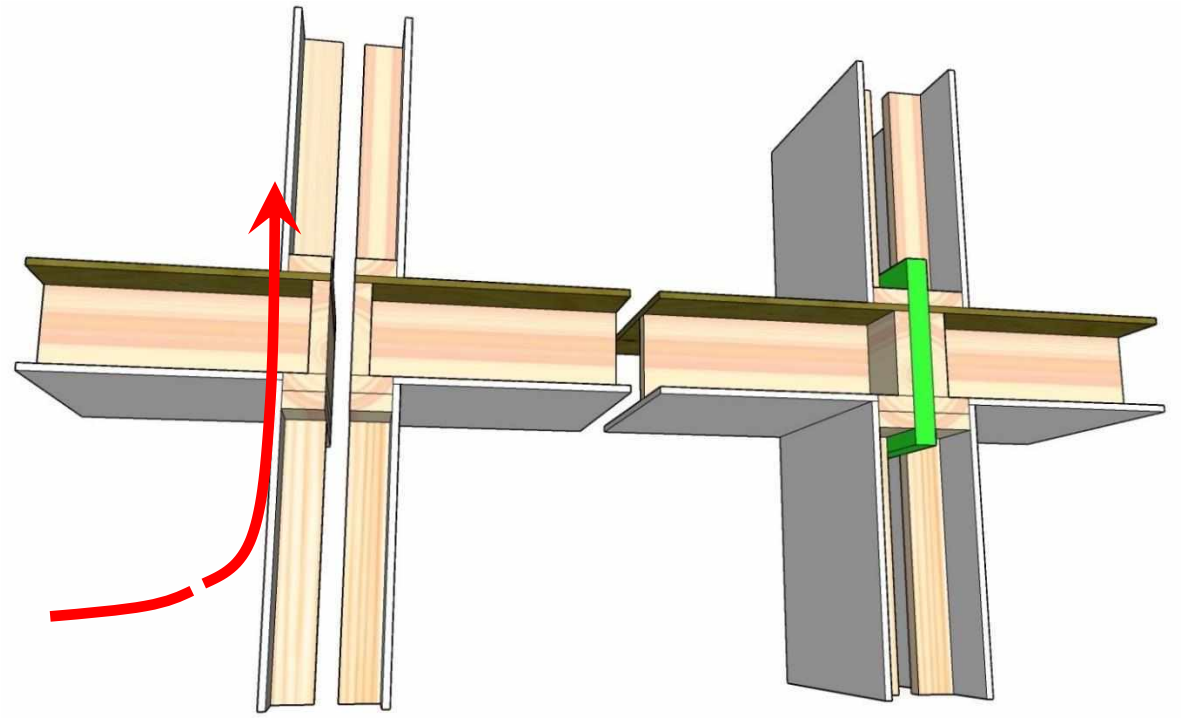
The 2018 BCBC does not define "concealed space" but in reference to the term identifies a space within an assembly and concealed is defined [Merriam-Webster Dictionary definition] to mean "out of sight, or away from view," which implies unoccupied. Therefore, a concealed space is not expected to have the same fire risk as an occupied space in terms of fuel and occupant loads, and correspondingly does not require the same degree of protection. However, one of the key risks associated with concealed spaces is the possibility of fire spreading to a concealed space and then to other fire compartments.

The 2018 BCBC addresses the potential for fire development and spread in a concealed space by limiting the size of the space, area of exposed combustible materials and flame spread propensity. This is primarily achieved in the 2018 BCBC through the following methods:

- Provision of barrier material (blocking) to limit the growth and spread of fire beyond a specific concealed space that generally aligns with fire compartment boundaries – i.e., blocking required at floor and ceiling level of a wall assembly.
- Provision of barrier material (blocking) to limit the potential size of a fire in a concealed space – i.e., blocking to divide a large attic space.
- Requiring noncombustible materials or limit the flame spread rating of exposed materials to limit fire growth and spread.
- Requiring filling of concealed spaces with noncombustible insulation to limit available oxygen for combustion (see **Section 2.2.2.2** of this guide).

Fire block materials are intended to remain in place and prevent the passage of flames for 15 minutes when subjected to the S-101 Test (see **Sections 2.3.3** and **5.1** of this guide). The specific origin of the 15 minutes is not known but is consistent with the time assumed in the Code for fire department response and initiation of suppression activities. In addition, it is assumed that fire will be limited from entering a concealed space by the protective membrane of the fire separation surrounding a fire compartment and the blocking is intended to further limit the spread of fire to other fire compartments.

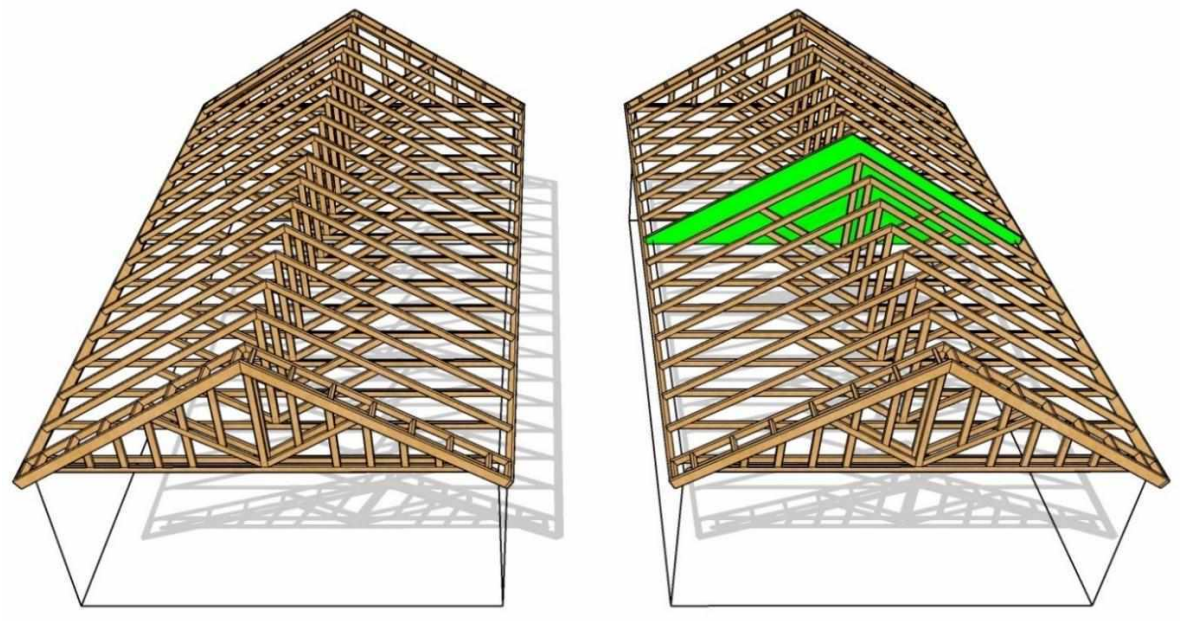
Figure 14(a) shows the path of fire spread through a wall assembly with no fire blocking at ceiling level. **Figure 14(b)** shows the same construction but with the required fire block (highlighted green) to limit the spread of fire from the lower to upper wall assemblies.



(a) **(b)**

Figure 14: (a) No fire blocking, (b) Fire blocking included.

Figure 15(a) shows a concealed attic space with no fire blocking. **Figure 15(b)** shows the same attic space with the required fire block (highlighted green) to limit the spread of fire to involve the entire concealed attic space.



(a) **(b)**

Figure 15: (a) No fire blocking, (b) Fire blocking included.

5.4 Application of Fire Compartmentation to Reduce Risk

Previous sections of this guide have discussed fire compartmentation relative to major occupancy separation (**Sections 2.3.3** and **4.1**) and structural fire protection (**Section 2.3.4**) in terms of the reduction of the risk of fire spread from one part of a building to another (macro-scale) and in the case of structural fire protection, to limit full involvement of the building. The trend in development of the Code has been to more precisely address the hazard of fire in a building through controls on smaller spaces. This was identified by one of the key individuals involved in the development of the NBCC who noted the following relative to fire protection of spaces [29]:

> *the problems of fire protection in buildings are always related to spaces. The three principle measures of control are:*
>
> 1. *Evacuating the occupants from the space.*
> 2. *Confining the fire to the evacuated space.*
> 3. *Extinguishing the fire in the space.*
>
> *It is necessary to define the space for purposes of control. Historically the "building" has been chosen as the space to which control measures have been applied, but in recent years the size and configuration of buildings and multiple building use has lessened the usefulness of "building" for this purpose.*
>
> *…*
>
> *The development of modern buildings in terms of size, shape, and occupancy has made the idea of a "building" as a space less realistic. Today building codes employ "rooms," "floor areas," and even arbitrary sized spaces depending on the circumstances.*
>
> *…*
>
> *The trend is toward the choice of smaller spaces for regulation purposes…[i]t follows that as space basis for regulation is reduced a better fit between control and hazard is achieved. Studies suggest that as this happens the trend is more from prohibition to regulation, which is more in keeping with the purpose of the Code.*

It is upon these principles that the hazard of fire has been addressed in the Code through an evolution towards protection of smaller spaces as a function of the activity contained within. An example is the spatial separation requirements (discussed in **Section 6 |** of this guide) originally applied to the face of entire buildings but evolved into consideration of the exterior walls of spaces within a building based on the provision of fire compartmentation to demarcate those spaces. Thus, fire compartmentation is generally used as the means to separate fire hazards associated with the use of smaller spaces and in doing so facilitate a better fit between control and hazard as noted earlier. The following sections of this guide provide a summary of this principle with respect to smaller spaces and in particular dwelling units.

5.4.1 Suite

A suite is used by the 2018 BCBC to further subdivide a building for purposes of more precisely addressing fire and life hazards. A suite is defined to mean:

> *a single room or series of rooms of complementary use, operated under a single tenancy, and includes dwelling units, individual guest rooms in motels, hotels, boarding houses, rooming houses and dormitories as well as individual stores and individual or complementary rooms for business and personal services occupancies.*

The determination of whether a room or group of rooms is a suite is complex in certain situations where "complementary use" and "single tenancy" are not clear. The Explanatory Note to the definition of suites clarifies the application by stating that the term "suite" applies to both rental and ownership tenure. Complementary use requires that a series of rooms must be in reasonably close proximity to each other and have access to each other either directly by means of a common doorway or indirectly by a corridor, vestibule or other similar arrangement to be considered a suite. More specifically:

> *A rented room in a nursing home could be considered as a suite if the room was under a separate tenure. A hospital bedroom on the other hand is not considered to be under a separate tenure, since the patient has little control of that space, even though he pays the hospital a per diem rate for the privilege of using the hospital facilities, which include the sleeping areas.*

Some additional guidance is provided in the following BCAB rulings:

- BCAB #1323 - Young Offenders Group Home Occupancy Classification & Definition of Suite, 3.1.2.6.(1) & 1.1.3.2,September 22, 1993
- BCAB #1593 - Enclosed Mezzanine, Sentence 3.2.1.1.(4) Definition of Suite related to Dormitories, Sentence 1.1.3.2.(1), November 7, 2003

The portion of the definition "operated under a single tenancy" implies care, control and awareness of the suite and the activities and events that transpire within, which also implies that occupants of adjacent suites or spaces may not be as intimately aware of an emergency within another suite and be delayed in responding. This is a key concept associated with suites and one of the main reasons they are required to be separated from adjoining suites, to limit the spread of fire and smoke and allow greater time for occupants of adjacent suites and spaces to evacuate. This then allows greater design flexibility within a suite by relaxing requirements such as the separation of occupancies, protection of corridors, travel distances, etc. Therefore, the hazard of delayed awareness of an incident by occupants outside a suite is addressed by fire separating the suite, and relaxation of the requirements within a suite are supported by the separation and the relative familiarity of the suite and activities within by the occupants.

Suites are generally required to be separated from adjoining suites and public corridors by a fire separation with a 1-hour fire-resistance rating. However, the fire-rating is not required where a building is sprinklered throughout, the suites are served by public corridors and contain occupancies whose occupants are considered to be aware, awake and have familiarity with the egress facilities (i.e., Office retail and fast-food with no seating). This relaxation recognizes the lower life safety risk associated with these occupancies (**Table 2** in **Section 2.3.2** of this guide) and the benefit of common routes of egress and suppression capability of sprinklers in facilitating egress and reducing fire growth and spread respectively.

5.4.2 Dwelling Unit

The 2018 BCBC refers to "suites of residential occupancy" where "suite" and "residential occupancy" are defined separately. The combination of the two terms implies a more specific type of suite that may include all types of residential occupancy (i.e., houses, apartments, hotels, etc. - A-3.1.2.1.(1)). Dwelling unit is referenced throughout the 2018 BCBC and in particular in Part 9. The 2018 BCBC defines a dwelling unit to mean:

> *a suite operated as a housekeeping unit, used or intended to be used by one or more persons and usually containing cooking, eating, living, sleeping and sanitary facilities.*

Therefore, a dwelling unit is a specialized type of residential suite and as such inherits the characteristics of a suite as detailed in the previous section of this guide. In particular, a dwelling unit is required to be separated from other dwelling units (and other suites and spaces) by a fire separation to address the hazard of delayed

awareness of an incident by occupants outside the dwelling unit. Thus, as for suites in general, requirements within dwelling units are relaxed based on this separation and the familiarity of the occupants of a dwelling unit on the activities taking place within.

Additional clarification is provided in terms of the evolution of the definition of "dwelling unit". The first NBCC (1941) included the following:

> *Dwelling Unit shall mean a room, or a suite of two or more rooms, designed, or intended for use by an individual or family, in which facilities are provided for cooking or for the installation of cooking equipment.*

The key elements of the definition are the number and relationship of occupants and the provision of cooking facilities. This definition was revised in the next edition (1953 NBCC) to the following:

> *Dwelling unit means two or more rooms used or intended for the domestic use of one or more individuals living as a single housekeeping unit, with cooking, living, sleeping, and sanitary facilities.*

The 1953 definition more specifically defined the use of the space as "domestic" with broadened uses "cooking, living, sleeping, and sanitary facilities" and included the concept of "housekeeping unit". This definition was more specific to the use of the space, which are implied to be encompassed by the term "housekeeping unit". The definition was next revised in the 1970 NBCC, which reduced the number of rooms to one and included "eating" to the intended uses:

> *Dwelling unit means 1 or more rooms for the use of 1 or more persons as a housekeeping unit with cooking, eating, living, sleeping and sanitary facilities.*

The definition was next revised in the 1975 NBCC, which added the term "domicile":

> *Dwelling unit means a room or suite of rooms operated as a housekeeping unit, used or intended to be used as a domicile by 1 or more persons and usually containing cooking, eating, living, sleeping and sanitary facilities.*

The definition was updated in the 1980 NBCC, which removed any reference to number of rooms:

> *Dwelling unit means a suite operated as a housekeeping unit, used or intended to be used as a domicile by 1 or more persons and usually containing cooking, eating, living, sleeping and sanitary facilities.*

Since the 1980 NBCC the definition has remained relatively unchanged with the exception of editorial changes.

A change was proposed to the 2010 NBCC to remove the word "domicile" from the definition based on the following justification:

> *There have been several court rulings in various jurisdictions (BC, Alberta, ongoing in North West Territories) on the use of the term "domicile" in the definition of "dwelling unit." The fact that a building is not considered your primary and permanent residence should not preclude the dwelling unit requirements for life safety.*

The implication of the term "domicile" is highlighted in BCAB Ruling No. 1621, which examines a specific case where a residential suite has several owners and can be occupied by the owners or rented to the public. The ruling focussed on the term "domicile" and a legal decision that identified a domicile as "fixed and permanent home of a person and cannot relate to a dwelling that a person occupies only on a temporary basis where it is clear that the person always intends to return to their permanent home". Therefore, in this case the residential suite is not a domicile and therefore not a dwelling unit. This ruling is consistent with the concept of a suite, which allows for a relaxation of the fire and life safety requirements within based on the provision of a fire rated separation and the familiarity of the occupants with the suite and activities within. The term domicile and its

intended application with respect to occupancy, as noted in the ruling, suggests a greater familiarity of the space than would be expected from a renting guest.

The definition was updated in the 2010 NBCC to be as follows:

> *Dwelling unit means a suite operated as a housekeeping unit, used or intended to be used by one or more persons and usually containing cooking, eating, living, sleeping and sanitary facilities.*

The term "secondary suite" was introduced into the 2010 NBCC to facilitate more affordable housing and provide the framework to regulate an existing condition in many jurisdictions. A secondary suite was defined to mean:

> *a self-contained dwelling unit located within a building or portion of a building*
>
> - *completely separated from other parts of the building by a vertical fire separation that has a fire-resistance rating of not less than 1 h and extends from the ground or lowermost assembly continuously through or adjacent to all storeys and spaces including service spaces of the separated portions,*
> - *of only residential occupancy that contains only one other dwelling unit and common spaces, and*
> - *where both dwelling units constitute a single real estate entity.*

The explanatory note to the definition of secondary suite further notes that:

> *A secondary suite is a self-contained dwelling unit of a prescribed maximum total floor area that is part of a building containing not more than two dwelling units (including the secondary suite) and any common spaces such as common storage, common service rooms, common laundry facilities or common areas used for egress. Secondary suites are typically created within an existing single dwelling unit—commonly called a "house"—either constructed as an addition to an existing house or incorporated during the construction of a new house. A secondary suite may have more than one storey and may be on the same level as the principal dwelling unit of the house or be above or below it.*

In the context detailed above, a secondary suite and (by implication) the associated primary suite are two dwelling units (suites) in the same building (house). The provisions associated with a secondary suite are consistent with those required for a suite, which includes a fire separation from other suites (primary suite) but also permits some flexibility by relaxing certain requirements within the suites.

While the degree of requirements and associated relaxations of floor area requirements vary as a function of the type of suite – i.e., general suite, residential suite, dwelling unit and secondary suite; the underlying concept to address the fire and life safety risk is consistent. This concept, as noted in the previous section of this guide, relates to managing the fire and life safety risk of adjacent spaces separately operated by requiring containment by fire separations, but allowing a relaxation of other requirements within the spaces based on familiarity and control.

5.4.3 Service/Storage Rooms and Spaces

Most buildings contain service and storage rooms that are subsidiary to the major occupancies they serve. Service rooms containing certain types of equipment, such as fuel-fired appliances, solid-fuel-burning appliances, oil containing electrical equipment, etc., are considered to pose a greater fire and life safety risk than the major occupancies they serve. These rooms are therefore required to be fire separated from the remainder of the building to address the increased risk. Fire rated separations are also required for rooms containing certain types of storage such as combustible refuse and hazardous materials.

5.4.4 Egress Facilities

Similar to service/storage rooms and spaces, egress facilities such as public corridors, exit corridors and exit stairs are required to be separated from the remainder of a storey (public corridor) or the remainder of a building (exit). However, where the service/storage rooms require a fire-rated separation due to their inherent greater fire risk, egress facilities are intended to provide a safe space for evacuating occupants. Thus, the fire separation required for egress facilities are intended to limit the fire risk associated with the building occupancy from impacting the safety of the evacuating occupants.

5.5 Fire Compartment Performance

The fire compartmentation concepts detailed in the previous sections of this guide do not dictate fire performance, especially in the case of referenced standards, which are not reflective of reality. However, the sum total of the fire compartmentation concepts defines an overall level of fire performance that can be used in the application of the fire compartmentation requirements to specific designs.

6 | Spatial Separation

The spatial separation requirements are located in Subsections 3.2.3., 9.10.14. and 9.10.15. of the 2018 BCBC and are intended to limit the spread of fire from one spatially separated building to another, which predominantly occurs by convective and radiative heat transfer, as outlined in **Section 2.2.1** of this guide.

6.1 Concepts and Definitions

As outlined in **Section 2.3.5** of this guide, the spatial separation requirements have been developed based on full-scale fire testing of houses in the St. Lawrence Seaway, and have been established assuming a structure or a fire compartment has transitioned to be fully involved in fire as detailed in **Section 2.2.2.4** of this guide, which is characterized by high temperature relatively uniform within the compartment and flame extension out of compartment openings. While the assumption of extent of fire growth and spread relative to building size limits in the Code is contingent on type of construction, the spatial separation requirements consider extent of fire growth and spread on a fire-compartment basis where fire compartment is defined in the Code to mean [1]:

> *an enclosed space in a building that is separated from all other parts of the building by enclosing construction providing a fire separation having a required fire-resistance rating.*

As noted in **Section 2.3.5** of this guide, the spatial separation requirements consider fire department intervention within a certain period of time, or that the storey on which the compartment of fire origin is located is sprinklered. Where the storey is not sprinklered and the time of fire department intervention cannot be demonstrated, the distance to the property line (or another building on the same property) is required to be increased. The consideration of fire department intervention was originally implicit to the requirements but has recently been included in the Code as an explicit requirement [Sentences 3.2.3.1.(8), 9.10.14.3.(1) and 9.10.15.3.(1)]. Therefore, the spatial separation requirements are limited to the compartment of fire origin assuming that either a sprinkler system will limit fire from spreading beyond that compartment, or a responding fire service will have the capability to control and suppress a fire in that compartment prior to it spreading to an adjacent compartment.

The key factors associated with radiant heat transfer from a compartment fire are:

- the area of the exposing source, which for a compartment fire is the flame front extending from openings in a compartment during full room fire involvement of the compartment.
- the distance between the flame front and an adjacent building (exposed exterior wall); and
- the degree of combustibility of the exposed exterior wall.

6.1.1 Exposing Building Face

The area of the exposing source is characterized in the Code by the fire compartment exterior faces, or the exposing building face which is defined in the Code to mean [1]:

> *that part of the exterior wall of a building that faces one direction and is located between ground level and the ceiling of its top storey or, where a building is divided into fire compartments, the exterior wall of a fire compartment that faces one direction.*

The minimum fire-resistance rating of a fire compartment to be considered for purposes of establishing the area of the exposing building face is 45-minutes [Sentences 3.2.3.2.(2), 9.10.14.2.(2) and 9.10.15.2.(2)], otherwise the exposing building face area is the total area of an exterior wall facing in one direction on any side of a

building measured from the finished ground level to the uppermost ceiling [Sentences 3.2.3.2.(1), 9.10.14.2.(1) and 9.10.15.2.(1)].

In addition to the area, the ratio of height-to-width (or width-to-height, whichever is greater) is important to the determination of the permitted percentage of unprotected openings for unsprinklered Part 3 buildings. **Figure 16** illustrates the importance of this ratio by showing fire compartments of approximately the same exposing building face area, but differing ratios and the shadows cast by those compartments to illustrate the difference in the potential heat exposure. Note that the ratio of height to width is not required for the determination of permitted percentage of unprotected openings for Part 9 buildings.

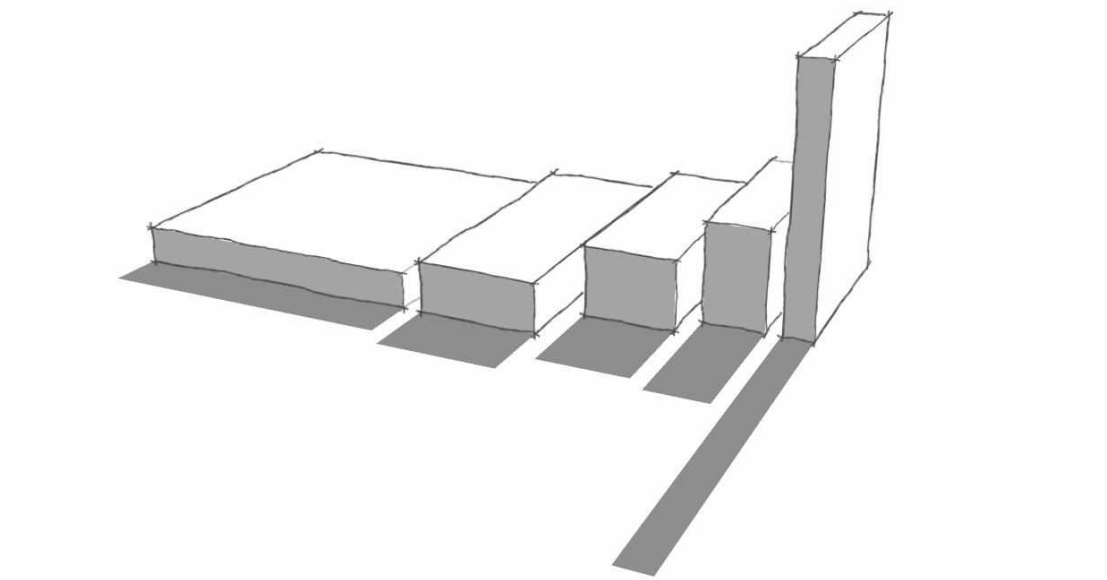


Figure 16: Exposing building face ratio.

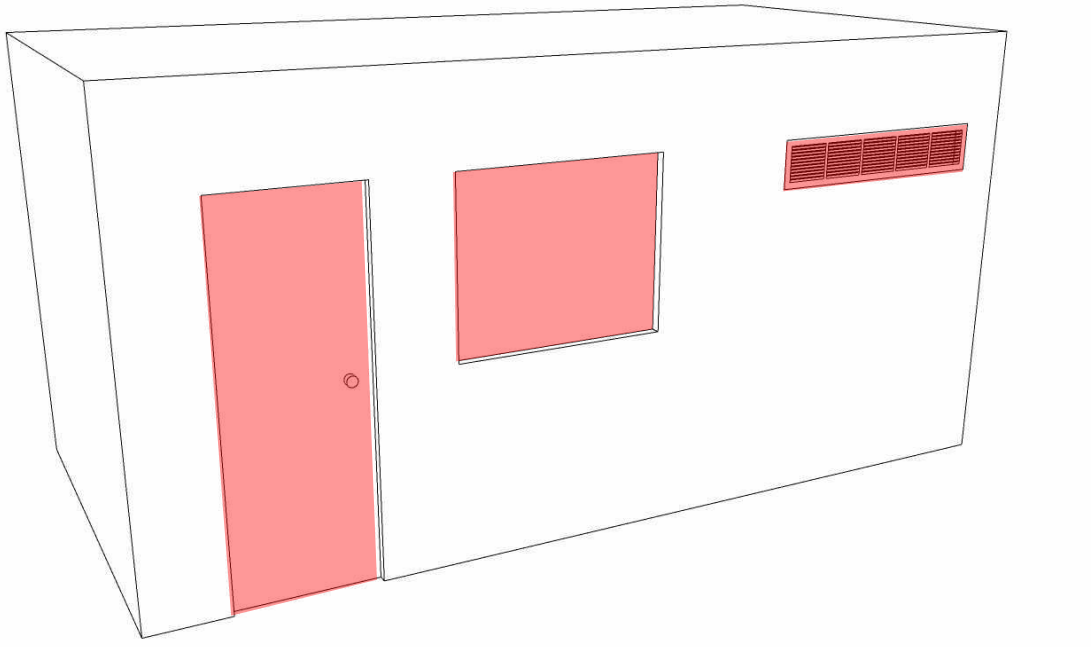


Figure 17: Unprotected openings.

6.1.2 Unprotected Opening

The extent of flame issuing from an exposing building face (flame front) depends on the number, area and location of unprotected openings in that face, where unprotected opening is defined in the Code to mean [1]:

> *a doorway, window or opening other than one equipped with a closure having the required fire-protection rating, or any part of a wall forming part of the exposing building face that has a fire-resistance rating less than that required for the exposing building face.*

Houses consider glazed openings rather than unprotected openings with respect to the source of radiant heat exposure. This will be discussed in more detail in **Section 6.3.1** of this guide.

6.1.3 Limiting Distance

Since the actual distance between buildings is not practical to regulate where the Code applies only to the building under consideration at the time, a simplification of the distance between buildings was developed relative to boundaries (i.e., property line). This simplification is termed the "mirror boundary condition" and assumes that opposite exposing building faces are equidistant from boundaries and of approximately equal exposure fire risk as the building under consideration. The mirror boundary condition assumption breaks down where a smaller structure is located opposite a larger structure as illustrated in **Figure 18**. This figure shows the theoretical exposure envelope for the larger building in orange and for the smaller building in yellow. This condition should be avoided and is identified in Explanatory Note A-3.2.3. of the Code relative to a potential increase in risk associated with fire spread.

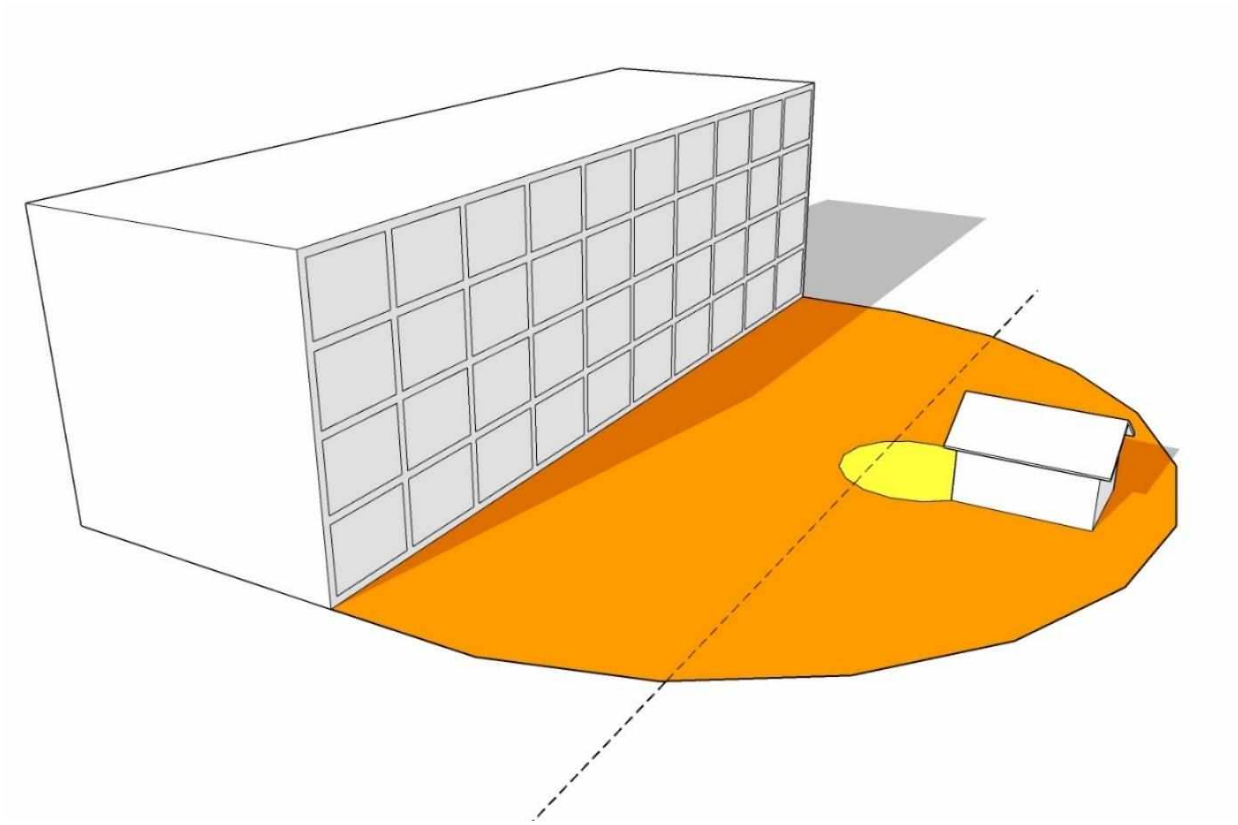


Figure 18: Mirror boundary condition.

The simplified distance to a boundary is approximately half the actual distance between buildings and is termed the limiting distance, which is defined by the Code to mean [1]:

> *the distance from an exposing building face to a property line, the centre line of a street, lane or public thoroughfare, or to an imaginary line between 2 buildings or fire compartments on the same property, measured at right angles to the exposing building face.*

The distances detailed above are illustrated in **Figure 19** and the limiting distance is illustrated in **Figure 20**.

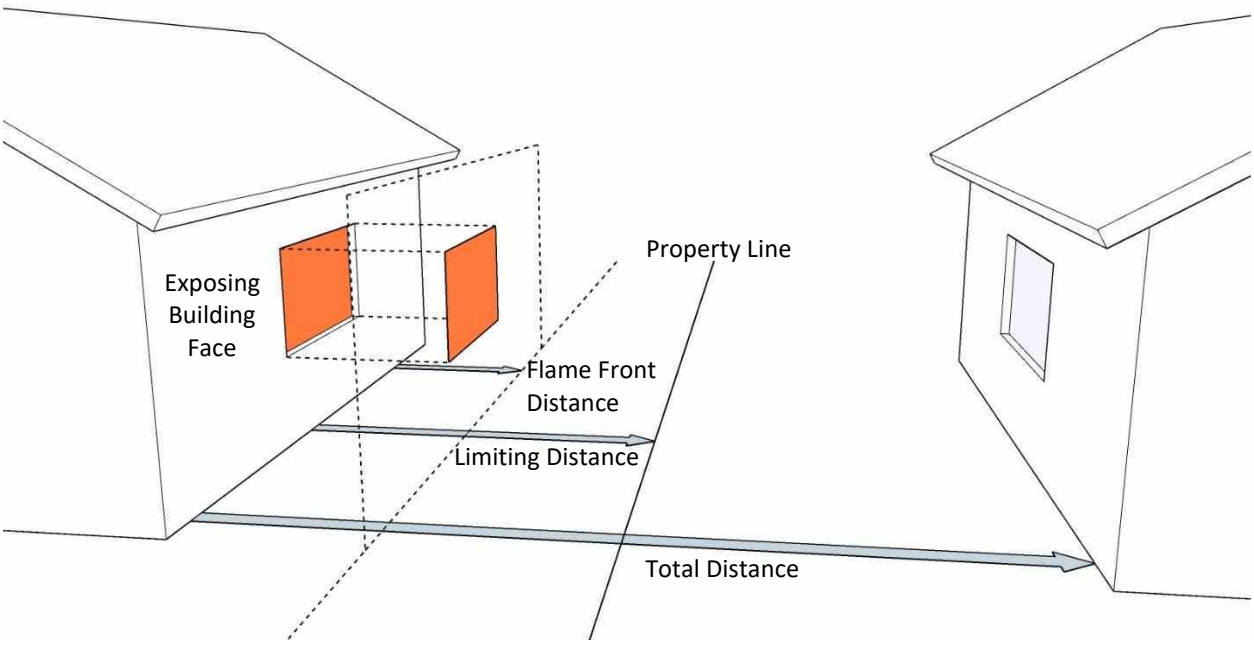


Figure 19: Spatial separation component distances.

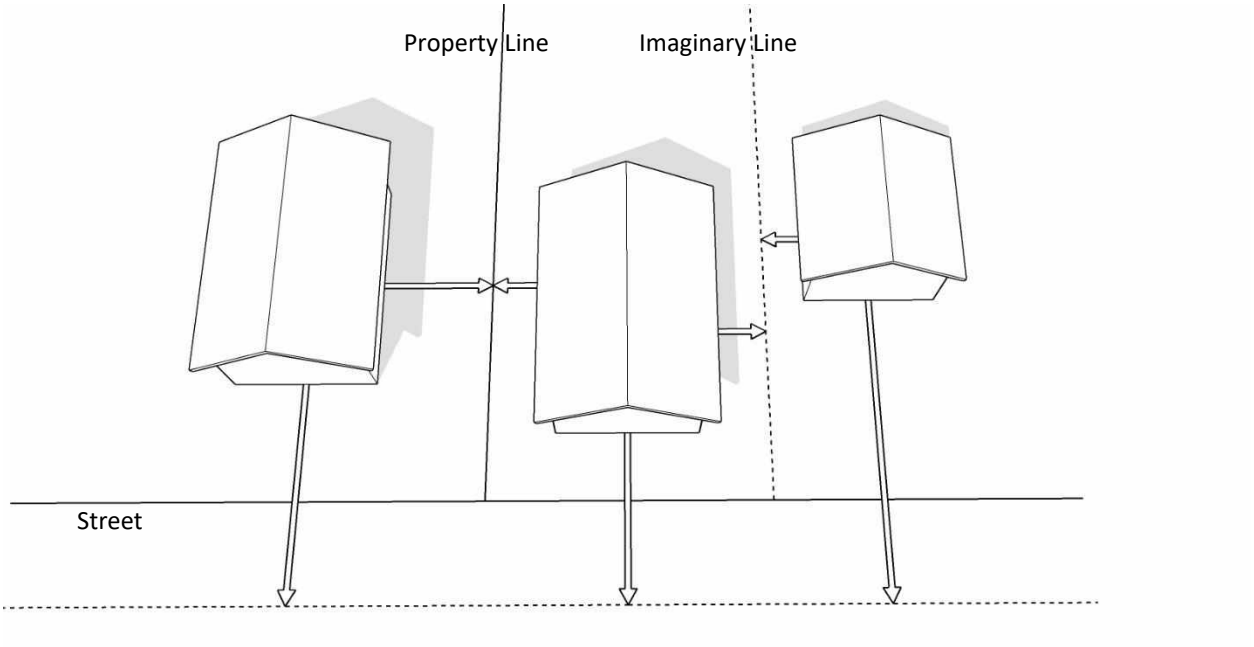


Figure 20: Limiting distance.

As noted in the definition outlined above, the limiting distance is “measured at right angles to the exposing building face”. Determination of the limiting distance can be complicated where the boundary to which it is measured is angled relative to the exposing building face, or the exposing building face is stepped or partially setback, as shown in **Figure 21**.

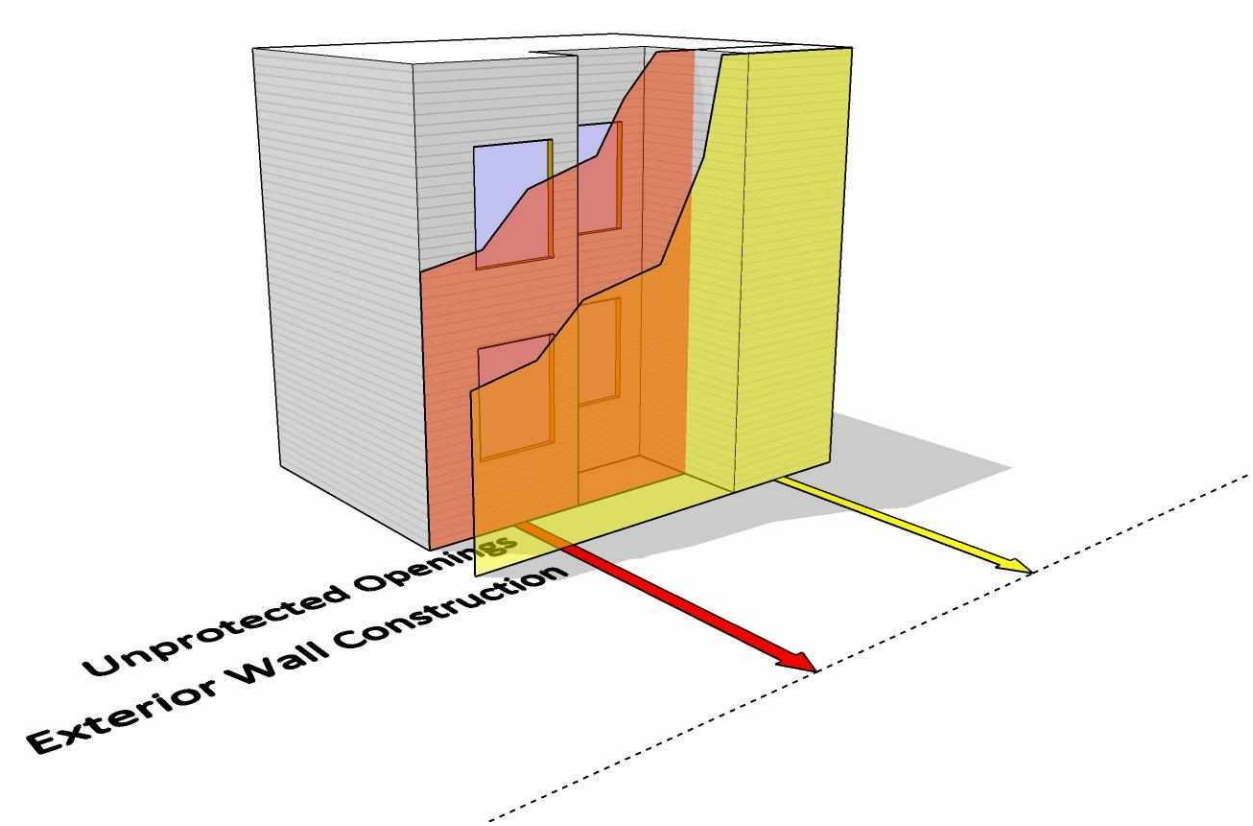


Figure 21: Limiting distance based on projected planes.

For purposes of determining the actual permitted percentage of unprotected openings, portions of a stepped exposing building face that contain unprotected openings are required to be projected onto a vertical plane (see the red plane in **Figure 21**) such that there are no unprotected openings between the vertical plane and the line to which the limiting distance is measured. The actual percentage of unprotected openings permitted in the exposed building face corresponds with the red plane. Similarly, for purposes of determining the construction requirements for the exposing building face, the exterior wall is required to be projected onto a vertical plane (see the yellow plane in **Figure 21**) such that no portion of the exterior wall of the building or of a fire compartment is located between the vertical plane and the line to which the limiting distance is measured. The exterior wall construction is then based on the percentage of unprotected openings that corresponds with the yellow plane, rather than the red plane.

An alternative method for determining the actual percentage of unprotected openings for stepped and angled walls of houses will be discussed in more detail in **Section 6.3.2** of this guide.

6.1.4 Concentration of Unprotected Openings

The grey radiator assumption, summarized in **Section 2.3.5** of this guide, applies to the distribution of unprotected openings in the exposing building face, and assumes those openings are evenly distributed over the exposing building face and the entire face is the radiating source. This assumption has been shown to be reasonable where limiting distances are more than 2 m and regardless of their distribution on the exposing

building face, the heat impact of individual openings at a distance becomes diminished. However, the impact of localized concentrations of unprotected openings on an exposing building face with a limiting distance of 2 m or less can result in localized heating of exposed building faces beyond the amount considered acceptable in the development of the spatial separation requirements (i.e., target criteria of 12.5 kW/m^2 as outlined in **Section 2.3.5** of this guide). This has been addressed in a more recent change to the Code limiting the maximum area of individual openings and minimum separation distances for those openings where a building is not sprinklered and the limiting distance is 2 m or less [Sentences 3.2.3.1.(5), 9.10.14.4.(3) and 9.10.15.4.(3)].

The spacing between individual unprotected (or glazed for houses) openings that serve a single room or space are not permitted to be less than [Sentences 3.2.3.1.(6), 9.10.14.4.(4) and 9.10.15.4.(4)]:

- 2 m horizontally of another unprotected (glazed) opening that is on the same exposing building face and serves the single room or space, or
- 2 m vertically of another unprotected (glazed) opening that serves the single room or space, or another room or space on the same storey.

A "single room or space" means [Sentences 3.2.3.1.(7), 9.10.14.4.(5) and 9.10.15.4.(5)]:

- two or more adjacent spaces having a full-height separating wall extending less than 1.5 m from the interior face of the exterior wall, or
- two or more stacked spaces that are on the same storey.

This requirement and explanation of "single room or space" was first introduced in the 2010 NBCC and is structured recognizing compartment fire dynamics (see **Section 2.2.2** of this guide) by assuming that fire growth and development in one room will be delayed from spreading to an adjacent room. This means that where the room of fire origin may transition through flashover to become fully involved, an adjacent room may be delayed from the same transition to full room involvement as a function of the separation from the room of fire origin [21]. The definition of "single room or space" originally referenced the criteria for the determination of whether 2 rooms are considered a "combination room" [22]:

> *two or more areas shall be considered to be a single room or space where there is an opening between the two areas that is no less than the larger of 3 m^2 or 40% of the area of the separating wall.*

For reference, the definition of a combination room at that time is as follows [Sentence 9.5.1.2.(1) of the 2005 NBCC]:

> *Two or more areas may be considered as a combination room if the opening between the areas occupies the larger of 3 m^2 or 40% or more of the area of the wall measured on the side of the dependent area.*

The definition of combination room above had been dropped from the 1995 NBCC and re-introduced to the 2005 NBCC. Part of the appendix note to the definition of combination room is as follows [Appendix Note A-9.5.1.2.(1) of the 2005 NBCC]:

> *a minimum opening of 3 m^2 is required, or the equivalent of a set of double doors.*

6.2 Application

The definitions and concepts outlined in the previous section of this guide can be used to determine the percentage of unprotected openings permitted in the exposed building face and are described in more detail in the following sections of this guide.

6.2.1 Methods for Determining Percentage of Unprotected (Glazed) Openings

The methods for establishing the permitted percentage of unprotected openings are shown in the flow chart included in **Figure 22**.

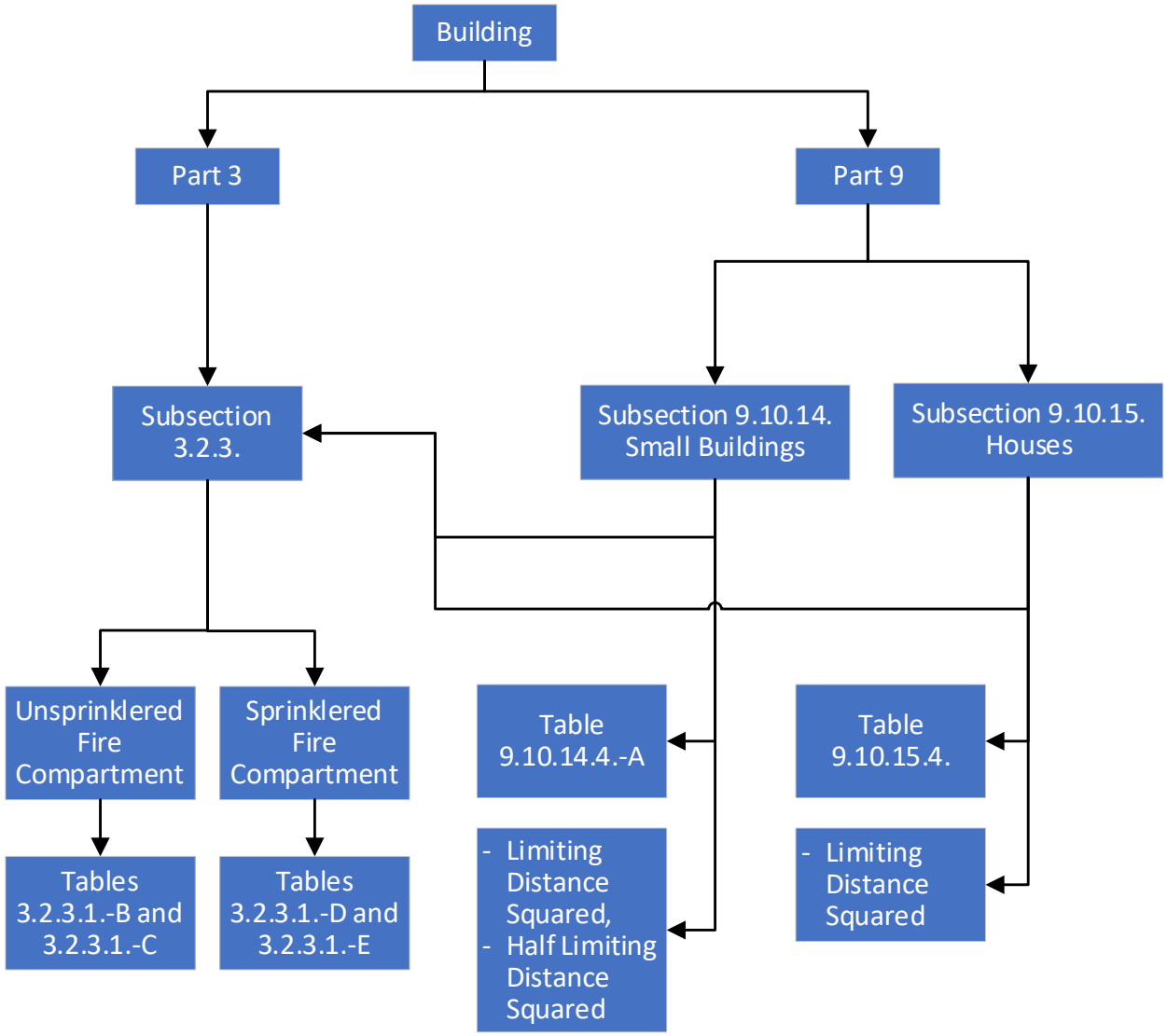


Figure 22: Permitted percentage of unprotected openings compliance paths.

6.2.2 Exterior Wall Construction

Exterior wall construction is governed as a function of the permitted percentage of unprotected openings as illustrated in **Figure 23**, with wall construction and cladding shown in blue for noncombustible and orange for combustible.

As shown in **Figure 23**, no foamed plastic insulation is permitted in a wall that is only permitted to have 10% or less of unprotected openings. In addition, the fire-resistance rating of the interior side of the exposing building face ranges from 45-minutes to 2-hours as a function of building/fire compartment occupancy and permitted percentage of unprotected openings. Note that where the permitted percentage of unprotected openings is

100% or greater, the construction of the exterior wall is not limited by the spatial separation requirements; however, may still be required to be constructed of noncombustible construction if governed by Part 3 and the building is required to be constructed of noncombustible construction based on Subsection 3.2.2.

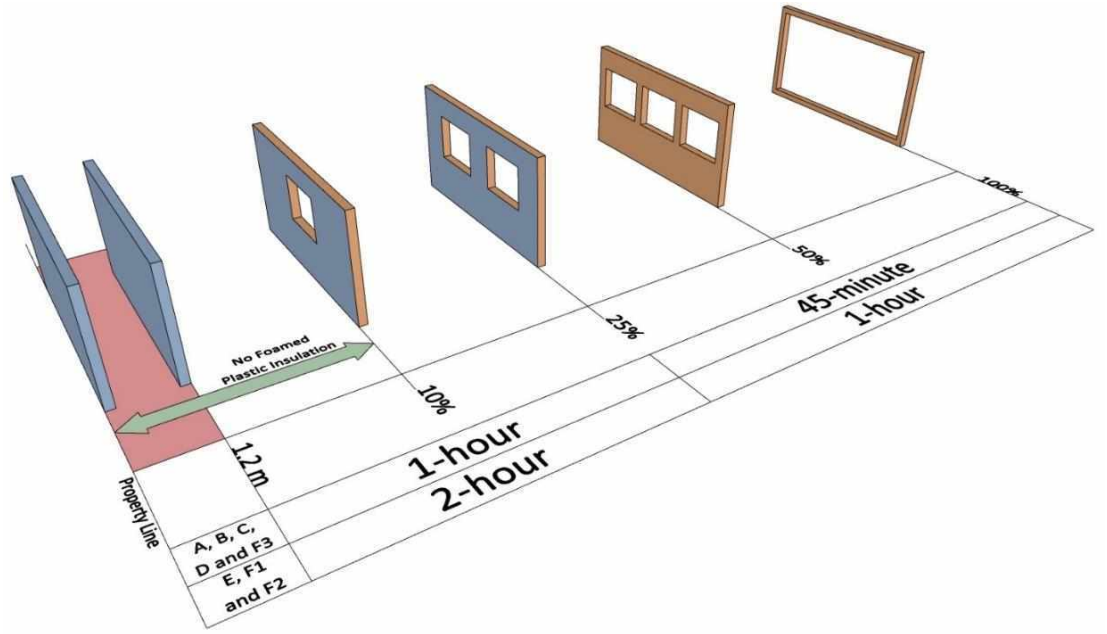


Figure 23: Exterior wall construction.

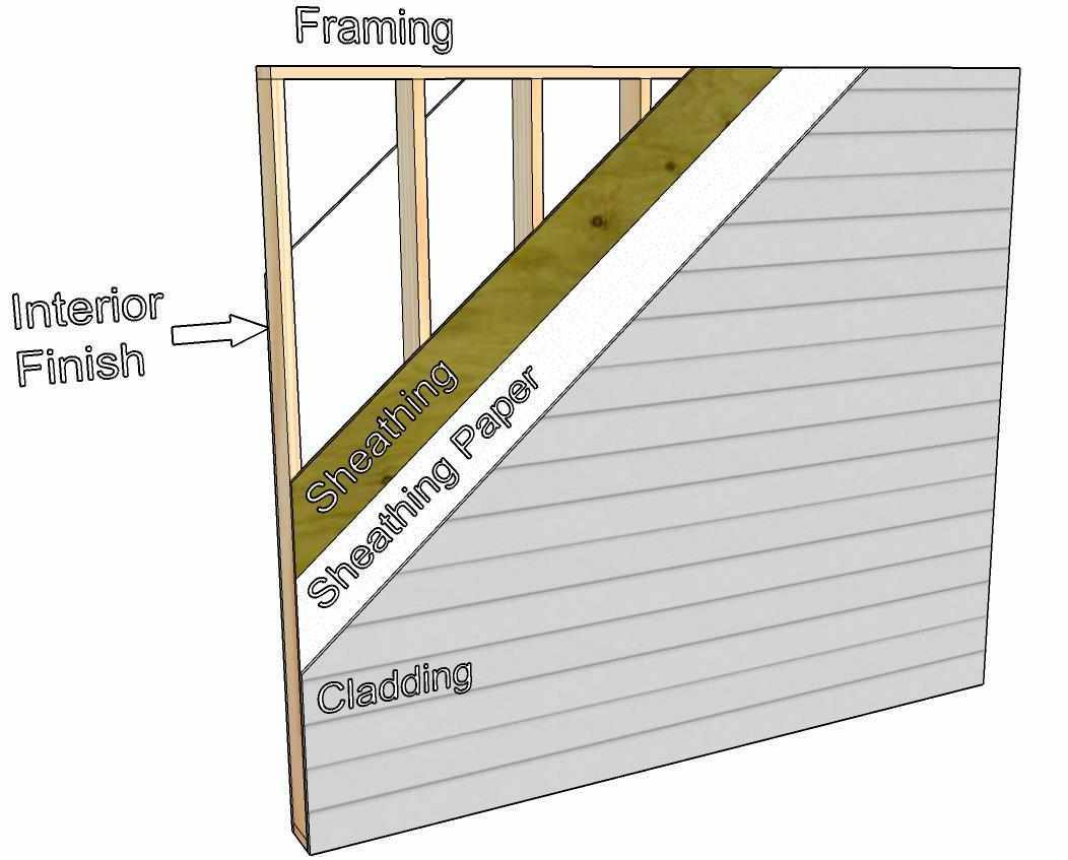


Figure 24: Example exterior wall.

With respect to wall construction, the wall is the set of components between the interior finish and the cladding. For example, considering **Figure 24**, the exterior wall includes the framing, sheathing and sheathing paper.

The exterior wall construction required for houses differs from the requirements detailed above and are determined as a function of the limiting distance being less than 0.6 m or 1.2 m respectively.

6.2.3 Buildings on the Same Property

As noted in the definition, limiting distance is "the distance from an exposing building face to…an imaginary line between 2 buildings or fire compartments on the same property". This is illustrated in **Figure 20** by the dotted line between the two structures on the right, which are located on the same property. This line is termed "imaginary" because it does not align with a property line or centre of a street or laneway and can be located to best suit the design of the buildings on the same property. For example, the area of unprotected openings on one building can be maximized by moving the imaginary line away from the face of that building; however, the area of unprotected openings on the other building will likely be reduced, and corresponding construction requirements more restrictive.

6.3 Simplifications and Exemptions for Houses

The following sections of this guide are specific to exemptions permitted for the application of the spatial separation requirements for houses.

6.3.1 Glazed Openings

The spatial separation requirements for Part 3 at one time referred to "window openings" prior to changing to unprotected openings today. The 1990 NBCC referred to "window openings" as the exposure hazard for houses, which was proposed to be changed to "glazed openings" for the 1995 NBCC based on the following rationale [24]:

> *The intention in having the existing sentence refer to "window" rather than "unprotected openings" was to avoid having the sentence limit the areas of normal solid swing-type doors in houses. However, this has the effect of exempting glazed openings in swing-type doors and glass sliding doors from the limitations as well. It does not make sense to place limits on windows and not on these other types of glazed openings. The proposed sentence therefore refers to "glazed openings" rather than "windows."*

The Illustrated User's Guide to Part 9 of the 2015 NBCC provides additional clarification on the determination of the area of glazed opening as follows [25]:

> *The area of glazed openings is measured to the rough opening of the window or door, not to the edges of the glazing.*

The following BCAB ruling is consistent with the interpretation in the Guide to Part 9 and the code change rational outlined above:

- BCAB #1845, "Spatial Separation Calculations for Houses"

6.3.2 Angled or Stepped Exposing Building Faces

Subsection 9.10.15. allows the determination of the permitted percentage of glazed openings for an exposing building face as a function of any number of individual vertical portions of that face. This method is detailed in

the Explanatory Note A-9.10.15.4.(2) including worked examples and provides flexibility for exposing building faces that are angled or stepped relative to the boundary to which the limiting distance is measured. This method was developed based on research by Sumathipala [26] showing that the heat flux at a property line using this method is consistent with that using the standard method provided in Subsections 3.2.3. and 9.10.14. of the Code.

Note that this method is only permitted where the limiting distance is greater than 2 m [Sentence 9.10.15.2.(3)].

6.3.3 Sprinklering

Subsections 3.2.3. and 9.10.14. allow for double the permitted percentage of unprotected openings where "all rooms, including closets and bathrooms, that are adjacent to the exposing building face and that have unprotected openings are sprinklered". However, Subsection 9.10.15. does not permit the same doubling of glazed openings for houses. This was confirmed in Interpretation 06-0081 issued by the BC Building Code Interpretation Committee [27].

The benefit of sprinklers can be realized by compliance with Subsection 3.2.3. relative to the determination of the maximum aggregate area of glazed openings in an exposing building face [Clause 9.10.15.4.(1)(b)]. BCAB Ruling #1845 noted the following:

> *Where the tables in Part 3 are used, the limits for unprotected openings apply to glazed openings.*

However, utilizing Subsection 3.2.3. instead of Table 9.10.15.4. limits the application of other options such as described in **Section 6.3.2** of this guide for angled or stepped building faces.

7 | Summary

This guide has been developed to provide building authorities, designers, architects, engineers and building code consultants (Stakeholders) with an understanding of some of the key fundamental concepts underlying the fire and life safety requirements of the BC Building Code.

The fundamental concepts underlying the fire and life safety requirements are not well understood, which leads to misinterpretation and misapplication.

This guide addresses the fundamental concepts for fire and life safety and how they relate to the development of the fire and life safety requirements of the BC Building Code:

- **Fire and Life Safety Risk Quantification:** occupancy classification, major and subsidiary occupancy differentiation, prohibited combinations and major occupancy separation.
- **Fire Containment:** building size, fire separations, fire-resistance rating, continuity, concealed spaces, suite (and similar) separations, protection of egress facilities.
- **External Fire Spread:** concepts and definitions to quantify degree of exposure, determination of appropriate separation, exterior wall construction.

This guide provides fundamental fire and life safety information upon which more practical guidelines to the application of the fire and life safety requirements of the BC Building Code can eventually be developed.

8 | Sources of Information

The following sources of information were referenced relative to the development of this guide:

1. British Columbia Building Code, 2018 Edition, Revision 3 (effective April 30, 2020).
2. Canadian Commission on Building and Fire Codes, “National Building Code of Canada”, 2015 Edition, National Research Council Canada.
3. American School, Cyclopedia of Fire Prevention and Insurance: A General Reference Work. 1912: American School of Correspondence.
4. National Board of Fire Underwriters, Building code recommended by the National Board of Fire Underwriters, New York: An ordinance providing for fire limits, and regulations governing the construction, alteration, equipment, repair or removal of buildings or structures. 1915: J. Kempster printing company.
5. United States. Dept. of Commerce. Building Code Committee, Recommended Minimum Requirements for Fire Resistance in Buildings. 1931: U.S. Government Printing Office.
6. Design United States. Central Housing Committee on Research, Construction. Subcommittee on Fire-Resistance Classifications, United States. National Bureau of Standards, Fire-resistance classifications of building constructions: report of Subcommittee on Fire-Resistance Classifications of the Central Housing Committee on Research, Design, and Construction. 1942: U.S. Dept. of Commerce, National Bureau of Standards.
7. Associate Committee on the National Building Code, National Building Code of Canada. 1953, Ottawa, ON: National Research Council of Canada.
8. American Society for Testing Materials, “A.S.T.M. Standards,” 1921.
9. Underwriters’ Laboratories of Canada, “Standard Methods of Fire Endurance Tests of Building Construction and Materials,” Fourth Edition, July 2007.
10. Ingberg, S.H., “Tests of the Severity of Building Fires”, National Bureau of Standards, Thirty-second Annual Meeting of the National Fire Protection Association, Atlantic City, May 9, 1928.
11. G.W. Shorter, National Research Council of Canada, “St. Lawrence Burns General Report,” DBR Internal Report No. 150, November 1959.
12. J. H. McGuire, National Research Council of Canada, “St. Lawrence Burns Radiometer Measurements,” DBR Report No. 153, December 1959.
13. J. H. McGuire, National Research Council of Canada, “Spatial Separation of Buildings,” DBR Internal Report No. 187, October 1959.
14. G.W. Shorter, National Research Council of Canada, “St. Lawrence Burns Summary Report,” DBR Internal Report No. 158, December 1959.
15. Canadian Commission on Building and Fire Codes, “User’s Guide – NBC 1995: Fire Protection, Occupant Safety and Accessibility (Part 3),” National Research Council Canada, 1996.
16. Ferguson, R.S., “What Constitutes a Building? Some Comments on a Tariff Board Ruling,” National Research Council of Canada, Technical Note 419, June 1964.
17. Associate Committee on the National Building Code, Minutes of the Seventh Meeting of the Panel on Heights and Areas (Advisory Fire Group). 1959, National Building Code of Canada: Ottawa, ON.
18. Calder, K.D., Senez, P.L., “The Historical Development of the Building Size Limits in the National Building Code of Canada,” Sereca Consulting Ltd., March 19, 2015.
19. Associate Committee on the National Building Code, “National Building Code of Canada 1960,” National Research Council of Canada, NRC No. 5800, 1960.
20. Associate Committee on the National Building Code, “Proceedings 1970 Building Officials’ Conference of Canada,” National Research Council of Canada, NBC Report No. 21, April 1970.

21. Canadian Commission on Building and Fire Codes, “Proposed Change: NBC05-03.02.03.01.(05)-(07)-insert-FP,HSB-V4_ed.doc,” 2008.
22. Canadian Commission on Building and Fire Codes, “Proposed Change: NBC05-09.10.14.04. (01)(03)(04)-insert-FP,HSB_v3.doc,” 2008.
23. Canadian Mortgage and Housing Corporation, “The Use and Design of Space in the Home,” NHA 5077 7/77, Second Edition, 1977.
24. Canadian Commission on Building and Fire Codes, “NBC 1990 CNB, 9.10.14.12.(2), Housing and Small Buildings,” HSB-646/r00, October 16, 1992.
25. Canadian Commission on Building and Fire Codes, “Illustrated User’s Guide – NBC 2015: Part 9 of Division B, Housing and Small Buildings,” National Research Council of Canada, Second Edition, 2018.
26. Sumathipala, K., “Committee Paper on Allowable Openings in Exterior Walls for Stepped Exterior Faces,” National Fire Laboratory, Institute for Research in Construction, National Research Council, October 16, 1992.
27. BC Building Code Interpretation Committee, “Spatial separation between sprinklered houses,” File No.: 06-0081, January 18, 2011.
28. Katnick, J.N., Ferguson, R.S., “Fire Separations in the National Building Code (1953),” Report No. 135, Division of Building Research, National Research Council of Canada, Ottawa, December 1957.
29. The Associate Committee on the National Building Code of Canada, “Minutes of the Ninth Meeting of the Standing Committee on Use and Occupancy,” National Research Council Canada, Ottawa, 15 April 1971.

Research Centre
1701-4555 Kingsway
Burnaby, BC V5H 4V8
Phone: 604 439 4135
Toll-free: 1 866 465 6873
Email: technicalresearch@bchousing.org
www.bchousing.org