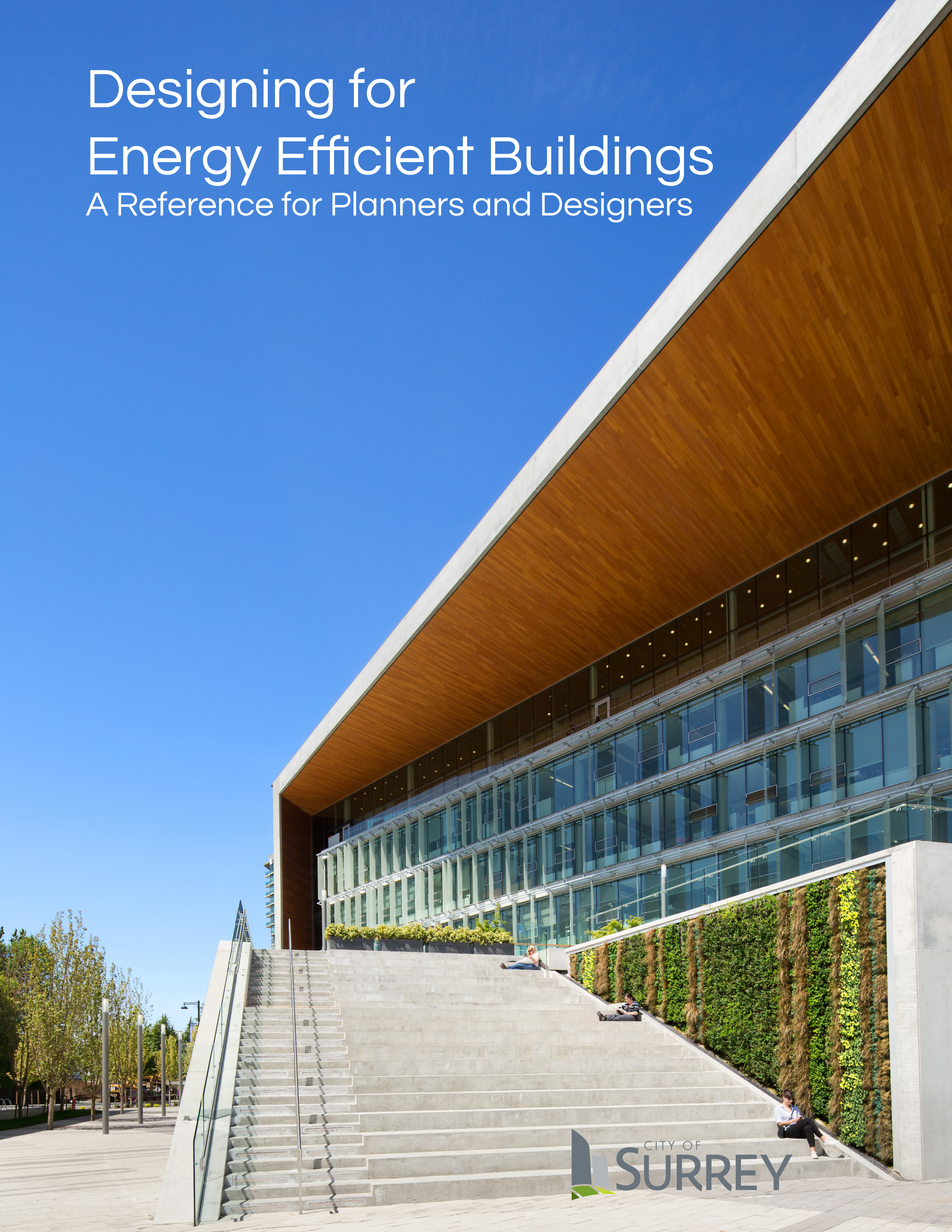
Designing for Energy Efficient Buildings

A Reference for Planners and Designers



CITY OF SURREY

Designing for Energy Efficient Buildings

A Reference for Planners and Designers

Prepared for:

CITY OF SURREY

Prepared by:

INTEGRAL GROUP

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INTRODUCTION

Sustainability has become an increasing priority in the City of Surrey. A number of policies have made Surrey a leader among British Columbian municipalities in action on climate change and energy efficiency, including the development of the Sustainability Charter, and the Community Climate Action Strategy. These have identified a number of goals and strategies for reducing energy use and the release of harmful greenhouse gas emissions into the atmosphere from a range of sources, including Surrey's built environment. This reference guide is the next step in Surrey's progress towards creating a sustainable, liveable environment for its residents. It identifies measures and strategies for improving the energy efficiency of Surrey's buildings using principles of sustainable design.

This Reference has been written to provide an accessible reference for both City of Surrey staff and applicants submitting development proposals to the city on the principles of sustainable design and their application to the Surrey context. The information provided in this reference will provide Surrey Staff and the Advisory Design Panel (ADP) with a means of ensuring sustainable building measures and strategies are incorporated into building projects. The Reference also provides Developers and other members of the Building Design and Construction industry with a means of ensuring that their applications meet accepted standards of sustainable building design.

Sustainable design principles can be found for each of the following key building types:

Form and Character Guidelines

This Reference should be used in conjunction with existing municipal and provincial policy, as well as the City of Surrey's Development Permit Guidelines for Form and Character. These offer a set of design guidelines to be considered in Site Design, Building Form, and Signage for residential, commercial, and mixed use buildings inside the city's limits. Some sections relevant to the strategies outlined in this guide include:

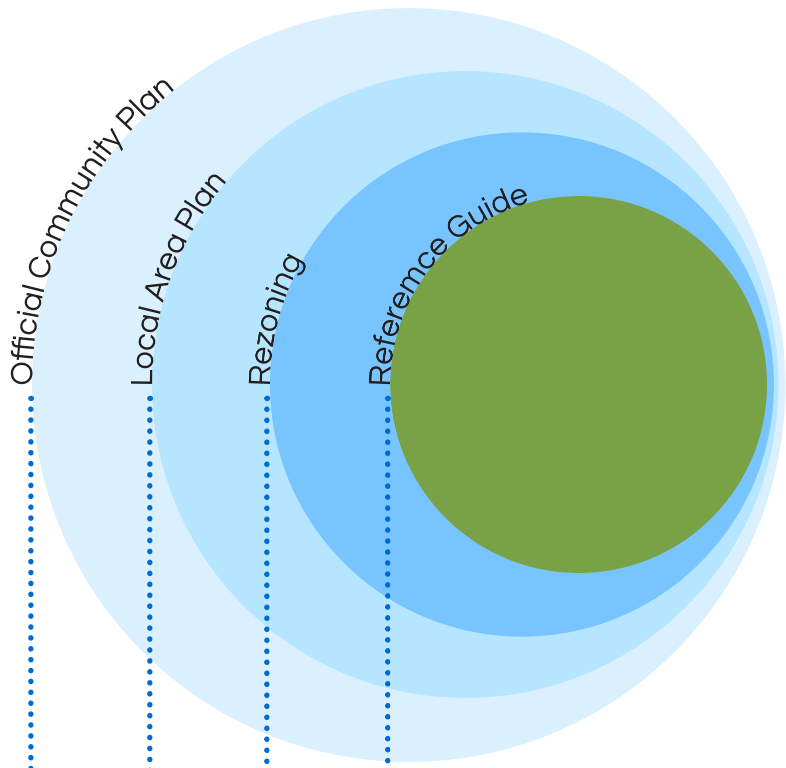
- **Site Landscaping**
- **Shared Outdoor Amenity Space**
- **Public Realm and Street Interface**
- **Building Ground Plane Interface**
- **Building Massing**
- **Architectural Character, Treatment and Materials**
- **Residential Liveability**

For full details on the development application and permitting process, developers should consult the City of Surrey's Land Development Process.

HOW TO USE THIS REFERENCE

A RESOURCE FOR PLANNERS

Long-range Community Planners may use the information presented here in the development and review of Surrey's Official Community Plan, as well as the city's Local Area Plans. For Development Planners, this Reference Guide provides a clear and simple means of evaluating development applications and verifying that they have incorporated energy efficiency measures into building design. The Refernce is intended to compliment and be used alongside existing permit evaluation processes.



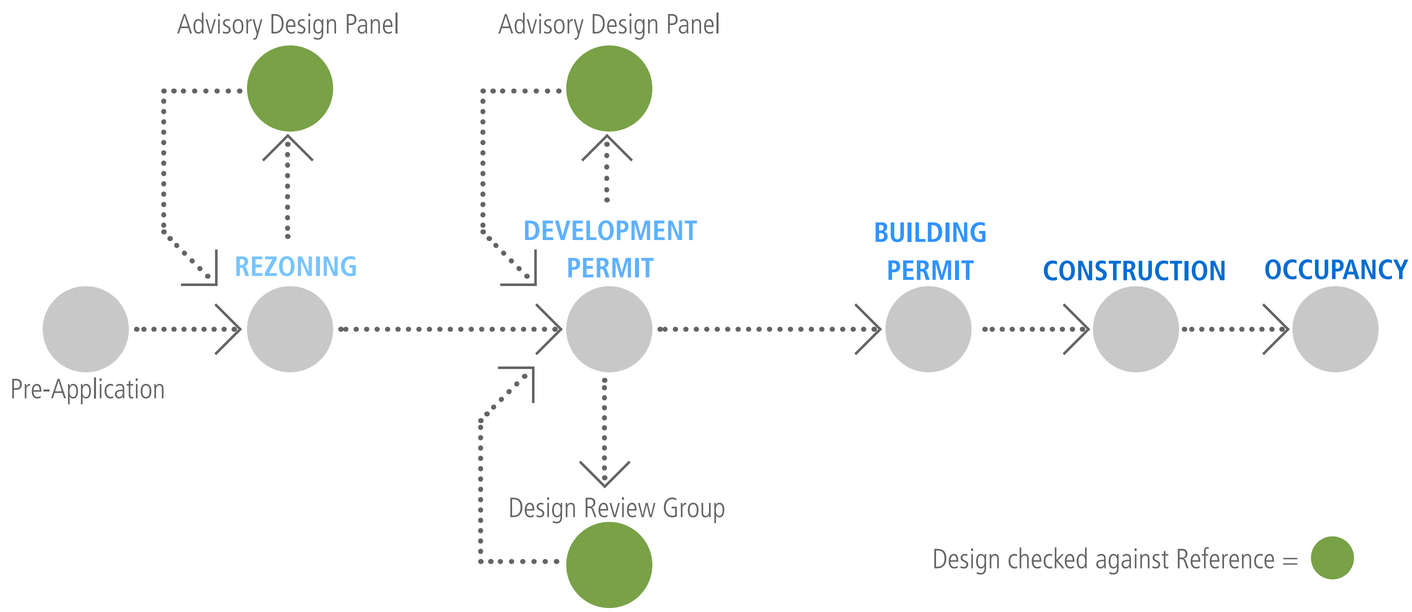
Area Planners, City Architects, and/or **Energy Planners** use this Reference Guide as a compliment to Sustainable Development Checklists submitted as a part of Development Packages.

Area Planners and **Energy Planners** use this Reference Guide as a resource to support density bonus requirements in rezoning stages of the development process.

Community Planners and/or **Energy Planners** consult this Reference Guide for relevant building types when creating Local Area Plans (e.g. NCPs, TCPs, CCP).

Community Planners, Energy Planners and/or **City Architects** use this Reference Guide to establish guidelines for urban form and character that promote sustainable building designs.

Developers consult this Reference Guide when preparing and submitting development applications for new buildings. This guide offers clarity on the appropriate and ideal ways of improving building energy efficiency, and identifies cost-effective strategies for improving overall building energy performance.



REZONING:
In submitting a development application for Rezoning, developers are required to ensure that their application includes all relevant documentation. Developers are encouraged to reference these guidelines and include elements into their building design documents as this will be reviewed by City staff and the ADP.

DEVELOPMENT PERMIT:
At this stage, the Design Review Group will use these guidelines to assess the extent to which the Development Package incorporates sustainable building design measures. Applications for large-scale or noteworthy projects may also be reviewed by the Advisory Design Panel. The developer must address any comments by the Design Review Group and/or the Advisory Design Panel by making any requested changes and resubmitting the application.

BUILDING PERMIT:
Once approval for the project has been granted by both Surrey staff and City Council, the developer may submit a Building Permit application package to Building Services. Using this Reference Guide will ensure City policies are being met.

CONSTRUCTION/OCCUPANCY:
City officials may inspect building to ensure elements agreed to in Development Permit are being adhered to and implemented.

REFERENCE TABLE

BUILDING TYPE	ELEMENT	EFFECTIVENESS	COST
4-6 Storey Wood-frame Residential & Mixed-Use  Photo: MAC Marketing Solutions	Compact Massing & Form	🍃	$
	40% Max. Window-to-Wall Ratio	🍃🍃🍃	$
	Minimum 24" Sill Height	🍃🍃	$
	Horizontal Shading on South	🍃🍃🍃	$$
	Vertical Shading on West	🍃🍃🍃	$$
	Deciduous Trees & Plantings	🍃	$
	Thermally Broken Balconies	🍃🍃🍃	$$
	Window Frame Detailing	🍃🍃	$$
	Natural Ventilation	🍃	$
	Material Selection	🍃🍃	$
Concrete Residential & Mixed-Use  Photo: Forum Skyscraper	Orientation	🍃	$
	Compact Massing & Form	🍃	$
	50% Max. Window-to-Wall Ratio	🍃🍃🍃	$$
	Minimum 24" Sill Height	🍃🍃	$
	Horizontal Shading on South	🍃🍃🍃	$$
	Vertical Shading on West	🍃🍃🍃	$$
	Deciduous Trees & Plantings	🍃	$
	Thermally Broken Balconies	🍃🍃🍃	$$$
	Continuous Insulation	🍃🍃	$$
	Window Frame Detailing	🍃🍃	$
	Natural Ventilation	🍃	$
	Material Selection	🍃🍃	$
Commercial Office  Photo: Stuart Olson	Compact Massing & Form	🍃	$
	50% Max. Window-to-Wall Ratio	🍃🍃🍃	$
	Minimum 24" Sill Height	🍃🍃	$
	Horizontal Shading on South	🍃🍃🍃	$$
	Vertical Shading on West	🍃🍃🍃	$$
	Deciduous Trees & Plantings	🍃	$
	Continuous Insulation	🍃🍃🍃	$$
	Window Frame Detailing	🍃🍃	$$
	Natural Ventilation	🍃	$
	Material Selection	🍃🍃	$
1-2 Storey Retail  Photo: Google Streetview	50% Max. Window-Wall Ratio	🍃🍃🍃	$
	Minimum 24" Sill Height	🍃🍃	$
	Horizontal Shading on South	🍃🍃🍃	$
	Deciduous Trees & Plantings	🍃	$
	Continuous Insulation	🍃🍃🍃	$$
	Window Frame Detailing	🍃🍃	$$
	Material Selection	🍃🍃	$

NATURAL GAS SAVINGS	ELECTRICITY SAVINGS	PAGE
🔥		28
🔥	⚡	30
	⚡	30
	⚡	31
	⚡	31
	⚡	31+35
🔥		32
🔥		34
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🔥	⚡	35
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🔥	⚡	40
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	⚡	41
	⚡	41+46
🔥		42
🔥		44
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🔥	⚡	46
🔥		50
🔥	⚡	52
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	⚡	53
	⚡	53
	⚡	53+56
🔥	⚡	54
🔥	⚡	54
	⚡	55
🔥	⚡	56
🔥	⚡	60
	⚡	60
	⚡	61
	⚡	61+63
🔥	⚡	62
🔥	⚡	62
🔥	⚡	63

DESIGNING SUSTAINABLE BUILDINGS

The principle objective of sustainable building design is to reduce, avoid, or even reverse the depletion or degradation of the earth's resources and ecosystems accrued through the construction and operation of buildings. Regionally, buildings account for over 50% of our total water and energy use and the associated release of climate-warming emissions into the atmosphere; it is important to ensure that new buildings are constructed to high efficiency standards that reduce their overall impact on the climate and environment. Such designs should simultaneously seek to create enjoyable spaces that improve the overall safety and liveability of the built environment, at a reasonable cost.

WHAT IS PASSIVE DESIGN?

While there are several different strategies involved in sustainable building design, "passive design" refers to the process of designing and constructing buildings in such a way that both energy requirements are minimized and the comfort of building occupants is improved. Passive design strategies use building characteristics such as massing, orientation and materials to maximize the use of free, ambient sources of energy to light, heat, cool, and ventilate building spaces. In following passive design principles, the need for more "active" systems that use energy and cost money to heat, cool, and circulate air through buildings is reduced. Reducing these systems can simplify building operations, as there is less need for complicated mechanical equipment. Implementing passive design strategies before scaling and deciding on mechanical systems can therefore help to minimize the total amount of energy and the overall building costs associated with keeping building occupants comfortable throughout the year.

Other benefits of passive building design include:

- Well-insulated building spaces that improve thermal comfort and reduce noise.
- Lower electricity and heating (e.g. natural gas) bills
- Lower incidences of moisture and associated mould growth.
- Reduce difficult-to-operate, and energy-intensive mechanical systems
- Well-ventilated, healthier building spaces.
- Fewer operational carbon emissions released into the atmosphere

Prior to the invention of mechanical and electrical systems for heating, cooling and ventilation, passive design techniques were needed to cool dwellings in hot climates, such as the use of mud or clay to keep out the hot sun. In cooler climates, techniques such as straw bale walls or turf roofs have long been used to create thick, insulating barriers to keep the cold out and the heat in.

These traditional building methods are just as effective today as they were in the past, and can be applied to modern buildings. Developed in Germany in the 1990's, the Passive House standard is the first third-party verified green building rating system to rely on passive design as the primary tool to achieve deep energy savings. The principles of Passive House include:

- **Thermal bridge-free design;**
- **Superior windows;**
- **Ventilation with heat recovery;**
- **Quality insulation; and**
- **Airtight construction.**

Some of these principles that impact urban design are included in this guide. Passive House and other design standards are being applied across North America, and many of these buildings and concepts can already be found in communities across British Columbia.

A Multi-Unit Residential Building designed to Passive House standards, by Cornerstone Architecture.

PASSIVE DESIGN BASICS

While passive design principles apply to all buildings, certain building types typically demand more cooling energy than heating energy over the period of a year, or vice-versa. Whether a building is classified as either **heating-dominant** or **cooling-dominant** is determined as a function of how the building is being used, the needs of the occupants, and any unusual circumstances that might change the overall design requirements.

HEATING DOMINANT BUILDINGS

A heating-dominant building consumes more energy annually in heating building spaces than it does cooling them. For example, daycare facilities typically use more energy to heat their buildings to ensure that small children are warm and comfortable. In general, all types of residential buildings are classified as heating-dominant, and as such require the use of passive design measures that focus principally on reducing the need for mechanical heating. The buildings types addressed in this reference that are considered heating-dominant include:

- **4-6 Storey Residential and Mixed-Use Buildings**
- **Concrete Residential Buildings**

COOLING DOMINANT BUILDINGS

A cooling-dominant building consumes more energy cooling building spaces than it does heating them. For example, a data centre filled with heat-generating computers and equipment has substantial annual energy costs from cooling the building, and would benefit from passive design strategies that maximize passive cooling. Office buildings are generally classified as cooling-dominant as a result of the high number of occupants, as well as the large number of heat-generating computers and equipment. The buildings types outlined in this guide that are considered cooling-dominant include:

- **4 Storey Office Buildings**
- **1-2 Storey Retail Buildings**

PASSIVE DESIGN STRATEGIES

Five major strategies form the basis of the material presented in this reference guide:

Building Envelope Design
Passive Heating,
Passive Cooling,
Passive Ventilation, and
Daylighting.

BUILDING ENVELOPE DESIGN

Elements of a good building envelope include:

- > Compact Massing & Form
- > Thermally Broken Envelope Details
- > Continuous Insulation
- > Window Frame Detailing

A building's envelope is made up of all the building components that separate interior spaces from the outside, and is central to the success of all other systems and strategies. A durable, high-quality building envelope that consistently prevents air and moisture from entering interior spaces is the most effective way of improving a building's energy performance. Passive buildings in particular require a highly sealed building envelope with high-performance insulation and windows in order to ensure that unwanted heat gains and losses are minimized. Good building envelopes also improve a building's longevity and durability by preventing deterioration caused by the entry of moisture into the building's structure or components. The well-known "leaky condo" phenomenon in the Lower Mainland was the result of poorly designed building envelopes.

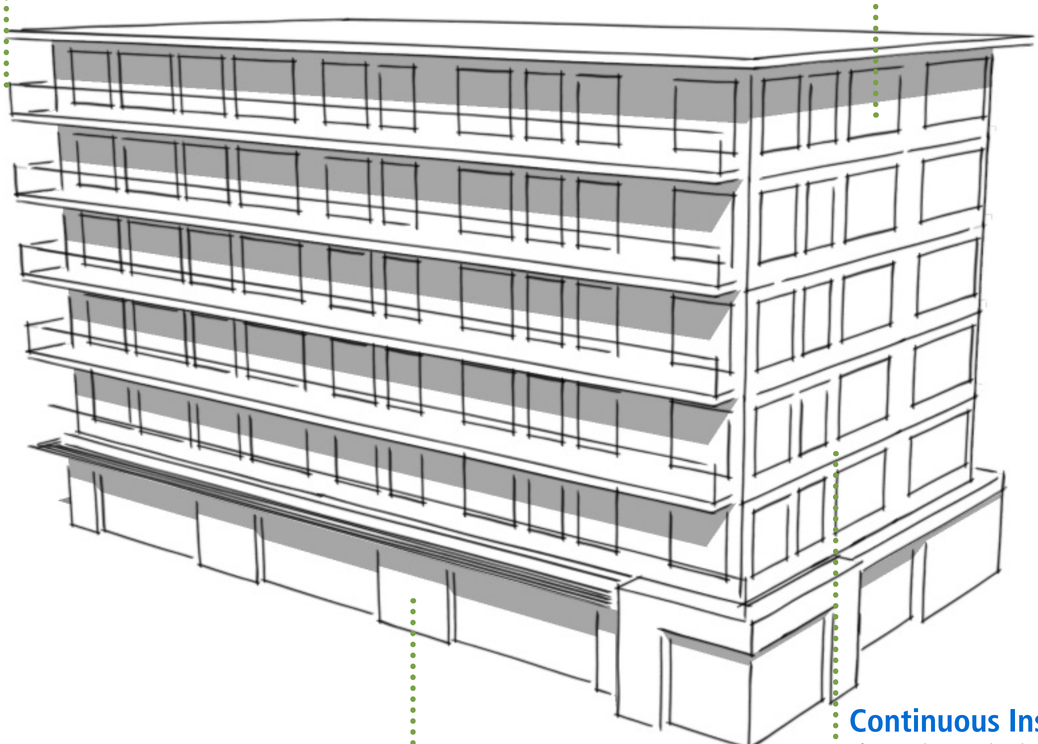
Another major issue to consider in building envelopes is the need to minimize thermal bridging. A **thermal bridge** refers to an area in the building envelope that creates a pathway for heat from within the building to escape, such as a balcony or a beam running from the building interior to exterior. To prevent heat loss and help keep heat inside a building, thermal bridges should be "broken" using insulating materials.

Thermally Broken Balconies

Balcony connections to the building structure should be thermally broken, ensuring a continuous insulation layer around the entire building envelope.

Windows

Window frames should be placed in line with the insulation layer, minimizing thermal bridging through the frame-to-wall connection.



Compact Massing & Form

A building with a simpler form lowers the potential for thermal bridging to occur through complex junctions in the building envelope.

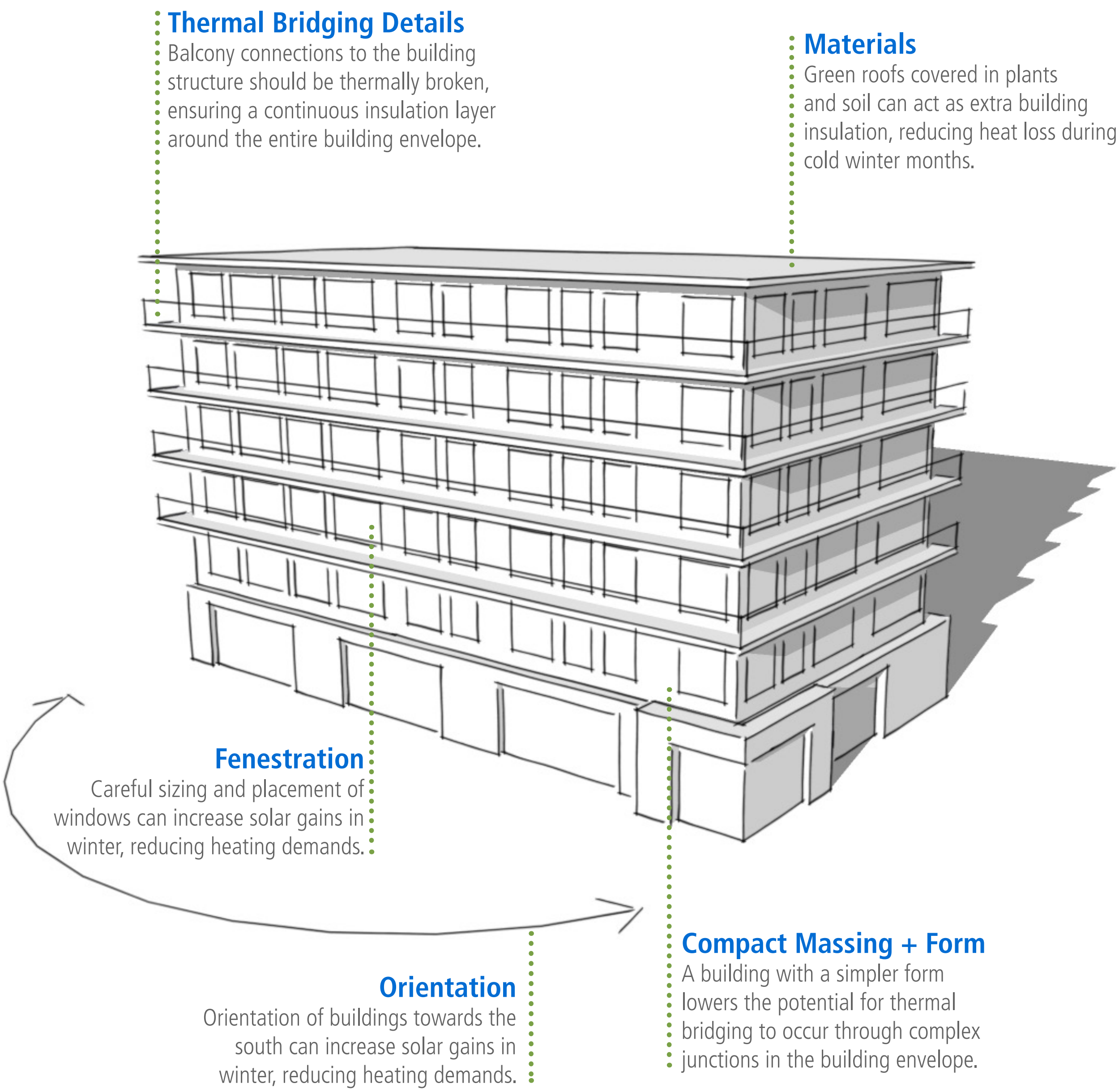
Continuous Insulation

Floor edges, whether in wood, concrete or steel, should be insulated on the exterior to minimize significant heat loss. This is particularly important in window wall construction.

Passive heating is achieved by collecting sunlight into a building's internal spaces via the use of properly-sized, south-facing windows that maximize heat gains without the addition of active heating systems. Well-insulated and airtight envelopes also prevent heat generated from solar radiation or from internal sources (such as people or equipment) from escaping the building. A building's passive heating strategy can be heavily impacted by thermal bridging in the building envelope, making the quality of the envelope a high priority.

Elements of a passive heating strategy include:

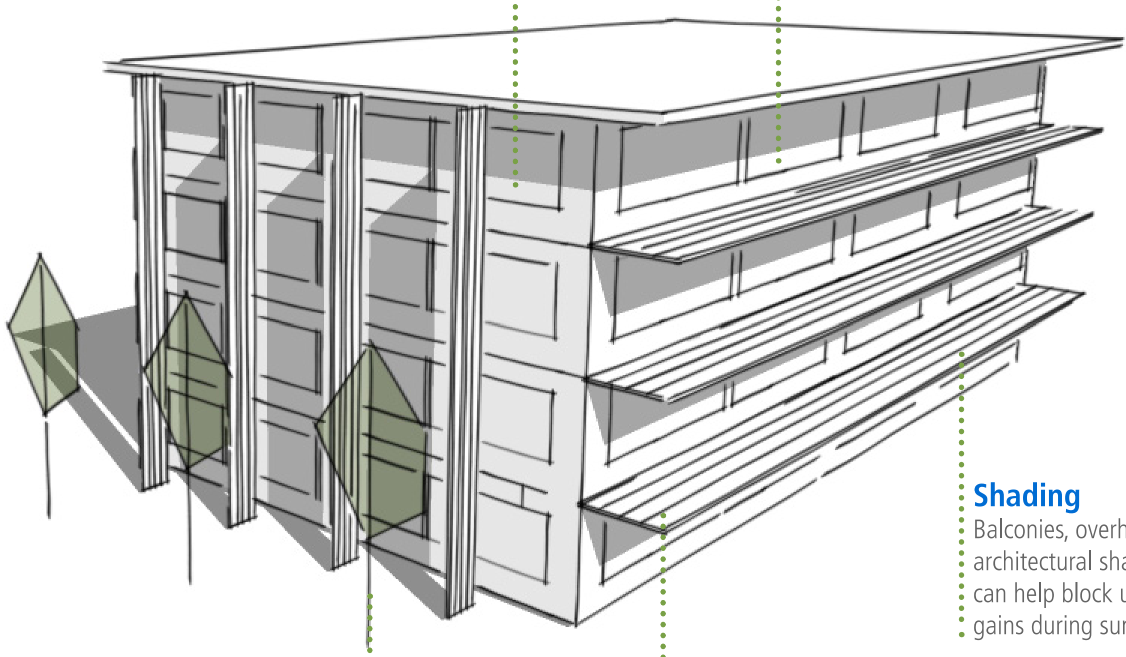
> Orientation
> Compact Massing & Form
> Fenestration
> Thermal Bridging Details
> Material Selection



Elements of a passive cooling strategy include:

> Fenestration
> Shading
> Natural Ventilation
> Material Selection

Passive cooling is typically achieved by preventing and/or removing unwanted heat gains to keep interior spaces at a comfortable temperature throughout warmer summer months. Unwanted heat from incoming solar radiation (or "solar gains") can be blocked by using external features such as shades, overhangs, and vegetation. Unwanted heat can be removed by naturally ventilating the space with cooler outdoor air, or by storing excess heat in thermal masses within the space. Overnight, **natural ventilation** can be used to remove heat that has accumulated in the building throughout the day. A well-insulated envelope and carefully placed windows can also impact a building's cooling potential.



Passive ventilation refers to the use of a natural flow of air to remove stale, unwanted air and introduce fresh air into a building. This can occur through **cross-ventilation,** in which air is moved across an individual dwelling unit or an entire building floor through adjacent or opposing windows or openings. Another form of passive ventilation can be achieved through the **stack-effect**, in which air is moved via convection through vertically stacked windows or vertically oriented spaces in a building, such as an elevator shaft. Passive ventilation reduces the need for mechanically-circulated air, thus reducing overall building energy consumption. However, as moving air can affect occupant comfort and carry odours or sounds, careful consideration should be used when selecting a passive ventilation strategy. Ventilation rates can also increase or decrease dramatically if wind direction is not taken into consideration.

Elements of a passive ventilation strategy include:

> Orientation

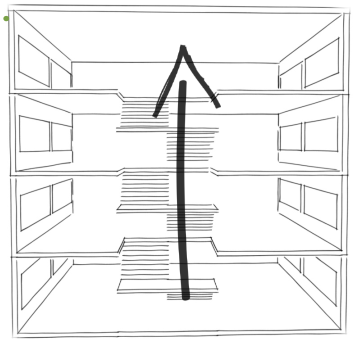
> Massing & Form

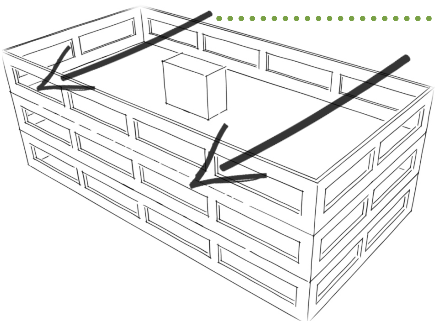
> Cross & Stack Ventilation

> Material Selection

Stack Ventilation

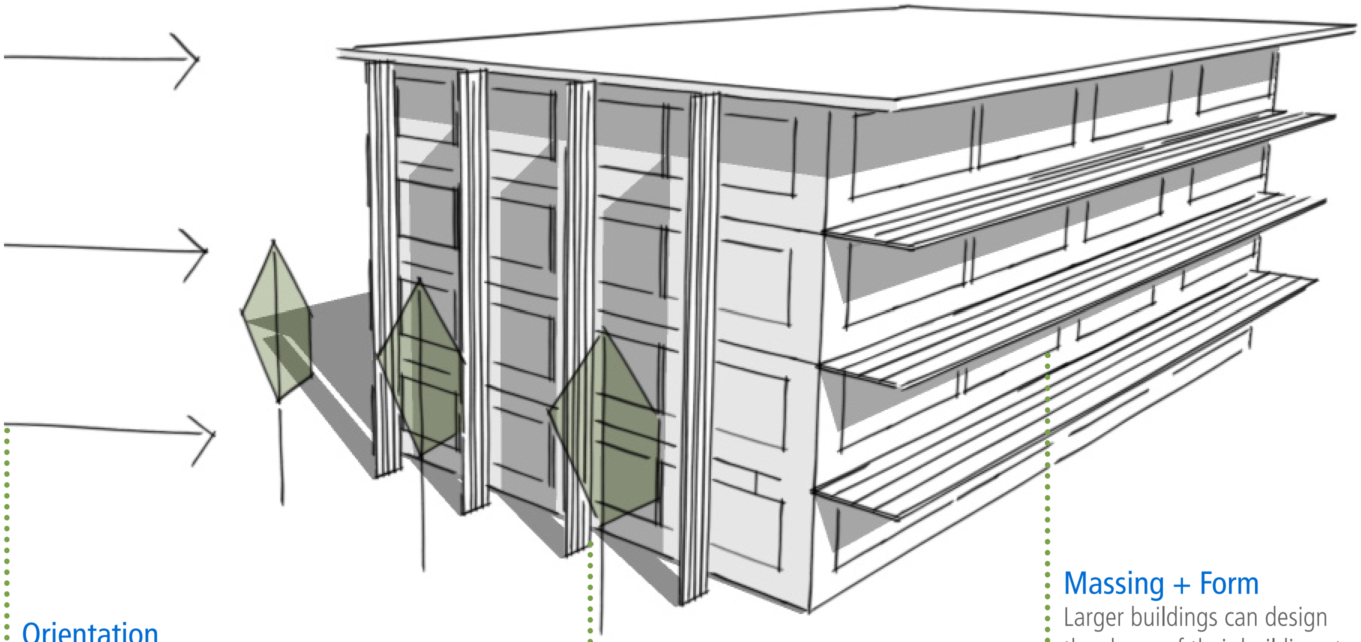
Using atria or other vertical spaces in combination with operable windows can naturally ventilate a building by drawing cool air in through lower floors and exhausting hot air out upper floors or vents.





Cross Ventilation

Careful sizing and placement of windows can ensure natural ventilation potential is maximized, particularly in residential corner suites or across commercial floorplates.



Orientation

Operable windows should be maximized on facades directly facing prevalent winds.

Materials

Vegetation can help clean and cool incoming outdoor air, before entering the building, increasing occupant comfort and health.

Massing + Form

Larger buildings can design the shape of their buildings to "harness" winds, increasing natural ventilation potential.

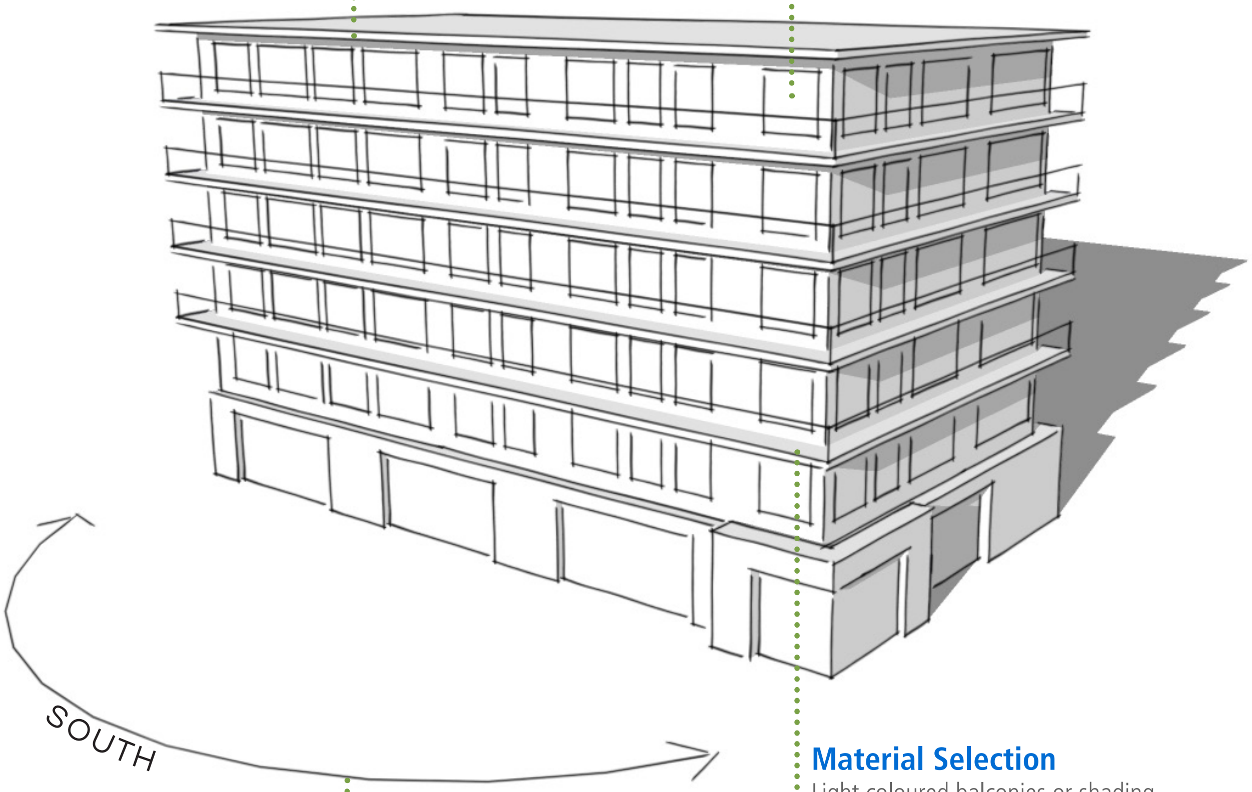
Elements of a passive daylighting strategy include:

> Orientation
> Fenestration
> Shading
> Material Selection

Daylighting refers to the use of natural light from the sun and reflected light from exterior surroundings to light a building interior. This strategy reduces the need for artificial, electric lighting, and can dramatically reduce a building's overall electricity consumption. The use of daylighting can also reduce energy requirements for space cooling through the elimination or reduction in the number of heat-generating light fixtures. To achieve this strategy, sensors can be placed around building perimeters to turn off overhead lighting when natural daylight is sufficient, and turn them back on in the evening or during cloudy periods. Sites and surroundings should be evaluated to understand daylighting potential, and careful design is needed to maximize the daylighting potential while minimizing the risk of overheating due to overexposure to solar radiation.

Fenestration
Careful sizing and placement of windows can ensure natural daylighting potential is maximized, reducing electrical lighting loads.

Shading
Balconies, overhangs and other architectural shading devices should be designed to block summer sun, yet allow winter sun to enter interior spaces, while minimizing glare.



Material Selection
Light coloured balconies or shading devices can act as exterior light shelves, reflecting natural daylight further into interior spaces.

Orientation
Whenever possible, buildings should be oriented with their long axis facing south to maximize daylighting potential.

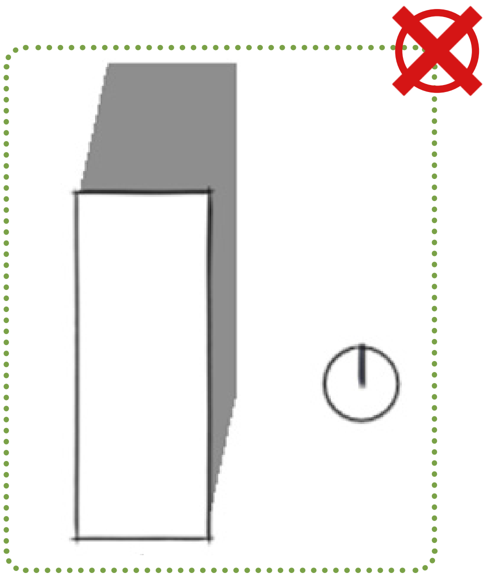
PASSIVE DESIGN ELEMENTS

Passive design strategies are achieved through the combined use of specific **building elements**, such as the careful selection of windows or the detailing of exterior balconies. Each element selected for inclusion into a building design will affect the performance of individual strategies, such as passive heating, cooling, or ventilation. The combined use of all elements will together affect the overall performance of the building. In the following sections, key passive design elements addressed in this guide are explained.

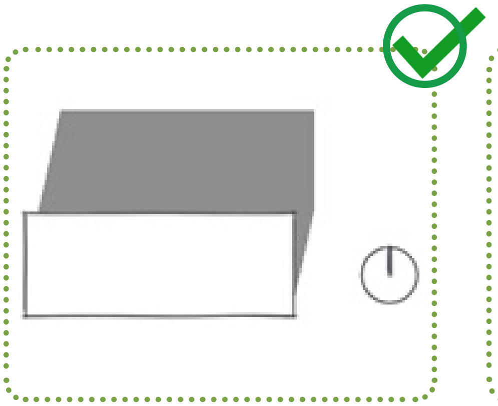
ORIENTATION

The appropriate orientation of a building on a site can help reduce lighting and heating loads significantly. In fact, annual heating demands can be reduced by as much to 30-40% when a building's solar gain potential is maximized, even while avoiding overheating. Solar gains are predominantly available from the south, but can come from the east and west facades when planned carefully.

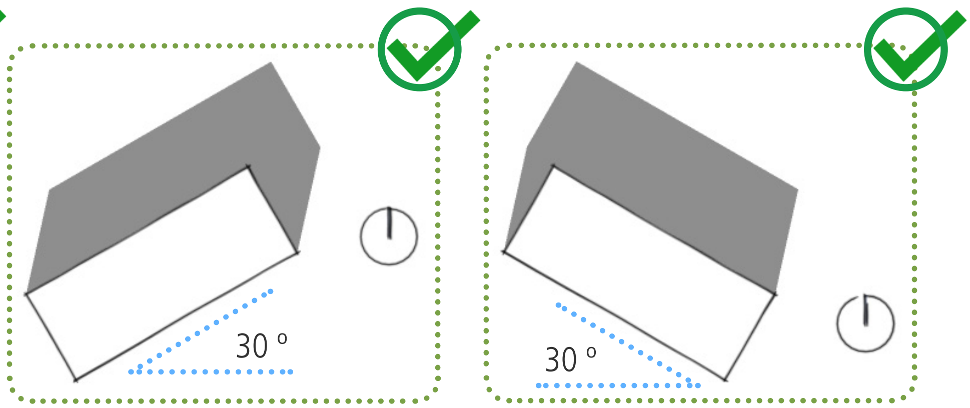
To maximize a building's potential for solar gains, the principle axis of a building should be aligned with an east-west axis as much as possible. In other words, the longest facade of a building should ideally face towards the south and span along an east-west axis. Owners and designers of many building types (e.g. single family dwellings, one and two story retail) have little ability to change the orientation of their buildings as they are constrained by existing lots and streets grids. Views of mountains or other geographic features may also dictate the predominant orientation of the built stock. However, the south-facing facade should ideally be within 30 degrees in either direction of true south.



A building with a primary axis running north-south does not take advantage of natural heating and daylighting.



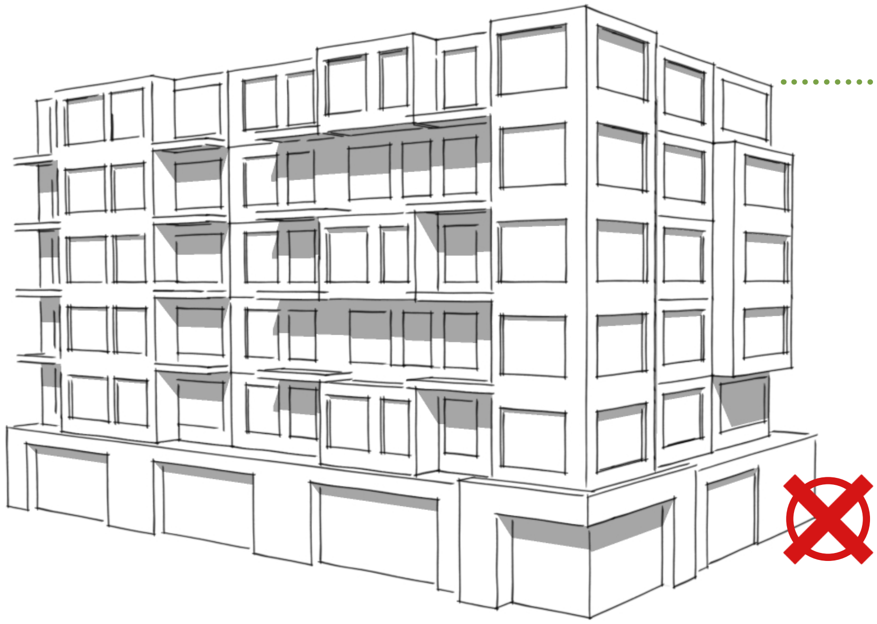
A building with a primary axis running east-west can take better advantage of solar gains, assisting in passive heating and daylighting strategies.



Keeping the building's longer facades within 30 degrees of east-west, maximizes solar gain potential.

Massing refers to the overall shape, form and size of a building, which can vary considerably in height, width, and design. When designed properly, a building can improve its overall potential for passive solar heating and cooling using appropriate massing. Simple, solid shapes such as cubes or rectangles minimize the loss of heating energy by reducing the number of corners and joints on a building's facade and thus the number of opportunities for thermal bridging. Compact buildings furthermore reduce the number of exterior walls where heat can be lost, as well as the number of ledges and other surfaces where moisture can collect. While massing has significant impact on passive heating, cooling and daylighting, such considerations unfortunately often go ignored until massing is already decided.

A building with a **simpler form** has fewer opportunities for thermal bridging through complex junctions in the building envelope.

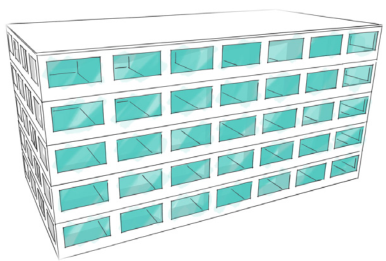


A building with a **complex building envelope** provides more opportunities for thermal bridging, air leakage and moisture infiltration to occur at complicated envelope junctions.

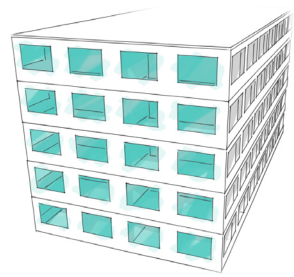
FENESTRATION

Fenestration refers to the size and placement of windows used on a building's facade. The number and placement of windows are both important to consider as a way of balancing the need to allow daylight into the building and maximizing potential solar gains in the winter months, while minimizing passive gains in the summer and losses in winter. The direction and intensity of incoming solar radiation should be considered for each site, as they vary considerably with general location (e.g. northern vs. southern hemispheres) and site-specific attributes (e.g. the presence of adjacent buildings or geographic features that block incoming sunlight).

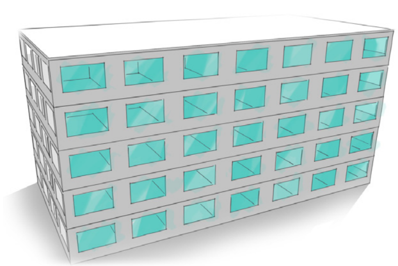
In general, reducing fenestration increases the insulated area of the building envelope, which creates a more comfortable interior temperature and reduces heat loss, which is especially important for heating dominated residential buildings. In northern latitudes, buildings with high fenestration (i.e. many windows) on the southern elevation of a building can maximize their solar gains in the cooler winter months when the sun is lower in the sky. East and west facing windows receive solar radiation year-round, and should therefore be minimized or shaded appropriately. While high rates of glazing on south and west facades allow solar heat gain during the winter months, the high potential for overheating should be addressed using proper shading during summer months.



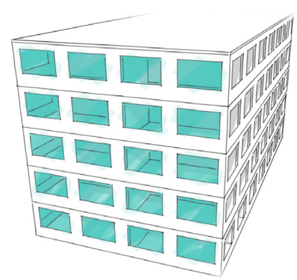
A south facade can have a higher glazing ratio, allowing solar gains in winter months. Overheating must be mitigated through shading devices in summer months.



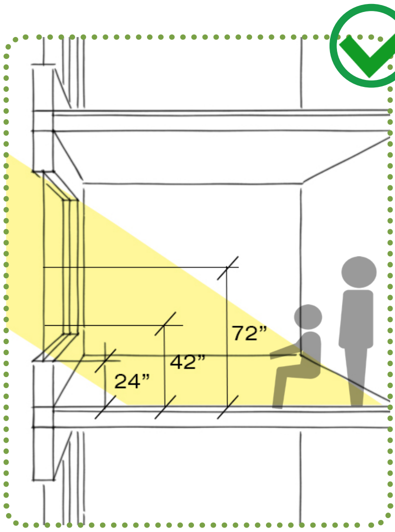
A west facade should have a glazing ratio that allows solar gains in winter months. Overheating must be mitigated through shading devices in summer months.



A north facade should have a lower glazing ratio, allowing for natural daylighting, while minimizing heat loss during winter months through excessive glazed area.



An east facade with an increased glazing area optimizes daylighting potential.



In general, glazing should be maximized in common living spaces, and reduced in sleeping spaces as per lighting and privacy requirements. Floor-to-ceiling glazing should be avoided by ensuring bottom window sill heights are placed at a minimum of 24 inches above the floor to block unnecessary solar radiation at foot level while allowing views from sitting height (approx. 42 inches) and standing height (approx. 72 inches).

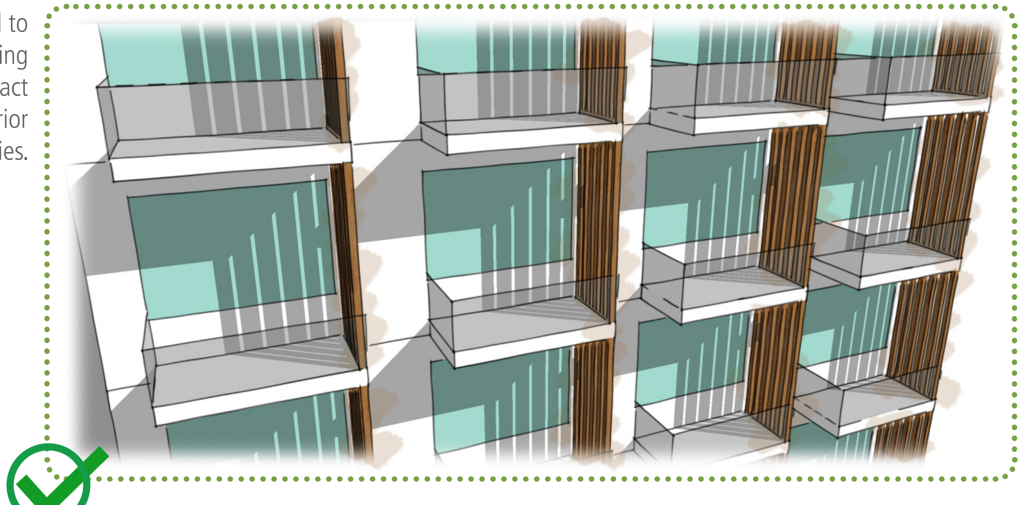
Windows on adjacent walls should be considered as a way of balancing lighting throughout a floor or dwelling unit and encouraging cross-ventilation. Operable windows further improve occupants' ability to ventilate the building and improve their overall thermal comfort.

A minimum sill height of 24" minimizes overall glazed area, while still allowing sitting and standing views. A floor-to-ceiling glazing strategy can result in glare and overheating during summer. The increased glazing area results in less insulated wall area, which contributes to heat loss during winter.

Where windows are included into the building, shades can be used to block incoming solar radiation to minimize unwanted solar gains in the summer. Louvers, overhangs, eaves, and sunshades are all forms of shading that help to block sunlight from entering windows in summer months when the sun is high in the sky, while allowing lower winter sunlight to enter and help warm the building. Vertical fins between suites can block the unwanted sun and increase privacy between suites while still allowing residents access to views.

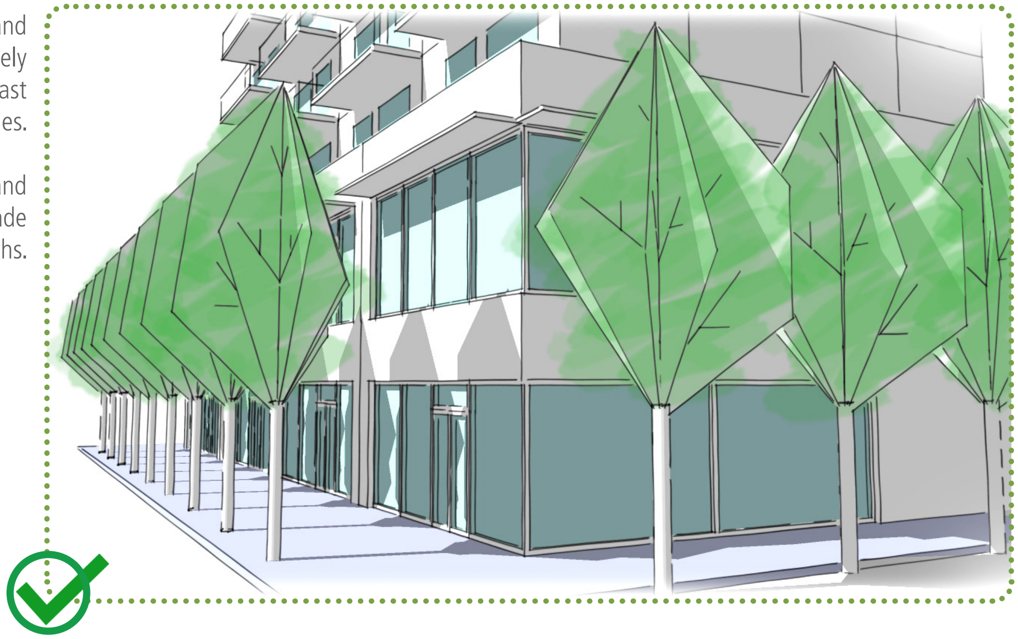
Other options for shading include the use of automated blinds that extend when incoming solar radiation is detected and retract when daylighting is needed. However, these require energy to operate, as well as considerable upkeep and maintenance. On lower floors, trees can also provide shading in summer months as well. Planting coniferous trees along the southern elevation should be avoided as they can block winter sunlight from entering the building. Deciduous trees that lose their leaves in winter are preferable.

Vertical shading devices can be added to the west facades to shade the building from hot afternoon sun, and can act as privacy screens between exterior balconies.



Balconies, overhangs, awnings and horizontal shading devices can effectively block unwanted solar radiation on east and south facades.

Deciduous trees planted on south and west facades can provide natural shade during hot summer months.



THERMAL BRIDGING DETAILS

Three major approaches to preventing thermal bridging through the building envelope are relevant to the building types considered in this guide:

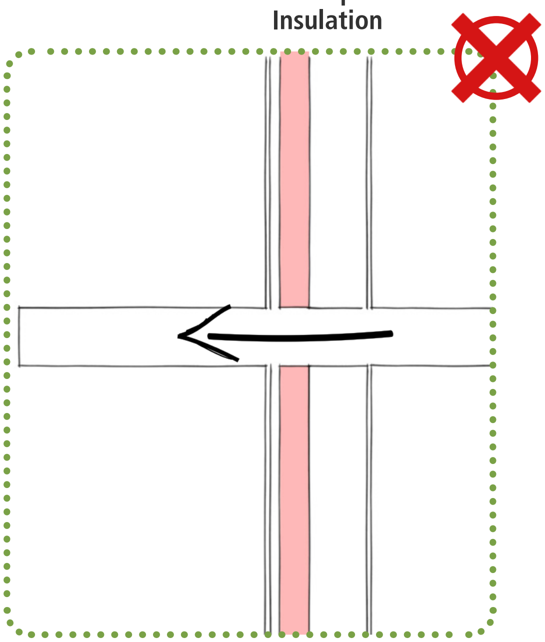
> Thermally Broken Balconies
> Continuous Insulation
> Window Frame Detailing

THERMALLY BROKEN BALCONIES

Where they are not insulated from the rest of the building, balconies are a primary source of building heat loss. To prevent these losses, balconies should be "thermally broken" from the building and/or tied back using materials such as stainless steel or with rubber gasket systems that minimize the opportunities for heat loss. These forms of balcony ensure that wall insulation is continuous, minimizing heat loss through the floor.

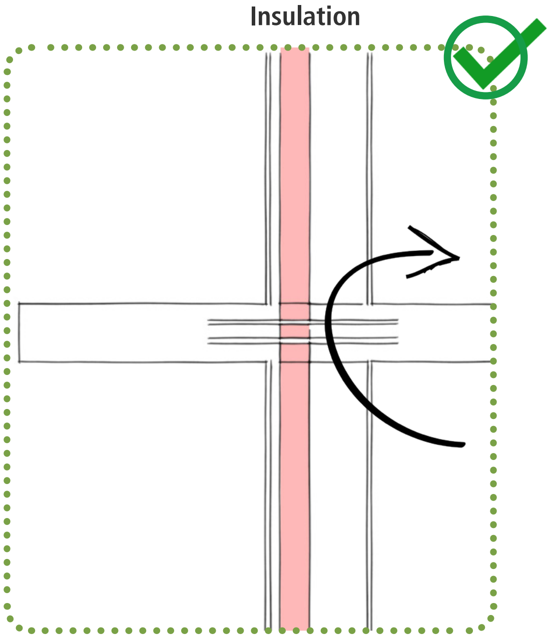
Several types of balconies can be used to reduce thermal bridging. **Externally supported balconies** are structurally designed as a separate element from the rest of the building. Such balconies are supported by footings at the ground level or can rest on the podium level of the building (e.g. in mixed-use buildings). **Externally suspended balconies** use tension cables hung from building exterior and are tied back into the structure. **Juliet balconies**, or balconets, place railings at the outer edge of large windows to provide access to the outdoors and maximize floor space while reducing thermal bridging.

Interrupted Insulation

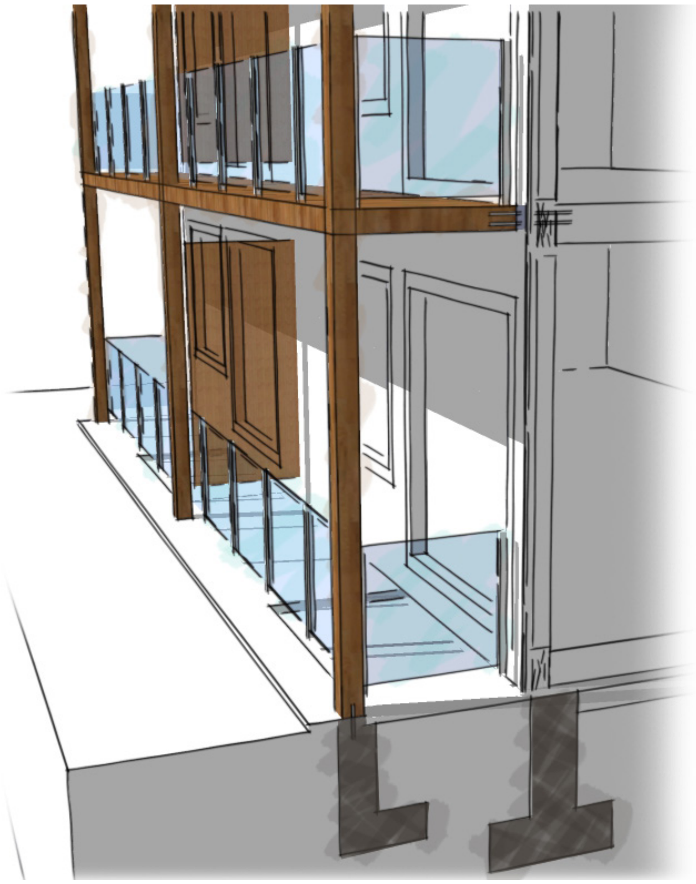


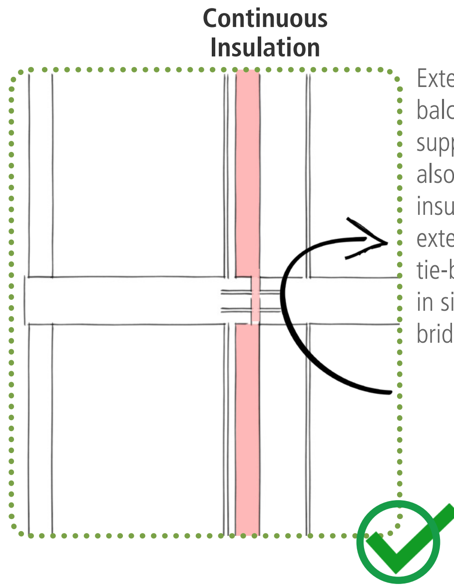
Balconies that are not thermally broken from the interior building structure provide a path for heat to escape through the envelope, increasing the building's heating demand.

Continuous Insulation

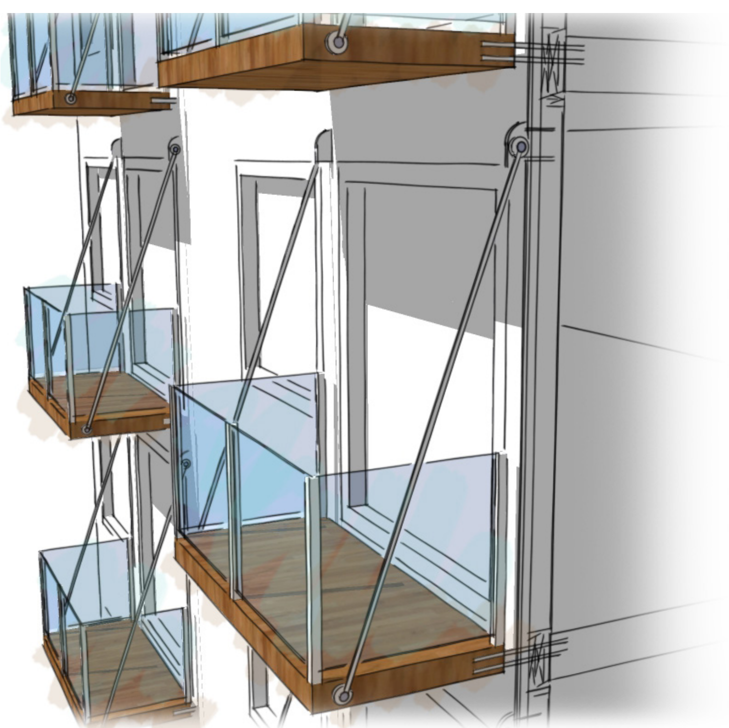


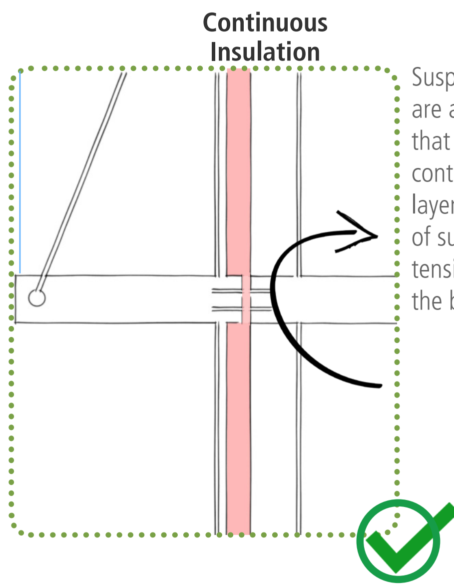
Balconies can be cantilevered and tied back to the interior floor structure, with low conductivity connections such as stainless steel, with a continuous insulation layer.





Externally supported balconies, or self-supporting balconies, can also provide a continuous insulation layer. The external support allows tie-backs to be reduced in size, reducing thermal bridging.



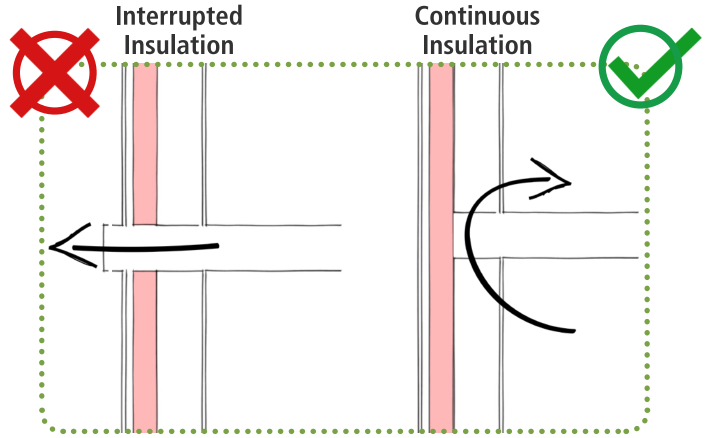


Suspended balconies are another solution that can include a continuous insulation layer, with the majority of support coming from tension cables tied into the buildings structure.

THERMAL BRIDGING DETAILS CONTINUED

CONTINUOUS INSULATION

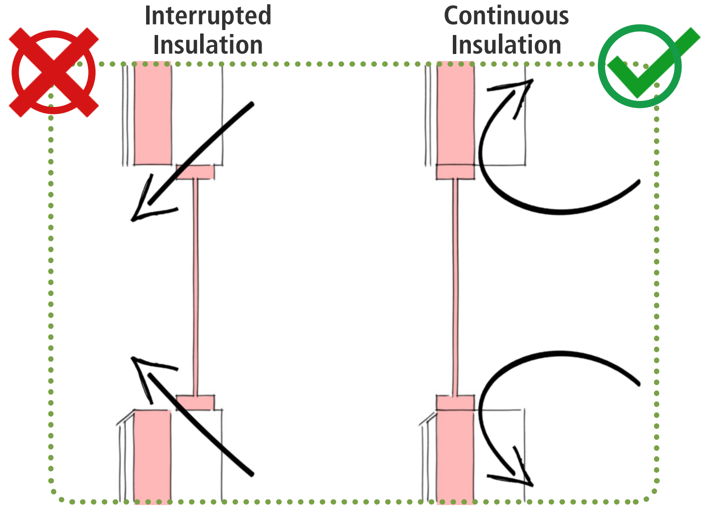
A second area in which thermal bridging can occur is where a building's floor slab, or floor structure meets the edge of the envelope. Heat losses can occur where insulation between the slab and the envelope is insufficient or absent, or where steel beams used in entryways or sunshades pass through the building envelope. Architectural details may also extend the building slab out from the envelope, creating more opportunities for thermal bridging. Reducing or eliminating these exposed slab edges, ensuring insulation runs continuously on exterior, and avoiding design details and projections that both increase the total surface area of the building and extend the slab out beyond the envelope can help reduce significant thermal bridges.



Concrete floor slabs that extend beyond the building envelope should be avoided or insulated to reduce thermal bridging.

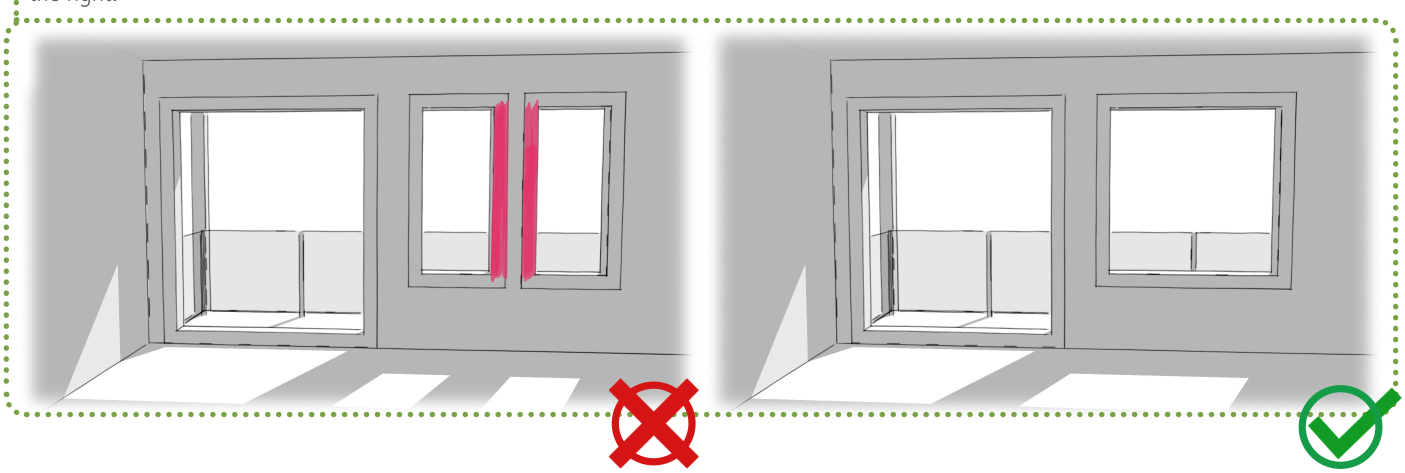
WINDOW FRAME DETAILS

Finally, windows can act as a major source of thermal bridging where the framework holding the window in place is thermally unbroken from the exterior. As with building detailing more generally, the addition of excessive or unnecessary design features that add to the surface area of the building provides additional opportunities for heat to escape from building interiors. As such, the use of several, smaller windows that increase the number of necessary junctions should be avoided. Instead, fewer, larger windows should be used that allow the same area of fenestration while reducing the number of thermal bridging opportunities.



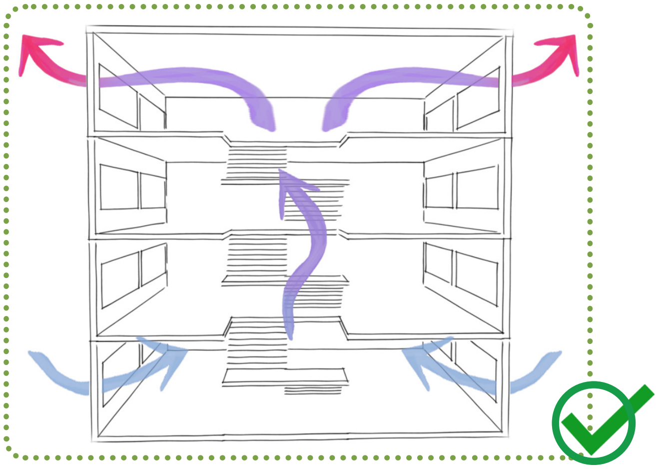
Window frames should be placed in line with the insulation layer, minimizing thermal bridging through the frame-to-wall connection.

Increasing the number of windows increases the length of window frames, where thermal bridging is most prevalent. More heat is lost through the frame than the glazing. The additional window (left) adds approx. 8 feet of window frame compared to the glazing scenario on the right.



NATURAL VENTILATION

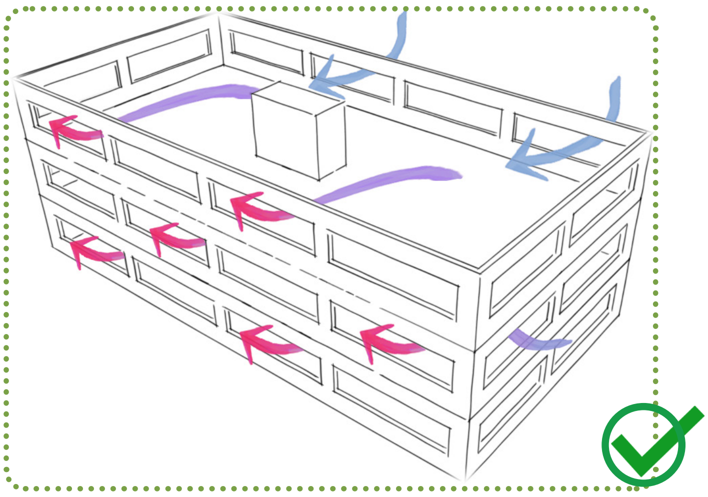
Natural ventilation refers to the process of supplying and removing air to interior spaces of a building by natural means, without the use of fans or mechanical systems. Air is circulated using differences in air pressure between a building and its surroundings, or between different spaces in the building itself. To optimize ventilation, patterns of prevailing winds and wind flow around a specific building should be identified so that fenestration can be oriented to capture and funnel breezes into the building. The co-benefits of such strategies should be considered when selecting unit designs, such as the ability to both improve ventilation and reduce heating requirements. Two forms of natural ventilation can be used: stack ventilation, and cross ventilation.



An atrium space can act as a transfer zone that draws cool air in from the lower spaces, and expels hot air through the upper floor windows.

STACK VENTILATION

In stack ventilation, a stack or "chimney" effect is achieved by placing windows at both lower and higher levels of a building (e.g. lower and upper floors) or wall. Natural processes of convection create a pattern in which cooler, heavier air pushes warmer, lighter air out of the building in a constant motion that resembles a continuous flow out a chimney. This motion can be used to cool building spaces, reducing the need for mechanically or electrically generated ventilation.



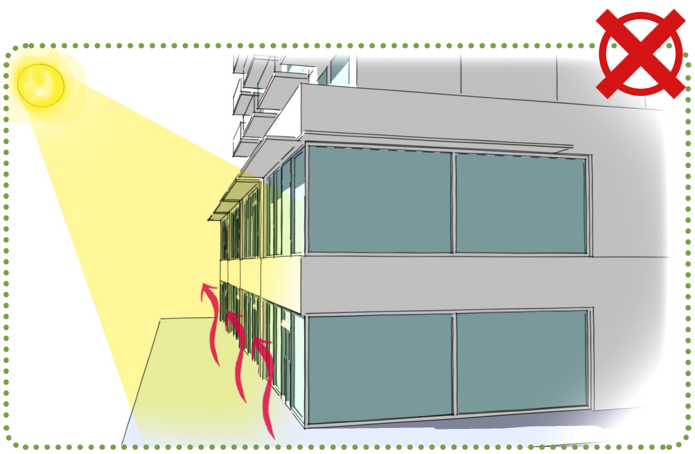
Operable windows on opposite and adjacent walls allow air to pass through interior spaces, using natural wind patterns.

CROSS VENTILATION

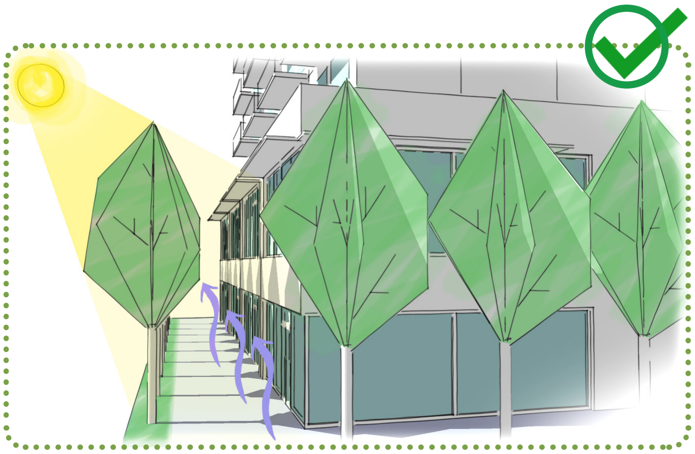
Cross ventilation is easiest to achieve in corner suites or single office floor plans in which windows and/or other openings such as patio doors are placed on opposing or adjacent walls. When oriented towards prevailing winds, this design can achieve significant cross-breezes that passively ventilate building spaces.

The materials selected in and around a building can either detract from or contribute to the success of any of the passive design strategies. The careful selection of building materials can help to support passive heating, cooling, ventilation and daylighting in particular, and help to prevent phenomena such as the 'Urban Heat Island effect'. This effect refers to the significant increase in air temperature found in urban areas, attributed to the higher proportion of built surfaces in urban areas (relative to natural landscapes) that absorb and re-radiate heat from incoming sunlight. Non-reflective surfaces such as concrete and asphalt in particular act as thermal masses that warm the air around them. In contrast, materials that reflect light away from a building move heat away from the site, improving the overall comfort of its occupants. Vegetated surfaces also help to cool building sites by absorbing a large proportion of the incoming solar radiation through the process of evapotranspiration, releasing cooling water vapour back into the air.

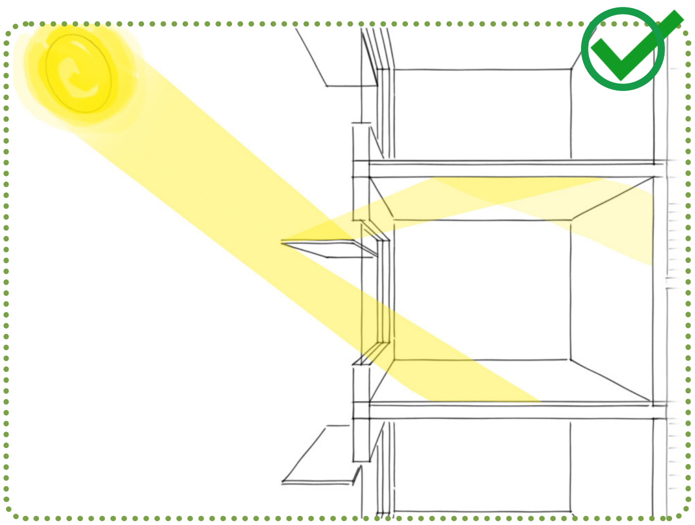
To reduce the Urban Heat Island effect, materials with higher albedo (e.g. light or white surfaces) can be used to help reflect sunlight away from buildings. White or "cool" roofs can assist in cooling building in hot summer months and improving occupant comfort. Vegetation on building sites and through the use of green roofs can also help to lower building temperatures. Vegetation planted on west and south facades can further reduce incoming heat and improve shading, and can additionally help to support natural ventilation by cooling incoming air. Planting vegetation around building air intakes can additionally improve the overall air quality inside building spaces by reducing pollution loads.



Low-albedo materials such as concrete, asphalt, paving materials, and dark coloured finishes can contribute to the Urban Heat Island effect.



Vegetation, plantings and deciduous trees can help reduce the Urban Heat Island effect at both site and city scales.



Finally, material selection can also improve daylighting. Light coloured materials on building interiors help to reflect incoming light into the building and minimize the need for artificial lighting. Exterior architectural shading devices can double as exterior light shelves, which reflect incoming light back into interior spaces while preventing heat gains. These should be designed in such a way as to minimize heat gain in summer and optimize heat gain in winter.

An exterior shading device can also act as a light shelf when finished with a light-reflecting material or colour, bouncing light further into interior spaces.

Four to six storey buildings represent the typical mid-rise residential building commonly built in BC's Lower Mainland. While these buildings usually range from four to six storeys, they can sometimes be as low as three storeys in height. They are often built entirely of wood-frame construction, though mixed-use buildings can also be constructed in such a way that the first storey is built of concrete. As in all residential buildings, they are heating-dominated, and as such require careful consideration of passive heating strategies.

This building type typically includes a common lobby, double loaded corridors, and residential balconies for every suite. Ventilation is commonly achieved through mechanically-aided pressurized corridors that ventilate suites through gaps under entry doors to individual suites. Residential-only buildings will include suites at the garden level, which can be set back from the property line to accommodate for private outdoor spaces. In mixed-use buildings, suites are located above one or more storeys of commercial retail units, which often house small businesses such as salons, corner stores, small grocers, general retail, and health services.

For guidance on the retail portions of these buildings, see "1-2 Storey Retail" (Page 57). Upper residential portions may follow this section of the guide.

Mid-Rise Mixed-Use Building
Quattro 3, Surrey BC
Photo: MAC Marketing Solutions (2012)

Mid-Rise Residential Building
Cambridge Park, Richmond BC
Photo: Cicozzi Architecture (2011)

APPLICABLE PASSIVE ELEMENTS

ELEMENT	COST	EFFECTIVENESS	NATURAL GAS SAVINGS	ELECTRICAL SAVINGS	PAGE
Compact Massing & Form	$	🍃	🔥		28
40% Max. Window-Wall Ratio	$	🍃🍃🍃	🔥	⚡	30
Minimum 24" Sill Height	$	🍃🍃		⚡	30
Horizontal Shading on South	$$	🍃🍃🍃		⚡	31
Vertical Shading on West	$$	🍃🍃🍃		⚡	31
Deciduous Trees & Plantings	$	🍃		⚡	31+35
Thermally Broken Balconies	$$	🍃🍃🍃	🔥		32
Window Frame Detailing	$$	🍃🍃	🔥		34
Natural Ventilation	$	🍃		⚡	34
Material Selection	$	🍃🍃	🔥	⚡	35

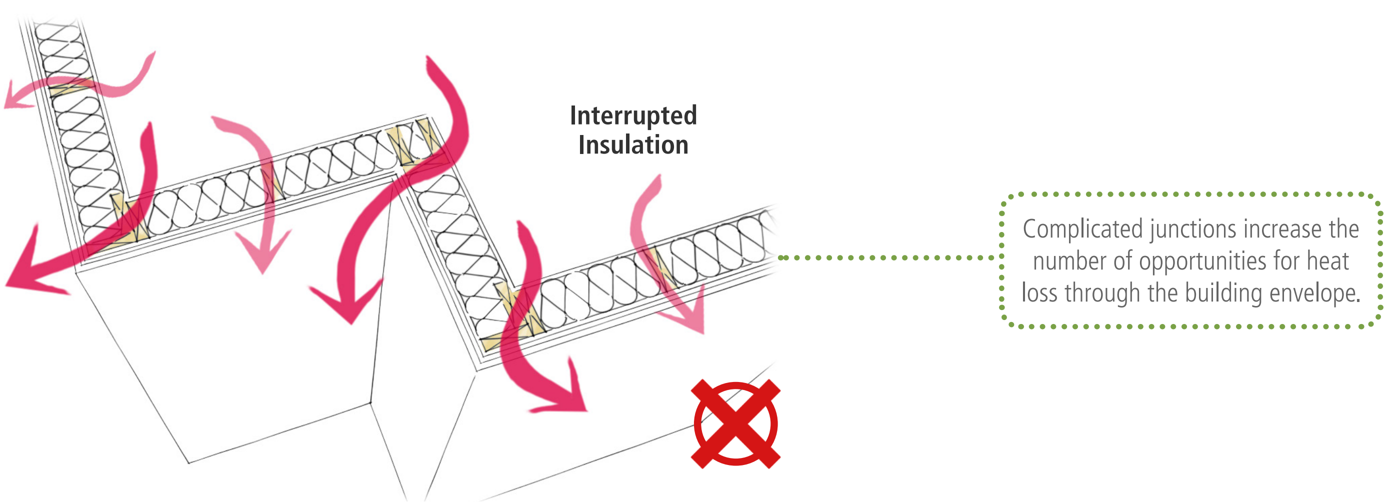
COMPACT MASSING & FORM

Four to six storey wood-frame buildings should be designed to reduce the number of articulations in the building envelope to lower the building's overall surface area-to-volume ratio and avoid the risk of air and water infiltration. Junctions created by intersecting walls, roofs, balconies, bay widows and other features that create projections in the building envelope should be avoided as much as possible.

> Visual and aesthetic impact can instead be achieved through a mix of visually interesting cladding materials that create a dynamic appearance. The thoughtful placement of windows can also add visual interest while maintaining compact form.

> Where complicated junctions do occur, a higher level of attention to detailing should be given to ensure air and water tightness through the use of sealants, gaskets, air-tight tapes, and other measures.

> Opportunities for thermal bridging should be avoided by ensuring proper breaks and the adequate insulation of floor slabs, balconies and other features from the building envelope.



A complicated form with many articulations increases the surface area through which heat can escape.

A simple building form with cladding colours can be used to create visual interest.

The Black and White condominium development in Victoria, BC uses alternating cladding materials to create architectural interest without dramatically increasing complicated junctions and overall surface area.

Rendering: Cascadia Architects

> Four to six storey wood-frame buildings should include a **maximum 40% window-to-wall ratio** averaged across all facades while allowing for natural daylighting to all suites.

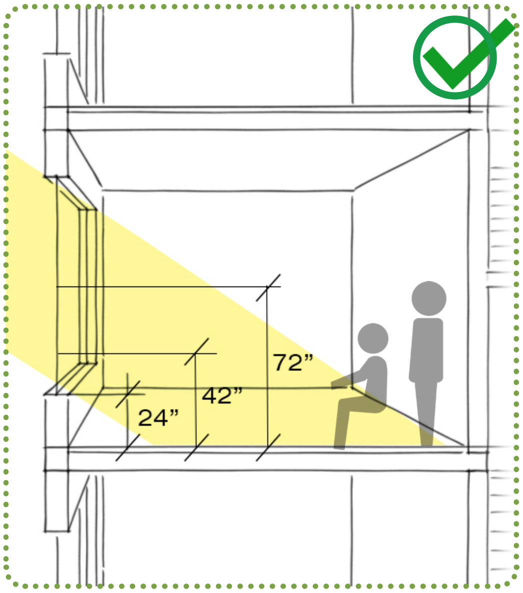
> Glazing should be maximized on east facades for natural daylighting in all seasons.

> Glazing on north facades should be minimized to reduce winter heat losses.

> Glazing should also be maximized in common living spaces while reducing window size in sleeping spaces as per lighting and privacy requirements.

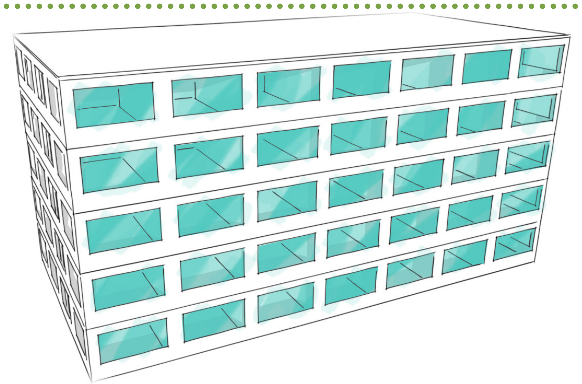
> Floor-to-ceiling glazing should be avoided by ensuring bottom window sill heights are placed at a minimum of 24 inches above the floor to block unnecessary solar radiation at foot level while allowing views from sitting height (approx. 42 inches) and standing height (approx. 72 inches).

(While ASHRAE 90.1 Prescriptive Path demands a 40% maximum glazing ratio, energy modeling allows you to exceed. This is not a hard requirement, so it is recommended not to exceed 50% under any circumstance.)

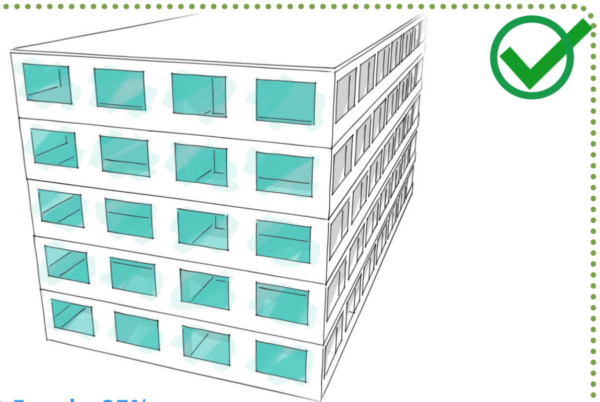


A minimum sill height of 24" minimizes overall glazed area, while still allowing sitting and standing views. A floor-to-ceiling glazing strategy can result in glare and overheating during summer. The increased glazing area results in less insulated wall area, which contributes to heat loss during winter.

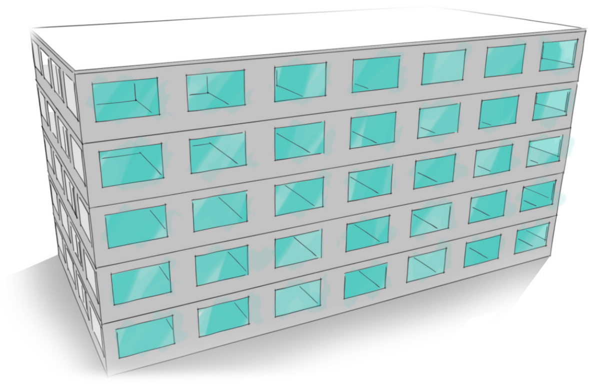
The following glazing scenarios for each facade represent an **average** glazing ratio of **40%** across the entire building.



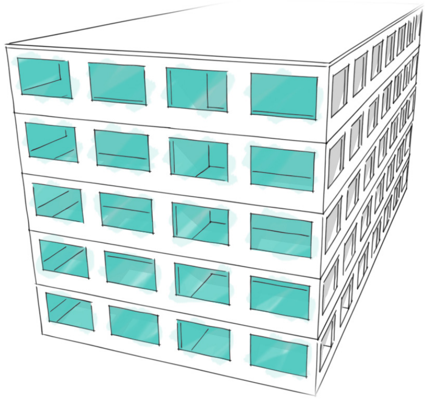
South facade: 50%
Increased glazing area allows solar gains in winter months. Overheating must be mitigated through shading devices in summer months.



West Facade: 37%
Reduced glazing area reduces risk of overheating in summer months.



North Facade: 35%
Reduced glazing area allows for natural daylighting, while minimizing heat loss during winter months through excessive glazed area.



East Facade: 40%
Increased glazing area optimizes daylighting potential.

Buildings of this type should be designed to include horizontal shading on south facades to minimize unwanted solar gains during the summer months and reduce the building's overall cooling load. Shading should also be optimized for daylighting and to allow for solar heat gain during winter months in order to reduce overall lighting needs and heating loads.

> Balconies can be designed to function as shading devices, as they are effective in blocking incoming solar radiation in the summer while allowing winter sun to enter through patio doors.

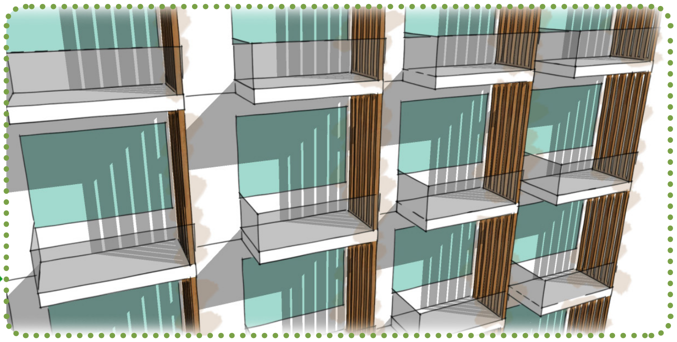
> Fenestration on the south facade should be shaded using overhangs or architectural shading devices. These overhangs and shading devices should be used in such a way that thermal bridging is avoided.

> As overheating is most common on western facades, vertical fins should be considered for use on the to provide shading from high intensity incoming solar gains from the west.

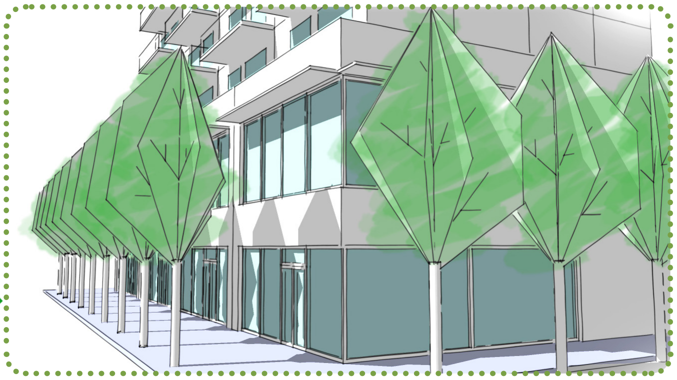
> Planting deciduous trees on the south and west facades can help mitigate solar heat gain during summer months while trees are in full leaf, while allowing solar heat gains during winter months when trees are bare.

> Trees selected for planting should have full canopies and be able to grow to a sufficient height to shade south and west facades.

Horizontal shading devices can be added to the south and east facades where balconies are absent, or where they do not provide adequate summer shading.



Vertical shading devices can be added to the west facades to shade from hot afternoon sun, and can act as privacy screens between exterior balconies.



Deciduous trees planted on south and west facades can provide natural shade during hot summer months.

THERMAL BRIDGING DETAILS

Four to six storey buildings should be constructed in such a way as to minimize the number of opportunities for thermal bridging. These major sources of heat loss should be mitigated by ensuring that floor slabs do not extrude to form a heat bridge to the building exterior.

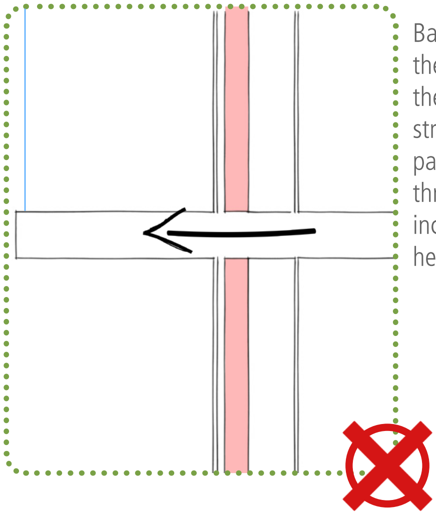
THERMALLY BROKEN BALCONIES

> To mitigate heat loss through balconies, cantilevered balconies should be avoided and replaced by a form of balcony that is thermally broken from the building. These forms of balcony ensure that wall insulation is continuous, minimizing heat loss.

> Options include the use of externally suspended balconies that are tied back to the building using tension cables, or externally supported balconies that rest on footings at the ground level or on the podium level of the building.

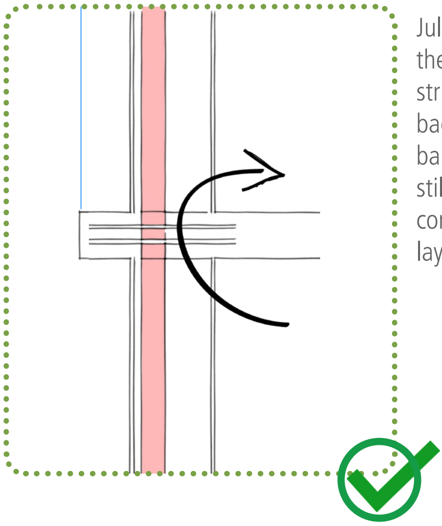
> Juliet balconies can also be used to allow residents' access to the outdoors while maximizing usable floor space.

Interrupted Insulation

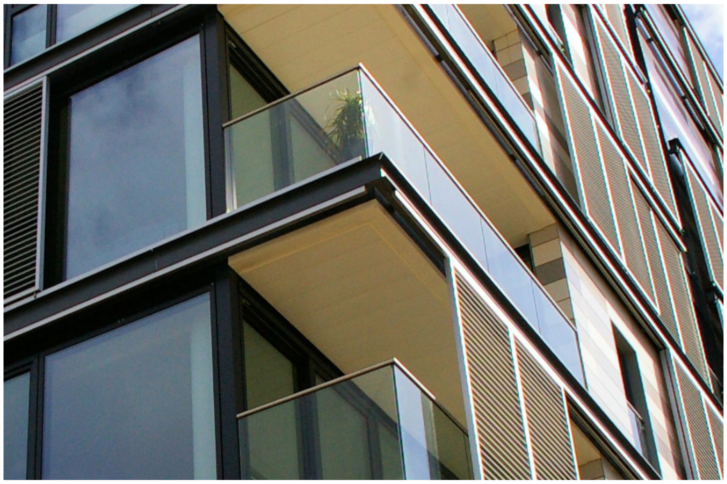


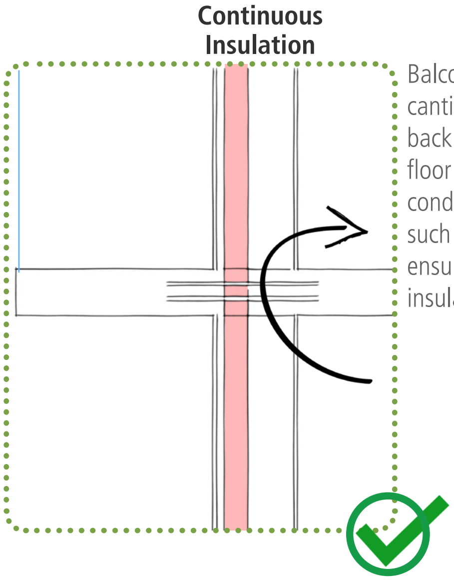
Balconies that are not thermally broken from the interior building structure provide a path for heat to escape through the envelope, increasing the building's heating demand.

Continuous Insulation

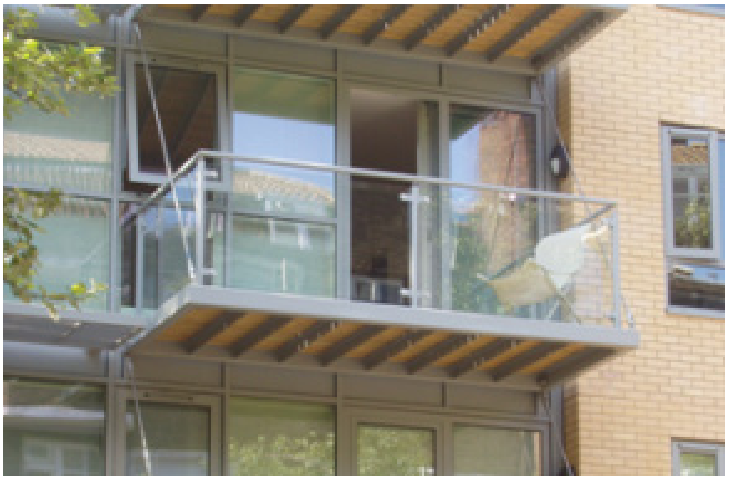


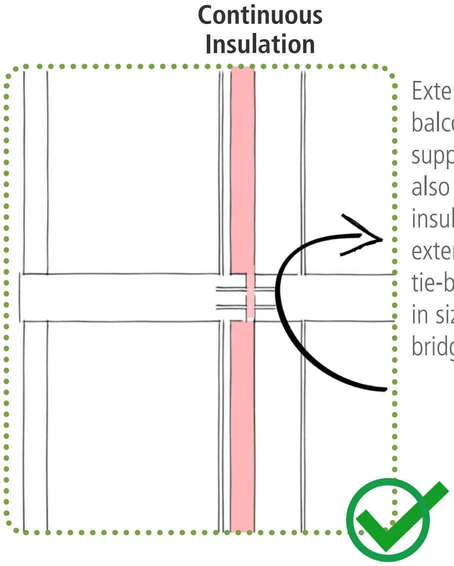
Juliet balconies hang off the buildings exterior structure using tie-back connections. This balcony configuration still allows for a continuous insulation layer.



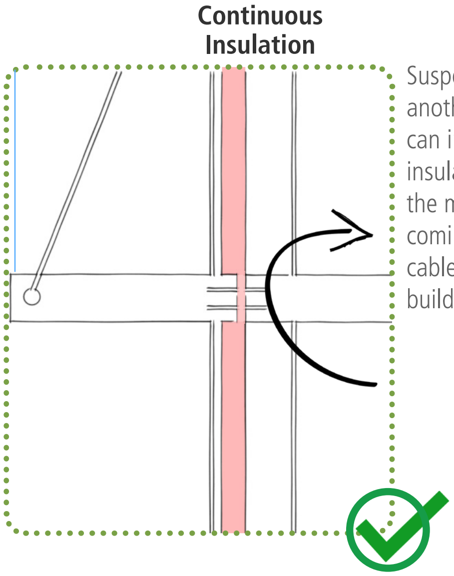


Balconies can be cantilevered and tied back to the interior floor structure, with low conductivity connections such as stainless steel, ensuring a continuous insulation layer.





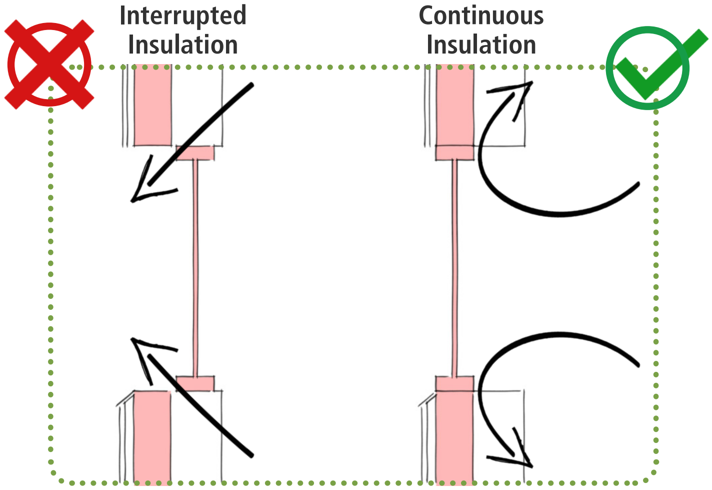
Externally supported balconies, or self-supporting balconies, can also provide a continuous insulation layer. The external support allows tie-backs to be reduced in size, reducing thermal bridging.



Suspended balconies are another solution that can include a continuous insulation layer, with the majority of support coming from tension cables tied into the buildings structure.

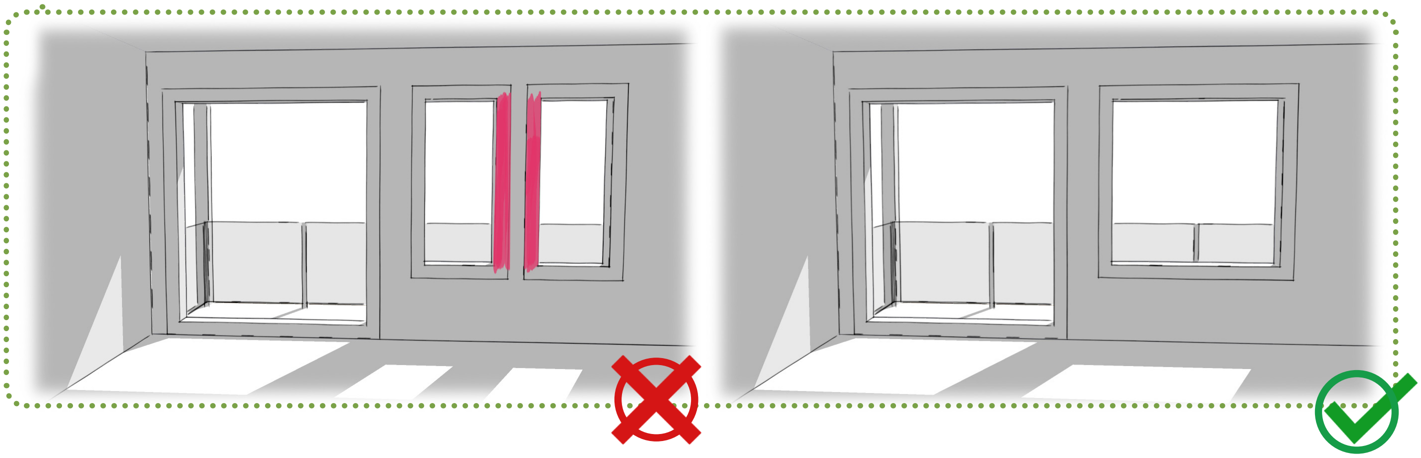
WINDOW FRAME DETAILS

Buildings should be designed to minimize the number of window frame connections by avoiding the use of a large number of smaller windows that increase the overall number of connection points in the building envelope. Instead, building should be designed using a smaller number of large windows.



Window frames should be placed in line with the insulation layer, minimizing thermal bridging through the frame-to-wall connection.

Increasing the number of windows increases the total length of window frames, where thermal bridging is most prevalent. More heat is lost through the frame than the glazing. In this scenario, the additional window (left) adds 8 feet of window frame compared to the use of one larger window (right).



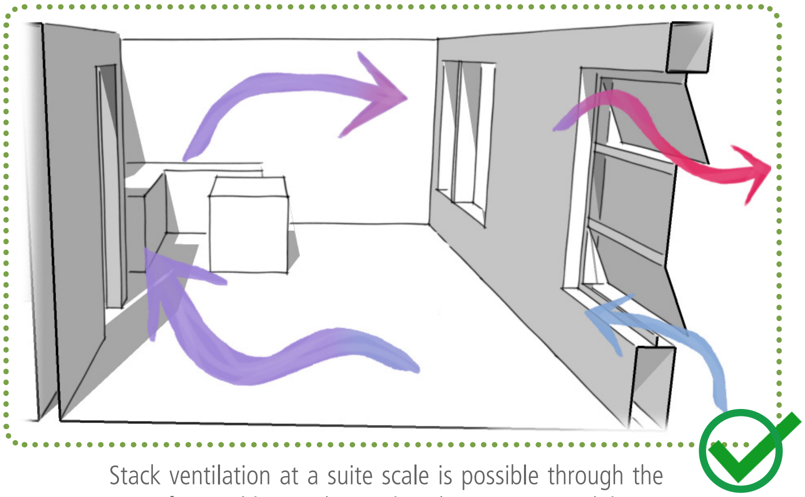
NATURAL VENTILATION

Buildings should be constructed to maximize the potential for natural ventilation, reducing the need for mechanical ventilation and improving overall occupant comfort.

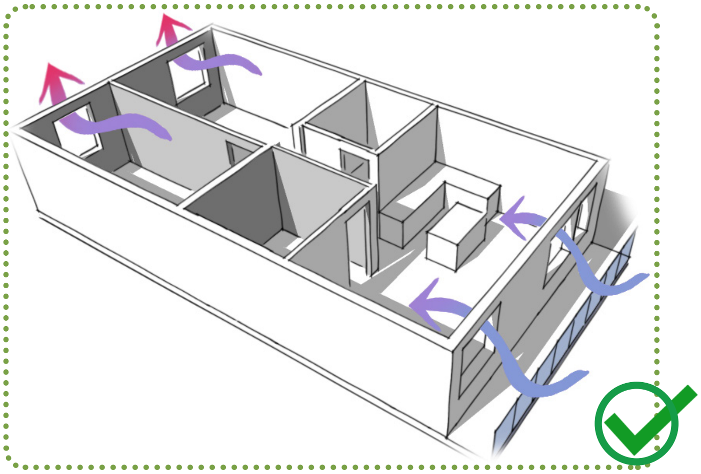
> Natural ventilation is most successful and should be maximized in corner units that allow for cross-ventilation between windows on adjacent facades.

> Units connected to a single-loaded corridor are also ideal candidates for cross-ventilation, in that windows can be placed on opposing facades. The use of single-loaded corridors can also reduce overall building heating loads.

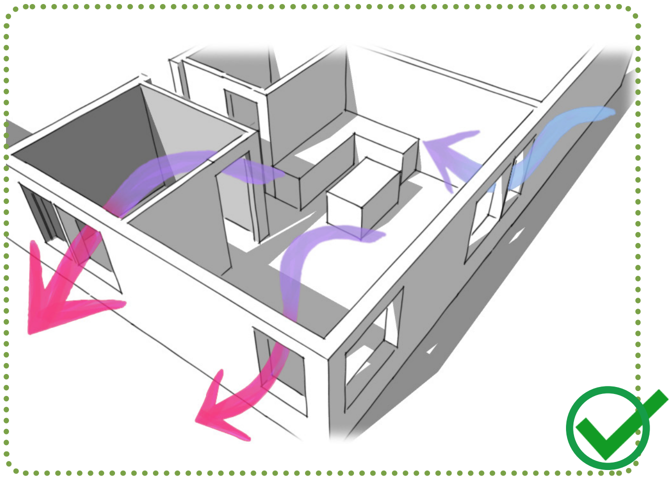
> Stack ventilation systems that allow for convective air flow in a building should also be used wherever possible. Operable windows should be placed at the lower and upper portions of unit walls to allow cool air to enter the building and move stale, warmer air out.



Stack ventilation at a suite scale is possible through the use of operable windows placed on upper and lower positions on a wall.



Cross-ventilation is an ideal natural ventilation solution for residential units in a single-loaded corridor configuration, with operable windows on opposite exterior walls



Corner units should have operable windows on adjacent walls to allow air to flow through the suite.

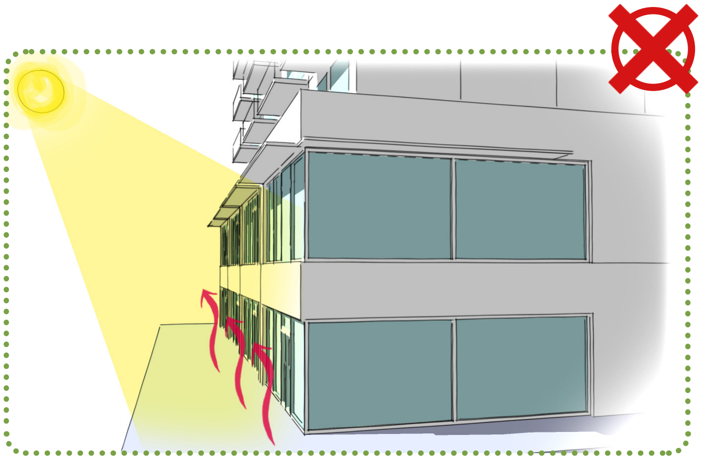
MATERIAL SELECTION

The materials used in the construction of four to six storey wood-frame buildings can have a high impact on the building's overall contribution to the Urban Heat Island effect and thus the overall comfort of its occupants.

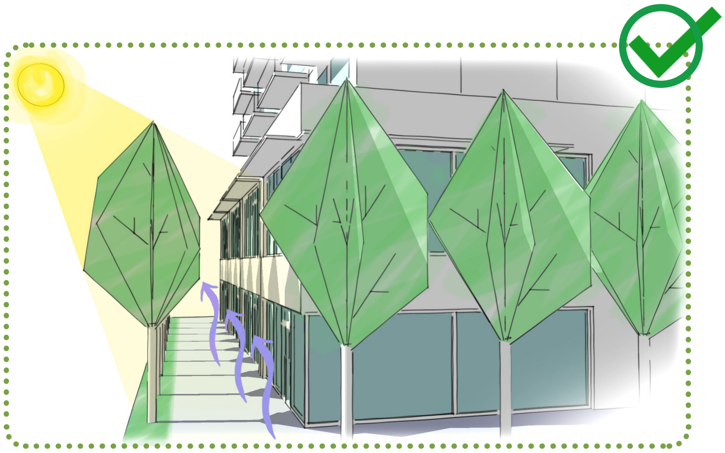
> Materials such as concrete and asphalt that absorb and re-emit radiation and contribute to the Urban Heat Island effect should be replaced wherever possible with materials that reflect heat away from the building.

> Strategies for reducing heat absorption include the use of green roofs that remove heat through the process of evapotranspiration, or cool roofs that reflect sunlight and heat away from a building. Vegetation should be maximized on the building site to reduce the use of pavement.

> On west and south facades, both vegetation generally and deciduous trees specifically should be planted to reduce heat and improve shading in summer months. Trees on these facades additionally help to support natural ventilation by cooling incoming air and improving overall air quality.

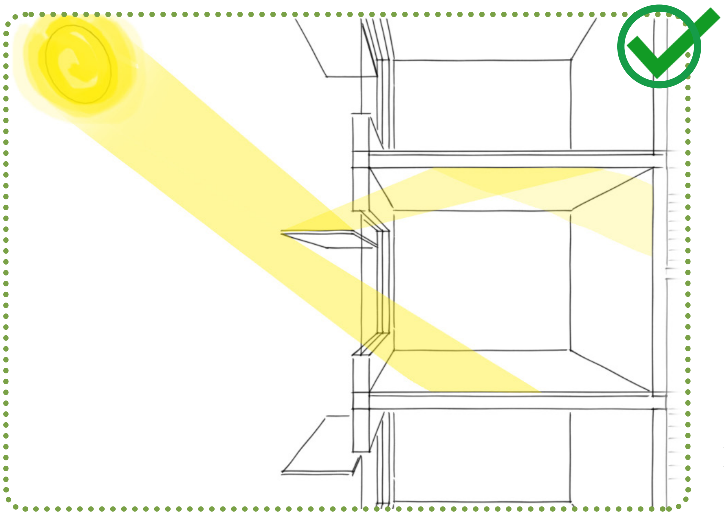


Low-albedo materials such as concrete, asphalt, paving materials, and dark coloured finishes can contribute to the Urban Heat Island effect.



Vegetation, plantings and deciduous trees can help reduct the Urban Heat Island effect at both site and city scales.

Daylighting of interior spaces should be facilitated through the selection of light coloured materials on building exteriors. Exterior architectural shading devices can double as exterior light shelves, which reflect incoming light back into interior spaces while preventing heat gains. These should be designed in such a way as to minimize heat gain in summer and optimize heat gain in winter.



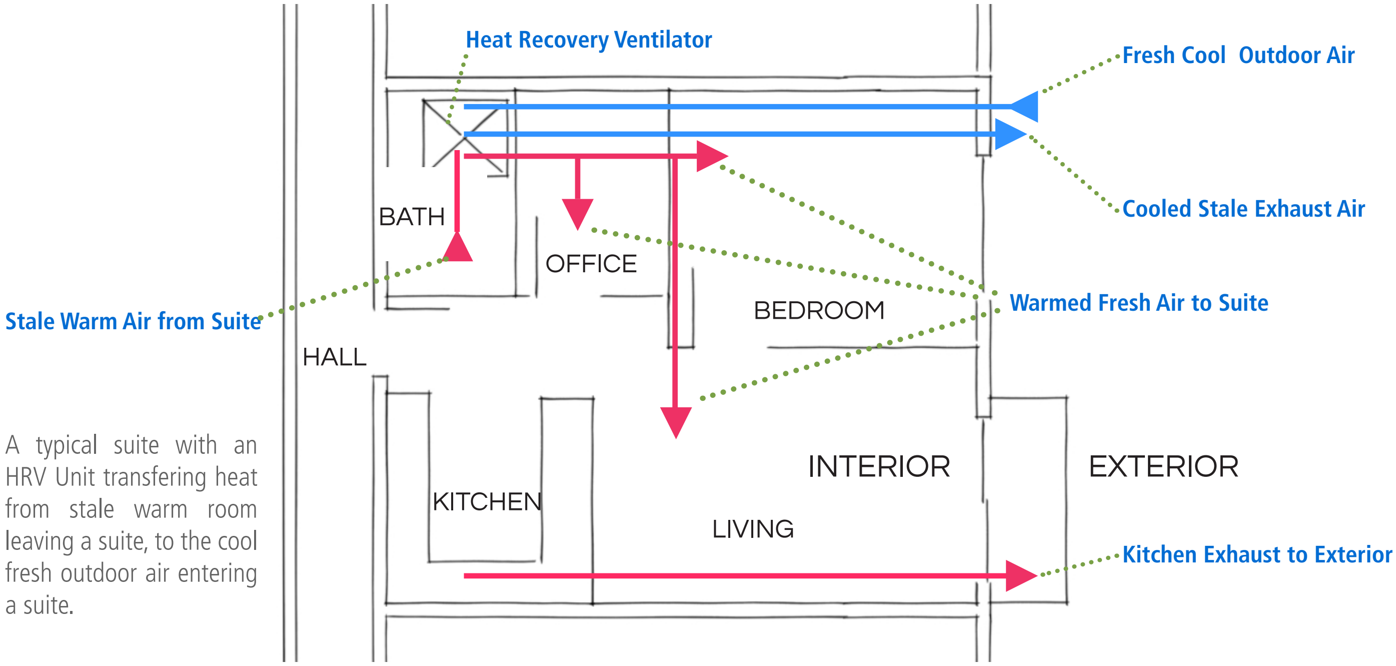
An exterior shading device can also act as a light shelf when finished with a light-reflecting material or colour, bouncing light further into interior spaces.

ACTIVE SYSTEM ASSISTANCE

While ventilation is commonly achieved through centralized systems in which pressurized corridors and undercut entry doors provide fresh air to individual suites, these have been found to be ineffective in providing ventilation. Alternative methods that improve ventilation and reduce heat losses should therefore be considered.

> Individual suites should be compartmentalized and outfitted with individual unit-controlled ventilation systems. Individually pressurizing units has been found to optimize suite temperature and moisture while reducing opportunities for cross-contamination of odours or smoke from adjacent units.

> Heat Recovery Ventilators (HRV) should be used on a unit-by-unit basis to allow for adequate ventilation without the need to open windows in cooler months. These systems reduce building heat losses by transferring heat from warm exhaust air to fresh incoming air, while improving indoor air quality and occupant comfort. HRV are also able to control indoor humidity levels, reducing incidences of mould, condensation on windows, and odours.



A typical suite with an HRV Unit transfering heat from stale warm room leaving a suite, to the cool fresh outdoor air entering a suite.

CONCRETE RESIDENTIAL & MIXED-USE BUILDINGS

This building type refers to taller condominium towers of concrete construction that use either cast-in-place or concrete panels. While they can be as low as four storeys, they are differentiated from other mid-rise buildings by the impact concrete forms have on building design, construction detailing, and energy use. One or two additional levels of retail at the ground level than mid-rise buildings can be included in this building type, which are often expressed as a retail podium with a setback residential tower. As with other residential buildings, concrete residential buildings are considered to be heating-dominated.

This building type typically includes a common lobby, but can include other accessory spaces such as a fitness room, rentable party rooms, meeting rooms and other amenities. Residential suites typically circle the building's elevator and exit stairwell cores, such that suites face outward from every facade. Most concrete residential buildings include balconies. Floor-to-ceiling glazing is commonly installed in these buildings (particularly in shared living spaces and kitchens), which can often lead to overheating in the summer and heat loss in the winter. Ventilation is commonly achieved through mechanically-aided pressurized corridors that ventilate suites through gaps under entry doors to individual suites.

Residential-only buildings sometimes include suites at the garden level, which can be set back from the property line to accommodate for private outdoor spaces. More often, however, ground levels house the amenity and shared occupant spaces, or commercial retail units. For guidance on the retail portions of these buildings, see "One to Two Storey Retail" (PAGE 55). Upper residential portions may follow this section of the guide.

Concrete Mixed Use Building
McLaren Housing Society | Vancouver BC
Photo: Comren

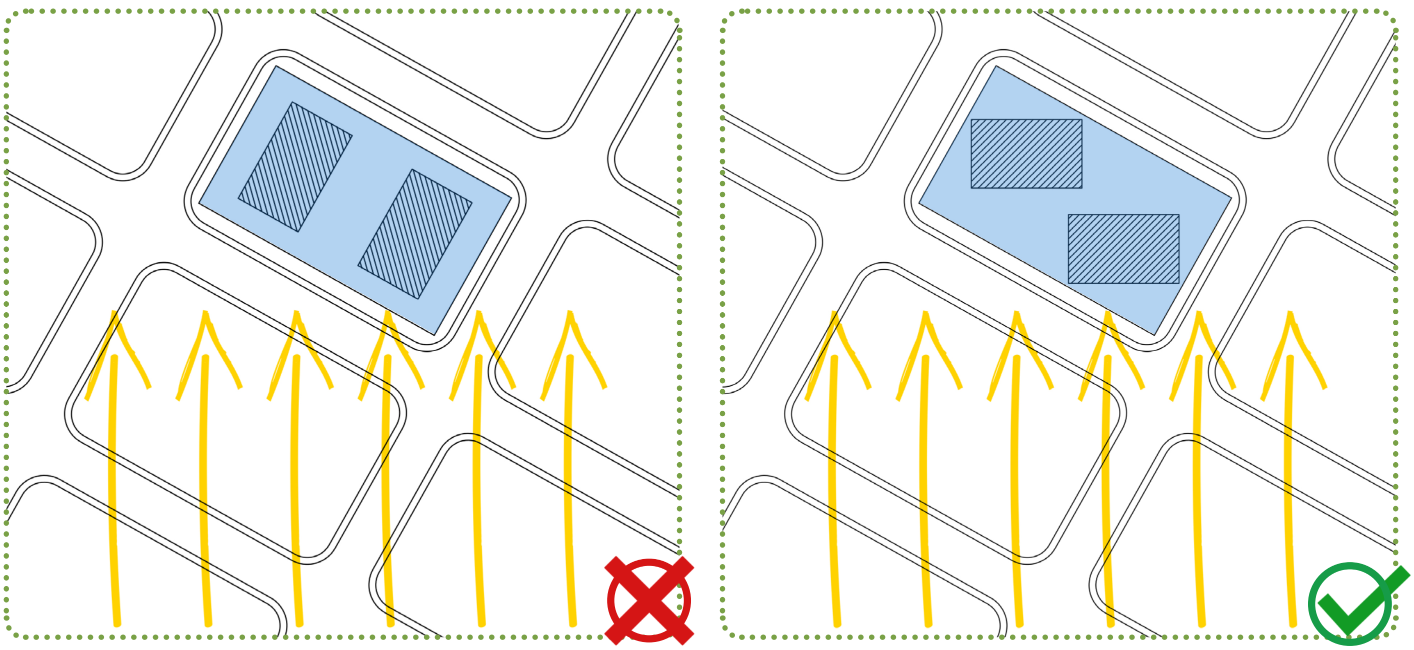
Concrete Residential Building
Affinity | Burnaby BC
Photo: Forum Skyscraper

APPLICABLE PASSIVE ELEMENTS

ELEMENT	COST	EFFECTIVENESS	NATURAL GAS SAVINGS	ELECTRICITY SAVINGS	PAGE
Orientation	$	🍃			38
Compact Massing & Form	$	🍃			39
50% Max. Window-to-Wall Ratio	$$	🍃🍃🍃	🔥	⚡	40
Minimum 24" Sill Height	$	🍃🍃	🔥	⚡	40
Horizontal Shading on South	$$	🍃🍃🍃		⚡	41
Vertical Shading on West	$$	🍃🍃🍃		⚡	41
Deciduous Trees & Plantings	$	🍃		⚡	41+46
Thermally Broken Balconies	$$	🍃🍃🍃	🔥		42
Continuous Insulation	$$	🍃🍃	🔥		44
Window Frame Detailing	$	🍃🍃	🔥		44
Natural Ventilation	$	🍃		⚡	44
Material Selection	$	🍃🍃	🔥	⚡	46

ORIENTATION

> Concrete residential buildings should be oriented in such a way as to maximize solar gains and reduce heating requirements in the winter. While podiums may be constrained to orient according to existing streets grids and existing buildings, a tower's orientation should be rotated such that the longest facade is within 30 degrees of true south. These buildings should also be designed in such a way as to maximize the length to width ratio of towers to take maximum advantage of potential solar energy.



High rise concrete developments with a podium and tower configuration can optimize the tower orientation to maximize solar gain and daylighting potential. While the podium is typically restricted to the orientation of the site, the towers can be rotated so their longer facades face south.

While concrete residential buildings tend to be more simplistic in their overall design when compared to low- or medium-rise structures, junctions created by intersecting walls, roofs, balconies, and other indents in the envelope can still lead to building envelope-related issues. Building design should therefore strive to reduce complicated articulations of the building envelope to lower the building's overall surface area-to-volume ratio and avoid the risk of air and water infiltration. Junctions created by intersecting walls, roofs, balconies, bay widows and other features that create projections in the building envelope should be avoided as much as possible. Visual and aesthetic impact can instead be achieved through a mix of visually interesting cladding materials that create a dynamic appearance.

> Where complicated junctions do occur, a higher level of attention to detailing should be given to ensure air and water tightness through the use of sealants, gaskets, air-tight tapes, and other measures.

> Opportunities for thermal bridging should be avoided by ensuring proper breaks and the adequate insulation of floor slabs, balconies and other features from the building envelope.

A complicated form with many articulations increases the surface area through which heat can escape.

A simple building form with cladding colours can be used to create visual interest.

The 3CivicPlaza condominium and hotel development in Surrey, BC uses simple massing with large concrete elements and glass elements to create visual interest, without dramatically increasing complicated junctions and overall surface area.

Rendering: ZFG Cotter Architects

> Concrete residential buildings should include a maximum 50% window-to-wall ratio averaged across all facades.

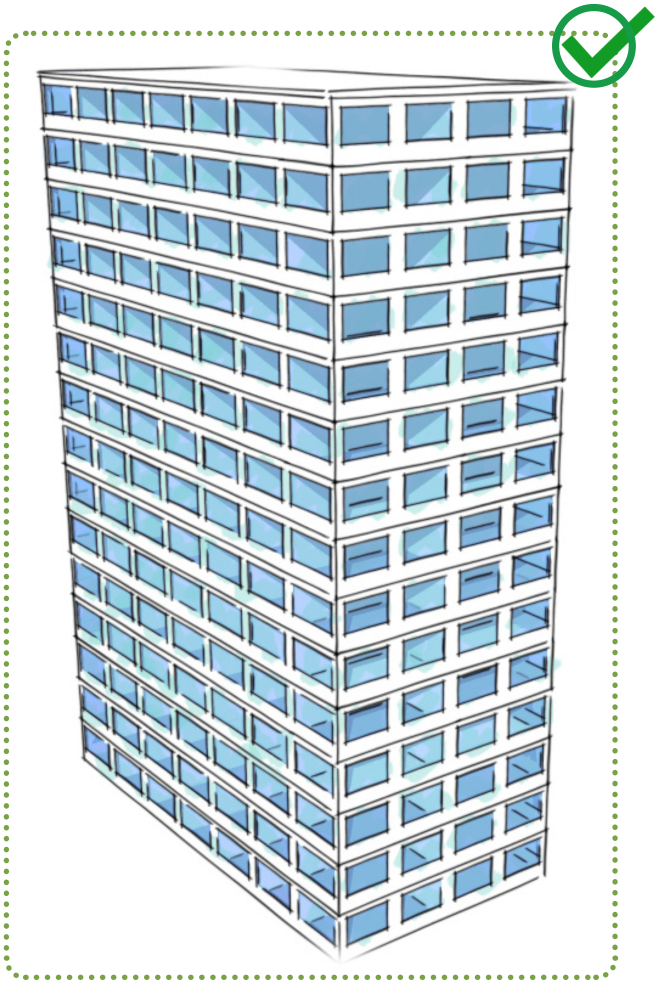
> Glazing should be maximized on east facades for natural daylighting in all seasons.

> Glazing on north facades should be minimized to reduce winter heat losses.

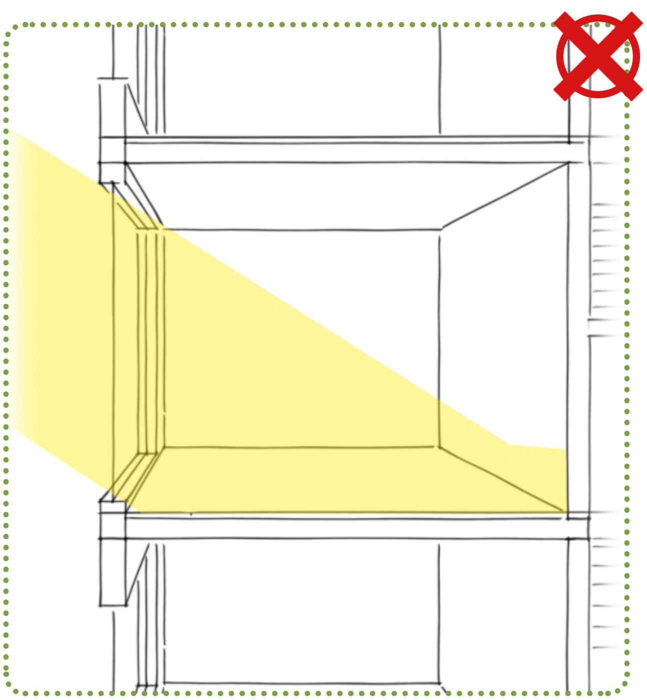
> Glazing should also be maximized in common living spaces while reducing window size in sleeping spaces as per lighting and privacy requirements.

> Floor-to-ceiling glazing should be avoided by ensuring bottom window sill heights are placed at a minimum of 24 inches above the floor to block unnecessary solar radiation at foot level while allowing views from sitting height (approx. 42 inches) and standing height (approx. 72 inches).

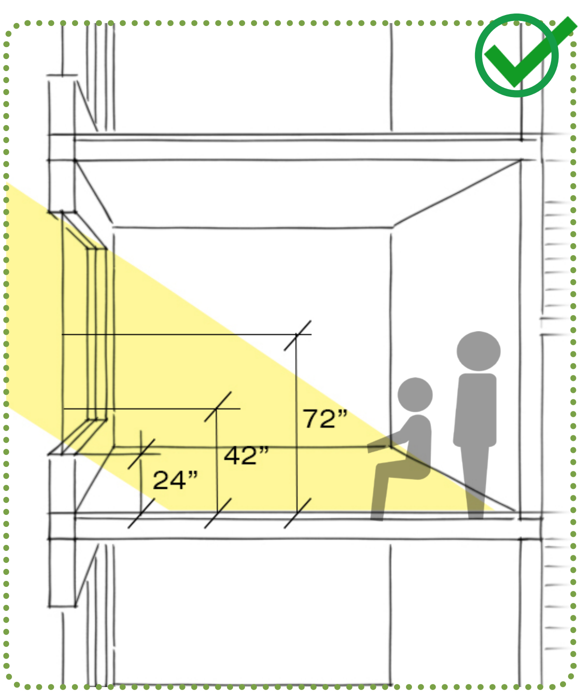
(While ASHRAE 90.1 Prescriptive Path demands a 40% maximum glazing ratio, energy modeling allows you to exceed. This is not a hard requirement, so it is recommended not to exceed 50% under any circumstance.)



Average Glazing Ratio across all Facades: 50%



A floor-to-ceiling glazing strategy can result in glare and overheating during summer. The increased glazing area results in a less insulated wall area, which contributes to heat loss during winter.



A minimum sill height of 24" minimizes overall glazed area while allowing sitting and standing views.

Buildings should be designed to include horizontal shading on south facades to minimize unwanted solar gains during the summer months and reduce the building's overall cooling load. Shading should also be optimized for daylighting and to allow for solar heat gains during winter months to reduce overall lighting needs and heating loads.

> Balconies can be designed to function as shading devices, as they are effective in blocking incoming solar radiation in the summer while allowing winter sun to enter through patio doors.

> Fenestration on the south facade should be shaded using overhangs or architectural shading devices. These overhangs and shading devices should be used in such a way that thermal bridging is avoided.

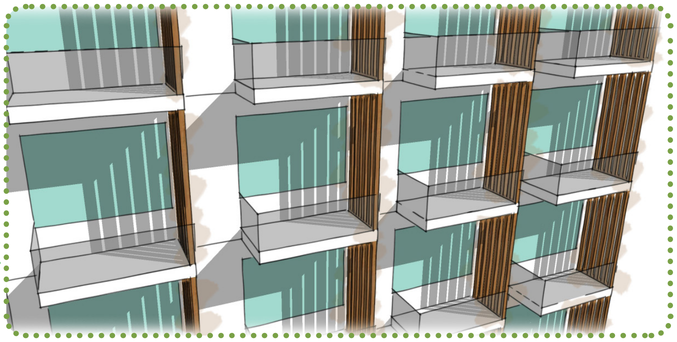
> As overheating is most common on western facades, vertical fins should be considered to provide shading from high intensity incoming solar gains when the sun is lower in the sky.

> Planting deciduous trees on the south and west facades can help mitigate solar heat gain during summer months while trees are in full leaf, while allowing solar heat gains during winter months when trees are bare.

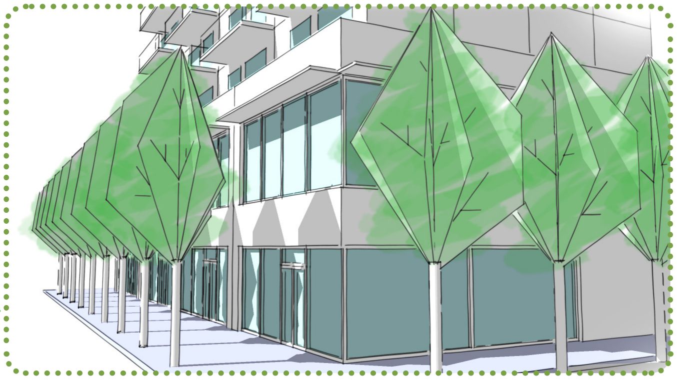
> Trees selected for planting should have full canopies and be able to grow to a sufficient height to shade south and west facades.

> Where plantings are not possible on all facades, priority should be given to plantings on south and west facades.

Horizontal shading devices can be added to the south and east facades where balconies are absent, or where they do not provide adequate summer shading.



Vertical shading devices can be added to the west facades to shade from hot afternoon sun, and can act as privacy screens between exterior balconies.



Deciduous trees planted on south and west facades can provide natural shade during hot summer months.

THERMAL BRIDGING DETAILS

High rates of thermal bridging are typical in concrete residential buildings, as they are constructed using materials (e.g. concrete and steel) with high thermal conductivity. These major sources of heat loss should be mitigated by ensuring that floor slabs do not create a heat bridge to the building exterior.

THERMALLY BROKEN BALCONIES

Balconies are the most common sources of thermal bridging in concrete residential buildings, as they are typically constructed by extruding concrete floor plates out beyond the building envelope.

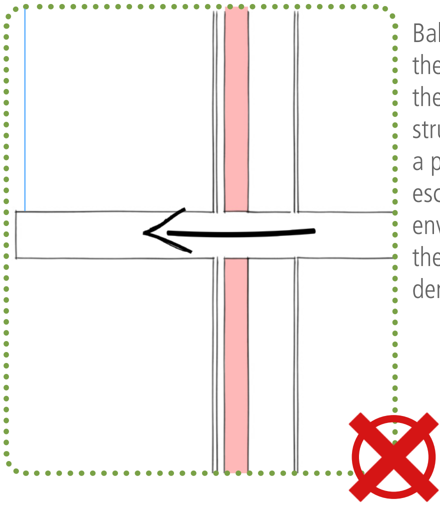
> To prevent this source of heat loss, thermal breaks should be incorporated between building floor slabs and balconies. These forms of balcony ensure that wall insulation is continuous, minimizing heat loss.

> Where possible, cantilevered balconies should be avoided and replaced by a form of balcony that is thermally broken from the building.

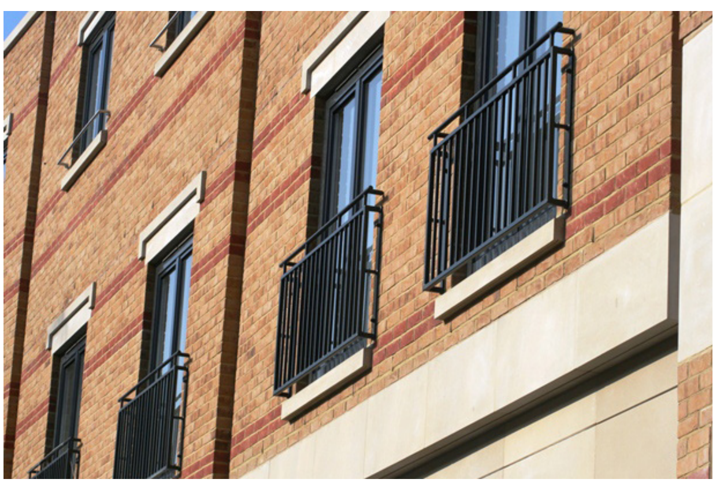
> Options include the use of externally suspended balconies that are tied back to the building using tension cables, or externally supported balconies that rest on footings at the ground level or on the podium level of the building.

> Juliet balconies can also be used to allow residents' access to the outdoors while maximizing usable floor space.

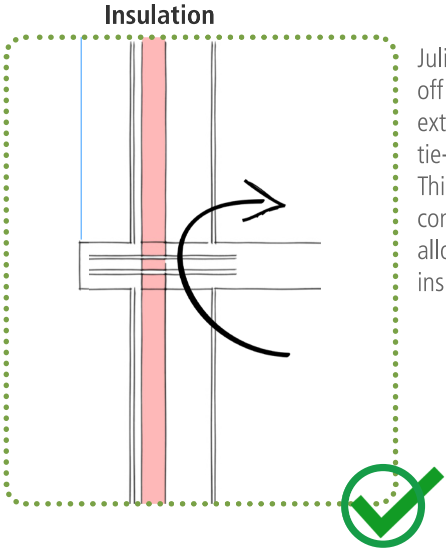
Interrupted Insulation



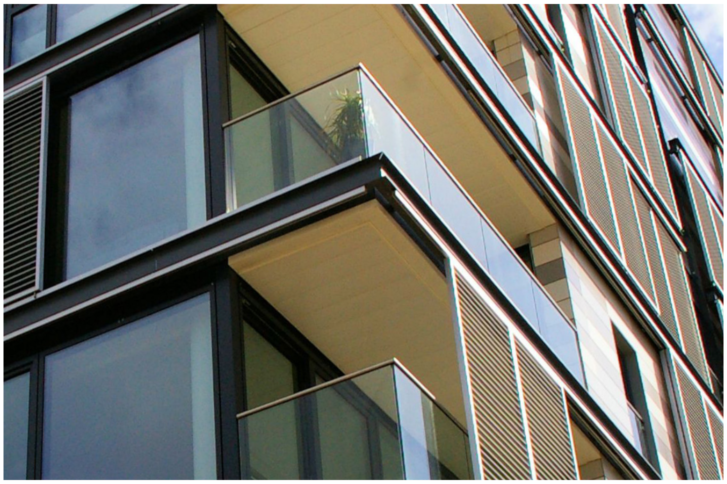
Balconies that are not thermally broken from the interior building structure provide a path for heat to escape through the envelope, increasing the building's heating demand.

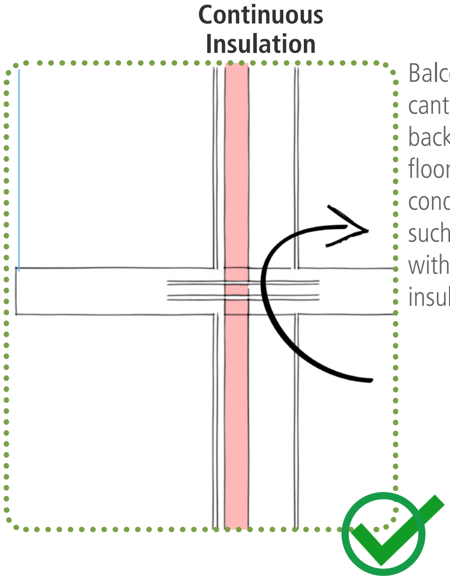


Continuous Insulation

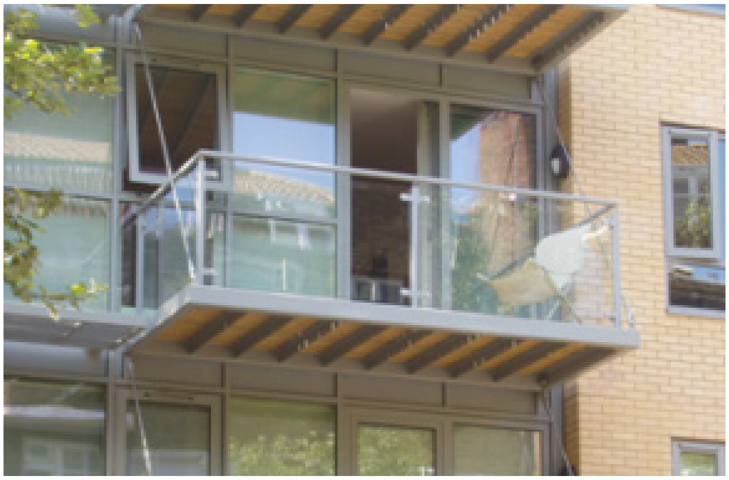


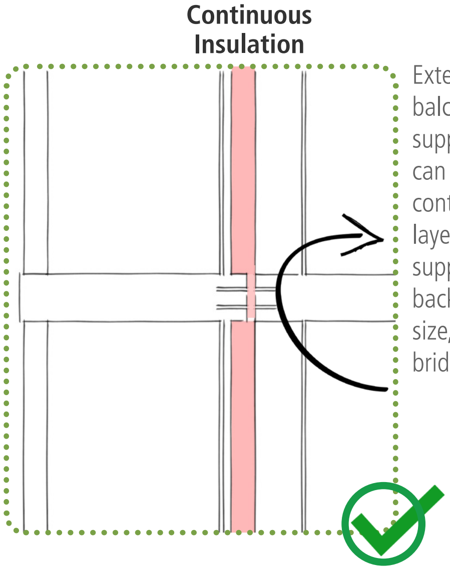
Juliet balconies hang off the buildings exterior structure using tie-back connections. This balcony configuration still allows for a continuous insulation layer.



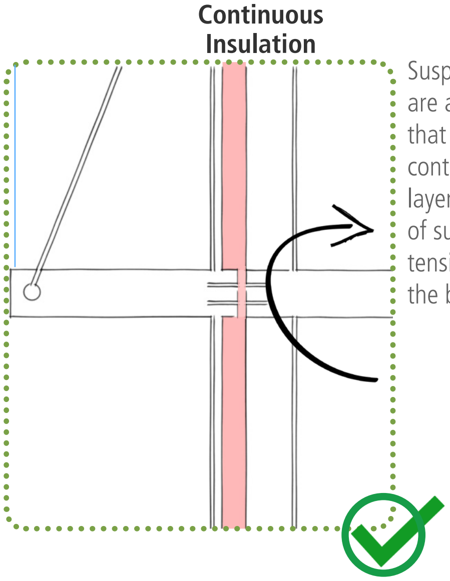


Balconies can be cantilevered and tied back to the interior floor structure, with low conductivity connections such as stainless steel, with a continuous insulation layer.





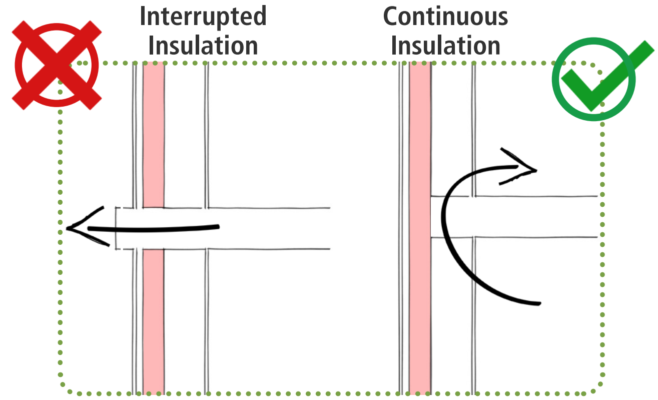
Externally supported balconies, or self-supporting balconies, can also provide a continuous insulation layer. The external support allows tie-backs to be reduced in size, reducing thermal bridging.



Suspended balconies are another solution that can include a continuous insulation layer, with the majority of support coming from tension cables tied into the buildings structure.

CONTINUOUS INSULATION

In concrete residential buildings, concrete floor slabs are often extended out from building facades for reasons of aesthetics, or to ease construction and reduce construction costs. While they do not extrude as far out as balconies, these details nevertheless create incidences of thermal bridging and should be avoided.



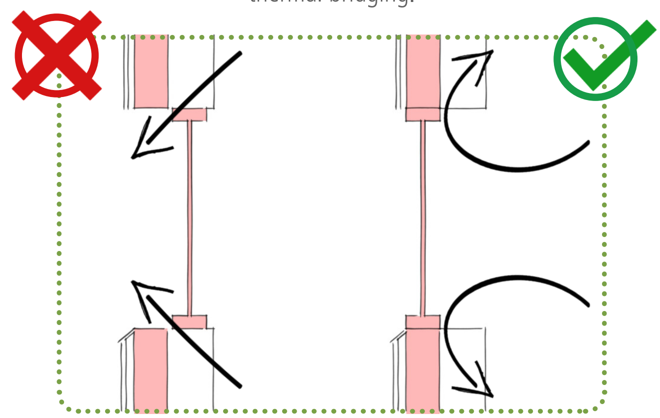
Concrete floor slabs that extend beyond the building envelope should be avoided or insulated to reduce thermal bridging.

WINDOW FRAME DETAILS

Concrete residential buildings typically have high areas of fenestration that present further opportunities for heat loss.

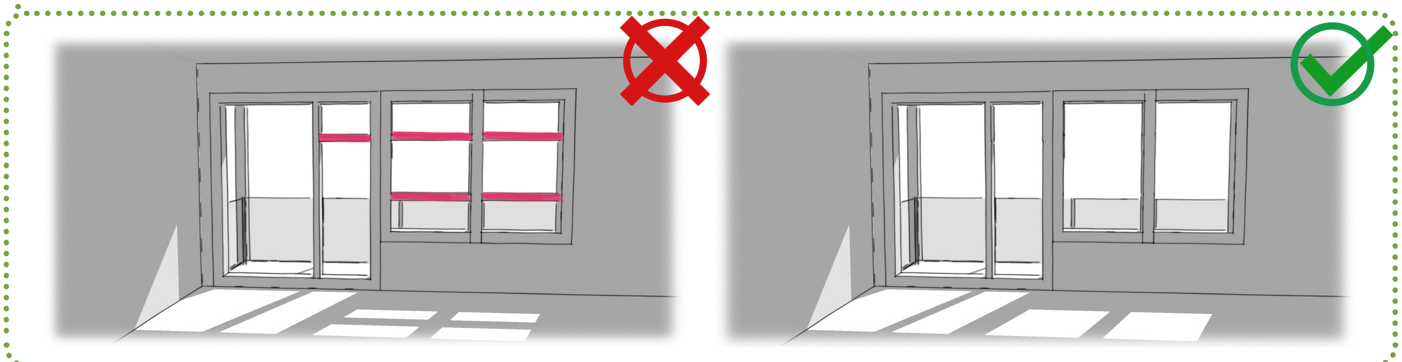
> The structures, or mullions, that hold each pane in place are major sources of heat loss and as such should be minimized.

> Mullions that are included for architectural and not structural reasons in particular should be avoided.



Window frames should be placed in line with the insulation layer, minimizing thermal bridging through the frame-to-wall connection.

Increasing the number of windows increases the length of window frames where thermal bridging is most prevalent. More heat is lost through the frame than the glazing. The additional window (left) adds approx. 10 feet of window frame compared to the glazing scenario on the right.

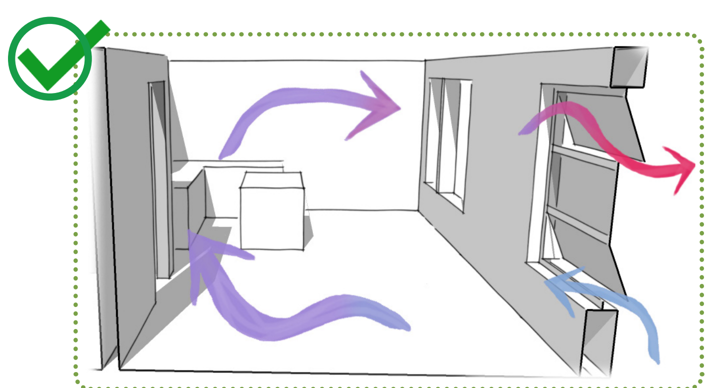


NATURAL VENTILATION

> Buildings should be constructed to maximize the potential for natural ventilation, thereby reducing the need for mechanical ventilation and improving overall occupant comfort.

> Stack ventilation systems that allow for convective air flow in a building should also be used wherever possible.

> Operable windows should be placed at the lower and upper portions of unit walls to allow cool air to enter the building and move stale, warmer air out.

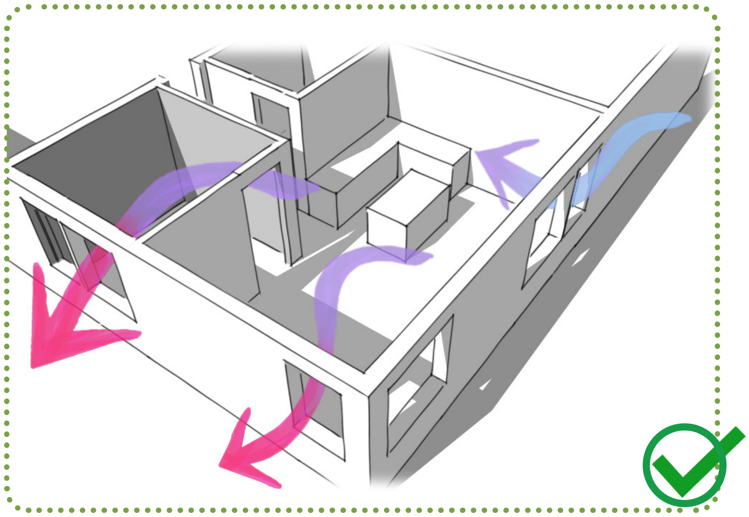


Stack ventilation at a suite scale is possible through the use of operable windows placed on upper and lower portions of the wall.

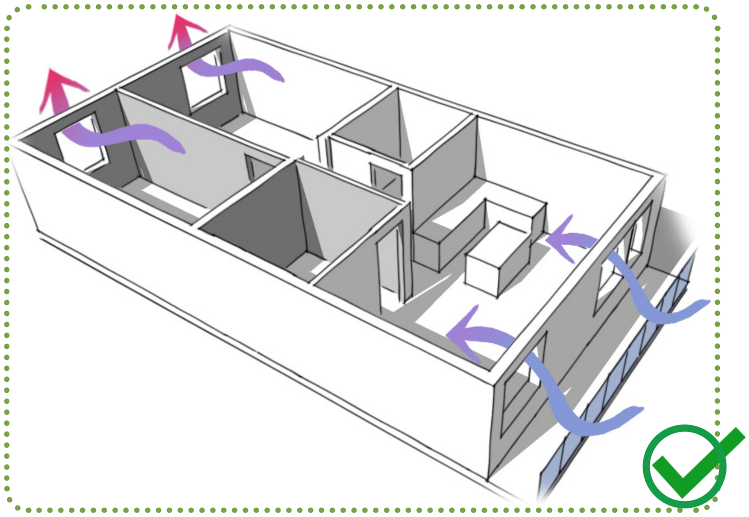
> Natural ventilation is most successful and should be maximized in corner units that allow for cross-ventilation between windows on adjacent facades. Units connected to a single-loaded corridor are also ideal candidates for cross-ventilation, in that windows can be placed on opposing facades.

> In high rise buildings, the stack effect air flow through elevator cores can become excessive and put additional burden on mechanical ventilation and heating systems. This is particularly the case in pressurized buildings, as the stack effect can act against desired building pressurization.

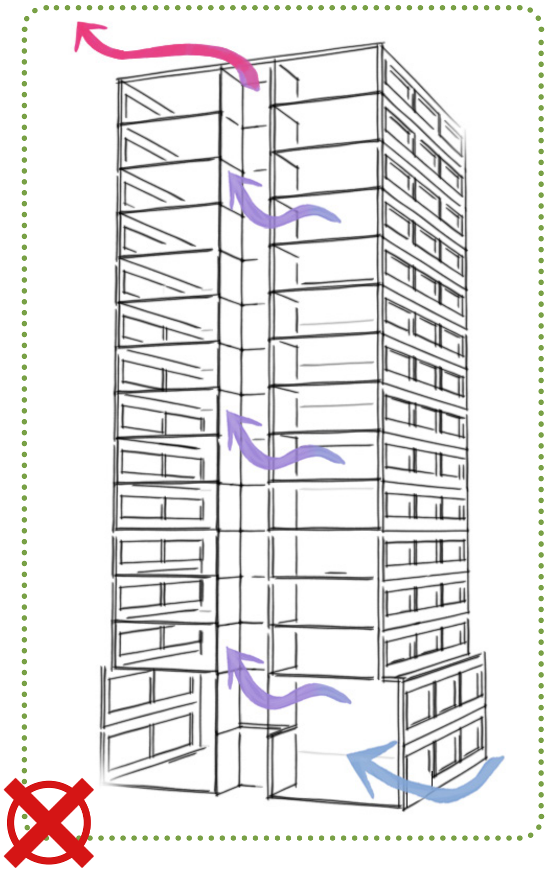
> To help reduce this effect, revolving doors or vestibules should be included into building design to create a buffer area between the building's interior and exterior, providing a second line of defense against inflows of air through entry doors. Consult vestibule requirements as indicated in ASHRAE 90.1 2010.



Corner units should have operable windows on adjacent walls to allow air to flow through the suite.



Cross-ventilation is an ideal natural ventilation solution for residential units in a single-loaded corridor configuration, with operable windows on opposite exterior walls



High rise buildings without vestibules or revolving doors are more susceptible to stack-effect in elevator shafts and building cores, significantly reducing ventilation efficiency in buildings.

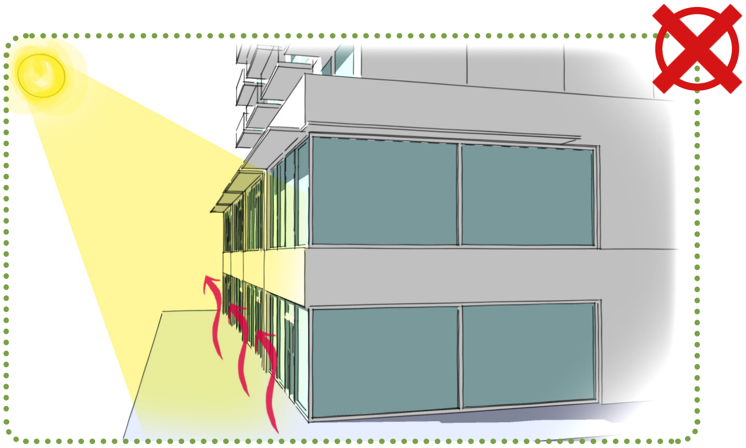
The materials used in the construction of concrete residential buildings can have a high impact on a building's overall contribution to the Urban Heat Island effect and thus the overall comfort of its occupants.

> Materials such as concrete and asphalt that absorb and re-emit radiation and contribute to the Urban Heat Island effect should be replaced wherever possible with materials that reflect heat away from the building.

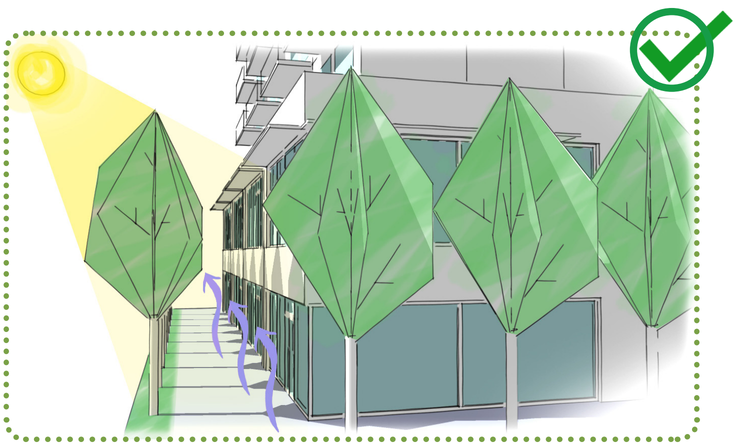
> On west and south facades, both vegetation generally and deciduous trees specifically should be planted to reduce heat and improve shading in summer months.

> Trees on these facades additionally help to support natural ventilation by cooling incoming air and improving overall air quality. Daylighting of interior spaces should be facilitated through the selection of light coloured materials on building exteriors.

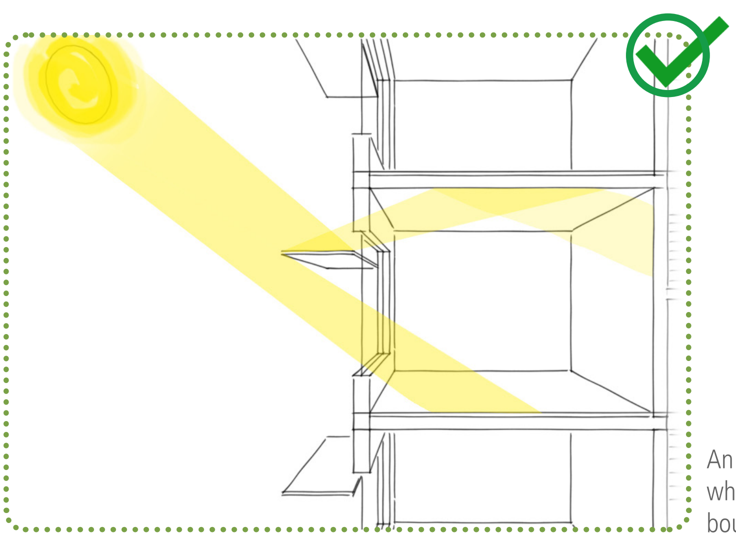
> Exterior architectural shading devices can double as exterior light shelves, which reflect incoming light back into interior spaces while preventing heat gains. These should be designed in such a way as to minimize heat gains in summer and optimize heat gains in winter.



Low-albedo materials such as concrete, asphalt, paving materials, and dark coloured finishes can contribute to the Urban Heat Island effect.



Vegetation, plantings and deciduous trees can help reduct the Urban Heat Island effect at both site and city scales.

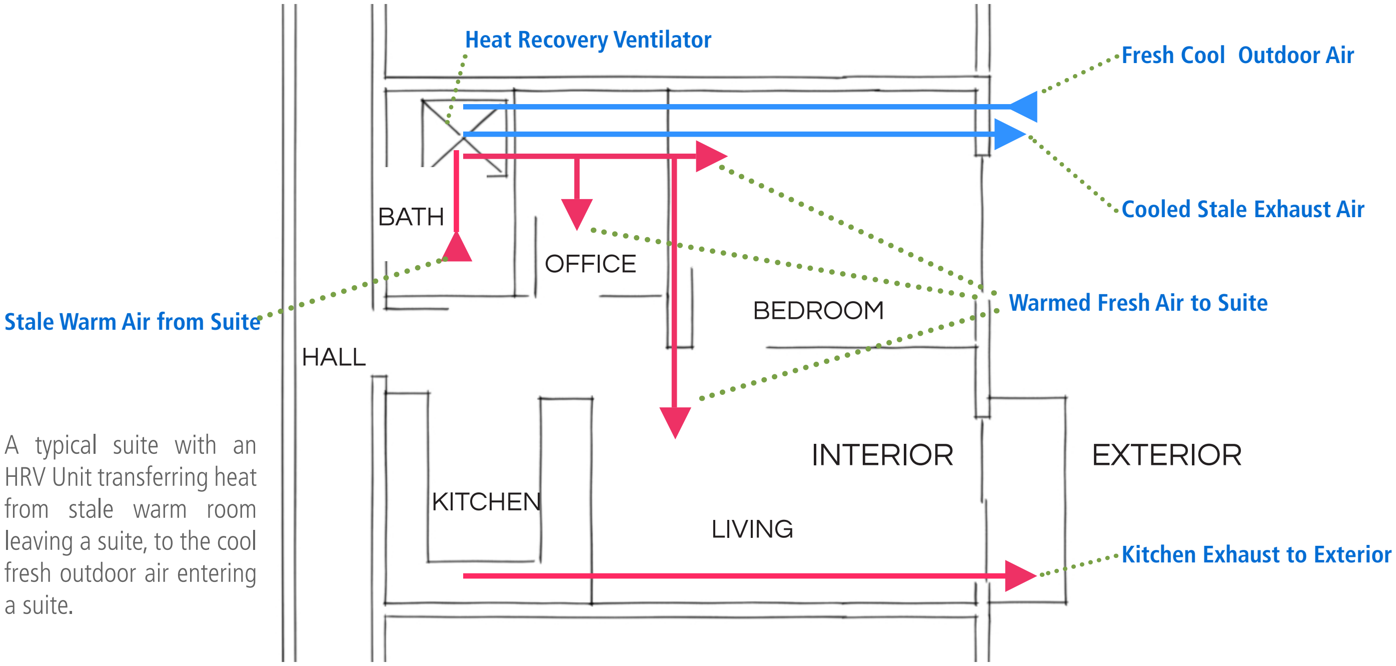


An exterior shading device can also act as a light shelf when finished with a light-reflecting material or colour, bouncing light further into interior spaces.

While ventilation is commonly achieved through centralized systems in which pressurized corridors and undercut entry doors provide fresh air to individual suites, these have been found to be ineffective in providing ventilation. Alternative methods that improve ventilation and reduce heat losses should therefore be considered.

> Individual suites should be compartmentalized and outfitted with individual unit-controlled ventilation systems. Individually pressurizing units have been found to optimize suite temperature and moisture while reducing opportunities for cross-contamination of odours or smoke from adjacent units.

> Heat Recovery Ventilators (HRV) should be used on a unit-by-unit basis to allow for adequate ventilation without the need to open windows in cooler months. These systems reduce building heat losses by transferring heat from warm exhaust air to fresh incoming air, while improving indoor air quality and occupant comfort. HRV are also able to control indoor humidity levels, reducing incidences of mould, condensation on windows, and odours.



A typical suite with an HRV Unit transferring heat from stale warm room leaving a suite, to the cool fresh outdoor air entering a suite.

This building type refers to the typical commercial office building. These buildings are often three to four storeys and can be constructed using a variety of materials, including wood-frame, steel stud, concrete tilt-up construction, prefabricated panel systems, cast-in-place concrete, or others. They are cooling-dominated as a result of high internal heat loads derived from office equipment and a high number of occupants. This translates into high cooling loads year round, even in Surrey's cool temperate climate.

This building type typically includes common lobbies and elevator and exit stair cores centrally located in the building, with office spaces located around the perimeter. In many cases, a single tenant can occupy one of more floors; however, floors are easily compartmentalized into several suites. Many of these buildings also include double or full height lobbies, central atria, and/or other amenity spaces such as fitness facilities.

Commercial Office Building
Broadway Tech Centre | Vancouver BC
Photo: Stuart Olson

Commercial Office Building
WCHM Office | Surrey BC
Photo: Avion Multiplex Construction

APPLICABLE PASSIVE ELEMENTS

ELEMENT	COST	EFFECTIVENESS	NATURAL GAS SAVINGS	ELECTRICITY SAVINGS	PAGE
Compact Massing & Form	$	🍃	🔥		50
50% Max. Window-Wall Ratio	$		🔥	⚡	52
Minimum 24" Sill Height	$	🍃🍃		⚡	52
Horizontal Shading on South	$$	🍃🍃🍃		⚡	53
Vertical Shading on West	$$	🍃🍃🍃		⚡	53
Deciduous Trees & Plantings	$	🍃		⚡	53+56
Continuous Insulation	$$	🍃🍃🍃	🔥		54
Window Frame Detailing	$$	🍃🍃	🔥		54
Natural Ventilation	$	🍃		⚡	55
Material Selection	$	🍃🍃	🔥	⚡	56

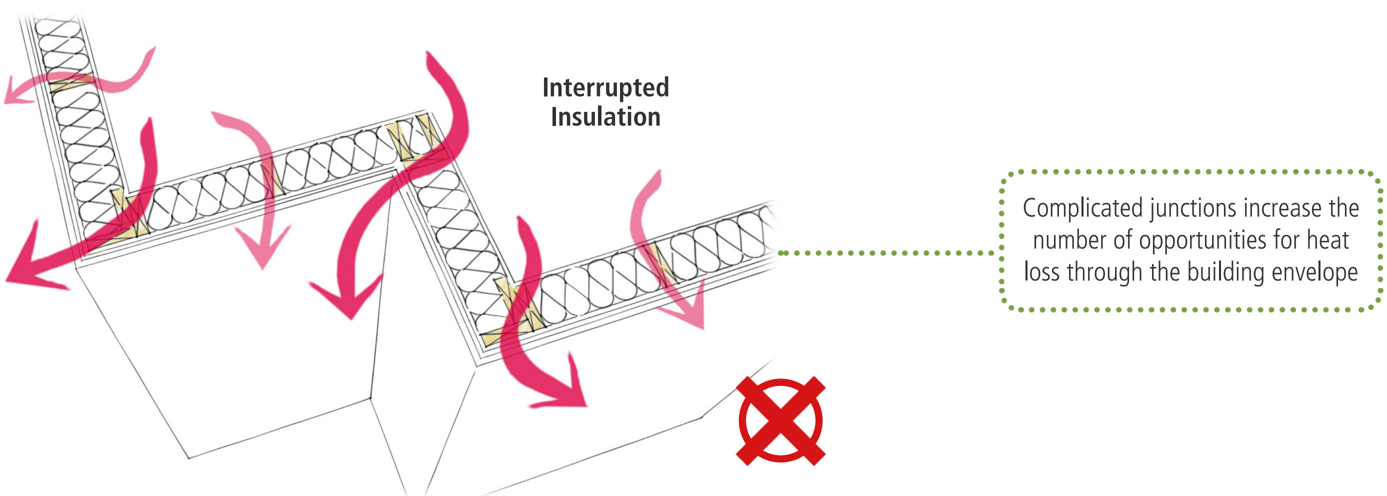
COMPACT MASSING & FORM

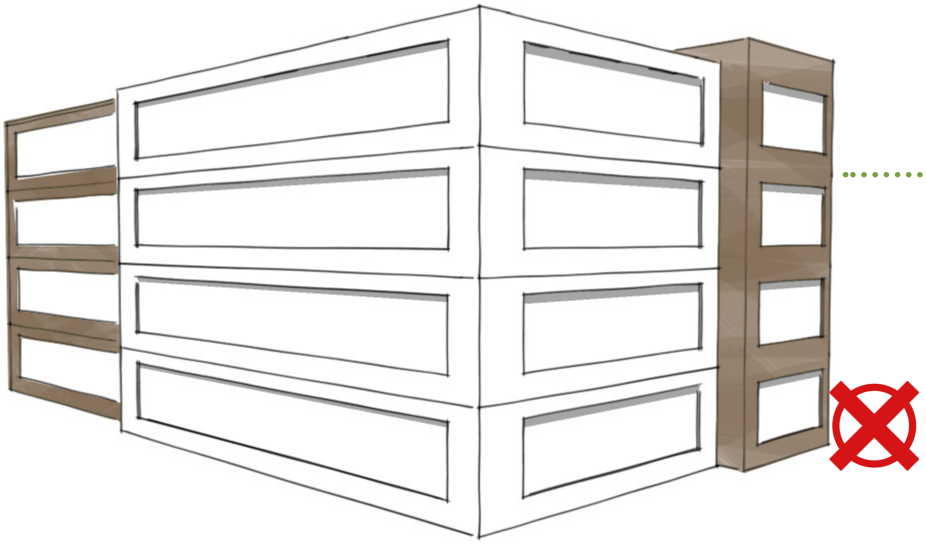
> Office buildings should be designed to reduce complicated articulations of the building envelope to lower the building's overall surface area-to-volume ratio and avoid the risk of air and water infiltration.

> Junctions created by intersecting walls, roofs, or other features that create projections in the building envelope should be avoided as much as possible. Visual and aesthetic impact can instead be achieved through a mix of visually interesting cladding materials that create a dynamic appearance. The thoughtful placement of windows can also add visual interest while maintaining compact form.

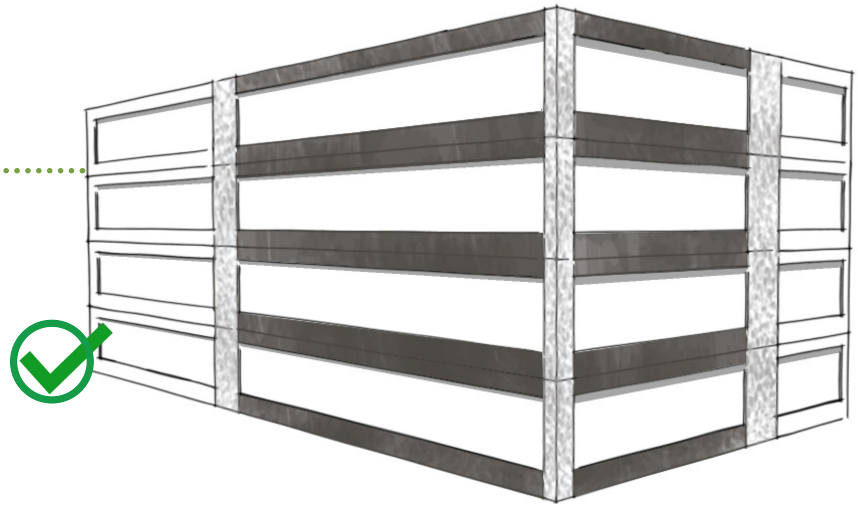
> Where complicated junctions do occur, a higher level of attention to detailing should be given to ensure air and water tightness through the use of sealants, gaskets, air-tight tapes, and other measures.

> Opportunities for thermal bridging should be avoided by ensuring proper breaks and the adequate insulation of floor slabs or other features from the building envelope.





A complicated form with many articulations increases surface area through which heat can escape.



A simple building form with cladding colours can be used to create visual interest.

The Broadway Tech Centre in Vancouver, BC uses simple massing, cladding individual elements with contrasting materials to create visual interest, without dramatically increasing complicated junctions and overall surface area. The stark contrast between black, white and grey is an effective way to create visual expression.

Photo: Stuart Olson

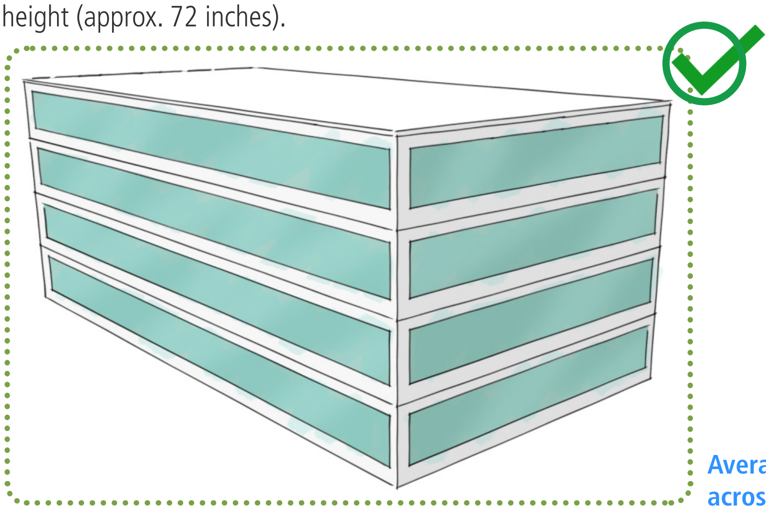
> Office buildings should include a maximum of 50% window-to-wall ratio averaged across all facades. (While ASHRAE 90.1 Prescriptive Path demands a 40% maximum glazing ratio, energy modeling allows you to exceed. This is not a hard requirement, so it is recommended not to exceed 50% under any circumstance.)

> Glazing should be maximized on east facades for natural daylighting in all seasons.

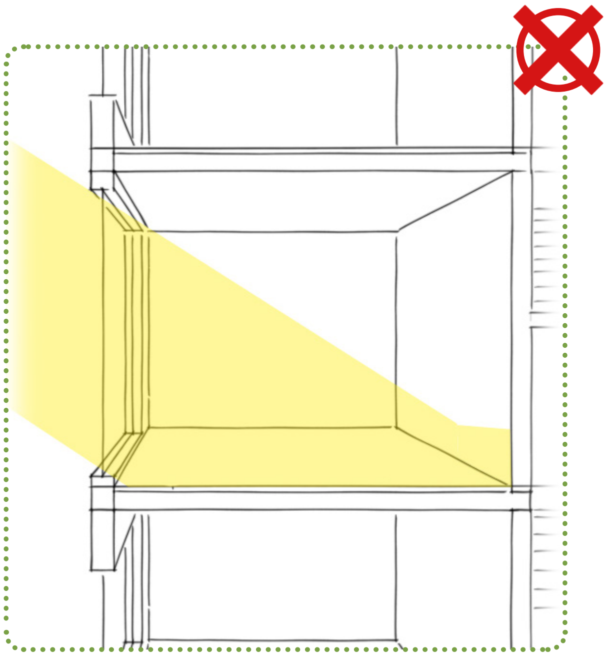
> Glazing on north facades should be minimized to reduce winter heat losses.

> Glazing should also be maximized in common living spaces while reducing window size in sleeping spaces as per lighting and privacy requirements.

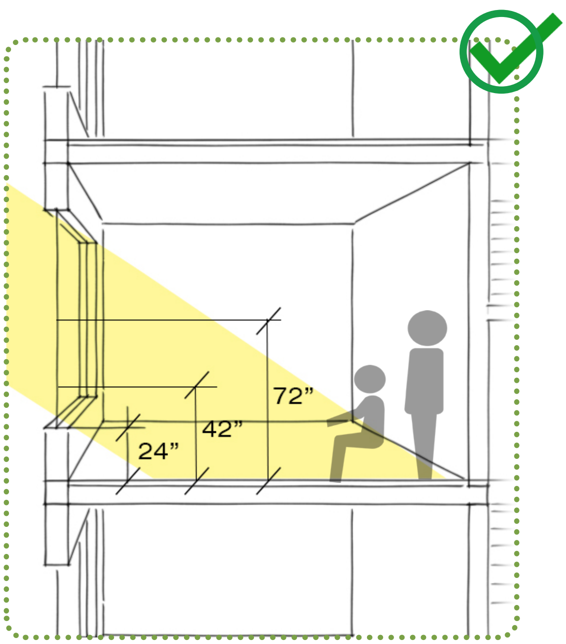
> Floor-to-ceiling glazing should be avoided by ensuring bottom window sill heights are placed at a minimum of 24 inches above the floor to block unnecessary solar radiation at foot level while allowing views from sitting height (approx. 42 inches) and standing height (approx. 72 inches).



Average Glazing Ratio across all Facades: 50%



A floor-to-ceiling glazing strategy can result in glare and overheating during summer. The increased glazing area results in less insulated wall area, which contributes to heat loss during winter.



A minimum sill height of 24", minimizing overall glazed area while allowing sitting and standing views.

> The use of shading devices to minimize unwanted solar gains during summer months and reduce the building's overall cooling load should be made a high priority. Shading should be optimized for daylighting and to allow for solar heat gain during winter months to reduce overall lighting needs and heating loads.

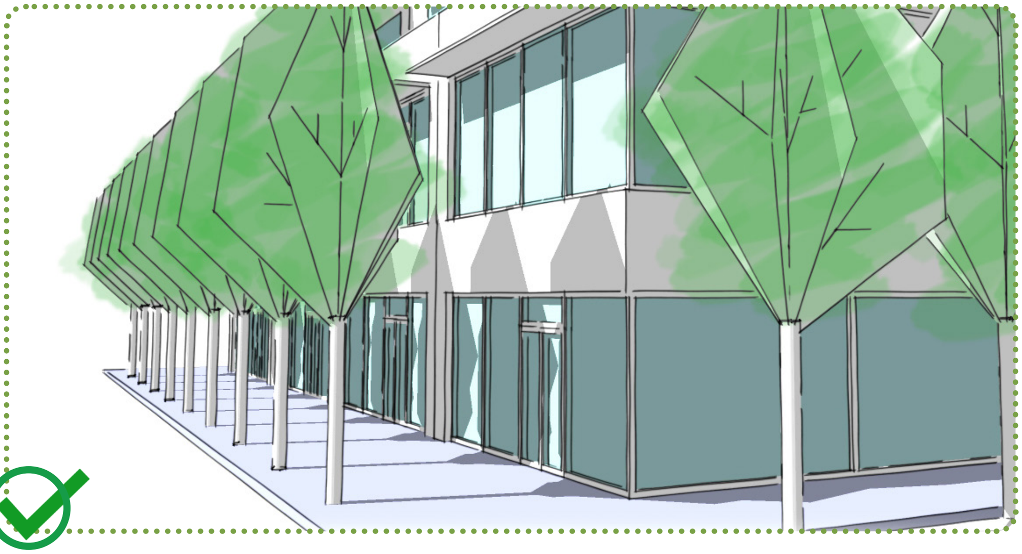
> Vertical fins should be considered for use on the west facade to provide shading from high intensity incoming solar gains from the west. South, east and west-facing windows can also be shaded using horizontal louvers, while taking care not to create opportunities for thermal bridging.

> Exterior shading devices such as roller shades can be installed that can either be operated automatically in response to occupancy, HVAC operations, or solar heating to shade incoming solar radiation. Such systems often include switches and/or hand-held remotes that also allow building occupants to control individual shades to suit occupant needs. While these improve occupant control, however, they can often require addition maintenance as well as a supply of energy and so should be considered carefully.

> Deciduous trees on the south and west facades should be planted to help to mitigate solar heat gains during summer months while trees are in full leaf, while allowing solar heat gains during winter months when trees are bare. Trees selected for planting should have full canopies and be able to grow to a sufficient height to shade lower floors on south and west facades.

Horizontal shading devices can be added to a building's south and east facades where balconies are absent, or where they do not provide adequate summer shading.

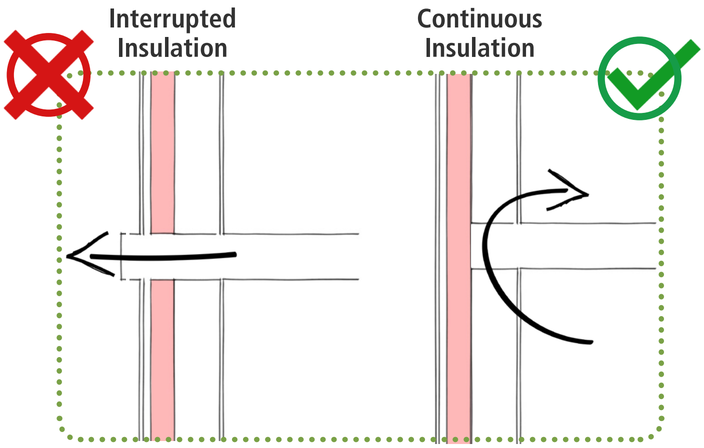
Vertical shading devices can be added to a building's west facade to shade from hot afternoon sun, and can act as privacy screens between exterior balconies.



Deciduous trees provide natural shade during summer months, and increase occupants' connection to nature and the outdoors.

THERMAL BRIDGING DETAILS

> Office buildings are often built in steel or concrete construction, both of which are building materials that transfer heat easily. Careful detailing is required to ensure thermal bridging through the building envelope is mitigated or avoided entirely.



Concrete floor slabs should avoid being designed to protrude through the building envelope. Concrete or metal protrusions through the exterior insulation are the largest contributors to thermal bridging.

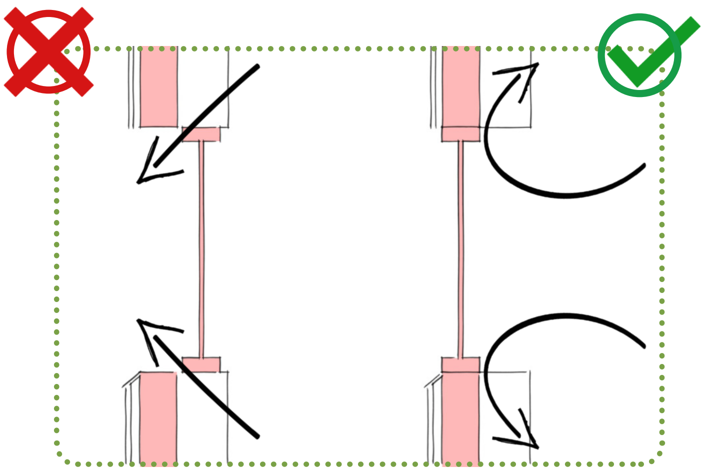
CONTINUOUS INSULATION

> In office buildings, concrete floor slabs are often extended out from building facades for reasons of aesthetics, or to ease construction and reduce construction costs. These details create incidences of thermal bridging and should be avoided.

WINDOW FRAME DETAILS

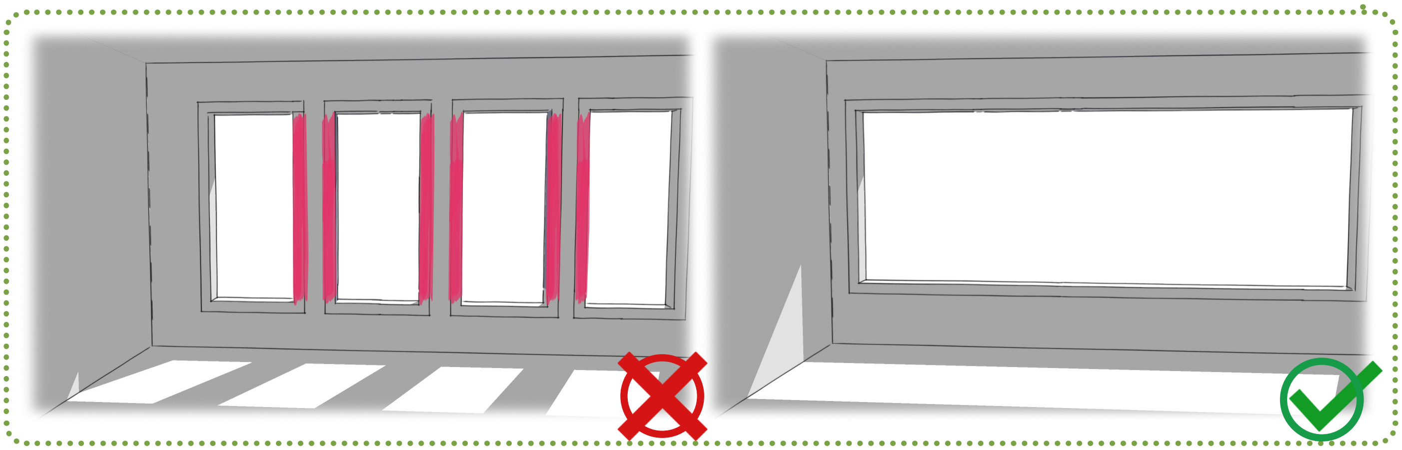
> Thermal bridging can also occur via thermal conduction through window frame connections to window sashes and sills. Buildings should therefore be designed to minimize the number of these connections by avoiding the use of a large number of smaller windows that increase the overall number of connection points in the building envelope. Instead, building should be designed using a smaller number of large windows.

> Office building designs that include large sections of window panes should limit the number of structures, or mullions, that hold each pane in place. Mullions that are included for architectural and not structural reasons in particular should be avoided.



Window frames should be placed in line with the insulation layer, minimizing thermal bridging through the frame-to-wall connection.

Increasing the number of windows increases the total length of window frames, where thermal bridging is most prevalent. More heat is lost through the frame than the glazing. In this scenario, the additional window (left) adds 24 feet of window frame compared to the use of one larger window (right).



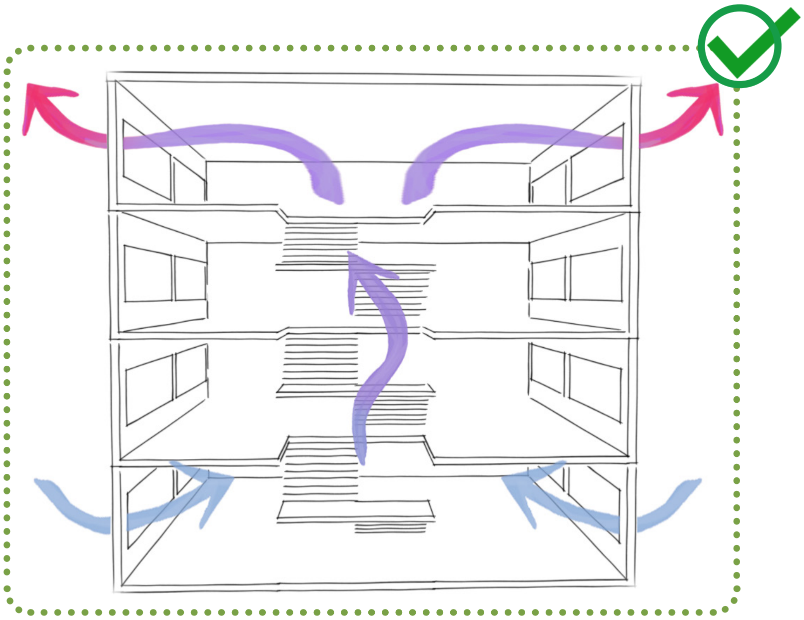
Office buildings should be constructed in such a way as to maximize the potential for natural ventilation, reducing the need for mechanical ventilation and improving overall occupant comfort.

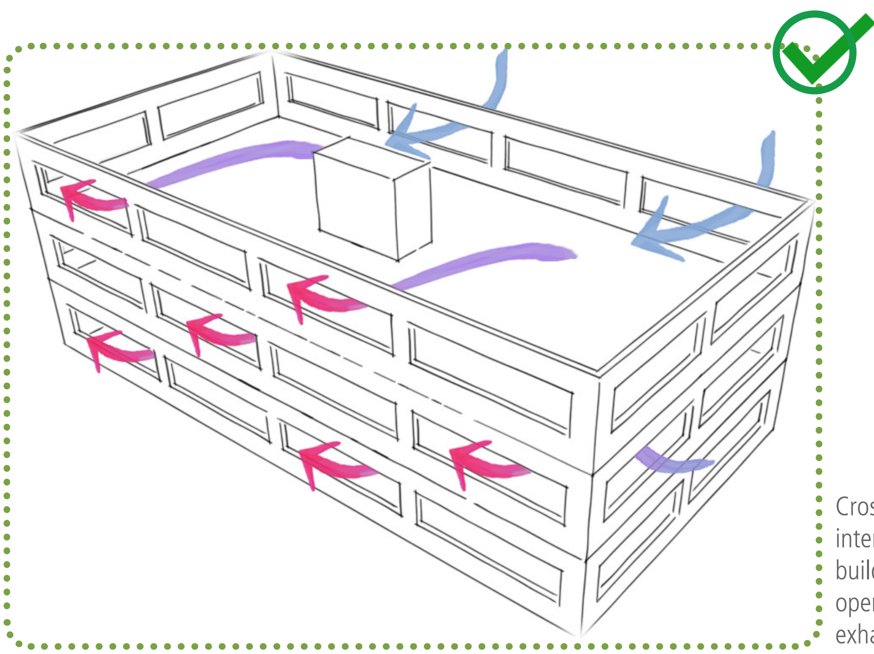
> Natural ventilation can be easily achieved in office spaces that occupy full floor plates which can achieve cross-ventilation between windows on adjacent or opposing facades. To allow air to be drawn across interior occupied spaces, a minimum of two exterior walls per occupied area should include operable windows as part of the building design.

> Buildings that include central atrium spaces and/or double height spaces should also make use of stack ventilation. Intake air can be sourced from windows on the lower floors and exhausted from upper floor windows, with the atrium space acting as a transfer zone.

> Operable windows in office spaces should be included into building design to facilitate the passive movement of air.

Stack Ventilation: the movement of cooler air drawn in through lower operable windows, up through an open atrium space, and out of the building through operable windows on upper floors.





Cross-Ventilation: Air movement inside the building interior follows natural wind pressures occurring on the buildings exterior. Cool air enters the building through operable windows on all floors, and warmer, stale air is exhausted on opposite and adjacent walls.

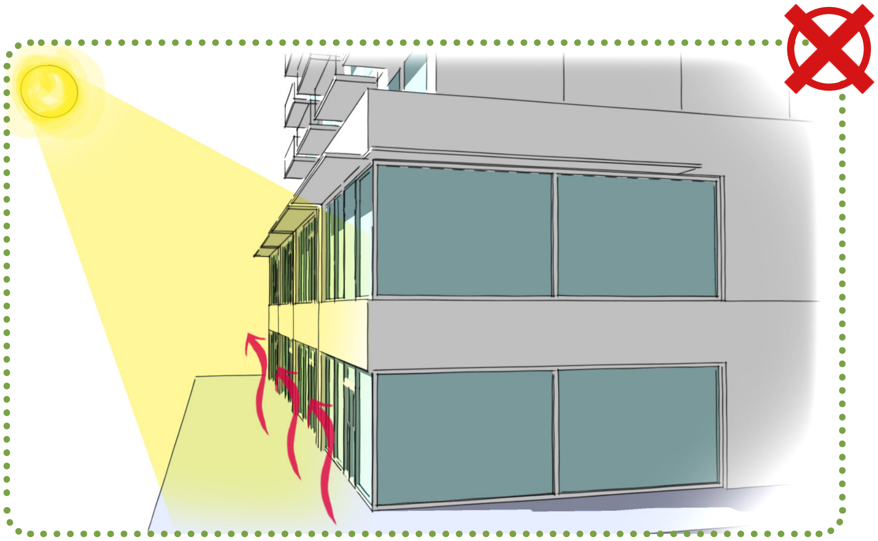
CITY OF SURREY

> The materials used in the construction of office buildings can have a high impact on the building's overall contribution to the Urban Heat Island effect and thus the overall comfort of its occupants. Materials such as concrete and asphalt that absorb and re-emit radiation and contribute to the Urban Heat Island effect should be replaced wherever possible with materials that reflect light and heat away from the building.

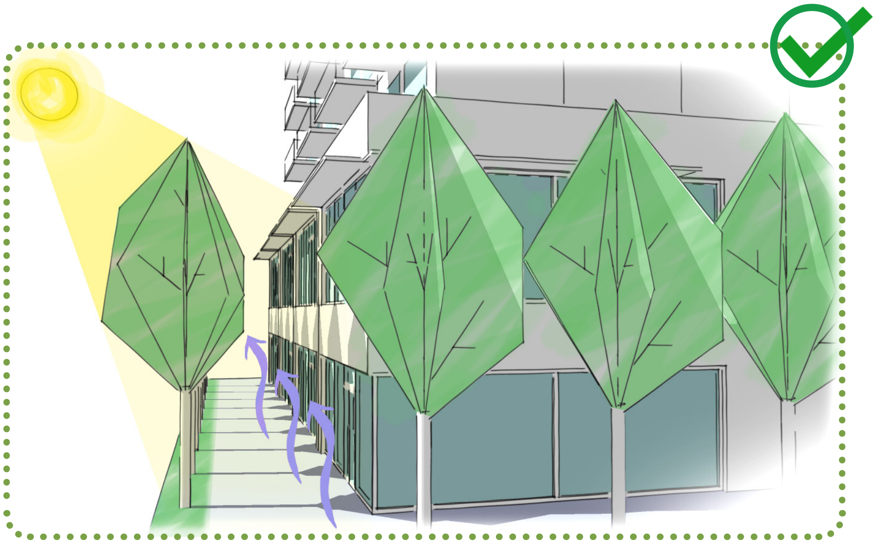
> Strategies for reducing heat absorption include the use of green roofs that remove heat through the process of evapotranspiration, or cool roofs that reflect sunlight and heat away from a building. Vegetation should be maximized on the building site to reduce the use of pavement.

> On west and south facades, both vegetation generally and deciduous trees specifically should be planted to reduce heat and improve shading in summer months. Trees on these facades additionally help to support natural ventilation by cooling incoming air and improving overall air quality.

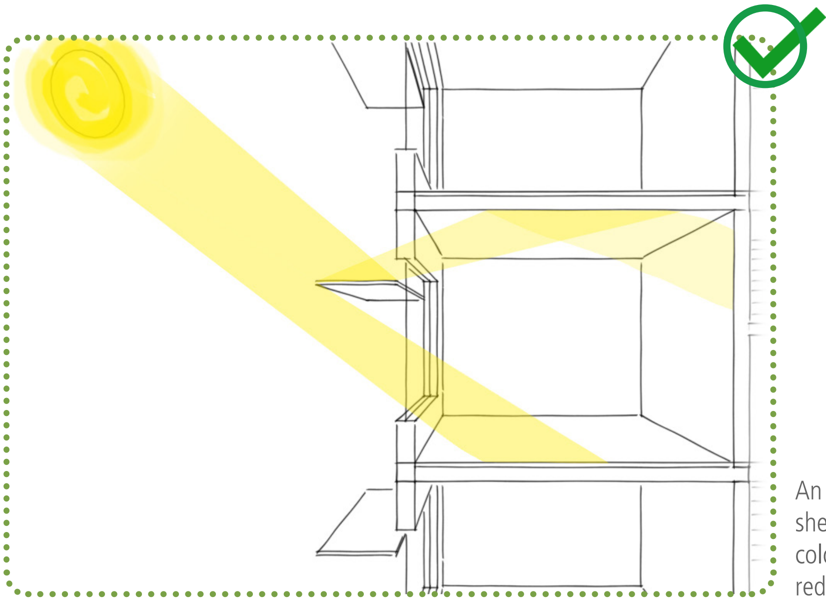
> Daylighting of interior spaces can be facilitated through the selection of light coloured materials on building exteriors. Exterior architectural shading devices can double as exterior light shelves, which reflect incoming light back into interior spaces while preventing heat gains. These should be designed in such a way as to minimize heat gains in summer and optimize heat gains in winter.



Low-albedo materials such as concrete, asphalt, paving materials, and dark coloured finishes can contribute to the Urban Heat Island effect.



Vegetation, plantings and deciduous trees can help reduct the Urban Heat Island effect at both site and city scales.



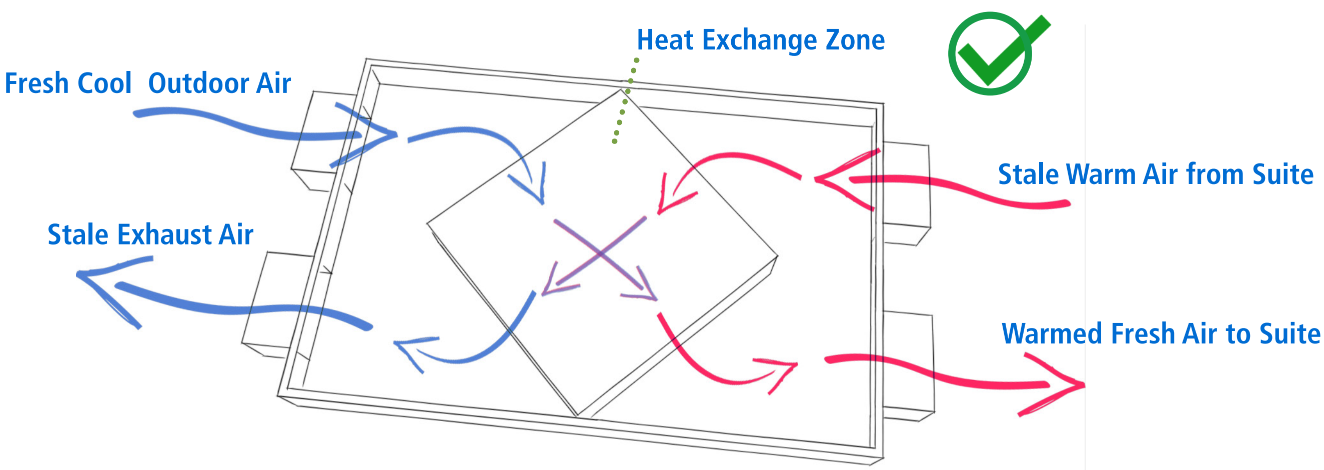
An exterior shading device can also act as a light shelf when finished with a light-reflecting material or colour, bouncing light further into interior spaces and reducing electrical lighting loads.

ACTIVE SYSTEM ASSISTANCE

While the passive design elements noted above should be prioritized, active means of space conditioning using mechanical HVAC systems will still be required. However, building designers should consider alternative systems or methods that improve ventilation and reduce heat losses.

> Underfloor ventilation should be considered as a means of providing air circulation and space conditioning through individual floor diffusers. Such systems are more efficient than overhead ventilation systems traditionally used in office buildings, and have been found to improve occupant comfort.

> Heat Recovery Ventilators (HRV) should be used on a suite-by-suite basis to allow for adequate ventilation without the need to open windows in cooler months. These systems reduce building heat losses by transferring heat from warm exhaust air to fresh incoming air, while improving indoor air quality and occupant comfort. HRV are furthermore able to control indoor humidity levels, reducing incidences of mould, condensation on windows, and odours.



A typical HRV Unit depicting the transfer of heat from stale warm room leaving a suite, to the cool fresh outdoor air.

Commercial retail businesses are typically housed in one-to-two storey units, either as standalone buildings, or as the first and/or second storeys of mixed-use buildings that comprise the base for additional storeys of residential use. The primary emphasis of these building types is typically a single facade that uses a glass "curtain wall" to display products to passersby and invite potential customers to enter the space. Larger commercial businesses often have double-height units that require more active ventilation, and generally tend to require significant heating and cooling loads to make up for the constant entry and exist of customers.

Single Storey Retail Building
Delta, BC
Photo: Colliers Canada

Retail and Office Building
Surrey, BC
Photo: vancouverofficespace.net

Grandview Corners Retail Building
Surrey, BC
Photo: Google Streetview

APPLICABLE PASSIVE ELEMENTS

ELEMENT	COST	EFFECTIVENESS	NATURAL GAS SAVINGS	ELECTRICITY SAVINGS	PAGE
50% Max. Window-Wall Ratio	$	🍃🍃🍃	🔥	⚡	60
Minimum 24" Sill Height	$	🍃🍃		⚡	60
Horizontal Shading on South	$	🍃🍃🍃		⚡	61
Deciduous Trees & Plantings	$	🍃		⚡	61+63
Continuous Insulation	$$	🍃🍃🍃	🔥		62
Window Frame Detailing	$$	🍃🍃	🔥		62
Material Selection	$	🍃🍃	🔥	⚡	63

FENESTRATION

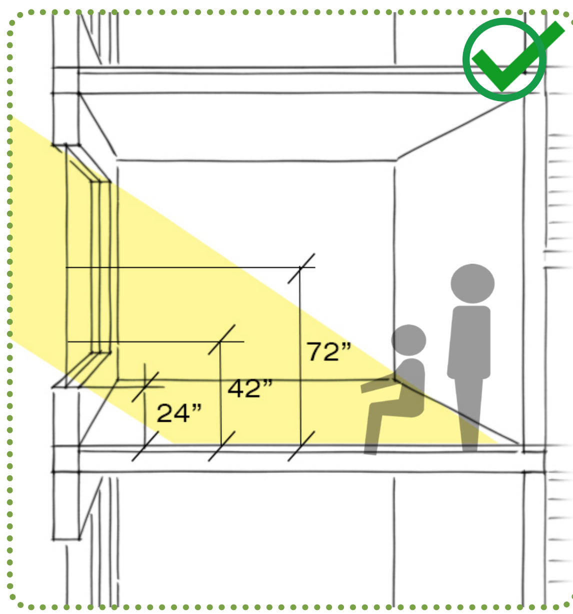
As the orientation of one to two storey retail buildings is generally constrained by lot orientation to the street grid, there are few opportunities to optimize fenestration on south or west-facing facades. However, the primary facade of these building types can implement smart fenestration strategies.

> The primary facade, or the shop fronts, should include a maximum of 50% window-to-wall ratio while allowing for natural daylighting to occupied spaces.

> A 50% glazing ratio should be considered on a unit to unit basis, as they are typically ventilated separately. Corner units may have 50% glazing on both street fronts.

> While lower floors typically have floor to ceiling windows to display products, or create indoor-outdoor visual connection, upper floors should avoid over-sizing their windows that increase heat gains in summer and heat losses in winter. Floor-to-ceiling glazing should be avoided on upper floors by ensuring bottom window sill heights are placed at a minimum of 24 inches above the floor.

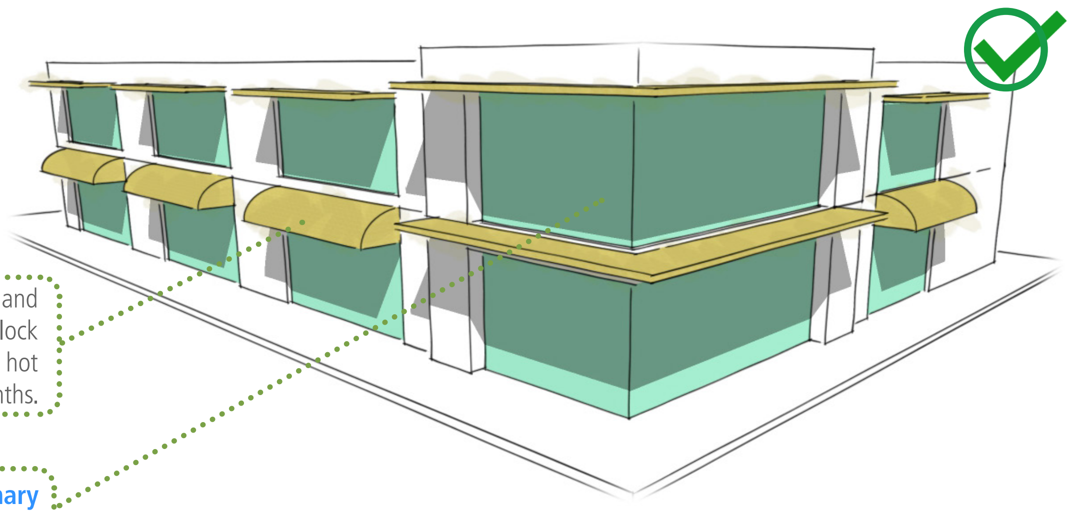
(While ASHRAE 90.1 Prescriptive Path demands a 40% maximum glazing ratio, energy modeling allows you to exceed. This is not a hard requirement, so it is recommended not to exceed 50% under any circumstance.)



A minimum sill height of 24" minimizes overall glazed area, while still allowing sitting and standing views. A floor-to-ceiling glazing strategy can result in glare and overheating during summer. The increased glazing area results in less insulated wall area, which contributes to heat loss during winter.

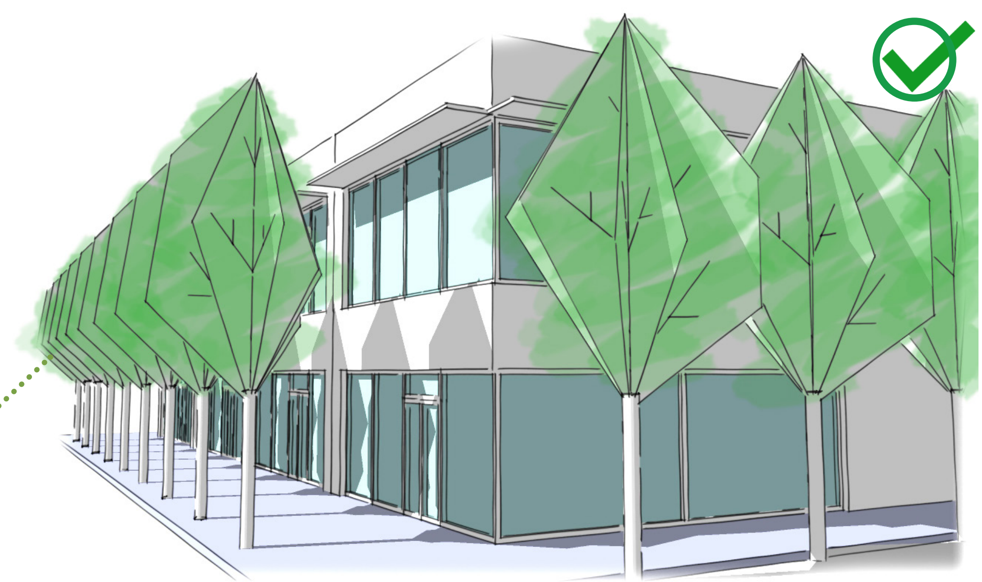
> Exterior features such as awnings and overhangs are often included into the design of one to two storey retail buildings with the intention of providing protection from the elements. These weather protection features can simultaneously act as shading features on the primary facades of retail buildings that face south and west to prevent overheating and reduce cooling loads in the summer months.

> Deciduous trees on the south and west facades should be planted to help to mitigate solar heat gains during summer months while trees are in full leaf, while allowing solar heat gains during winter months when trees are bare. Trees selected for planting should have full canopies and be able to grow to a sufficient height to shade lower floors on south and west facades.



A combination of awnings and exterior shading devices can block unwanted solar gains during hot summer months.

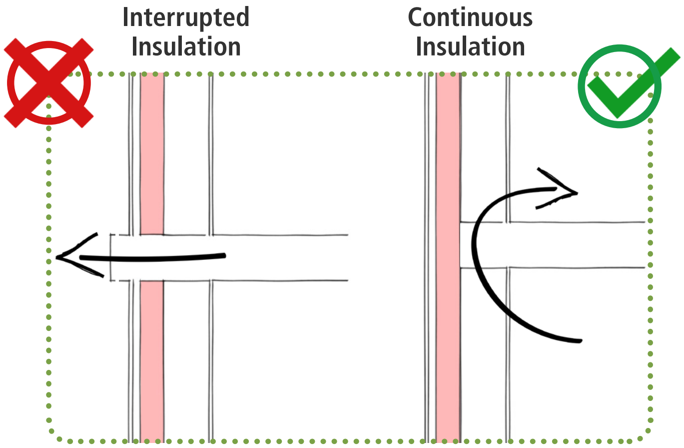
Glazing Ratio across Primary Facades: 50%
This example retail building shows approximately 50% glazing area on the street fronts.



Deciduous trees provide natural shade during summer months, and increase occupants' connection to nature and the outdoors.

THERMAL BRIDGING DETAILS

> Office buildings are often built in steel or concrete construction, both of which are building materials that transfer heat easily. Careful detailing is required to ensure thermal bridging through the building envelope is mitigated or avoided entirely.



Concrete floor slabs should avoid being designed to protrude through the building envelope. Concrete or metal protrusions through the exterior insulation are the largest contributors to thermal bridging.

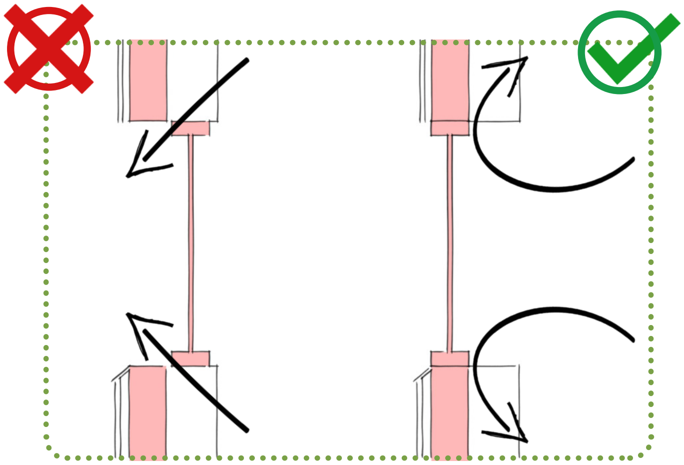
CONTINUOUS INSULATION

> In office buildings, concrete floor slabs are often extended out from building facades for reasons of aesthetics, or to ease construction and reduce construction costs. These details create incidences of thermal bridging and should be avoided.

WINDOW FRAME DETAILS

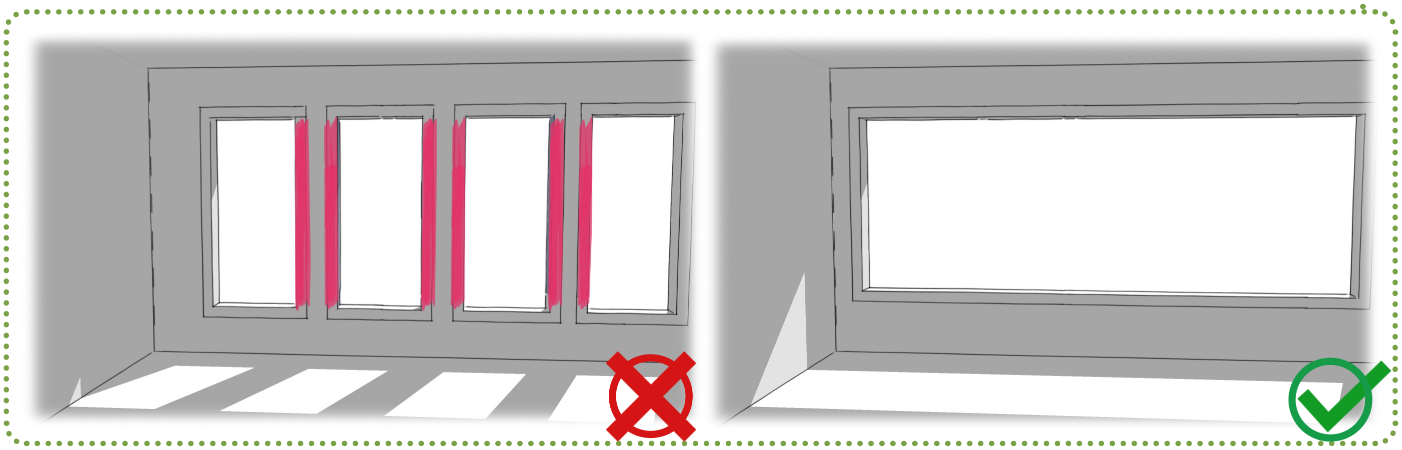
> Thermal bridging can also occur via thermal conduction through window frame connections to window sashes and sills. Buildings should therefore be designed to minimize the number of these connections by avoiding the use of a large number of smaller windows that increase the overall number of connection points in the building envelope. Instead, buildings should be designed using a smaller number of large windows.

> One to two storey commercial buildings should be constructed in such a way as to minimize the number of opportunities for thermal bridging. Designs that include large sections of window panes on the front facade should limit the number of structures, or mullions, that hold each pane in place. Mullions that are included for architectural (and not structural) reasons in particular should be avoided, as this is where the majority of heat loss occurs in windows or glazing units.



Window frames are ideally placed in line with the insulation layer, minimizing thermal bridging through the frame-to-wall structure connection.

Increasing the number of windows increases the total length of window frames, where thermal bridging is most prevalent. More heat is lost through the frame than the glazing. In this scenario, the additional window (left) adds 24 feet of window frame compared to the use of one larger window (right).



NATURAL VENTILATION

> One to two storey retail buildings tend to rely heavily on active ventilation strategies to provide both heating in winter and cooling summer. Given their orientation and design, these buildings also have few opportunities for the use of passive ventilation strategies. However, oversized commercial units should include vestibules or revolving doors that reduce heating or cooling losses in winter or summer, respectively. These buffer zones act to control the rate of air flow between interior and exterior spaces.

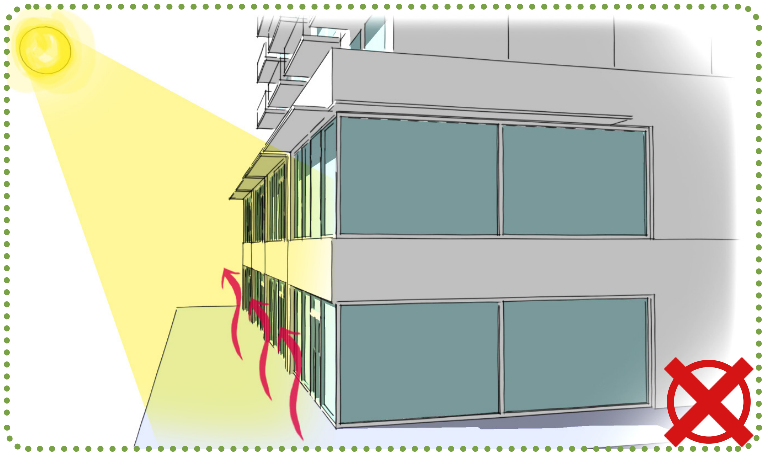
MATERIAL SELECTION

The materials used in the construction of one to two storey retail buildings can have a high impact on the building's overall contribution to the Urban Heat Island effect.

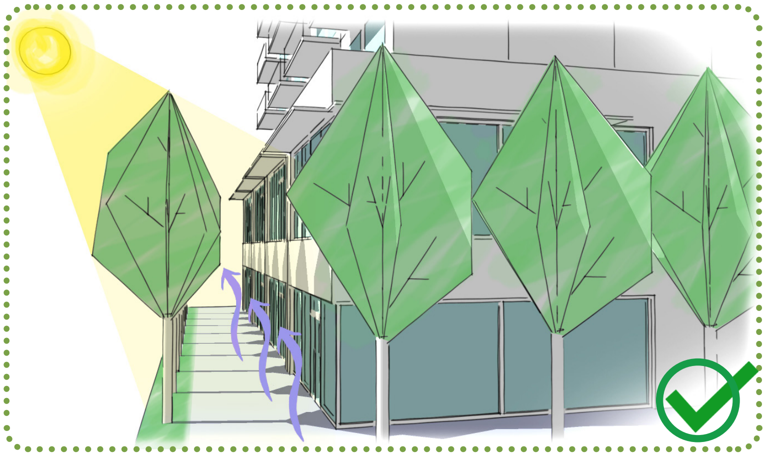
> Materials such as concrete and asphalt that absorb and re-emit radiation and contribute to the Urban Heat Island effect should be replaced wherever possible with materials that reflect heat away from the building.

> Strategies for reducing heat absorption include the use of green roofs that remove heat through the process of evapotranspiration, or cool roofs that reflect sunlight and heat away from a building. Vegetation should be maximized on the building site to reduce the use of pavement.

> Where retail buildings have either west or south-facing facades, both vegetation generally and deciduous trees specifically should be planted to reduce heat and improve shading in summer months. Trees on these facades additionally help to support natural ventilation by cooling incoming air and improving overall air quality. They also help to improve the overall aesthetic of commercial zones.



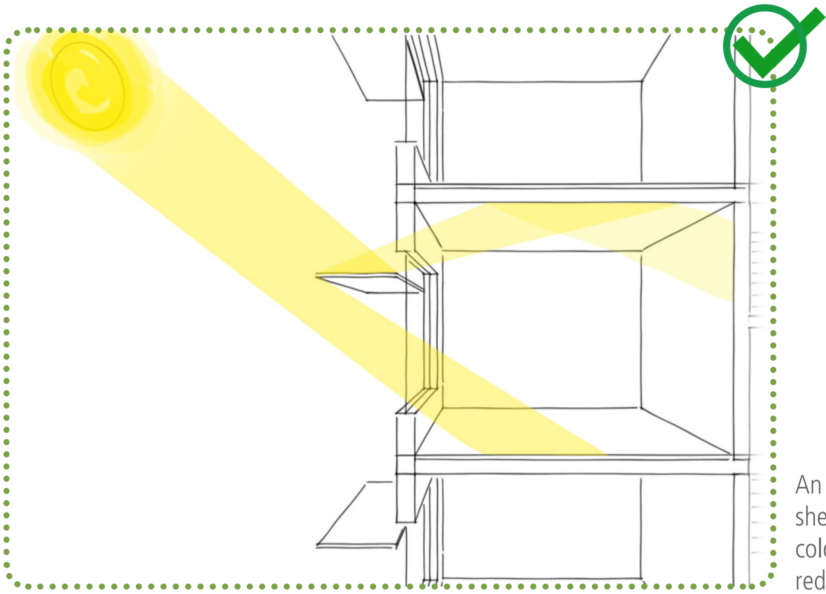
Low-albedo materials such as concrete, asphalt, paving materials, and dark coloured finishes can contribute to the Urban Heat Island effect.



Vegetation, plantings and deciduous trees can help reduct the Urban Heat Island effect at both site and city scales.

MATERIAL SELECTION

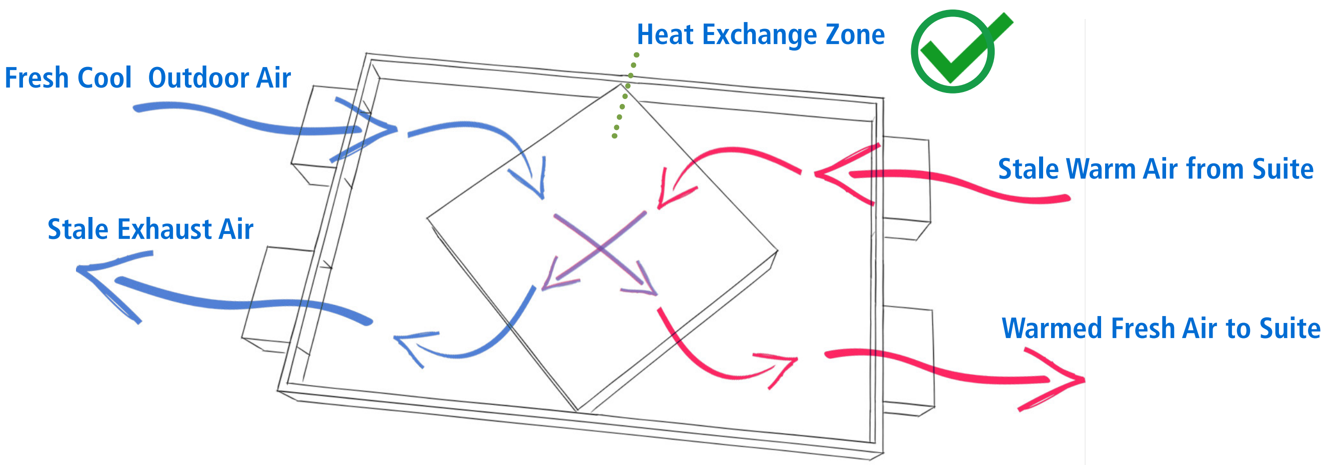
> Daylighting of interior spaces can be facilitated through the selection of light coloured materials on building exteriors. Exterior architectural shading devices can double as exterior light shelves, which reflect incoming light back into interior spaces while preventing heat gains. These should be designed in such a way as to minimize heat gains in summer and optimize heat gains in winter.



An exterior shading device can also act as a light shelf when finished with a light-reflecting material or colour, bouncing light further into interior spaces and reducing electrical lighting loads.

ACTIVE SYSTEM ASSISTANCE

> Heat Recovery Ventilators (HRV) should be used on a unit-by-unit basis to allow for adequate ventilation without the need to open windows in cooler months. These systems reduce building heat losses by transferring heat from warm exhaust air to fresh incoming air, while improving indoor air quality and occupant comfort. HRV are furthermore able to control indoor humidity levels, reduce incidences of mould and condensation on windows, and the transfer of odours from outside.



A typical HRV Unit depicting the transfer of heat from stale warm room leaving a suite, to the cool fresh outdoor air.

Airtightness: a building property that refers to the measure of a building envelope's resistance to the leakage of air in our out of a building.

Air quality: a measure of the risk of exposure to airborne contaminants including pollution from fossil fuel combustion and pollen.

Albedo: refers to the ratio of solar radiation that is reflected away from a surface relative to the amount of incoming solar radiation. Materials with high albedo have a highly reflective surface, while materials with low albedo absorb more radiation than they reflect.

Articulation: an approach to building design that uses joints between different sections of a building's form such that they stand out individually. Highly articulated buildings have several transition points that create opportunities for thermal bridging to occur.

ASHRAE: The American Society of Heating, refrigerating, and Air Conditioning Engineers publishes a well-established and commonly used series of standards on energy efficiency.

Building envelope: all of the elements that make up the outer shell of a building that maintain a division between outside weather and the conditions inside the building's spaces. The major function of the building envelope is to prevent or control the entry of water, air, and moisture from entering or leaving the building.

Building form: see massing.

Cast-in-place construction: a building construction technique in which ready-mixed concrete is transported to a site and poured into forms, or moulds.

Cladding: a layer of the building envelope that is added to provide weather protection and/or visual interest.

Compact form: a building form that is characterized by a low surface-to-volume ratio.

Compartmentalization: the isolation of individual suites or units in a building from one another such that they are individually pressurized and ventilated.

Concrete panel: a form of construction in which pre-cast and insulated panels of concrete and brought and installed on a building envelope.

Conductivity: a measure of a material's ability to conduct, or transfer heat.

Cooling degree days: The total number of days per year that the average outdoor temperature is above a certain threshold as to require cooling.

Cooling load: the amount of heat energy that needs to be removed from a space to maintain indoor temperatures within an acceptable range for occupant comfort.

Curtain wall: a window system that is non-structural and is hung from the building structure, primarily concrete floor slabs.

Energy efficiency: a measure of the effectiveness of energy use. A building with high energy efficiency requires less energy to perform the same tasks (e.g. heating, cooling, ventilation, etc.) as a building with lower energy efficiency.

Envelope: see building envelope.

Evapotranspiration: the process through which the air in a micro-climate is cooled via evaporation from soil and the transpiration of plants.

Facade: the exterior face of a building.

Fenestration: the placement or arrangement of windows on a building.

Glazing: windows on a building.

Heating degree days: a measure of how much energy a build requires to heat a building in a year. The number of days that the average outdoor temperature in an area is above a certain threshold to require heating.

Heating load: the amount of heat energy that needs to be added to a space to maintain indoor temperatures within an acceptable range.

Heat recovery ventilator (HRV): a ventilation system that harnesses the heat of indoor air before expelling it to the outside of a building. This heat is then used to warm fresh air from outside before circulating it throughout a building's spaces.

HVAC: Heating, Ventilation, and Air Conditioning, (usually refers to equipment).

Massing: the general shape and size of a building.

Mullion: the vertical frame that supports and/or separates different panes of glass in a framed window, glazing unit or curtain wall assembly. Mullions can be either structural or aesthetic.

Natural Ventilation: the process of intentionally exchanging air in a building to replace stale air with fresh air from the building exterior, using non-mechanical means such as stack effect, cross ventilation, architectural design and operable windows.

Pane: a sheet of glass used in a window or glazing unit, held in place by the frames, mullions, sills or sash.

Passive cooling: the use of non-mechanical means to cool the spaces of a building by controlling incoming solar radiation and harnessing local air flow patterns.

Passive design: a building design and construction approach that makes use of building form to harness natural conditions to heat, cool, ventilate and light buildings, minimizing or eliminating the need for mechanical systems.

Passive heating: the use of non-mechanical means to heat the spaces of a building by harnessing and storing heat from incoming solar energy.

Prefabricated panel: wall sections of any material (often concrete or steel) that are manufactured off-site and transported to be installed on a building facade.

Punched windows: windows that are placed into the facade and surrounded by cladding, instead of arranged together.

Slab: a horizontal structural element, often made of steel-reinforced concrete, that forms the floors and ceilings of a building.

Solar heat gain: the amount of heat absorbed into a building by way of incoming solar radiation.

Solar radiation: energy emitted by the sun in the form of heat and light

Steel stud construction: a form of construction that utilizes vertical frames made of steel to form the interior and exterior wall structure, an alternative to wood-frame or stick-frame construction.

Thermal bridging: the transfer of heat through materials that interrupt the building's continuous insulation layer, causing heat to escape the interior of the building to the outside air. Thermal bridges increase heat loss from building and lower overall building energy efficiency.

Thermal break: the placement of a material of low conductivity (such as insulation) to prevent the transfer of heat through a building envelope.

Thermal comfort: a subjective measure of satisfaction with the thermal environment of a building. Thermal comfort is informed by building temperatures, as well as individual or cultural practices and preferences.

Tilt-up construction: an approach to building construction in which concrete is poured into pre-formed horizontal moulds on the project site, and then "tilted-up" to form vertical building walls.

Urban Heat Island effect: refers to the warmer temperatures found in urban areas relative to natural landscapes as a result of the lower albedo of man-made materials.

Ventilation: the process of intentionally exchanging air in a building to replace stale air with fresh air from the building exterior.

Vestibule: a small space or room that connects an outdoor door of a building with the building’s interior.

Window sill: the lower frame and extruding portion of a window.

Window sash: the frames that hold individual panes of a window.

Window wall: a prefabricated system in which glazing units are installed from floor-to-ceiling, most commonly in concrete high-rise construction.

APPENDIX A: Sustainability in Surrey

This reference guide is informed by and intersects with several other strategies and goals established by both the City of Surrey and by the Province of British Columbia. This appendix provides an overview of key policies and actions relevant to the execution of the sustainable building design strategies outlined in this guide.

SUSTAINABILITY IN SURREY

THE SUSTAINABILITY CHARTER

Adopted in 2008, Surrey's Sustainability Charter provides an overarching, vision for Surrey to become a Sustainable City by the year 2058. To ensure its continued relevance and Surrey's position as a leader in sustainability efforts, the Charter is currently in the process of being updated. The Sustainability Charter 2.0 outlines eight focal areas, each with their own long-term goals, desired outcomes, and strategic areas: Inclusion; Built Environment and Neighbourhoods; public Safety; Economic Prosperity and Livelihoods; Ecosystems; Education and Culture; Health and Wellness; and Infrastructure. Some of the most relevant aspects to the recommendations made in this reference guide are the following strategic directions, or priority areas:

Neighbourhoods and Urban Design

- Promote mixed use development in and around Town Centres and along transit corridors.
- Prioritize redevelopment of existing urban areas over green field development.
- Increase accessibility to public amenities such as restrooms, water fountains, public art, and benches in Town Centre areas.
- Design public spaces to enable flexible uses.
- Integrate natural areas, ecosystems, and green areas in all neighbourhoods.

Buildings and Sites

- Continue to support low-carbon district energy networks.
- Promote and strengthen high quality design and healthier, more energy efficient buildings in public and private development.
- Provide greater multi-family housing choice, and options for affordability and accessibility.
- Better integrate community and corporate green building and infrastructure strategies (e.g. through strategically locating complementary loads, sharing learnings, etc.).

Energy and Climate

- Work collaboratively with diverse stakeholders to lower greenhouse gases and to improve air quality
- Identify and implement renewable energy opportunities.
- Identify areas (residential, commercial and industrial) where low-carbon district energy is viable and support development of new systems.

COMMUNITY CLIMATE ACTION STRATEGY

Surrey's City Council approved the Community Climate Action Strategy in 2013, which outlines the City's approach for action on climate change. Together with Surrey's Corporate Emissions Action Plan, the Strategy offers a means of strengthening resilience and ensuring the continued prosperity in the face of a warming climate. The Strategy combines two separate sections: the Community Energy and Emissions Plan (CEEP, 2007), and the Climate Adaptation Strategy (2013).

Community Energy and Emissions Plan (CEEP)

In 2007, the City of Surrey became a signatory to the Province of BC's Climate Action Charter, which committed BC communities to reducing energy use and greenhouse gas (GHG) emissions. Surrey adopted the provincial emissions reduction target of 33% per capita below 2007 levels by 2020, and 80% per capita below 2007 levels by 2080. To achieve these targets, the Community Energy Emissions Plan (CEEP) outlines specific targets and strategies in the five key areas of Land Use, Transportation, Buildings, Energy Infrastructure, and Solid Waste. Strategies for improving the energy and emissions performance of new and existing buildings include capacity building efforts for low-carbon, high-efficiency building among City staff and industry; integrating third party retrofit and incentives programs into City Planning and Development activities; and improving Code compliance.

Key Targets:

- Improve building energy performance 10% beyond typical new construction by 2040
- Increase the annual retrofit rate of existing buildings to 2% from 1% by 2040

Additional Targets:

- -31% average per resident tonnes of personal building GHGs by 2040
- -14% average per resident gigajoules of building energy use
- $200 average household building energy savings relative to BAU
- 434 GWh community-wide building power conservation relative to BAU

CLIMATE ADAPTATION STRATEGY

Climate Adaptation Strategy provides 91 recommended actions to strengthen the City's resilience to climate change impacts. The Adaptation Strategy also notes important synergies between these recommended actions and the CEEP, or areas in which actions to mitigate GHG emissions compliment or support adaptation efforts. Among these, actions for heat management are highlighted as supporting passive solar design in the built environment, in that such actions serve to both reduce the Urban Heat Island effect and the health risks associated with heat waves, as well as improved thermal performance and reduced GHG emissions. As such, the Strategy includes the goal of supporting the design of climate-resilient buildings in Surrey, with the following recommended actions:

- Advance energy efficiency in new construction and building retrofits;
- Increase education and awareness on energy efficiency opportunities among City staff and developers;
- Encourage the Province to ensure the BC Building Code adequately reflects and accounts for current and projected climate (i.e. increased winter precipitation, storm events and increased summer temperatures); and
- Incorporate guidelines for water conservation in new and existing development.

PROVINCIAL ENERGY PERFORMANCE TARGETS

Several provincial codes and standards that both incentivize the use of passive design strategies in Surrey's buildings and can guide their implementation. The energy performance of BC buildings are determined primarily by the BC Building Code (BCBC) and the Province of BC's Energy Efficient Buildings Strategy (EEBS). These are based off of national standards, including the National Building Code (NBC) and the National Energy Code for Buildings (NECB), which are often used as a reference or baseline of comparison for the relative stringency of other codes. The recently adopted BC Building Act has also introduced a new building regulatory system in BC, with implications for local governments.

THE SUSTAINABILITY CHARTER

Energy efficiency requirements were first adopted into the BCBC in 2008, which introduced standards that reduce energy demand for new homes by roughly 27% and for new commercial and institutional buildings by 18%. In 2013, code revisions (BCBC-2012 r2, Part 10) were adopted that introduced more stringent energy efficiency measures, which now require all new Part 3 (multi-family, commercial, and institutional) buildings to comply with either ASHRAE-90.1-2010, or NECB 2011. These requirements are estimated at a 33% and 37% improvement in performance over NECB.

BC BUILDING ACT (BILL 3-2015)

The BC Building Act is the first of its kind in BC, which seeks to modernize the building regulatory system in British Columbia. The Act limits the authority of BC local governments (except Vancouver) to set building requirements; as such, any local governments building bylaws that go beyond the BC Building Code no longer be permitted. In addition to centralizing and streamlining building regulation, the Act also introduces new qualification requirements for building officials, and establishes a review process to evaluate individual proposals for innovative building projects.

ENERGY EFFICIENT BUILDINGS STRATEGY (EEBS)

Introduced by the Province in 2005, the EEBS set an original target of 25% improved performance over MNECB for Part 3 buildings and a minimum EnerGuide 80 rating for new residential homes. These targets were updated in 2008, which required a 9% reduction in energy use per square meter for commercial and institutional buildings, and a 20% reduction in energy use per household by 2020.