

TROPICAL URBANISM

TROPICAL URBANISM
A DESIGN APPROACH

TECHNICAL REPORT

MOUNT PETER STRUCTURE PLAN

FEBRUARY 2010



This Technical background report informs the Mount Peter Structure Plan. Specifically, this report is in support of, and in response to, elements of *item 3.4 (Housing Strategy)* & *item 3.12 (Visual Character Strategy)* of Section 4.1 (Outputs) of the Mount Peter Master Planning Specification.

DIP DISCLAIMER

Draft for discussion purposes. This document is not endorsed by the Department of Infrastructure and Planning acting as the Coordinating Agency for the Mount Peter Master Planned Area. It contains information that is not State Government policy.

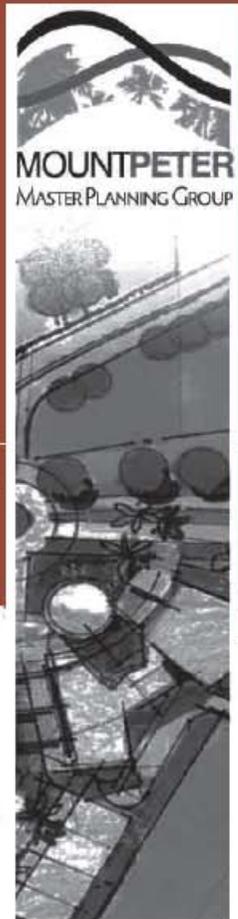
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MOUNT PETER

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TROPICAL URBANISM

A DESIGN APPROACH
CAIRNS, QUEENSLAND, AUSTRALIA



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Introduction

The Mount Peter Design Manual describes and illustrates the impact of tropical wet-dry climates on urban design and building traditions, and documents proper planning and design responses to such conditions.

The climatic conditions of a region used to shape and inform the urban context of that region. However, with the advent of mechanical cooling, contemporary planning and architecture have, for the most part, ignored climate and designed with little concern for sustainable environmental practice. With a better understanding of historical building traditions, contemporary planning and architecture can respond to climatic considerations by 1- applying high performance technological advances to architecture and infrastructure which realize tangible cost savings for fiscal and environmental bottom lines, and 2-introducing traditional passive and light imprint urban design techniques to increase absolute human and environmental community sustainability.



16°51' S 145°43' E

The Manual promotes low impact, high quality of life communities and architecture. While each design technique is analysed separately, the principles and techniques discussed herein work cumulatively to fully achieve comfortable and robust human habitats. Decisions made at each scale affect all other scales, from the master plan down to building components. Thoughtful design at a macro scale can have major impacts on the quality of a building at a micro scale. Where applicable, global precedents are used to establish and define archetypes. These are both illustrated and described with narrative to set out the strategic urban and architectural design responses to local climate conditions.

Urban Design Principles

Traditional urbanism represents an outwardly simple, yet highly evolved system for human habitation that encompasses all of the necessary ingredients for daily living in a compact, efficient, and robust form, which is often aesthetically pleasing. As such, community-building represents the largest and most complex, as well as the most successful, tool ever devised by mankind for maximising the value and efficient use of human resources, while also enhancing the health, well being, and productivity of civilization as a whole. And yet it is not a single, monolithic construct, but rather, a system of parts that evolved to work collectively in delivering the benefits described above.

Urbanism is composed of four major parts: The Region, which represents the larger context in which the Metropolis, the City, and the Town reside; The Neighbourhood, the District, and the Corridor which, taken together, constitute the fundamental building blocks of the community types listed above; and the Block, the Street, and the Building, the essential elements making up a neighbourhood, and which, collectively make up the street and block network which defines compact, walkable urbanism. Each is a necessary and integral part of the system, mutually and sympathetically evolved to optimise the collective value of the whole.

Urban form, as expressed through these community types, tends to reflect regionally-derived influences and traditions, of which climatic considerations are an important part. At the Neighbourhood, and Street/Block Network level, the principal form-generating factor remains a spatial one, based upon the distance an average human can comfortably walk in five minutes, or approximately 400 metres. As a result, most urban codes focus predominately on that defining spatial metric, versus anything overtly linked to climatic considerations. However, it should be noted, and this document is predicated on the premise, that there is nothing intrinsically unique about communities designed on the basis of the human dimension, that is at odds with designing with the goal of human physiological comfort in mind. The two are not mutually exclusive.



@James Willamor



@BoB Miami

There are a number of recognised sources outlining the basic urban design principles of walkable, sustainable communities, those places defined by a spatial adherence to the parameters of the five-minute walk, regardless of climate. They can be summarised as follows:

- **The neighbourhood is the fundamental building block of urban community types.**
- **The neighbourhood has a discernable centre, usually a public square or green, which is spatially articulated by architecture which can include civic buildings, commercial uses, and residences, and can be connected by transit to other neighbourhoods nearby.**
- **The neighbourhood is of finite dimension and has a discernable edge, where one neighborhood stops and another begins, or where a shared amenity resides, and/or the rural landscape begins.**
- **A neighbourhood is designed with a network of pedestrian-friendly streets, with on-street parking, to encourage walking, reduce vehicular use, and encourage and support a variety of transportation modes.**
- **A neighbourhood contains a variety of housing types, able to accommodate diverse ages, lifestyles, and incomes, strengthening the personal and civic bonds of community.**
- **A neighbourhood should have shops and offices either near its center, or along principal streets and avenues, such that the daily needs of a typical household can be easily and conveniently met.**
- **Building densities should be allocated with consideration to facilitating walkable access to services and transit.**
- **A neighbourhood should reserve special sites for Civic Buildings, and neighbourhood schools should be situated such as to allow children to walk or bicycle to them**
- **A range of parks, greens, playgrounds and open space should be appropriately distributed within the neighbourhoods, and conservation areas and open lands should be used to define and articulate different neighbourhoods and districts.**
- **Architecture and landscape design should emerge from local climate, topography, history, and building practices of the region.**



All of the above attributes and characteristics certainly promote a comfortable walking environment, regardless of local climatic conditions, but do not specifically address the issue of coding urbanism for hot, humid climates. The authors are not aware of any existing codes, which, in fact, explicitly do. However, there are open-source form-based codes that are currently being developed that will have the ability to address these issues in more concrete terms

The Block, the Street, and the Building

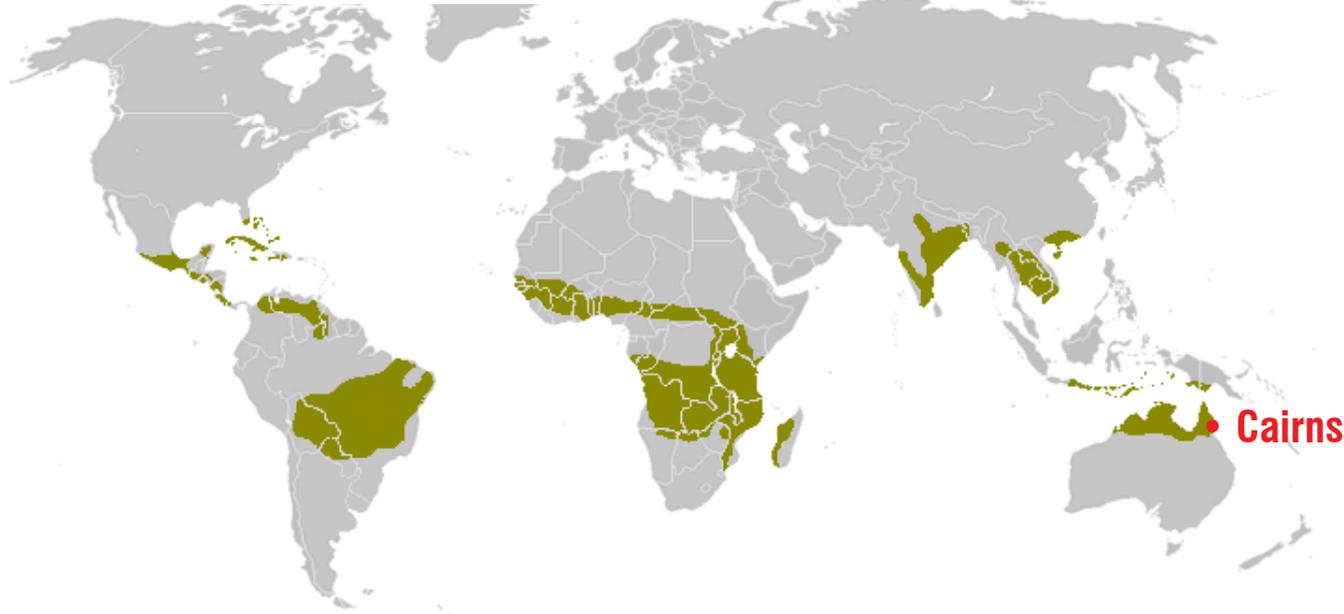
The smallest increment of scale at which the principles of compact, walkable urbanism apply are the level of the Block, the Street, and the Building. At this level urban design principles are wholly consistent with the known techniques of designing for tropical climates, in that they promote less reliance on the automobile, and on the use of fossil fuels in general, by creating a compact and attractive walking environment, within a larger community and regional framework that facilitates the use of transit within a more rational land-use pattern that makes the most of location efficiencies (movement economies).

In addition to these more universally applicable principles, many other factors become critical in ameliorating the net affects of hot, humid climates on human comfort and productivity, including the disposition of the building within the block, the specific nature of the pedestrian environment in terms of shade and air movement, the orientation of the street and block network relative to prevailing winds and solar angles, etc., as well as how all of these elements interact with each other. A form-based code, informed by these considerations, and incorporated into a larger regional planning framework, could provide a more comprehensive mechanism for ensuring a thoughtful and effective approach to climate-sensitive planning and design.

The strategies and techniques outlined in this document speak directly to these ideas and concerns from a practical point of view, based upon the recognised natural laws, and informed through the empirical analysis of existing places. By comparing these case studies with one another, each responding to similar climatic conditions, but filtered through the lenses of their respective cultures and building traditions, it is hoped that new insights might be gained with regard to our knowledge and understanding of the benefits of urbanism. And that these new insights might continue drive the ongoing evolution of our cities, towns and villages, as we find new applications for these time-tested concepts and ideas.



Places With Similar Climates Across the Globe



North America

- Palm Beach and the Keys, Florida, United States
- Cuba
- The Bahamas
- Haiti
- Yucatan Peninsula, Mexico
- Venezuela
- Parts of Brazil

Europe, Africa, and Asia

- Guinea
- Ghana
- Togo
- Angola
- Zambia
- Mozambique
- Northwest and Southern Madagascar

Oceania and Southeast Asia

- Much of India
- Thailand
- Cambodia
- Vietnam
- Southern China
- Parts of Indonesia
- Parts of The Philippines
- Parts of Papua New Guinea

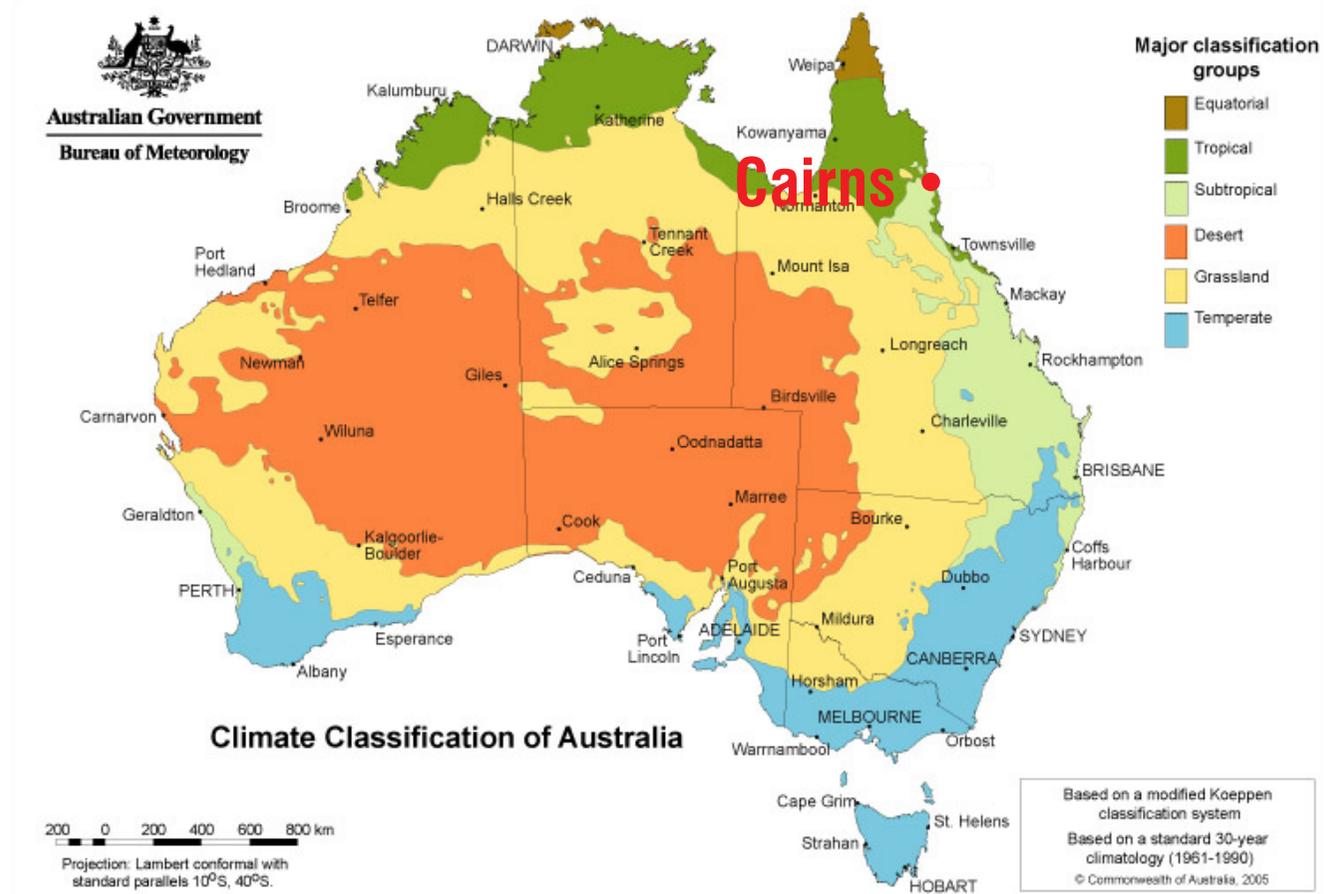
Climate

Global Climate Context

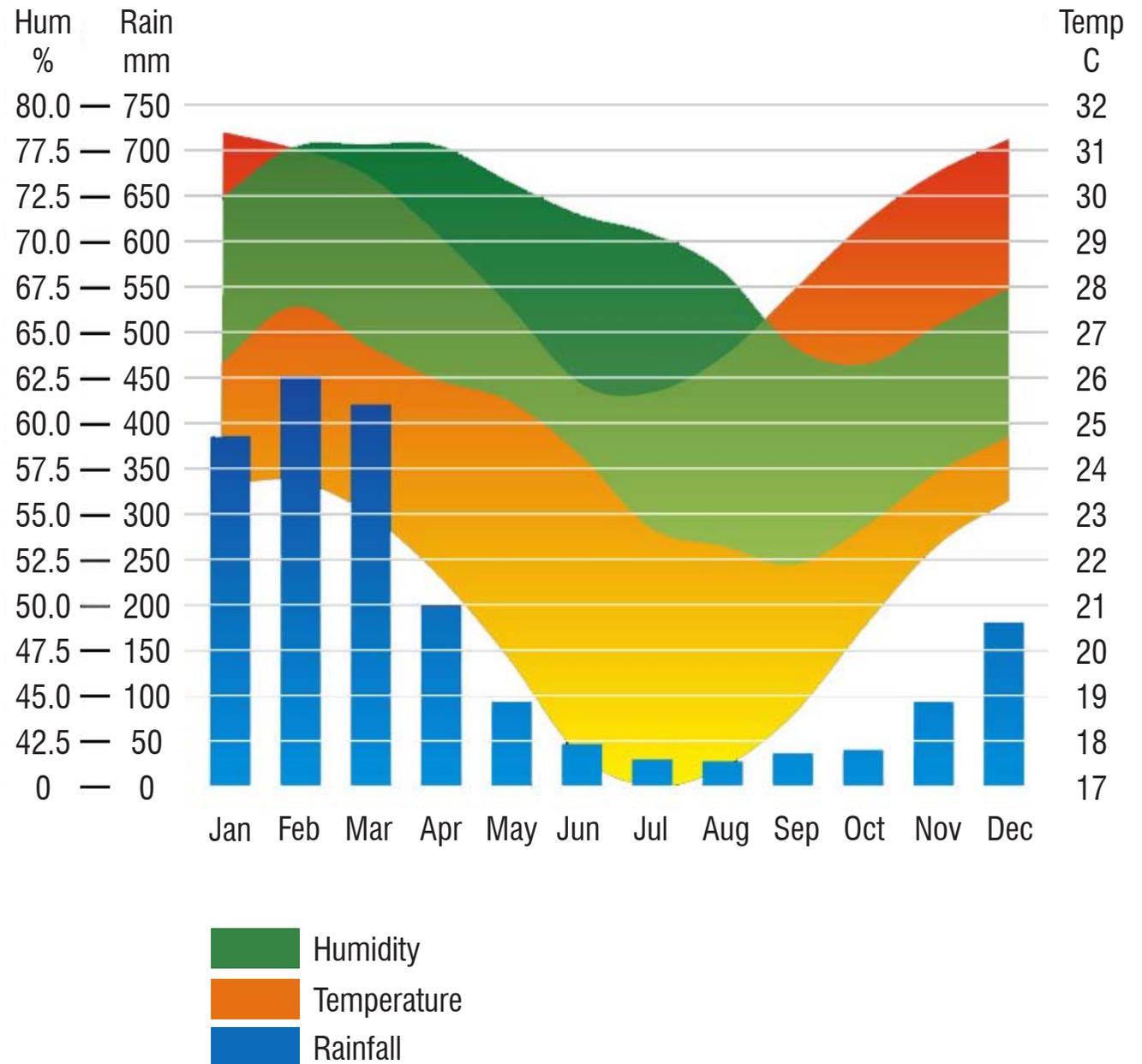
Cairns is located in the tropical wet and dry, or tropical savannah, climate, which can be found throughout the world between the Tropic of Cancer and the Tropic of Capricorn. The map at left illustrates the other regions throughout the world that have the same climate as Cairns, and which can be used to draw precedents from for design techniques that will also work in Cairns. Like most tropical savannah climates, Cairns is located between the Intertropical Convergence Zone and the subtropical high. The convergence of these two climatic systems is what creates the wet and dry seasons in the tropical savannah climates. The Intertropical Convergence Zone is a belt of converging trade winds and rising air which produces high cloudiness, frequent thunderstorms, and heavy rainfall near the Equator. Further south, between 20° and 40° latitude, the subtropical high is a region of high atmospheric pressure with a pronounced temperature inversion, in which warm air sits on top of cold air, that creates a relatively arid environment. Because of its location at 16° latitude, between these two systems, Cairns, and other tropical savannah regions, have distinct wet and dry seasons with high temperatures year round.

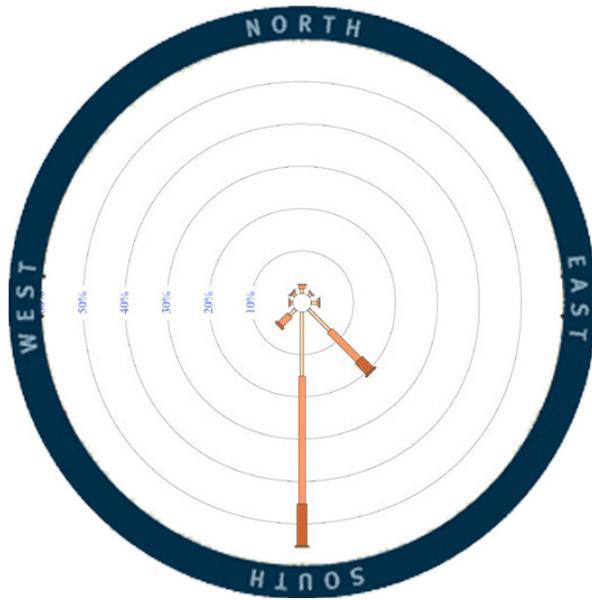
Local Climate Context

The tropical savannah climate in which Cairns is located is characterized by its distinct wet and dry seasons and have mean monthly temperatures above 18 degrees Celsius every month. A large portion of northern Australia, including Western Australia and The Northern Territory, share the savannah climate. Located just to the north of Cairns are areas that are in the next-wettest classification, the tropical monsoon climate. This climate is very similar to the tropical savannah but receives more annual rain. The wet season in Cairns lasts from November to May, with some months averaging more than 400 mm of rainfall, and the dry season is from June to October.



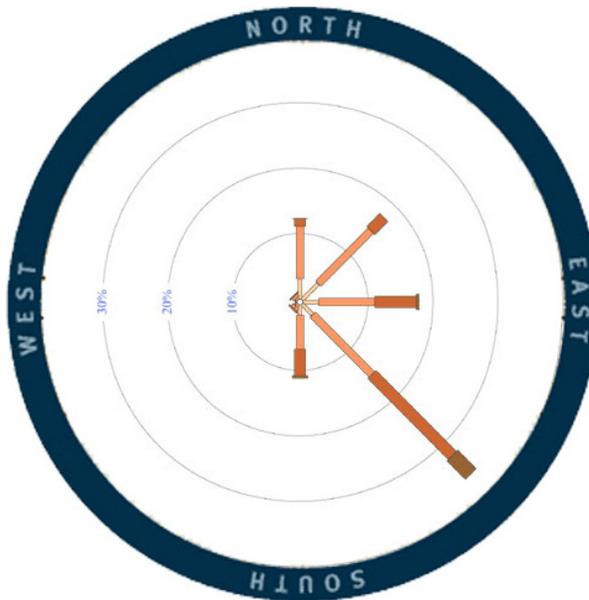
The tropical savannah climate is hot and humid all year long, during both the wet and dry seasons. Relative to other climates, there is little variation in temperature between the hottest and coldest months. The average high in the coldest month of July is 26° Celsius while the average high in December is 31°, a difference of only five degrees. The average diurnal swing, the difference between daytime and night-time temperatures is about 6° Celsius year round. Because of the high temperatures year round in Cairns, and the large amount of insolation, shading is one of the most effective strategies to keep people comfortable. And, with an average humidity of 68 percent, it is extremely important to make use of the strong prevailing winds to assist cooling. Because of the high humidity and significant rainfall during the wet season, techniques that allow for natural ventilation while providing protection from the rain are most effective. The heavy rains contribute to the lush, tropical vegetation found in Cairns and help to compensate for the relatively little rainfall during the dry months from June to October.





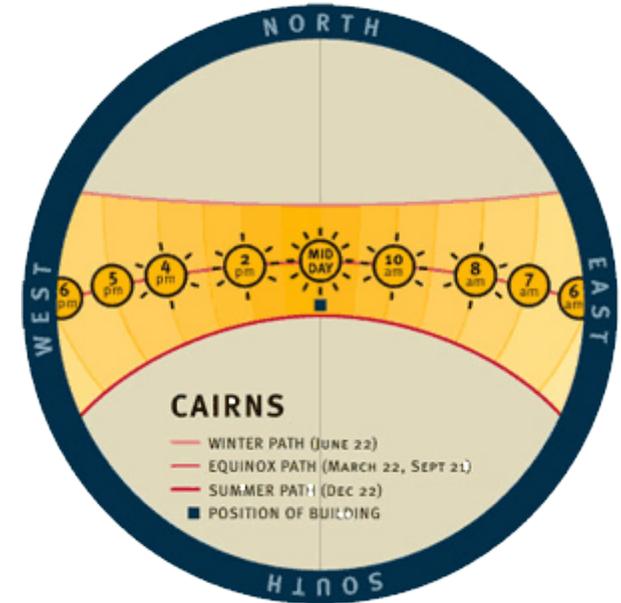
Morning Wind Conditions

Morning in Cairns provides the most opportunity for cooling through natural ventilation, as the temperature is still relatively low with consistent prevailing southerly wind.



Afternoon Wind Conditions

While afternoon winds tend to be more dispersed, they are consistently stronger.

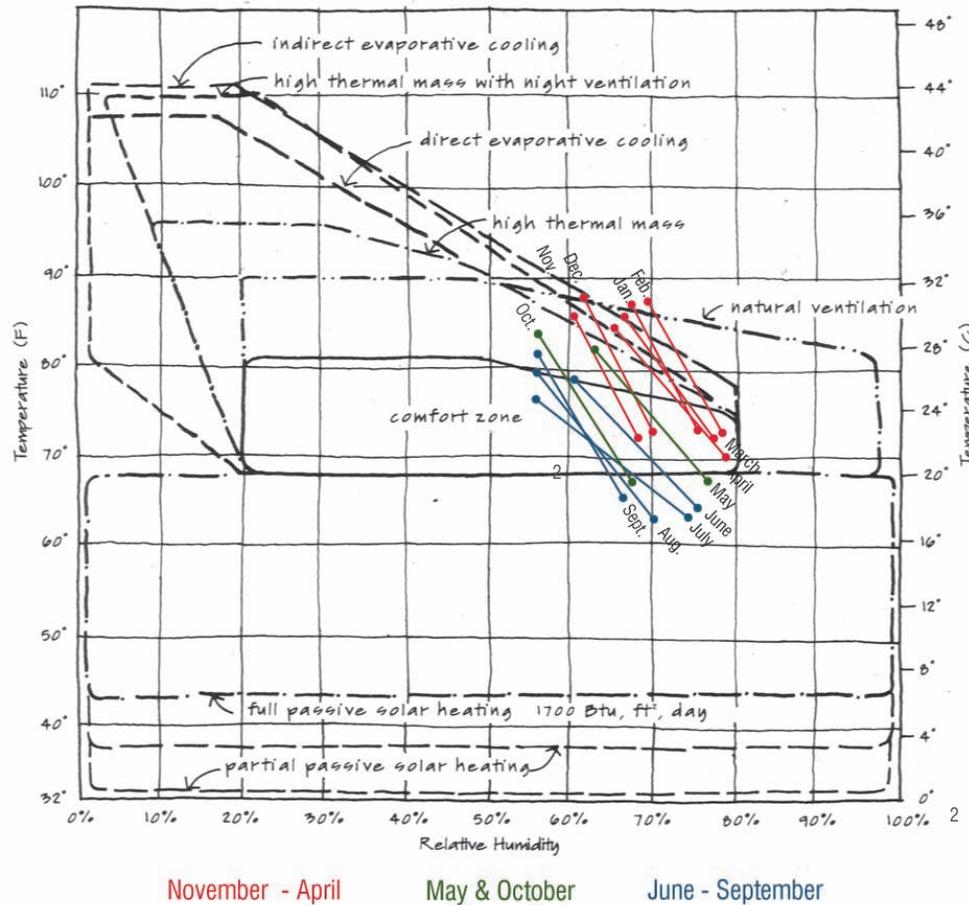


Sun Path

At 16 degrees latitude, the sun is nearly directly overhead most of the year, without much variation, and the sun rises and sets at a fairly even time throughout the year. Because Cairns has few heating days, this makes the strategy for managing solar insolation very straightforward.

Bioclimatic Chart

An understanding of the climatic context is the building block to designing a building in which climate, program, and form all work together to create a comfortable, efficient, and meaningful space. But the climatic information does not mean anything on its own. It must be understood in the context of how it affects the human body; specifically, how the body responds to both temperature and humidity. The bioclimatic chart offers a way to understand the relationship between climate and human comfort and suggests techniques for responding to that climate. By plotting average temperature and humidity highs and lows for each month, it is easy to see what steps need to be taken in order to provide comfort. The data for Cairns is plotted on the chart and shows that the majority of the year falls into either the comfort zone or the natural ventilation zone. The times during the comfort zone means that during that time of year, the outdoor temperature is comfortable enough to live in. When the lines move out of the comfort zone, it is necessary to either heat or cool the space in order to make it comfortable. During parts of the day in each month in Cairns, there are times when a building will be comfortable without any cooling and there will be times when cooling will be needed. This means that many passive cooling techniques used in Cairns will have to be operable, so that the amount of ventilation can be controlled by the occupant. During the warmer months, between November and April, natural ventilation will be necessary and sufficient to cool the building, and during the cooler months, between May and October, no passive cooling should be necessary. Although the cooler months do dip into the passive solar heating range, this occurs during the night, after the building has stored up some heat from the day, so no heating should be necessary. The techniques that follow are based on the results from this chart specifically for Cairns. They focus on passive cooling through ventilation, providing shade from the sun, and protection from the rain, and should be consistent with the traditional building patterns of the area.



Design Principles

Each region has distinct characteristics in their urbanism and architecture that are a result of responses to the climate. This section will study those responses that apply to the tropical wet and dry climate of Cairns, Australia. The bioclimatic chart suggests that the best responses for Cairns are to employ passive cooling because it is always hot and humid. As a result, the best techniques for creating comfortable environments are those which provide protection from the rain and sun, and access to the wind from the south and east. These techniques are based on widely accepted urban planning principles and adapted for a tropical climate. The basic principles of quality town planning discussed previously apply everywhere, but must be customised for the climate. Because humidity is often harder to bear than heat, ventilation is the most important passive cooling technique to employ in Cairns. Ideally, both access to ventilation and protection from the sun will be provided, but in the event that both are not possible, design for proper ventilation. Each technique listed in the following pages should be understood individually but applied in concert with the other techniques so that they all work together. The techniques are divided into two scales: Urban and Building. Decisions made at each scale will affect the design at all scales, so it is important to understand how each design decision affects others to be made later in the process. All of the techniques are specific to Cairns and can be used to design towns and buildings that respond thoughtfully to the local climate.

General Strategies

- **Provide green space throughout the urban fabric to provide places for warm air to cool.**
- **Orient wide, breezy streets to the wind to provide ventilation while reducing solar heat gain for buildings.**
- **Use deep overhangs, colonnades, arcades, verandahs, porches, and balconies to provide protection from the elements to both people and buildings, and to effectively funnel cooling breezes through the urban environment and the buildings.**
- **Use courtyards and atriums to promote airflow through buildings.**

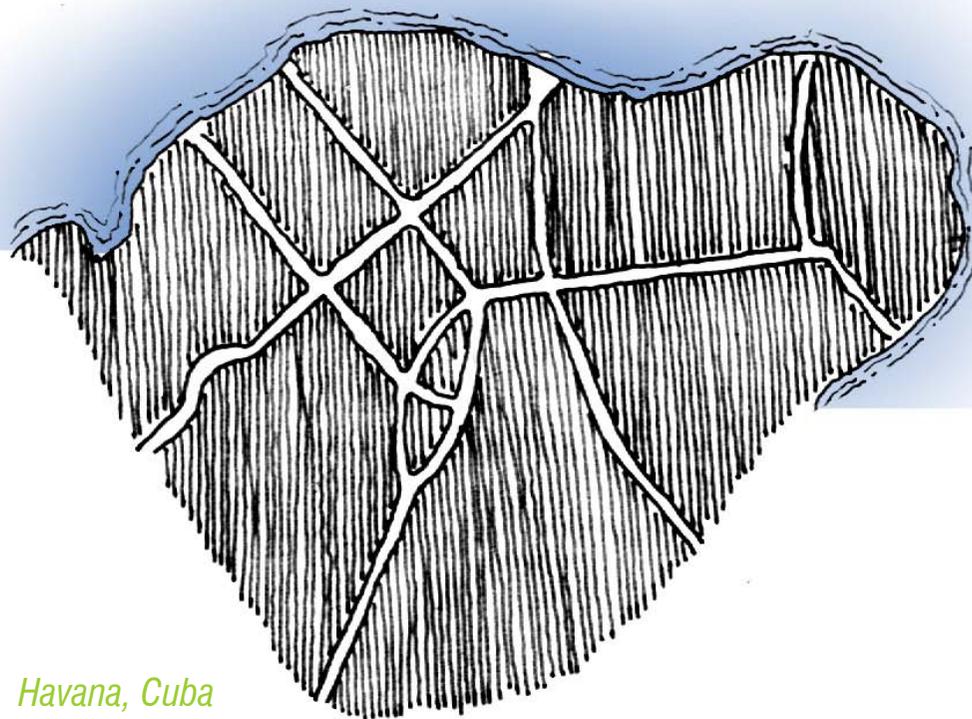
Specific Techniques

Urban Planning Techniques

1. Ventilation Corridors
2. Interweave Buildings and Greens
3. Block Orientation
4. Breezy Streets
5. Lot Disposition
6. Wide Streets
7. Shady Streets
8. Wide Sidewalks
9. Hierarchy of Streets
10. Short, Walkable Streets

Building Techniques

11. Outdoor Rooms
12. Cool Courtyards
13. Permeable Buildings
14. Deep Overhangs
15. External Shade Size
16. Ventilation Opening Arrangement
17. Ventilation Opening Size
18. Stack Ventilation



Havana, Cuba

Urban Techniques

1. Ventilation Corridors

Because dense urban areas store more heat during the day than surrounding rural areas, they also take longer to cool. The warm city air rises and sucks cooler air from the city perimeter to the centre. This effect can be used to cool the city if the air coming in is significantly cooler than the air leaving the city. A band of undeveloped, vegetated land at the perimeter of the urban area can serve as a cool air source. Wide corridors for the cool air to circulate through the city are necessary. In Cairns, the undeveloped land should be to the south and east, so the prevailing winds can bring in cool air from the perimeter of the city. Orient the ventilation corridors near southeast/northwest to facilitate access to winds from the east and south. Corridors should extend from the greenbelt to the centre uninterrupted. Corridors can be boulevards, parkways, or a network of parks.²

Climatic Context: Hot and Humid

Scale: Urban

Response: Design ventilation corridors into an urban centre to bring cool air into the city from the undeveloped perimeter.



Savannah, Georgia, United States

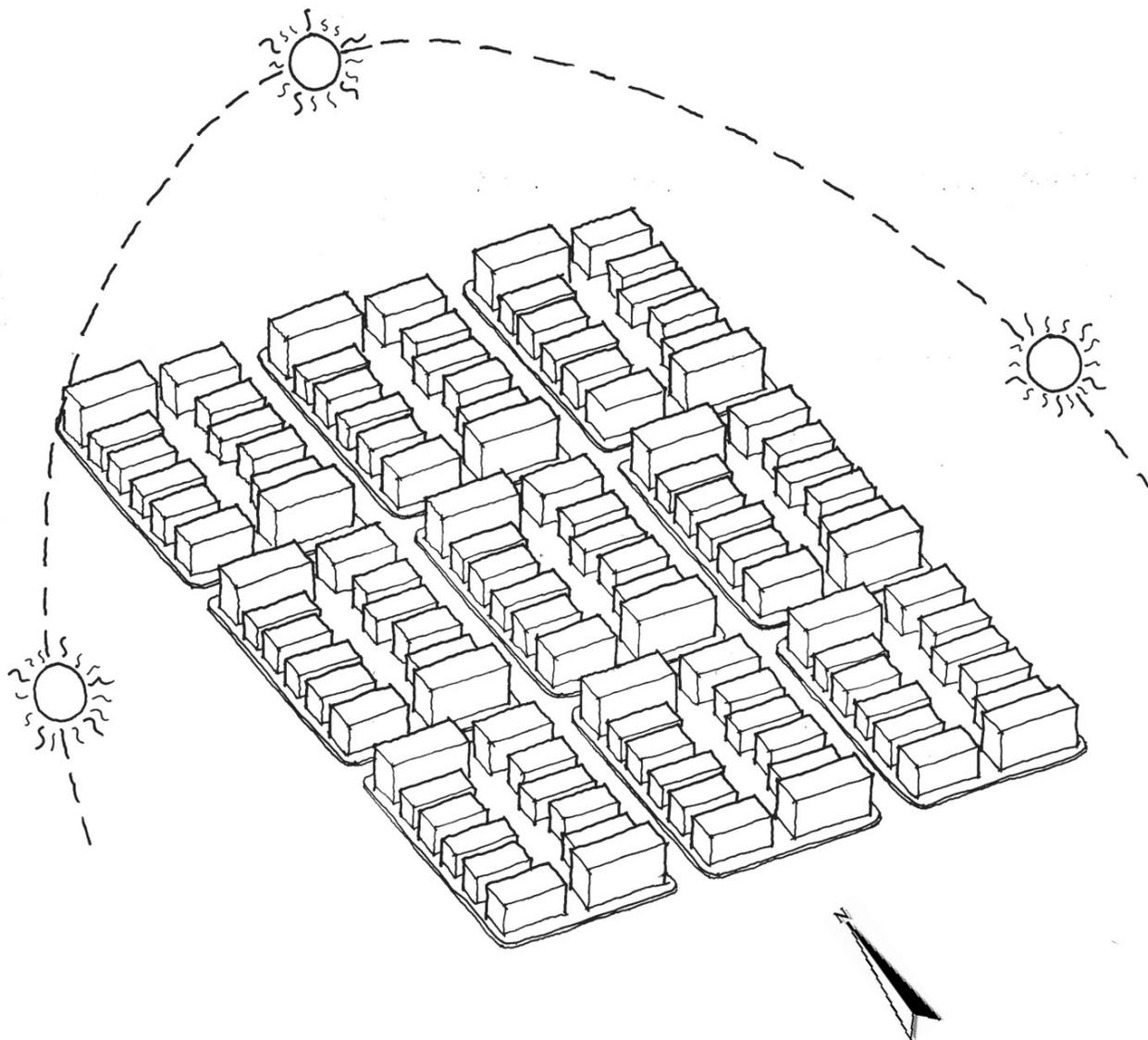
2. Interweave Buildings with Greens

The temperature in urban areas is often higher than in rural areas due to the heat island effect. Because cities have more impervious surfaces that absorb solar radiation, such as roads and rooftops, temperatures are often considerably higher in urban areas than in surrounding rural areas. This is most noticeable at night, when objects that have retained heat during the day begin to release it to the cooler night air, thus keeping the city warm while it should be cooling. Planted greens placed throughout an urban area along with the technique “#1 Ventilation Corridors,” will help to circulate cooler air more consistently and absorb more heat without re-radiating it into the air at night. It is preferable to have many smaller, evenly distributed greens than fewer large ones. Deep building lots with large rear setbacks provide places for green space and planting mid-block which can contribute to the reduction of the heat island effect. The cooling effect is a result of planted trees and other vegetation, which provide shade, and evapotranspiration, which replaces rising heated air in urban areas with cooler air from the parks. Additionally, replacing hardscape surfaces with grass and building green roofs on buildings can substantially reduce the heat island effect in an urban area.³

Climatic Condition: Hot

Scale: Urban

Response: Interweave buildings and planted greens to reduce ambient air temperature in urban areas.



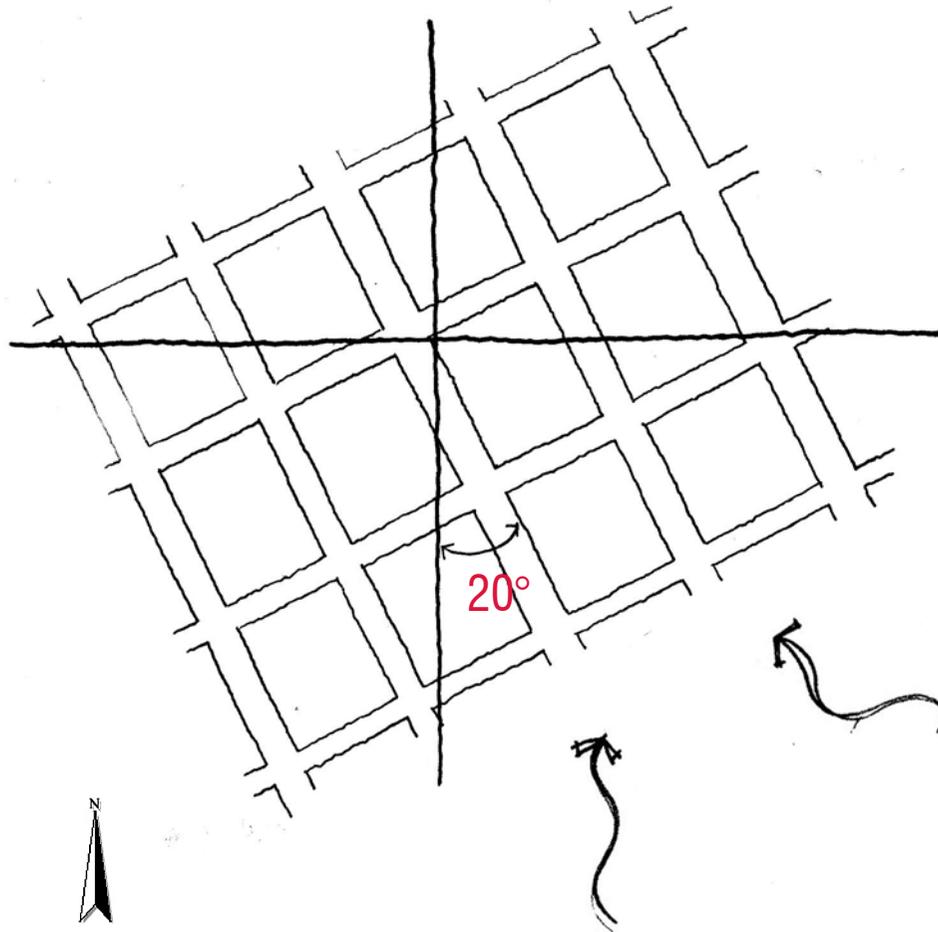
3. Block Orientation

Because heating is never necessary in Cairns, buildings, and especially windows, should be shaded from the sun as much as possible. Correctly orienting the blocks will provide buildings with less surface exposure that can gain solar heat. Because the sun is low in the sky in the morning and evening, it can shine into a building's east and west exposures and heat up the building quickly. To combat this, buildings should have short east and west exposures and long north and south exposures. The north exposure should be well shaded (see #15 External Shade Size) to protect from solar gain, while the south exposure should have large windows to increase daylighting. Based on these factors, blocks should be oriented with the major streets running near north-south so that deep lots will allow buildings to be oriented with their long sides facing north and south. Major streets should run near north-south with secondary streets running east-west. This also allows the short sides of the building to face the street, adding diversity and interest to the streetscape. Use this technique with #4 Breezy Streets to create the most comfortable urban environment.

Climatic Condition: Hot

Scale: Urban

Response: Orient blocks with the long sides running north-south and short sides running east-west to reduce solar gain in buildings.



4. Breezy Streets

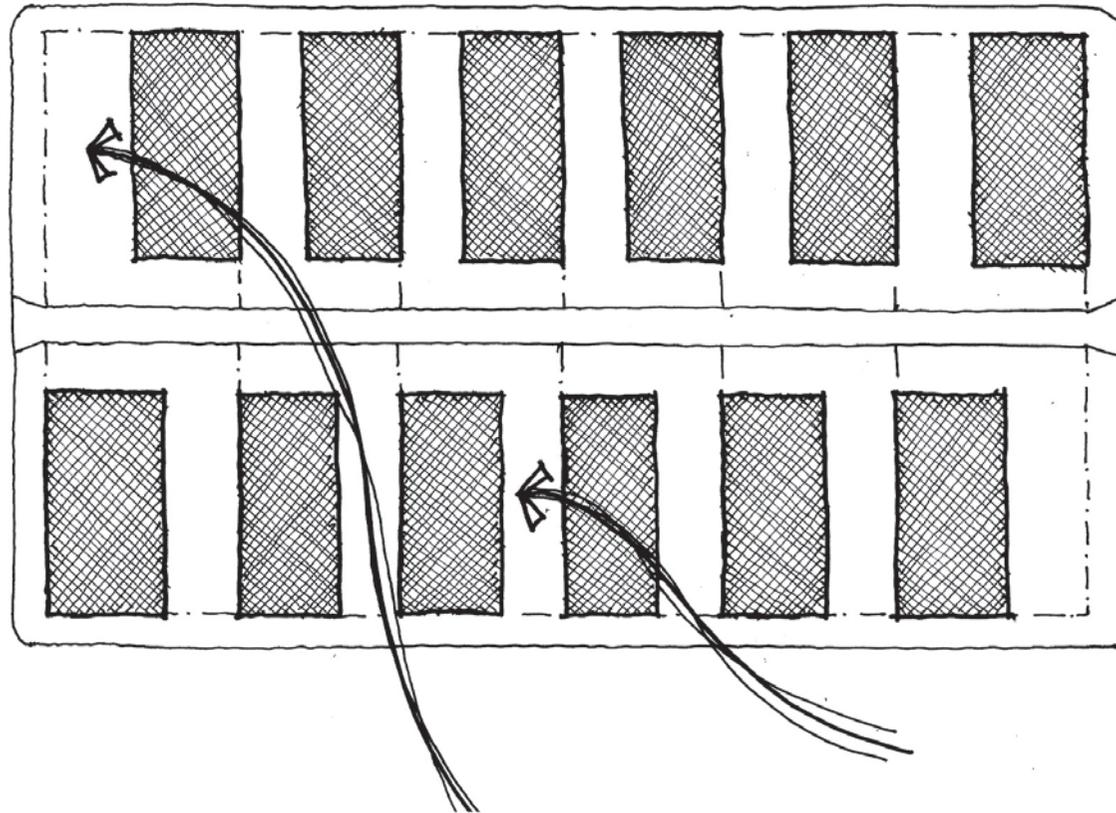
Proper ventilation in hot, humid climates helps to remove excess heat from the city and provide cross ventilation in buildings. Urban areas dramatically reduce wind speed at ground level, so a thoughtful arrangement of streets and buildings can help to counter this effect. Orienting streets parallel to the prevailing wind will provide those streets with maximum air movement, but cross streets perpendicular to the wind will not have good ventilation. To create breezy streets and maximize cross ventilation in buildings, main streets should be oriented 20-30° to the prevailing wind. This will promote air flow down all streets and create positive pressure on two sides of the buildings. By creating positive pressure on two sides of a building, there will be more surface area to use as inlets for cross ventilation. Since the wind in Cairns is from the south-southeast, main streets should be oriented 20° from due south to maximize wind speed in streets and keep block orientation closest to north-south as recommended in #3 Block Orientation.⁴

Climatic Condition: Hot and Humid

Scale: Urban

Response: Orient streets to the prevailing wind to increase breezes and access to cross ventilation.

5. Lot Disposition

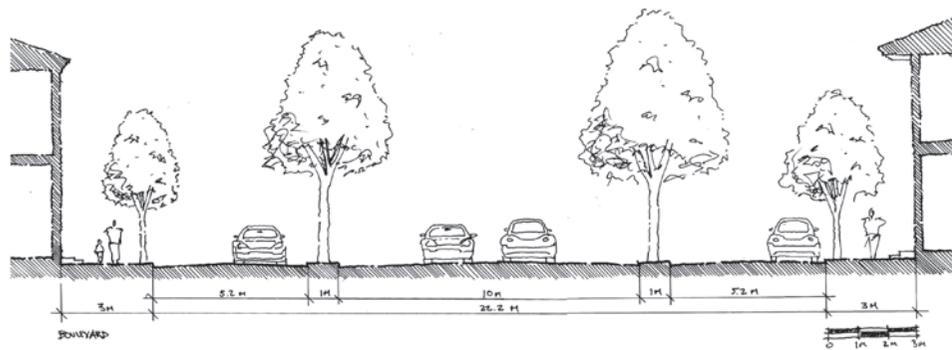
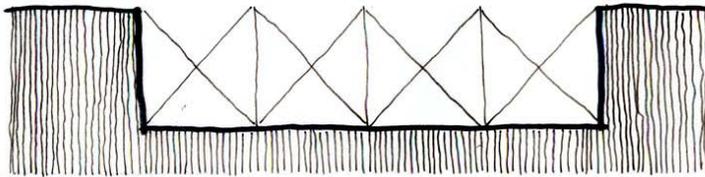
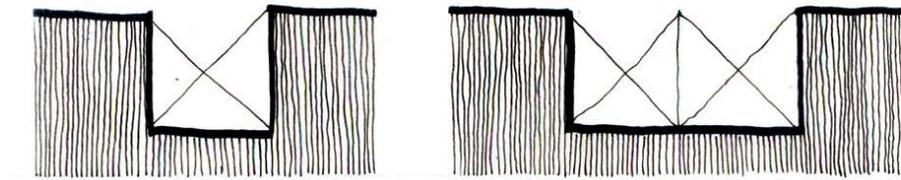


The placement of buildings on a lot can have an impact on the quality of the neighbourhood but can also create desirable microclimates and direct the wind for natural ventilation. By offsetting buildings on opposite sides of the block, paths for the wind to move through are created, as well as private outdoor rooms. The placement of buildings on a lot must be coded and adhered to by all lots for the desired effect to occur. Lots and buildings should be both deep and narrow, with the building pushed up against one of the side lot lines. The building should have the majority of openings facing into its own lot while the side against the lot line should have minimal windows for sunlight and ventilation. This will create a private outdoor space on each lot for the occupants of the building. See Technique #11 Outdoor Rooms for information on where to design outdoor rooms effectively. By offsetting the buildings on either side of the block, wind paths are created that provide better cross ventilation to all buildings.

Climatic Condition: Hot and Humid

Scale: Urban

Response: Offset buildings on lots to encourage air flow between and through buildings while creating private microclimates.



Boulevard Section

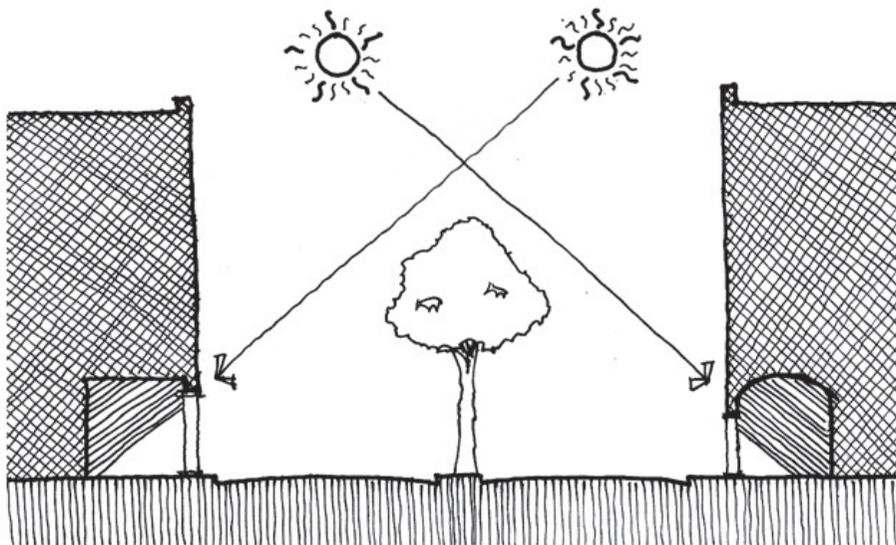
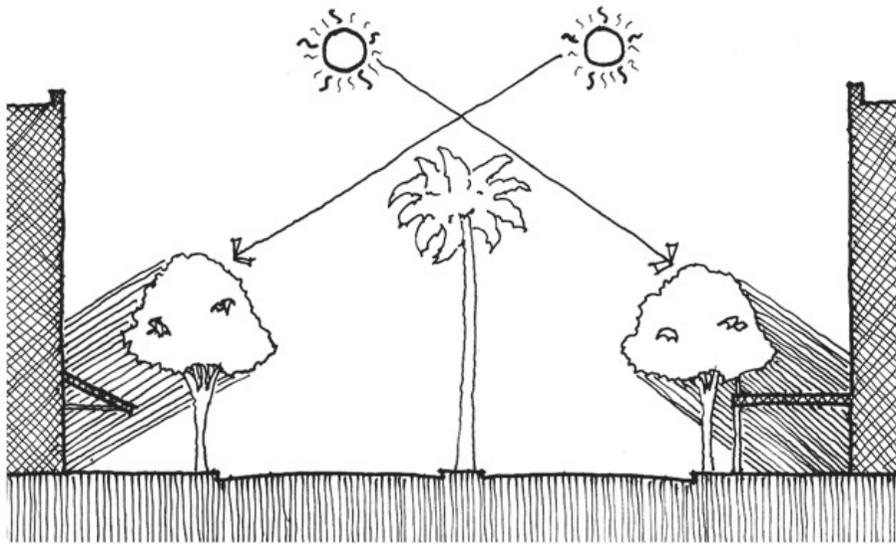
6. Wide Streets

In Cairns, it is desirable to have air movement through the streets at all times of the year. Short buildings on wide streets promote more air movement than tall buildings on narrow streets. The following ratios are determined for streets oriented parallel with the prevailing wind. A street section that has a 1:1 ratio of building height to width will allow approximately 50% of the unobstructed wind velocity in the area, but that percentage will go up as the street gets wider, but still retains a 1:1 ratio. A street section of approximately 1:2 height to width will allow approximately 60% of the unobstructed wind speed. A street section of approximately 1:4 height to width will allow approximately 75% of the unobstructed wind velocity. Therefore, in Cairns with an unobstructed wind velocity of 20 km/h, a 1:1 ratio will allow a 10 km/h breeze through the streets, a 1:2 ratio will allow 12 km/h wind, and a 1:4 ratio will allow 15 km/h winds, if the street is parallel to the wind direction. Because it is preferable to have the street oriented at an angle to the wind (see #4 Breezy Streets) these percentages will decrease slightly. While the street should be wide to allow breezes, it must be designed thoughtfully to create a pleasant pedestrian experience. Medians in the middle of a boulevard break the street into walkable sections and give pedestrians a refuge while crossing, and also provide a place for more trees. See also #7 Wide Sidewalks for street detailing information. Driving lanes should not be widened or added to increase street width.⁵

Climatic Context: Hot and Humid

Scale: Urban

Response: Design wide streets to encourage breezes.



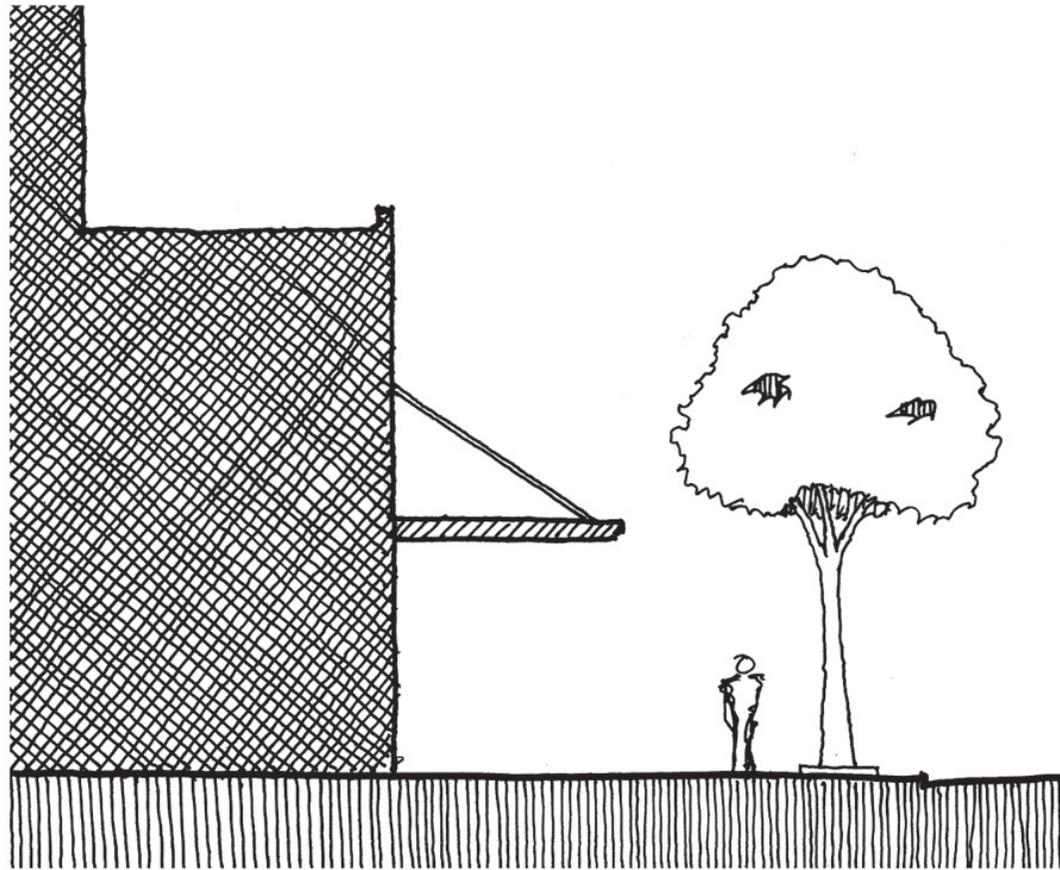
7. Shady Streets

In hot-humid climates, buildings should be placed on wide streets to encourage cross ventilation down the street. Because wide streets do not offer much shade, use horizontal shading elements such as roofs, pergolas, awnings, colonnades, arcades, and trees to shade the street and the buildings. In hot arid climates, it is better to design tall narrow streets to provide shade because there is no need for ventilation. In Cairns, ventilation is more important than shade because of the humidity, so short, wide street sections are preferable. Use building elements to provide shade while allowing ventilation and providing protection from the rain. Street trees reduce overall solar insolation, provide a more comfortable walking environment, and create a more pleasing urban environment by reducing the apparent width of the street.

Climatic Context: Hot and Humid

Scale: Urban

Response: Use horizontal shading elements to shade buildings and pedestrians on wide streets.



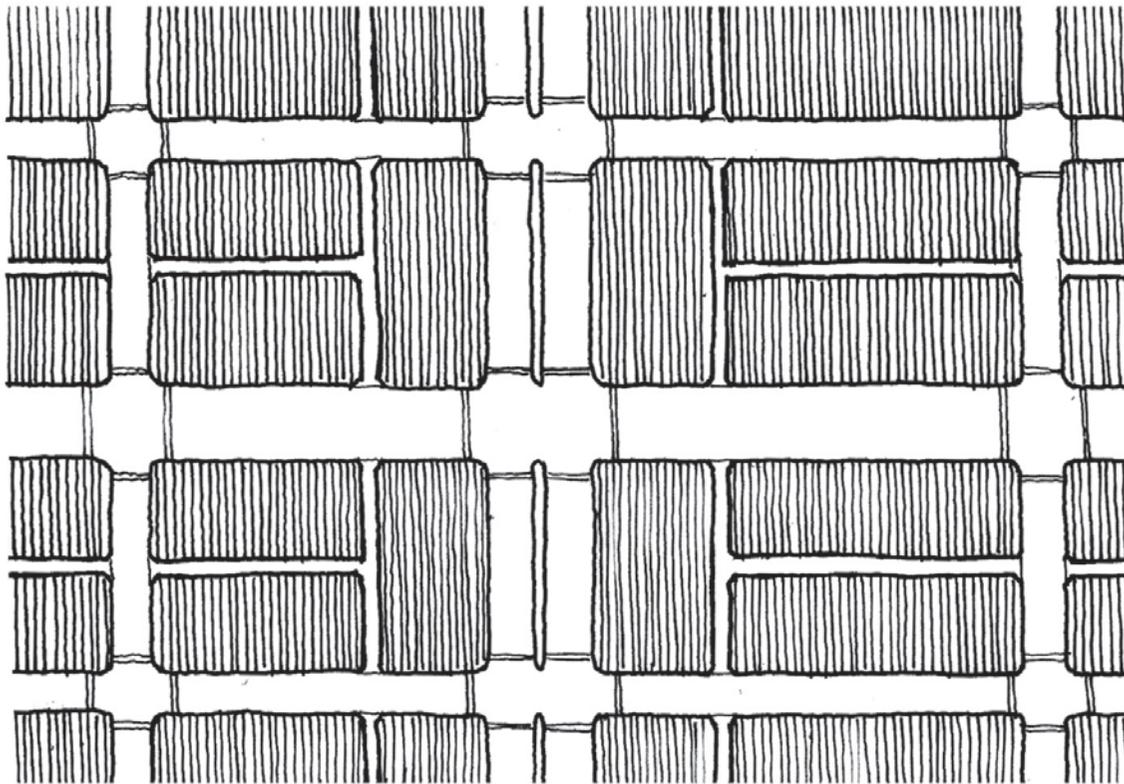
8. Wide Sidewalks

Sidewalk design can greatly enhance the urban environment and is very important when designing wide streets. Because wind moves faster down wide streets, street sections should have greater than 1:1 ratios (see #6 Wide Streets), but actual pavement for cars should be kept as minimal as possible to encourage slower driving and a safer pedestrian environment. To accomplish this, design wide sidewalks that increase the street section, but always provide shade for the street (see #7 Shady Streets). Trees in planters or planting strips should line the streets and be spaced every 10 metres to decrease the perceived width of the street. Additionally, porches, canopies, and verandahs on buildings that extend into the sidewalk permit breezes to pass while decreasing the width between buildings. For tall buildings, design the base of the building up to the sidewalk and set the tower back to create a wider space for air flow two stories above the ground. Finally, design streets with on-street parking to both widen the street for ventilation and encourage slow traffic. Wide sidewalks can be oppressive in hot climates so be sure to provide enough shade to counter the width.

Climatic Condition: Hot

Scale: Urban

Response: Design wide sidewalks, scaled to the buildings with ample sun and rain protection, to widen the street section without adding driving lanes.



9. Hierarchy of Streets

Urban areas should be designed with a well developed street network with a hierarchy of street types. A hierarchy of streets support different building types, heights, and setbacks which can promote a greater variety of site specific climatic design responses, including vegetation and creation of individual microclimates in addition to facilitating cross-ventilation.

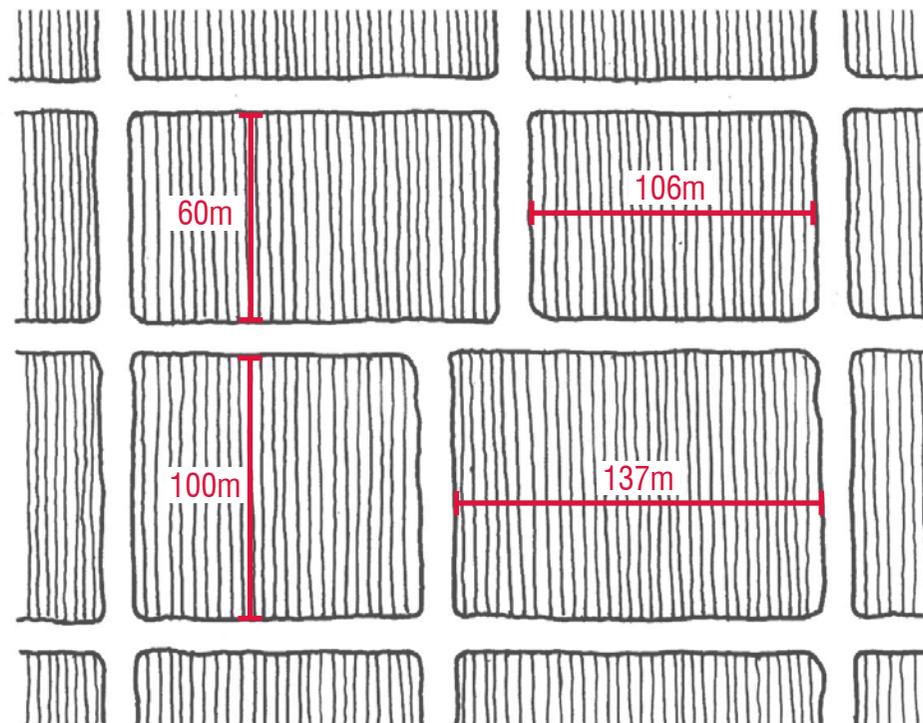
A diverse network also disperses traffic throughout the urban area, discouraging traffic jams, and provides a number of efficient options for getting between two points, both of which reduce VMT and heat island effects. In a hierarchical network, streets are designed specifically for the volume of activity they carry, from wide boulevards down to alleys, and can be optimized around both pedestrian comfort, to encourage more walking, and/or vehicular efficiency.

A hierarchical street network can also divide the city into a series of inter-connected, discreet neighbourhoods which function more efficiently, both individually and collectively.

Climatic Condition: Hot and Humid

Scale: Urban

Response: Design a hierarchy of streets to disperse traffic, reducing the heat island effect, and create walkable streets.



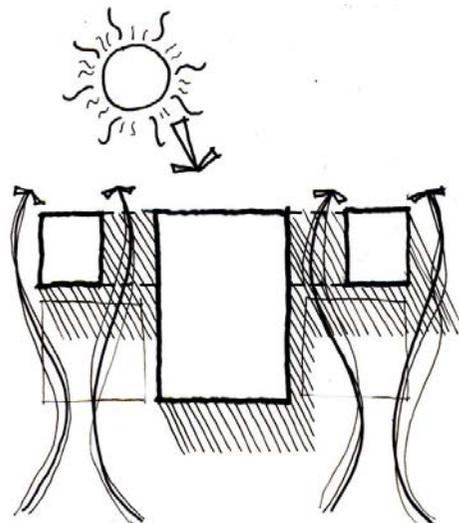
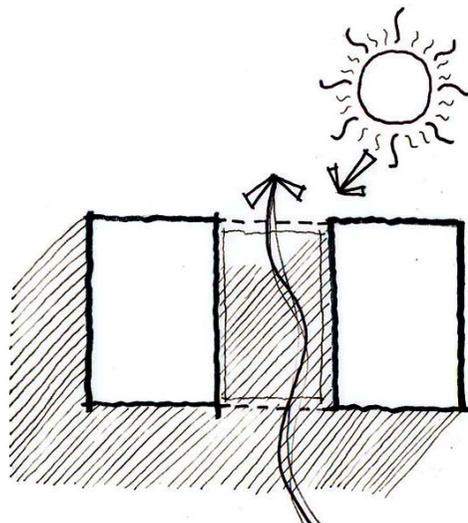
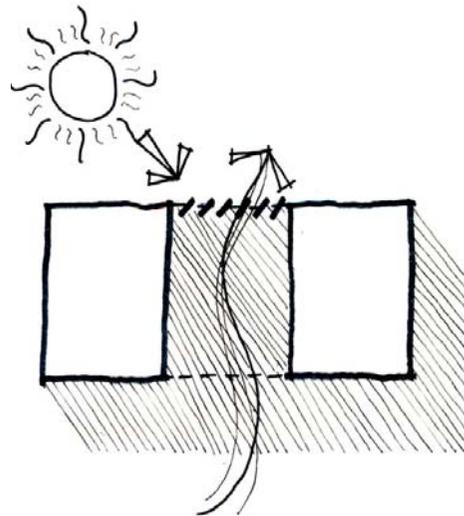
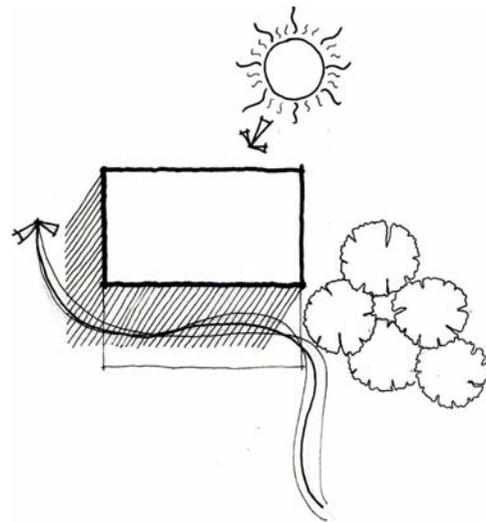
10. Short, Walkable Streets

Short streets break up the urban context into blocks that are comfortable for pedestrian activity and provide many avenues for ventilation. Shorter blocks create more streets, which adds to a robust street network while providing more avenues for ventilation through the city. They also create more intersections which slow traffic, enhancing the pedestrian environment. The result of short, walkable streets is a network of corridors for air movement throughout the urban area as well as a network of streets for traffic to disperse among. Blocks should be dimensioned approximately between 60 to 100 metres for the short sides and 106 to 137 metres for the long sides to be comfortable for pedestrians. Deeper lots provide the additional benefit of creating more space inside the block for green space and shade, helping to reduce the heat island effect in urban areas. These dimensions provide deep enough lots and enough length to have a variety of buildings on one block while not creating an overbearing distance for pedestrians to walk.

Climatic Condition: Hot

Scale: Urban

Response: Design short streets to encourage pedestrian movement and slow traffic while providing many corridors for air movement.



Building Techniques

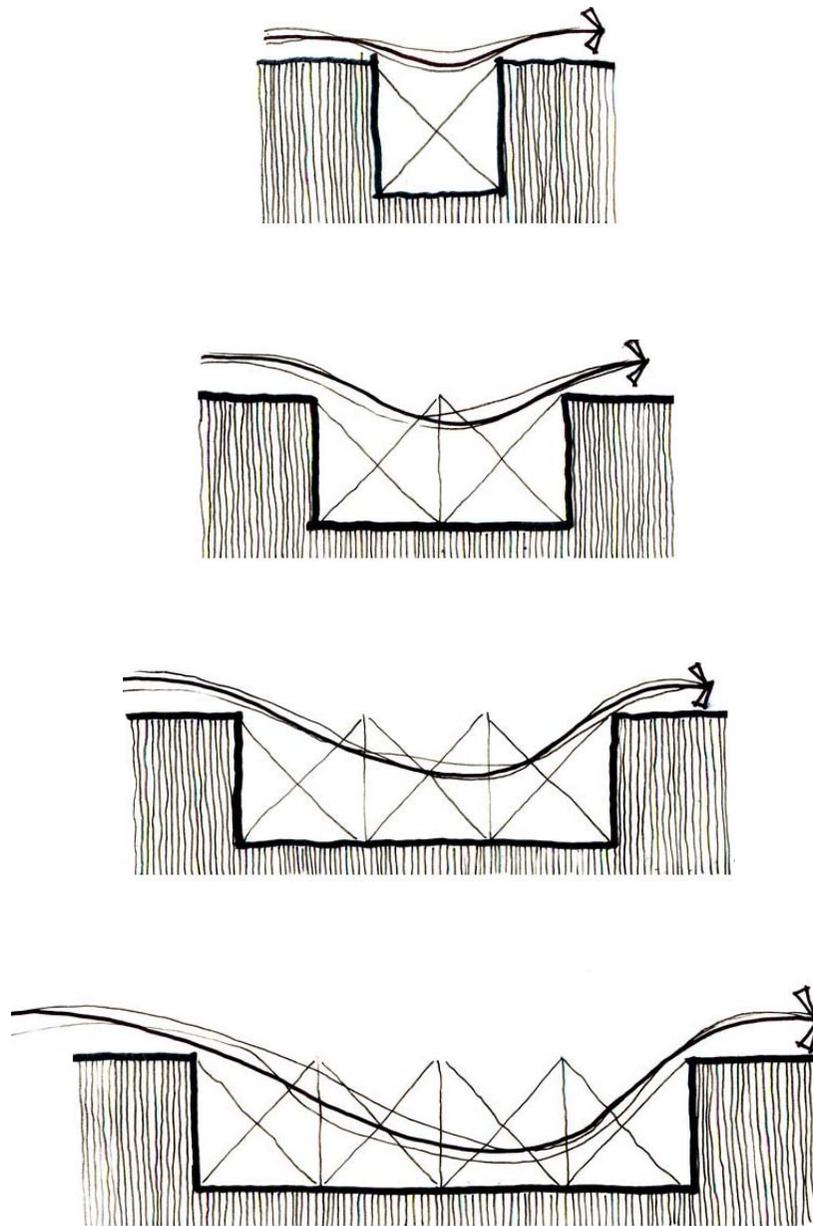
11. Outdoor Rooms

Buildings can be arranged to create outdoor microclimates that are comfortable to occupy. Arranging outdoor spaces with respect to buildings and vegetation so that they are ventilated and shaded provides comfort for occupants all year. Because the sun is shining from the north, but the majority of prevailing winds are from the south and east in Cairns, outdoor rooms should ideally be located to the south with objects to funnel the wind through the space or between buildings with a roof overhead. Other options include designing multiple outdoor rooms to use during different times of day or to use shutters or vertical louvers to shade while allowing ventilation. Porches and balconies with deep overhangs located in the path of the wind provide comfortable outdoor rooms. If it is not possible to provide both shade and ventilation through an outdoor room, design first for ventilation. In Cairns, because the humidity causes more discomfort than the heat, it is more important to design for adequate cross-ventilation than shading.⁶

Climatic Condition: Hot and Humid

Scale: Building

Response: Arrange outdoor rooms to be shaded while encouraging cross ventilation.



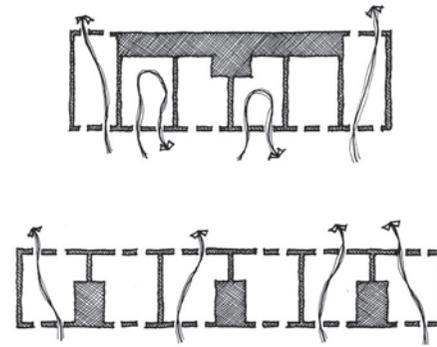
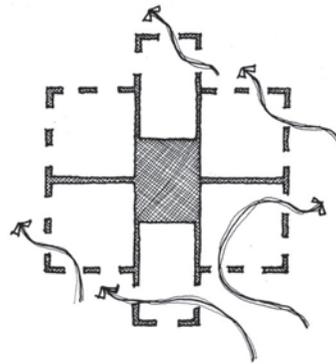
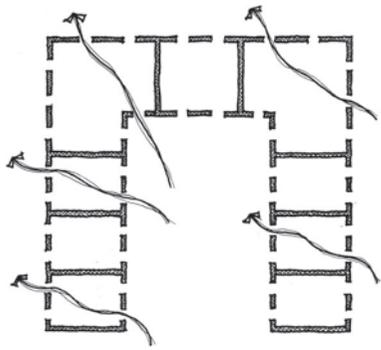
12. Cool Courtyards

In courtyards, wind conditions are a product of the proportion of building height to courtyard width, similar to a street. Buildings create a zone of low pressure behind them that the wind does not reach, so the wider the courtyard in the direction of the wind, the greater the velocity of the air movement. In Cairns, a wide courtyard will allow little protection from the sun so other shading elements, such as trees, balconies, and verandahs should be used to provide shade. Providing places in the building where the wind can enter and exit the courtyard at ground level, such as a loggia, can help to dramatically cool the space. A courtyard orientation 45° from the prevailing wind will maximize breezes in the courtyard and cross ventilation for the building.⁷

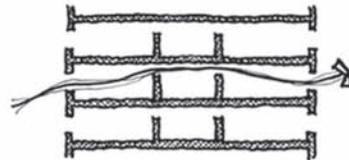
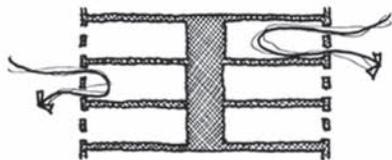
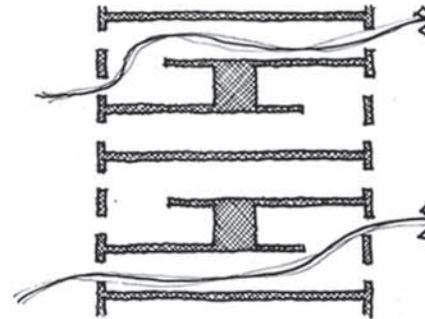
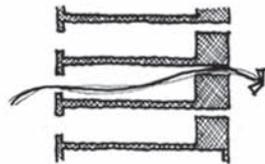
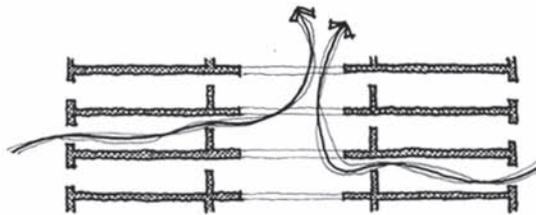
Climatic Condition: Hot and Humid

Scale: Building

Response: Design low, wide, permeable courtyards to allow maximum airflow.



Plan



Section

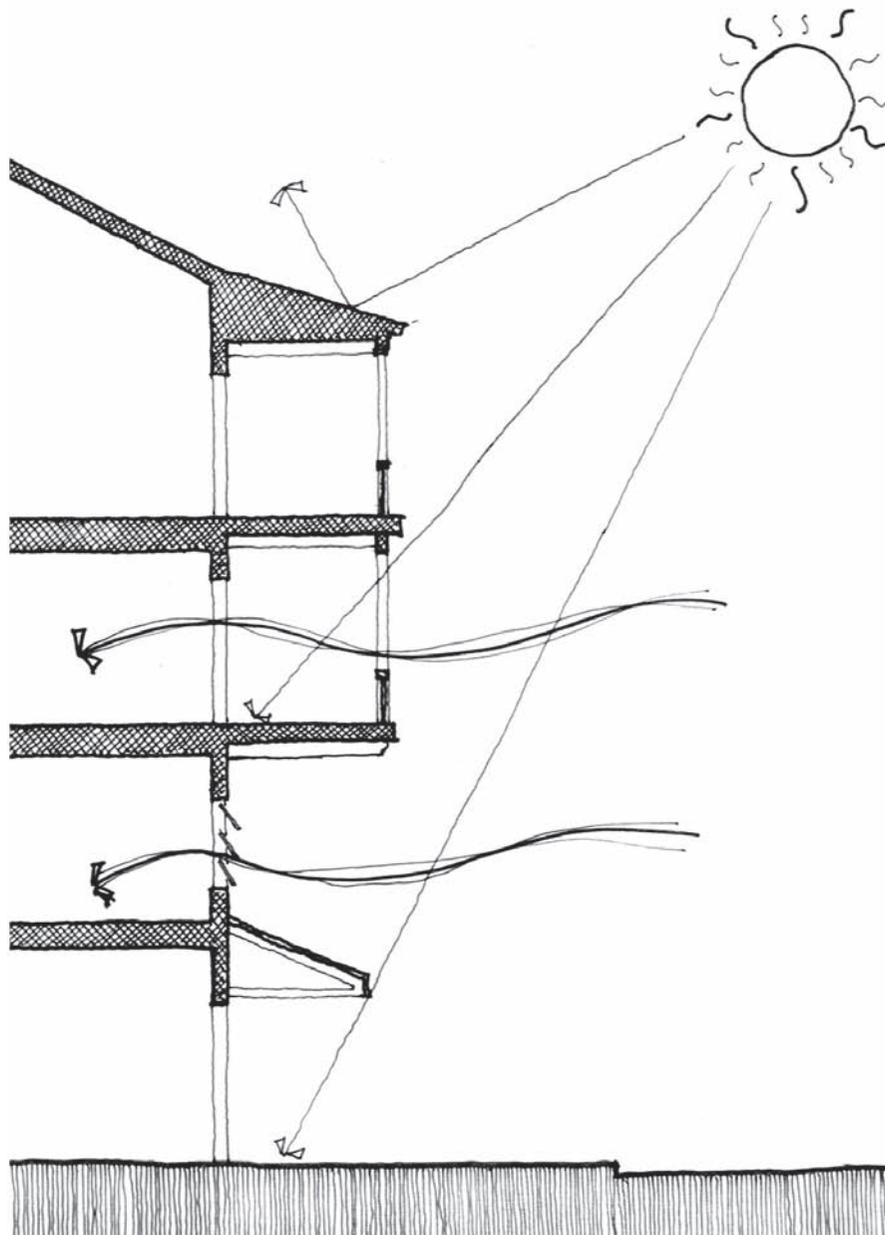
13. Permeable Buildings

Open floor plans and building sections encourage cross ventilation through a building. The fewer obstructions in a building, the less resistance the breezes will encounter. Openings on both sides of a room in plan, and stack ventilation techniques in section, encourage maximum airflow. A number of design strategies to optimize ventilation include high ceilings, atriums, elevated first floors, open floor plans, and transom windows. Plenums above hallways in single loaded buildings can provide cross ventilation to those units. Use transom windows to provide privacy while promoting cross ventilation within units or in motel style building types. Cross and stack ventilation can work independently of each other or in concert, but when designed together, parts of both the plan and section must be kept open to air movement.⁸

Climatic Condition: Hot and Humid

Scale: Building

Response: Design permeable buildings in plan and section to encourage air flow through the building.



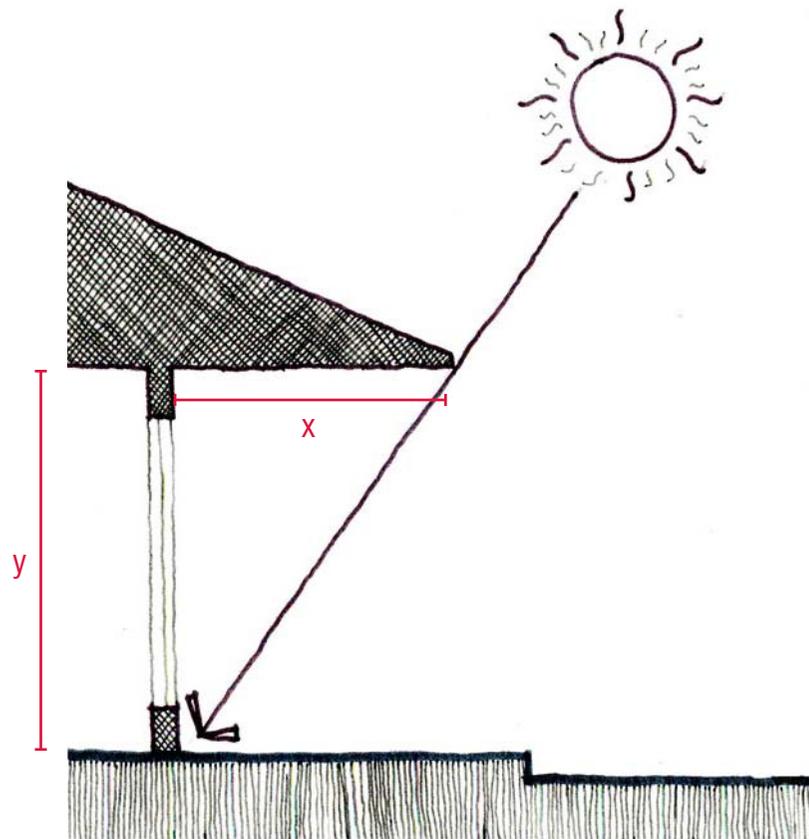
14. Deep Overhangs

The east, north, and west orientations of buildings in Cairns should have shading devices such as overhangs, porches, verandahs, and awnings to keep the sun off the walls and windows to reduce solar heat gain. These shading devices also help keep rain away from the building so that windows can be left open to ventilate the spaces. See “#15 External Shade Size” to determine how deep an overhang should be. Overhangs on the east and west sides of buildings should be deeper than those on the north side because the sun is lower in the sky in the morning and evening, when it is in the eastern and western skies. Louvers and lattices in the vertical plane, and plants, can also be used to shade walls. At the street level, design arcades, colonnades, and awnings to protect pedestrians from the sun and rain. A continuously covered streetscape will greatly enhance the pedestrian environment.

Climatic Condition: Hot

Scale: Building

Response: Design deep overhangs, porches, and verandahs to shade windows and walls from the sun. Design colonnades, arcades, and awnings to protect pedestrians from the elements.

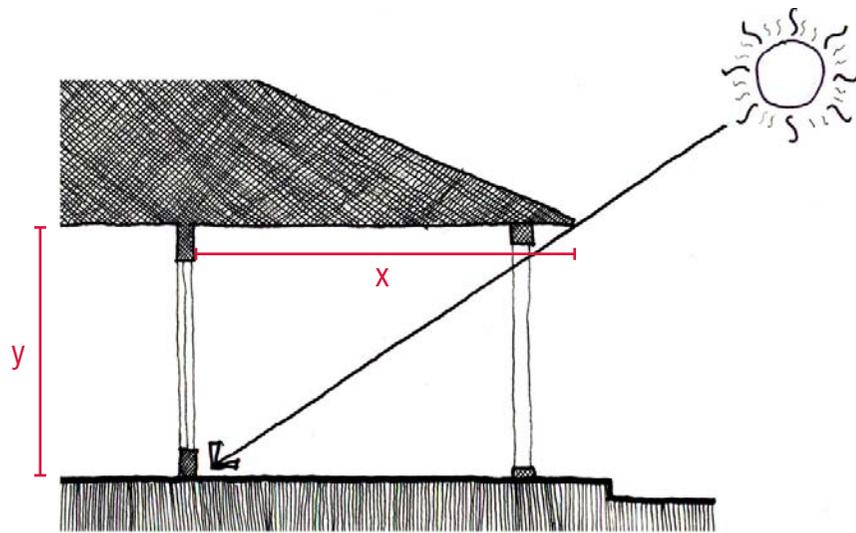


Northern Exposure

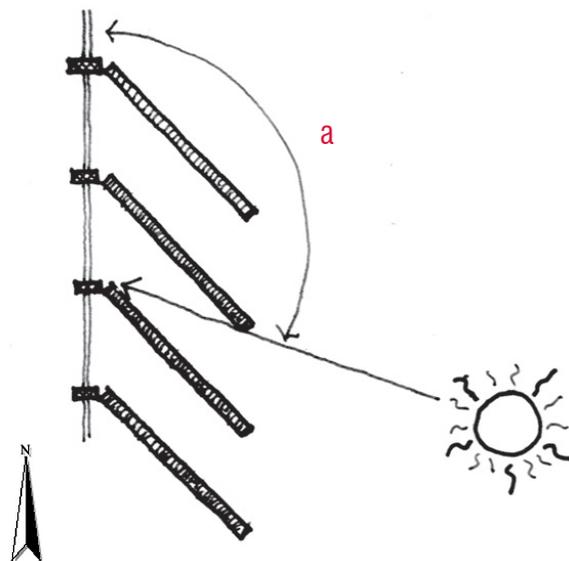
15. External Shade Size

Shading devices should be sized based on the times of year when it is advisable to keep direct sun off the building. Because of the high year round temperatures in Cairns, shading devices should protect against the sun all year long. Because the sun is higher in the middle of the day, horizontal shading devices are effective on northern exposures while on east and west exposures, vertical shading devices are best because the sun is lower in the sky. Horizontal shading would have to be very deep to be able to shade east and west exposures. Vertical shading on the east and west exposures are most effective when slanted, as opposed to perpendicular, so that the sun can not shine in when perpendicular to the building. Using a combination of horizontal and vertical shading is also effective. Horizontal shades such as deep roof overhangs, porches, and balconies are effective in blocking heat gain, but also limit the amount of daylight into a space. On the other hand, a brise soleil or horizontal louvers will block heat gain while allowing more daylight, but do not protect against the rain. Vertical louvers are also effective at providing protection from the sun. These issues must be taken into account when designing. It is important to shade walls as well as windows in Cairns, and provide protection from the rain. Therefore, when possible, deep overhangs and covered porches are preferable to other types of shading devices. When overhangs and porches are not deep enough, use either horizontal or vertical shading elements.⁹

Use the following equations to determine how deep a shading device should be:



East and West Exposures



Vertical Shading

For horizontal shading on a Northern Exposure: $x = p(y)$

$P = 1.54$ to shade all year at 16°S

$P = .75$ to shade August – April at 16°S (minimum overhang)

For horizontal shading on East and West Exposures: $x = p(y)$

$P = 2.4$ to shade all year at 16°S

$P = 2.02$ to shade August – April at 16°S (minimum overhang)

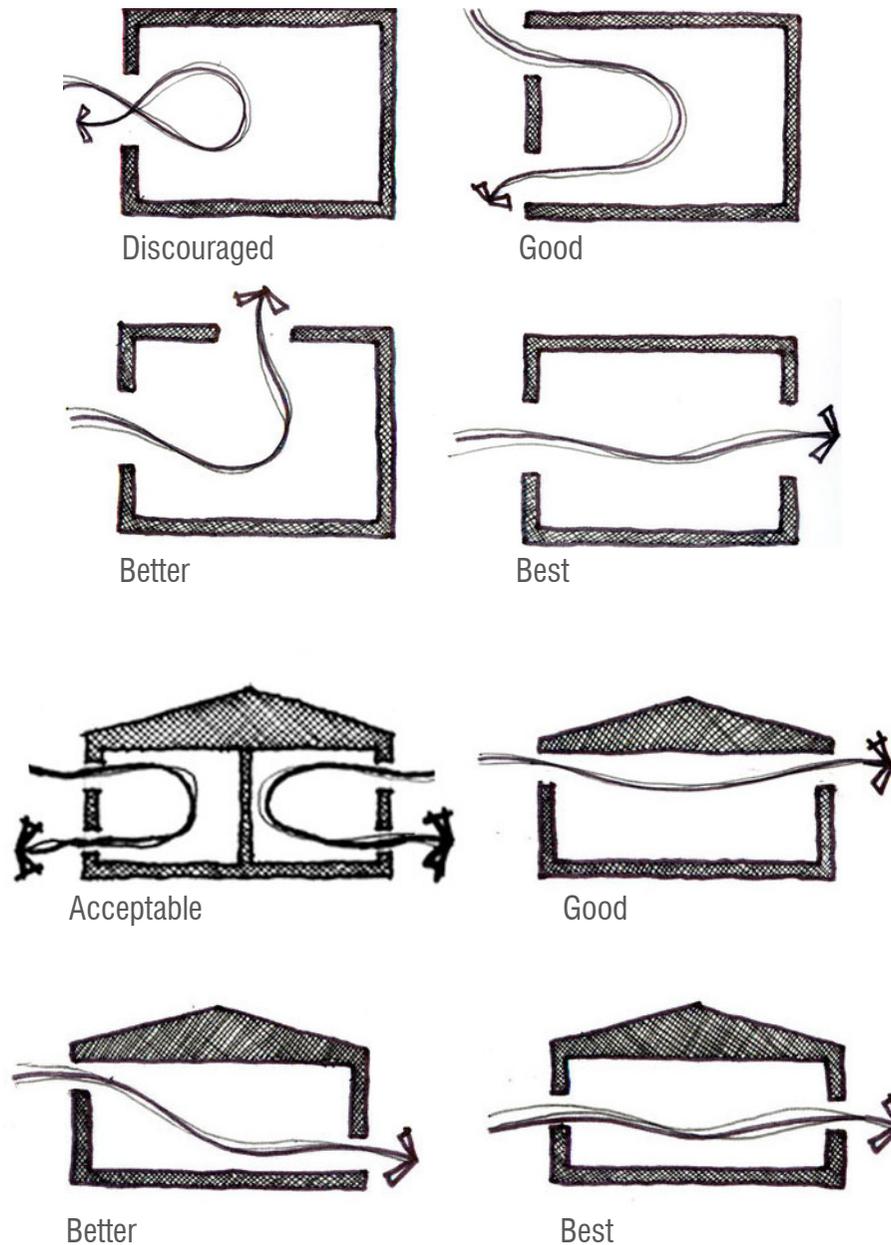
For vertical shading on East and West Exposures

Azimuth angle (measured from north) = 108° to shade all year.

Climatic Condition: Hot and Rainy

Scale: Building

Response: Size shading devices to protect walls and windows from solar heat gain while also providing protection from the rain.



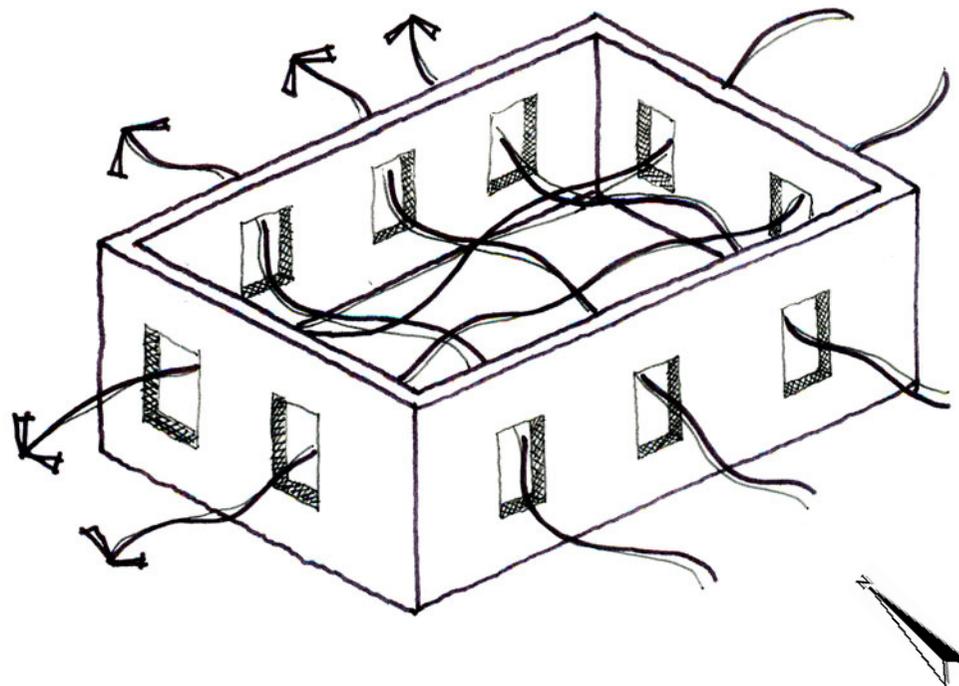
16. Ventilation Opening Arrangement

The placement and size of ventilation openings has an impact on the velocity of the wind through a space. To maximize the rate of cross ventilation in a room, the optimal placement for windows is on opposite walls or adjacent walls. Locating inlets and outlets on different walls allows the wind to move through the space at a higher velocity while also cooling more of the space. If it is not possible to have openings in two walls of a room, locate two openings in one wall to allow air to circulate between them. The placement of openings in section is also important to make sure that the ventilation is moving across the occupants of the room. Cooling occurs faster when the wind actually moves across the body, so openings located in the middle of the rooms are optimal to allow wind movement in spaces occupied people. The wind will follow the path that it is given, so it will flow between the openings if they are at different heights in section.

Climatic Condition: Hot and Humid

Scale: Building

Response: Arrange ventilation openings to increase the rate of cross ventilation in a room.



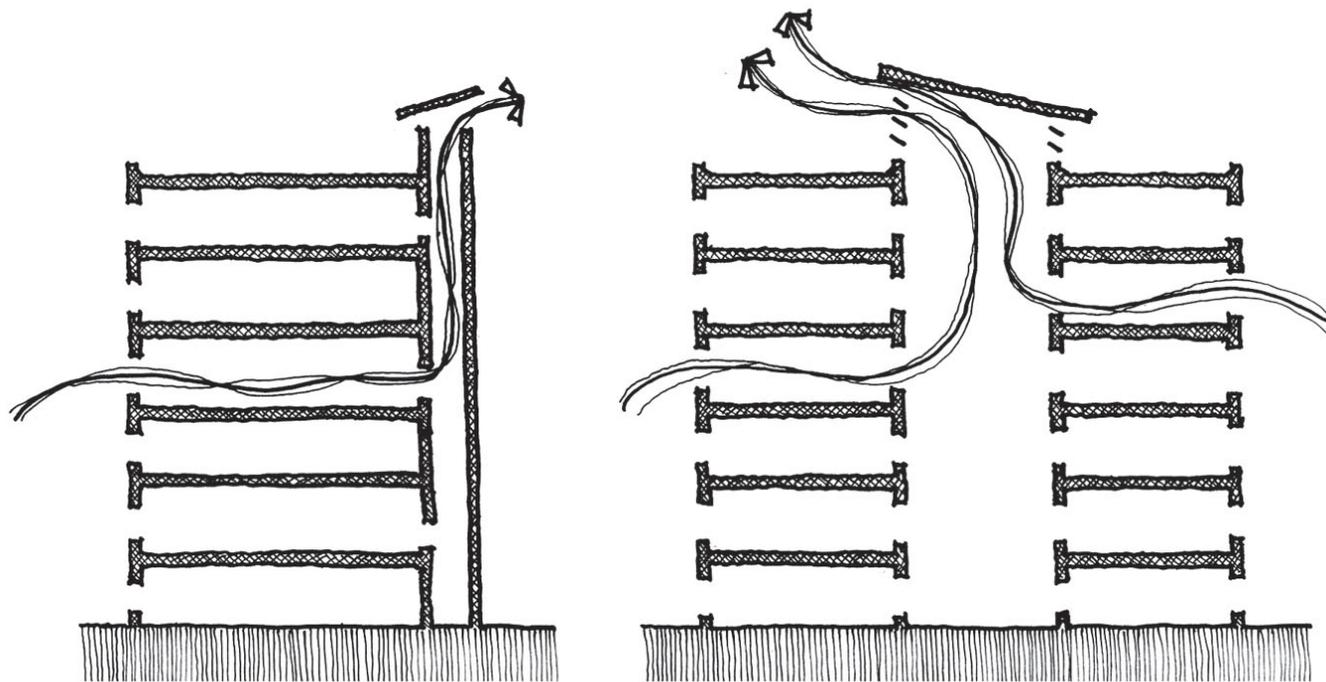
17. Ventilation Opening Size

Ventilation is maximized when large openings are placed perpendicular to the wind direction, as it is a function of the wind speed and the size of the inlets and outlets. The wind in Cairns is predominantly from the south/southeast in the morning and from the east/southeast in the afternoon, all year long. Therefore, inlets should be placed on the southern and eastern exposures with outlets on the northern and western exposures. The rate of airflow will be determined by the smaller of the openings, the inlet or outlet. In Cairns, the area of the openings needed to effectively cool a building should be between 5 -7% of the total floor area. For example, if a building is 150 square metres, the total area of inlets should be 7.5 – 10.5 square metres. More than 5 – 7% will allow for more cross ventilation, which would not be bad in Cairns, but 5% should be a minimum. For the most efficient cross ventilation, have as few obstructions, such as walls, as possible between the inlet and outlet. Ideally, each room will have a windward and leeward exposure.¹⁰

Climatic Condition: Humid

Scale: Building

Response: Size and locate cross ventilation inlets and outlets to effectively cool the space using the wind.



18. Stack Ventilation

Stack ventilation enhances the cooling effect by creating air movement within a building by pulling hot air up without the use of cross ventilation. The concept is based on the principle that warm air rises and cool air sinks because of their respective densities. When warm air is allowed to escape through high openings in a structure then cool air can replace it. This design strategy is effective even when site conditions do not permit cross ventilation or optimum orientation for ventilation is not an option. Optimizing the rate of air flow is a function of the vertical distance between then inlet and outlet, the height of the stack from inlet to outlet. Maximizing the ceiling height of the rooms as well as the height of the stack are both beneficial to capitalizing on stack ventilation. The greater the distance between the low openings, inlets, and high openings, outlets, the greater the rate of air flow.¹¹

Climatic Condition: Hot and Humid

Scale: Building

Response: Design a stack ventilation system when site conditions prohibit successful cross ventilation to cool the building.

References:

- | | | |
|-------------------|------------------|-------------------|
| 2. Brown 81-21 | 6. Brown 139-141 | 10. Brown 182-184 |
| 3. Brown 121-1232 | 7. Brown 207-209 | 11. Brown 185-187 |
| 4. Brown 114-115 | 8. Brown 146-149 | |
| 5. Brown 107-108 | 9. Brown 262-269 | |

Case Studies

Urban Patterns

- Aerial Photo
- Plan
- Street Network
- Green Space

Urban Components

- Blocks
- Streets
- Building Placement
- Building Types

Representative Photos

Urban Patterns

The case studies explored here, the cities of Miami Beach, USA; Sao Paulo, Brazil; Teresina, Brazil; and Hong Kong, are all located in the same tropical wet and dry climate which characterizes Cairns' climate, and provide good examples of climate-sensitive urban design tailored to their specific circumstances. These cities are used to illustrate the techniques described earlier, in practical application. The following diagrams illustrate the urban patterns of these four cities and describe the lessons to be learned from each. These cities, though different in scale and structure, and unique in their context and history, demonstrate that the techniques described earlier can be successfully applied in response to unique contextual conditions, while still following climate-sensitive town planning principles. These case studies are relevant to Mount Peter, in that they illustrate the flexibility of the techniques in successfully addressing the challenges of climatic-sensitive design in diverse urban settings, proving that specific site context should not deter the application of these principles.



Sao Paulo, Brazil

Aerial Photo

The cities of Teresina, Sao Paulo, Miami Beach, and Hong Kong are all densely populated urban areas. The diagrams on the following pages illustrate the basic principles of these cities: interconnected street networks, an integration of vegetation, and a diversity of building and street types the work together to create the urban fabric.



Teresina, Brazil



Miami Beach, USA



Sao Paulo, Brazil



Hong Kong

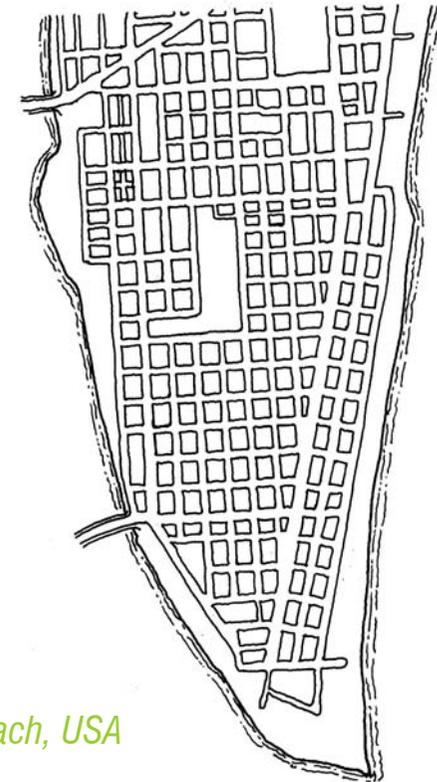


Plans

The block network is typically oriented toward major physical features, such as the coast, rivers, or mountains. The major streets in Miami Beach run north to south and so the longer side of the block is oriented along that alignment. Because the coastline on the east and west sides of the island are not parallel, major avenues change orientation to relate to the coasts and create unique blocks where the different geometries intersect. Sao Paulo and Teresina have generally square blocks that are intersected by avenues connecting major points in the cities. Hong Kong also has an orthogonal block structure on the flat ground but as the topography increases the roads begin to follow the grade and become more organic.



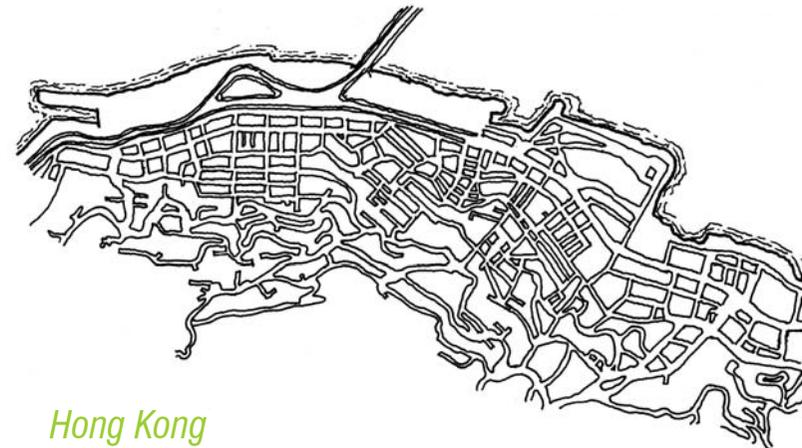
Teresina, Brazil



Miami Beach, USA



Sao Paulo, Brazil



Hong Kong

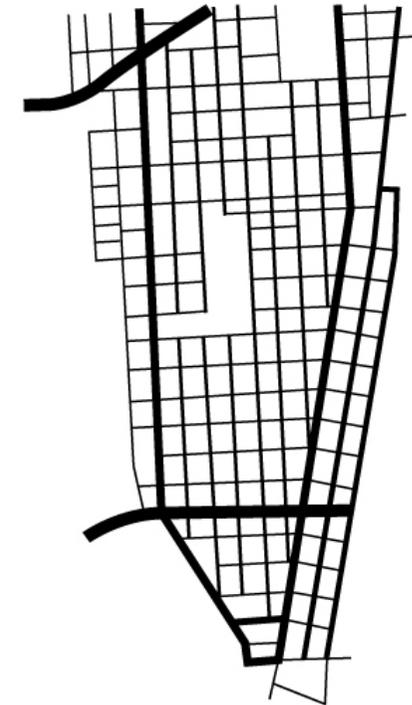


Street Network Diagrams

The street network provides both mobility and the basic urban structure. A good street network articulates a diffuse web of interconnecting streets, allowing multiple routes to any destination, easing the burden on major thoroughfares. It also provides a number of movement options, increasing the likelihood of pedestrian activity. All of these networks have a clear hierarchy of streets and a number of different street types.



Teresina, Brazil



Miami Beach, USA



Sao Paulo, Brazil



Hong Kong

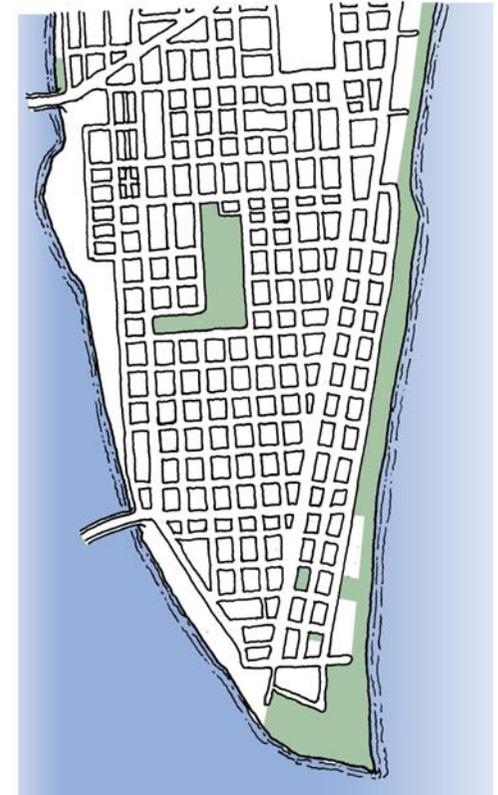


Green Space

An essential part of any city is its network of parks and green spaces, which help to cool the city as well as provide convenient recreational opportunities for residents. Note how green spaces are distributed throughout these cities at regular intervals and at many different scales.



Teresina, Brazil



Miami Beach, USA



Sao Paulo, Brazil

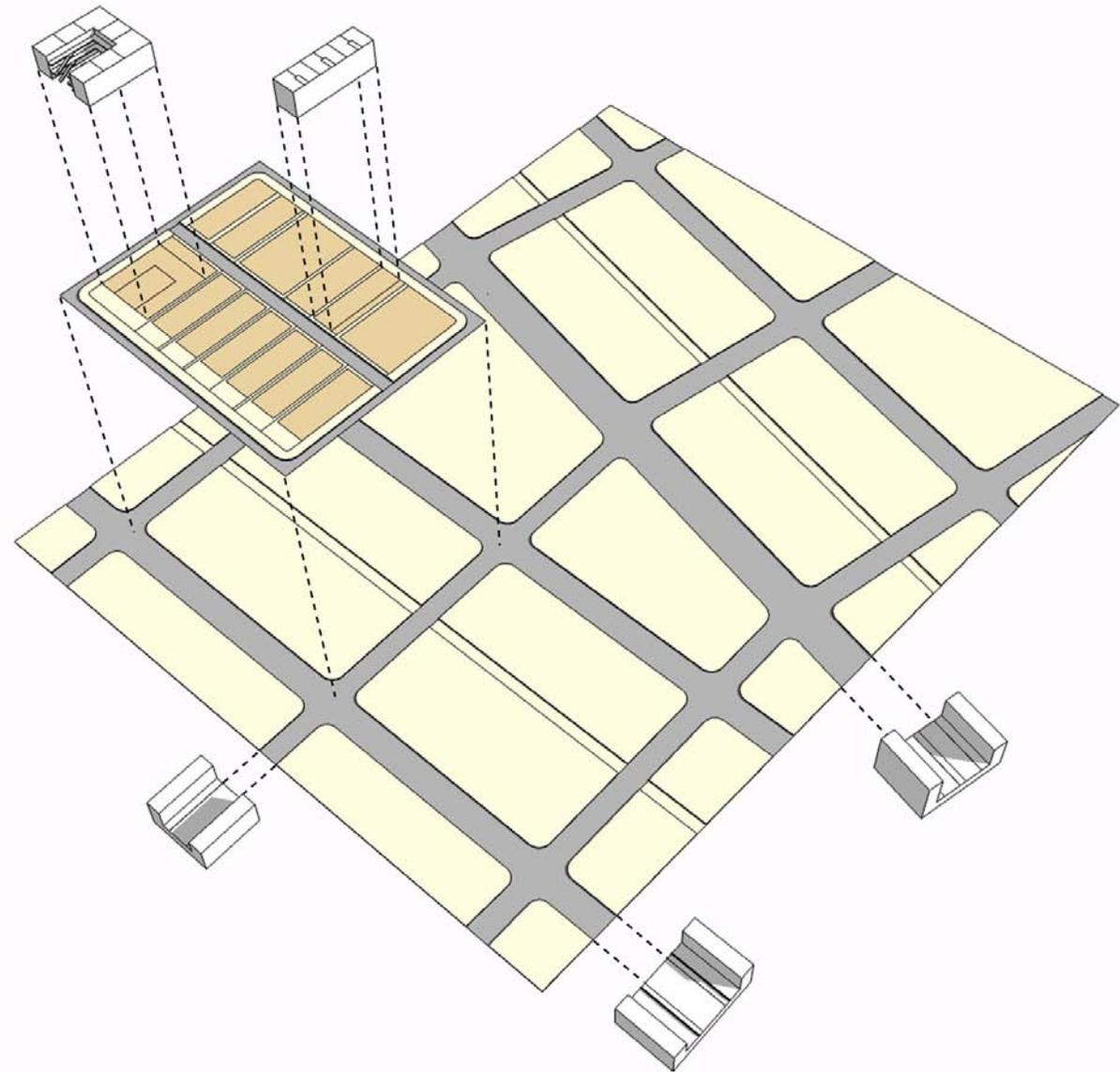


Hong Kong



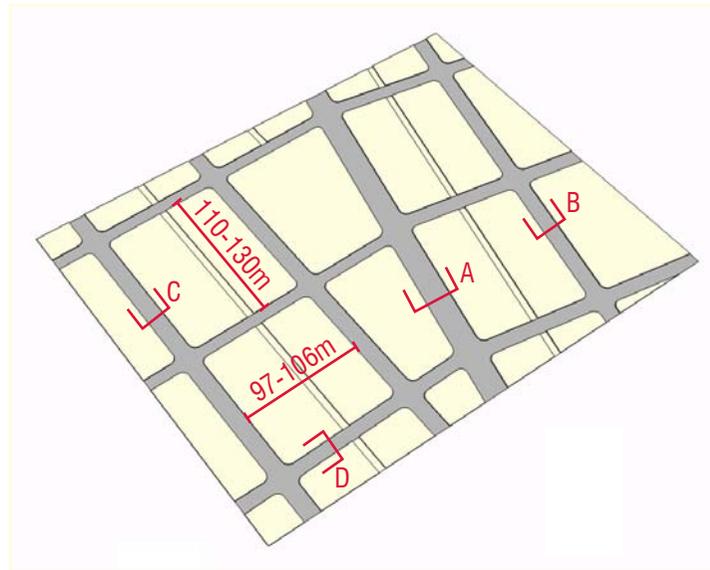
Urban Components

Each city is made up of a number of components that work in concert to create an urban environment. The way in which these components relate and respond to each other determines the relative comfort, both physically and psychologically, of the occupant. Block structure, street width, building placement, and building types are the major components that make up an urban context. By combining each of these components, and utilizing the techniques outlined earlier, a cohesive urban fabric can be created which responds to a tropical wet and dry climate and also creates a robust urban setting. The cities diagrammed previously at a larger scale: Miami Beach, Sao Paulo, Hong Kong, and Teresina, here are broken down and analysed for their individual components. These cities, all in tropical wet and dry climates, have features that make them unique but that are also based on traditional planning techniques and environmentally responsive design. As case studies, these cities provide a snapshot of successful urban design in a tropical climate, and each of these components can be combined with others as a kit-of-parts to create a unique environment.

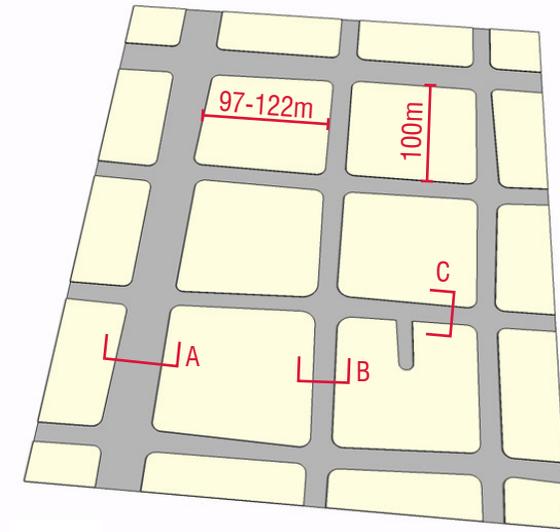


Blocks

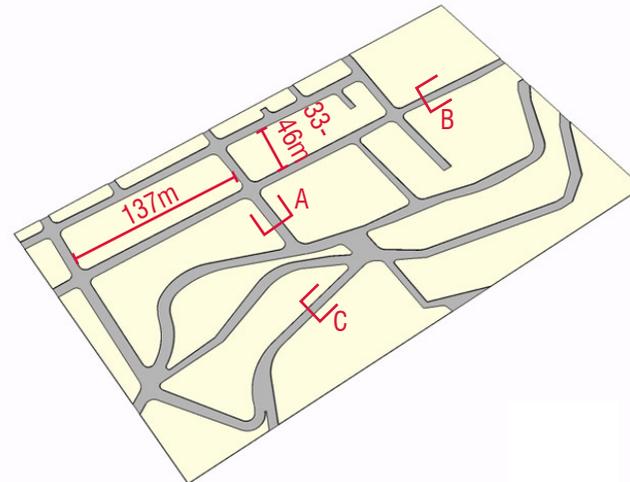
A simple and functional block network is made up of a number of blocks that should be short enough for a pedestrian to comfortably walk. A network of short blocks also creates more avenues for wind access through the city, increasing ventilation on individual lots and creating comfort for the occupants. All the blocks illustrated here are properly sized to create comfortable walking distances and correspond to Technique #10 Short Streets. Often an orthogonal block structure is interrupted by avenues and major streets that relate to either the topography and site conditions or connect major points in the city. This collision of different geometries creates unique blocks and opportunities to place important buildings. The rectangular blocks of Miami Beach create a clear distinction between the major and minor streets in the city. Both Sao Paulo and Teresina use relatively square blocks and face buildings onto all side of the block. All three of these cities have blocks big enough to have deep lots that allow buildings to extend into the block. In Hong Kong, the short side of the blocks have very prohibitive dimensions in terms of flexibility. The more organic blocks in Hong Kong are a result of the steep topography of the site.



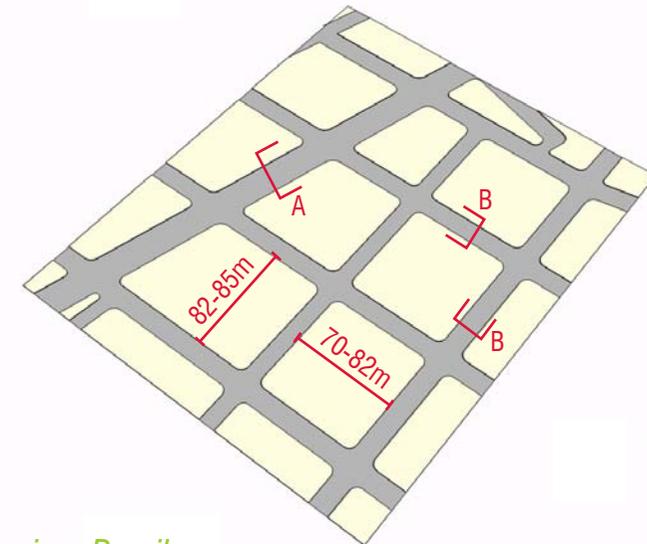
Miami Beach, USA



Sao Paulo, Brazil



Hong Kong

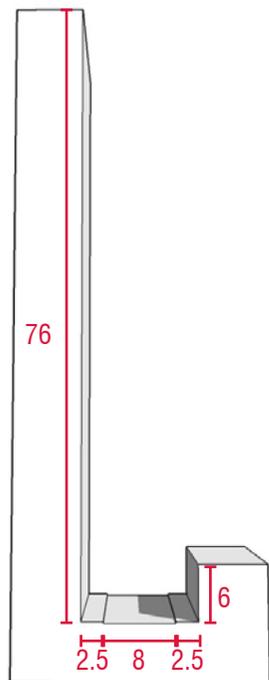


Teresina, Brazil

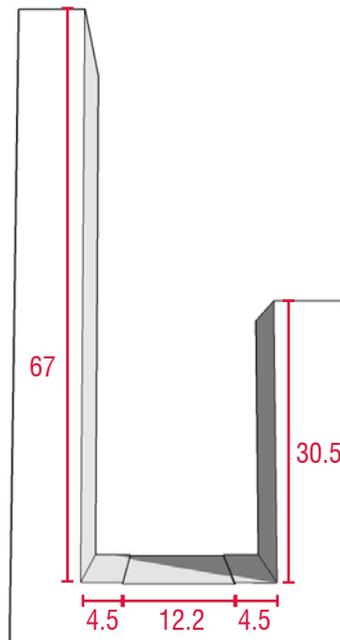


Streets

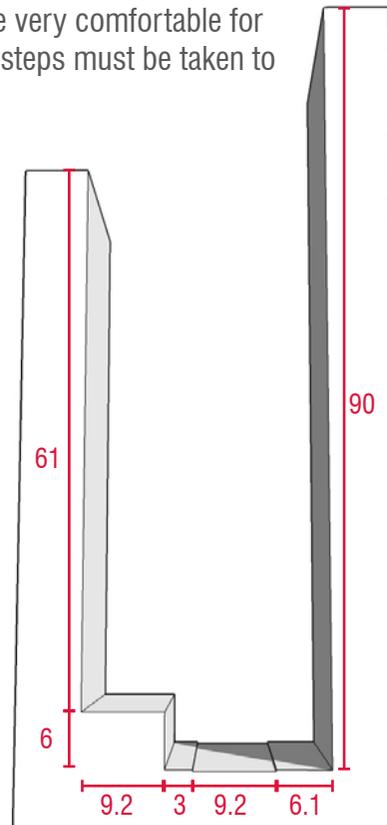
The street network should be designed with a number of different street types to create a hierarchy of streets as previously explained in Technique #9 Hierarchy of Streets. Also, as detailed in Technique #6 Wide Streets, the section should be designed with ratios of 1:1 or wider. Because of the population density in Hong Kong and lack of available buildable space, street sections are very tall and narrow and prevent wind from moving through the city, while also creating a canyonised feeling for the pedestrian. The sections of Teresina and Sao Paulo are slightly taller than 1:1 but because there are a number of short buildings in these cities, the wind can move over these short buildings and still provide access to the taller buildings. The sections of Teresina and Sao Paulo are slightly taller than 1:1 but because there are a number of short buildings in these cities, the wind can move over these short buildings and still provide access to the taller buildings. Additionally, the taller buildings provide good shade for the street. The short and wide streets of Miami Beach allow the most wind access through the city and are very comfortable for the pedestrian but do not provide sufficient protection from the sun so additional steps must be taken to provide shade, as described in Technique #7 Shady Streets.



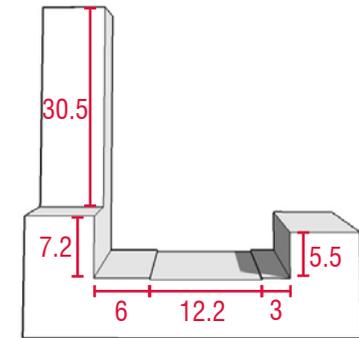
Section A



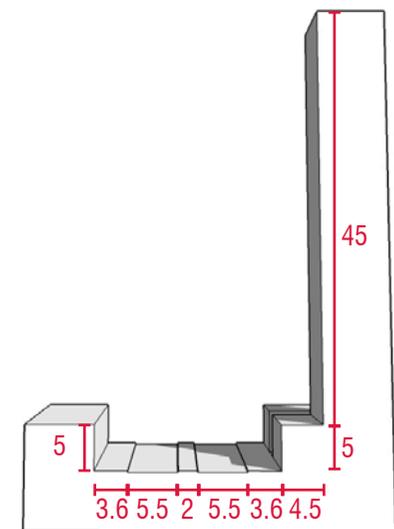
Section B



Section C



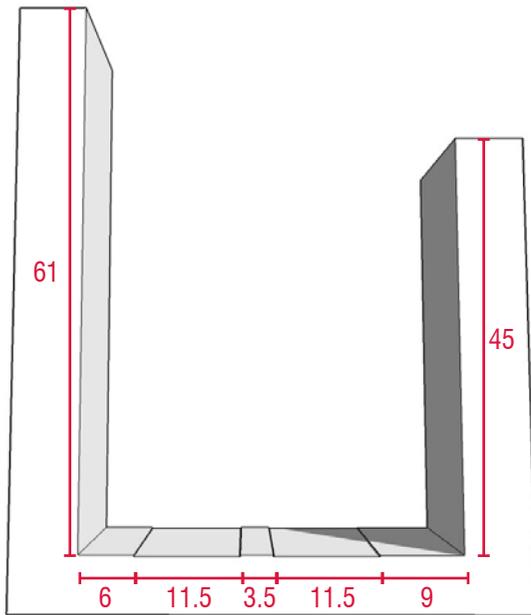
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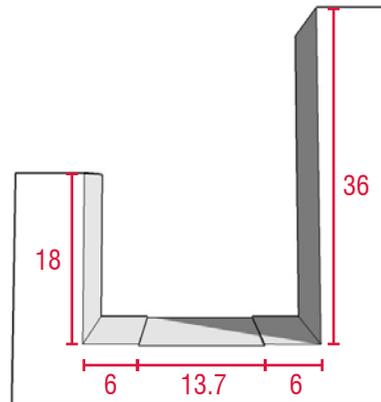
Section A

Hong Kong

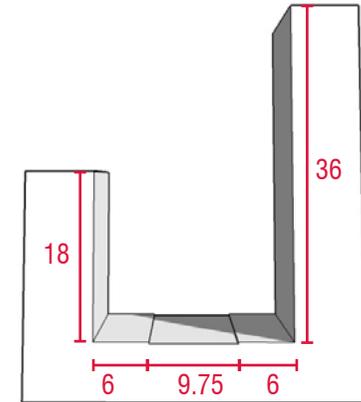
Teresina, Brazil



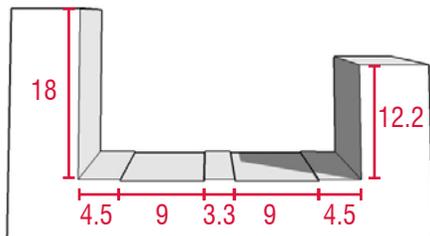
Section A
Sao Paulo, Brazil



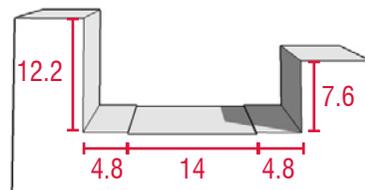
Section B



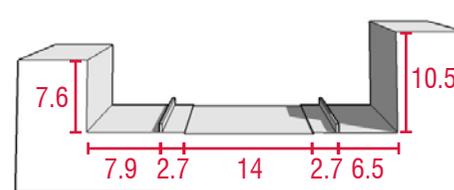
Section C



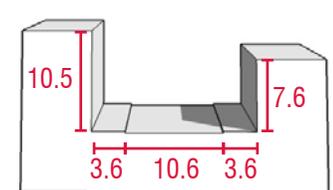
Section A



Section B



Section C

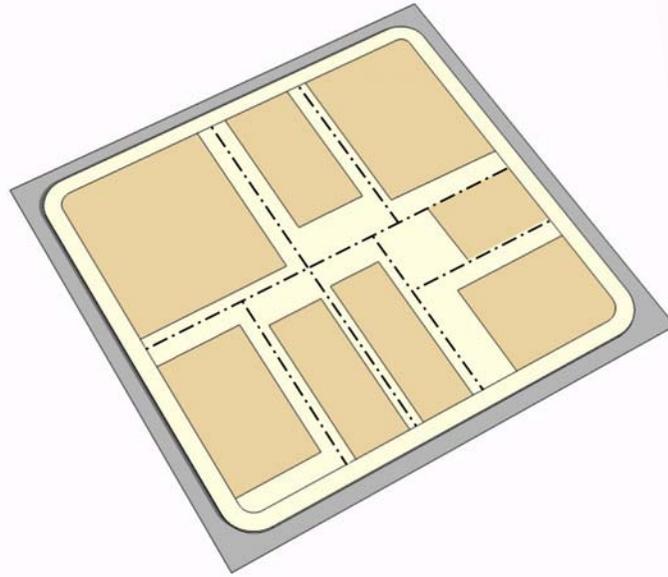


Section D

Miami Beach, USA

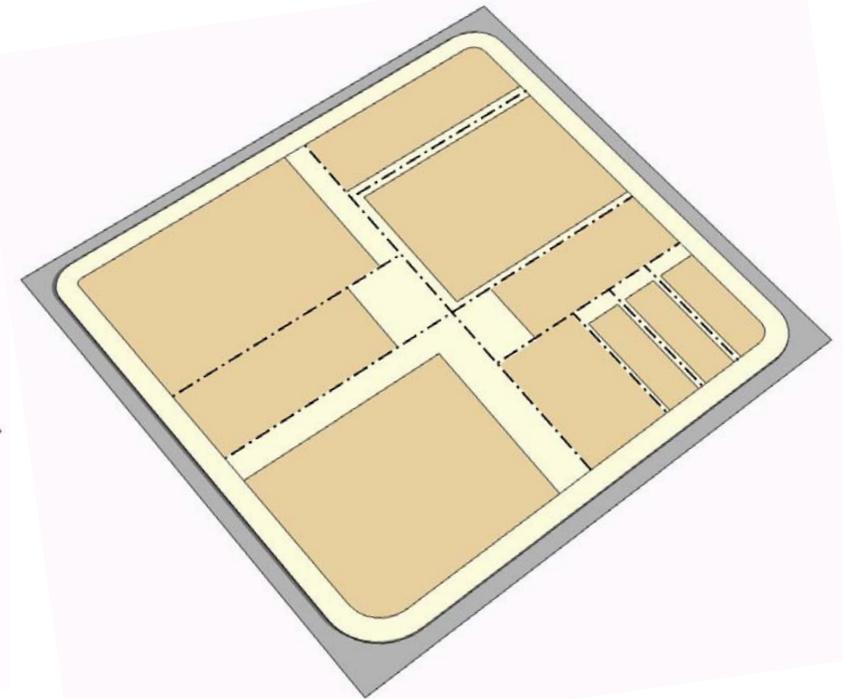
Building Placement

The urban fabric is defined by the buildings placed on the blocks. The way the building relates to the street creates the setting for typical daily life. In urban areas, building should be brought up close the edge of the lot to create a well defined street space. Space in the back creates a private zone for the lot and also allows access to the lot if alleys cut through the blocks. The desired density of the urban environment should determine where buildings should be placed in the lot. In dense urban areas, buildings should be close to the edge of the lot and close to their neighbours to create a unified streetscape. A uniform street edge can provide a constant source of shade for pedestrians while creating a tunnel effect for the breezes. See also #5 Lot Disposition for information about spacing buildings to encourage breezes. Here building should cover most of the lot. In more low density residential areas, buildings can be set back from the street as long as the street edge is defined with a fence, hedgerow, or treeline. Lot width is also important to consider when laying out blocks. While lot width changes with building type, there should be enough lots per block to create a diverse streetscape.



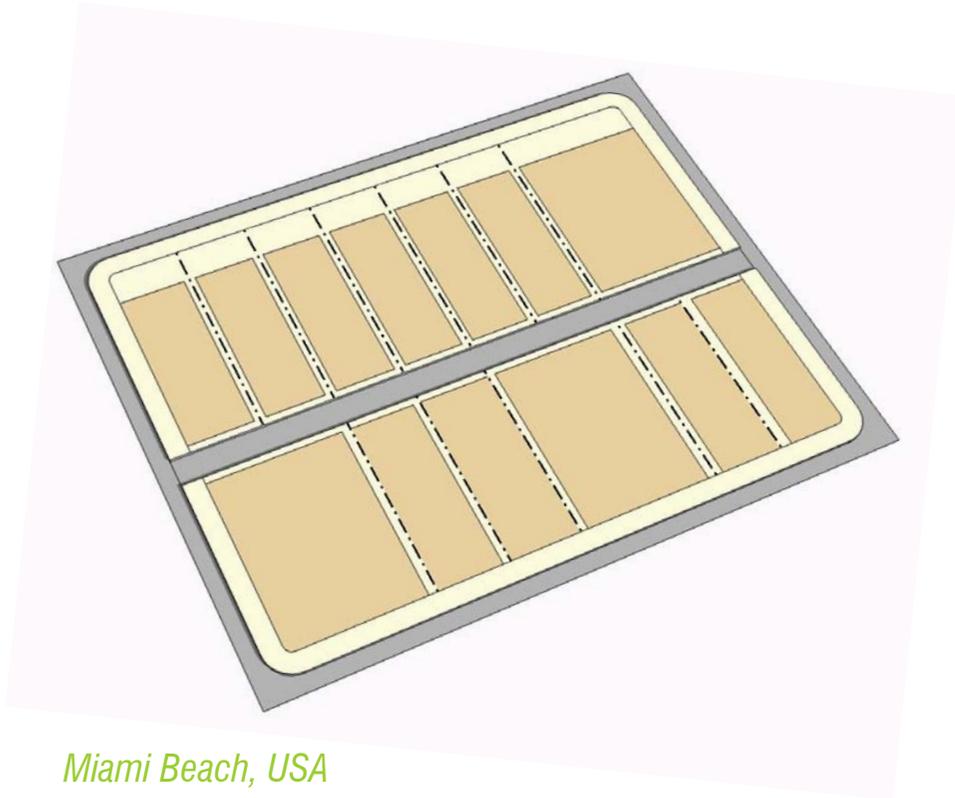
Teresina, Brazil

The building placement in Teresina tends to be towards the front of the lot, with the majority of the lot frontage built to. Because the blocks are essentially square, buildings face all four sides of the block. Lots are, on average, 15 metres or 20 metres wide for low rise buildings and 27 metres to 36 metres wide for mid to high rise buildings. Buildings are set back a few metres from the side property line and up to six metres from the back property line.



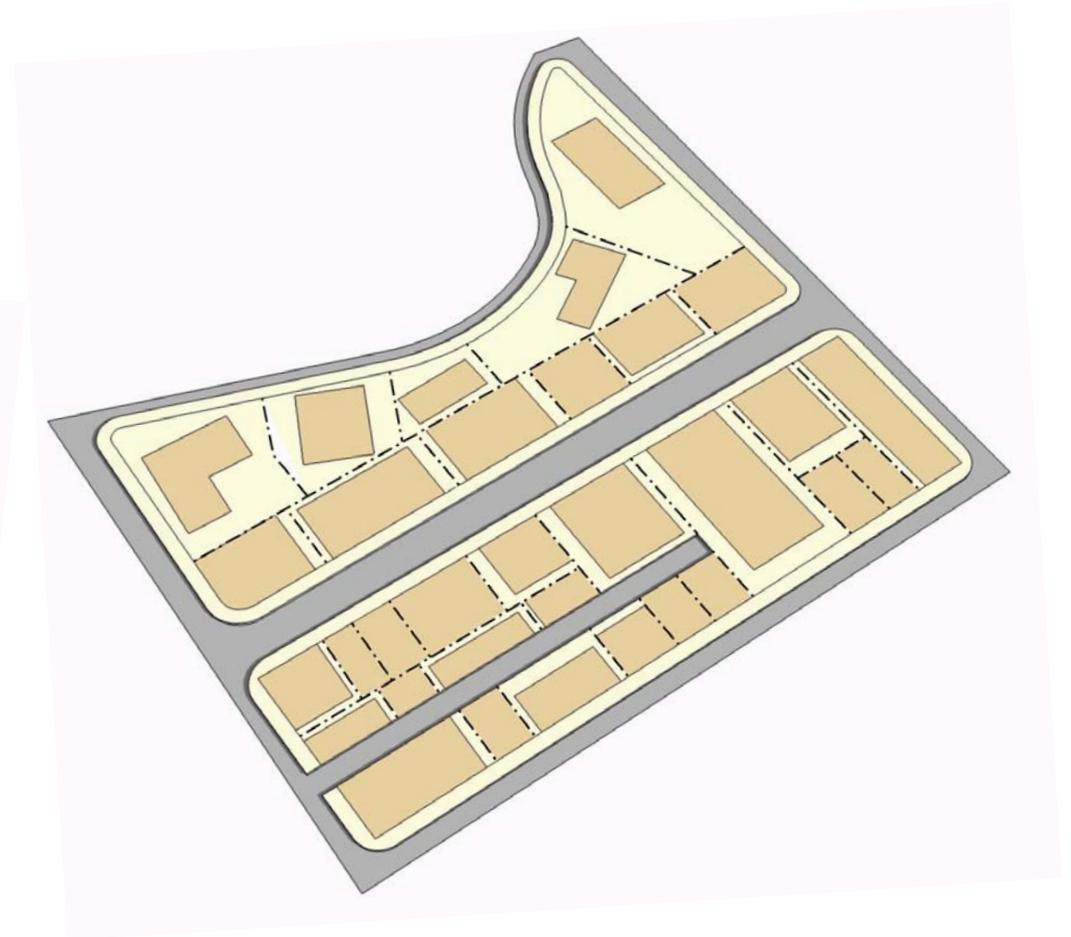
Sao Paulo, Brazil

Buildings in Sao Paulo are built up to the front property line and generally cover the majority of the lot. Like in Teresina, because blocks are square, buildings face all four sides. Average lots are 15 to 18 metres wide for low to mid rise buildings and 36 to 45 metres for high rise buildings. Setbacks are zero to two metres on the side and zero to four metres in the back.



Miami Beach, USA

The buildings in Miami Beach are all either built up to the front property line and occupy 90 -100% of the lot or set back 7.5 metres from the front and occupy 90% of the rest of the lot, depending on where they are located. Lots are either 15.25 metres wide or 30.5 metres wide. In the more dense part of the city, buildings are built up to the property line on one side and 1.5 to two metres from the property line on the other and extend all the way to the back property line. In the less dense areas buildings are set back 7.5 metres from the front and 1.5 metres from the side.



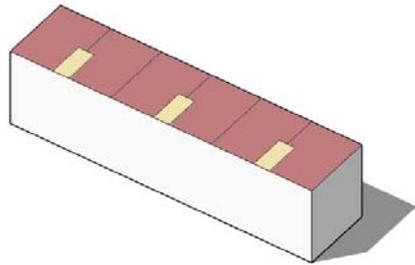
Hong Kong

Hong Kong has two distinct types of blocks and therefore, different building placements. In the gridded part of the city buildings are built up to the street edge and occupy the majority of the lot. Lot widths vary drastically and there is not a typically lot width, although they tend to be very shallow because of the short block depth. Many of the buildings in this part of the city occupy the entire lot. In the more organic part of the city, building placement is determined more by the steep topography. Lots are much larger here and buildings do not take up as much of the lot, although when possible they are built to the street edge.

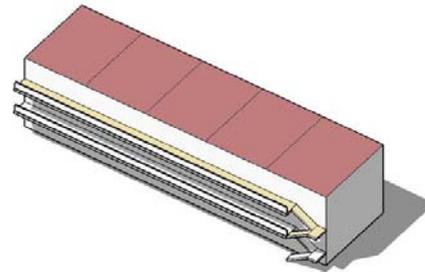
Building Types

Building types should both respond well to the climate and create a successful urban environment. Therefore, buildings should be designed for quality cross ventilation in all units while acknowledging the street. The following building types can be used in tropical climates to create a comfortable urban and climatic environment. See Technique #13 Permeable Buildings for more information about designing in section and plan for ventilation. Mid-rise buildings, shown here, are useful for creating and taking advantage of microclimates, such as shaded and ventilated outdoor rooms.

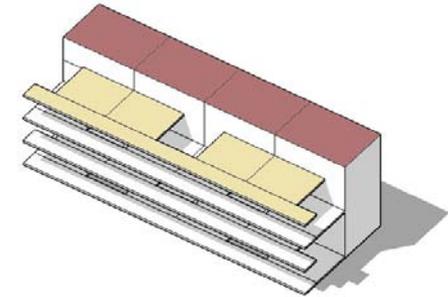
■ Unit
■ Circulation



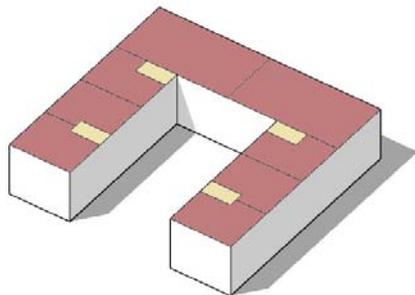
This 3-4 story walk-up has multiple circulation cores that allow units to have two full exposures for cross ventilation.



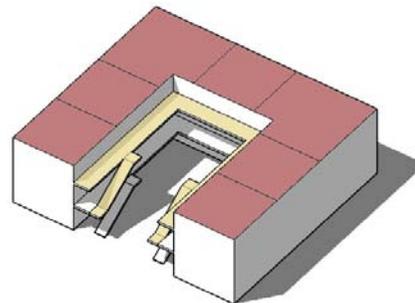
The motel style apartment building has an exterior hall along one side of the building which allows each unit to have two exposures.



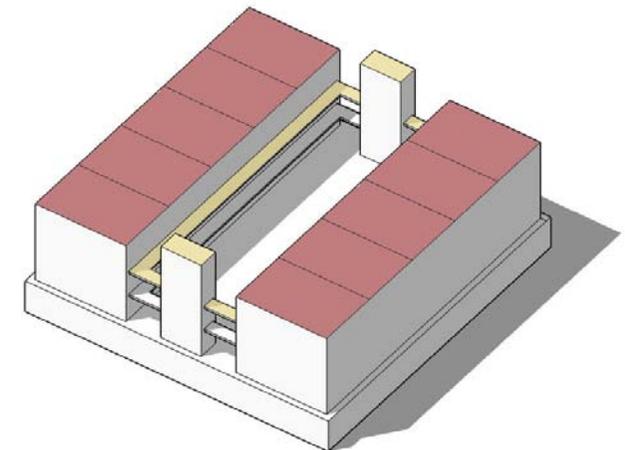
Bedok Court in Singapore is a multi-story building with exterior "yards" (patios) that separate the walkway from the unit, adding some privacy.



The courtyard building is 2-4 stories with multiple interior cores that allow each unit two exposures.

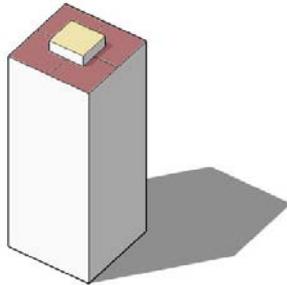


The courtyard motel type combines the courtyard and motel types to create more privacy than a motel type that front on the street.

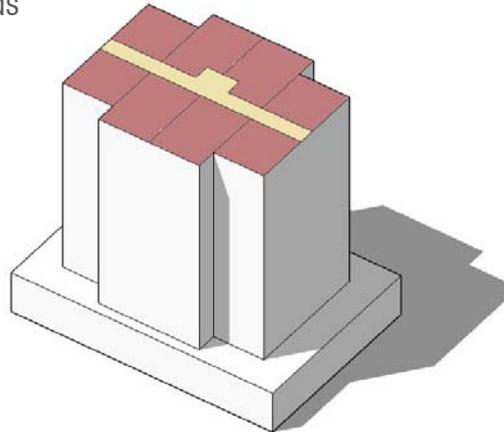


The raised courtyard creates a solid base at the street with public uses and raises the units above the street, adding more privacy while allowing two exposures for each unit.

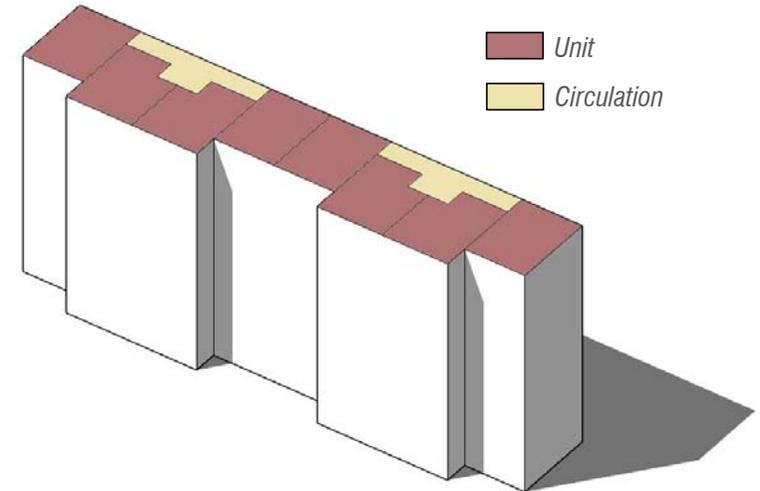
High rise buildings, illustrated here, are excellent for cross ventilation because of the unobstructed, higher velocity winds although at the expense of designing for micro-climates. High rise buildings must also be designed so as not to be overwhelming for the pedestrian.



The four unit can be any number of stories with a central core and each unit occupies a corner, allowing excellent cross ventilation to three of the four units.

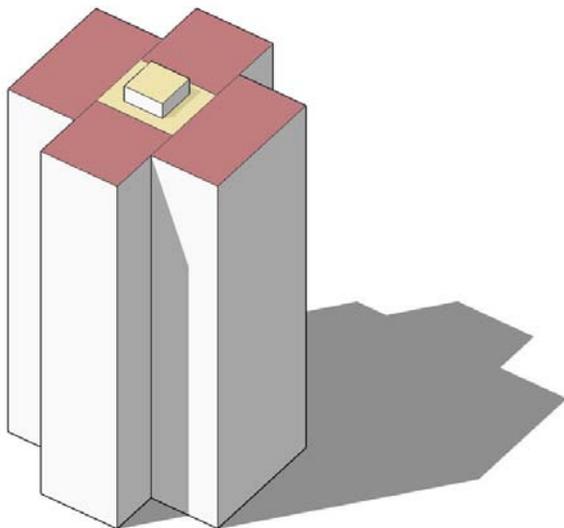


This eight unit type is double loaded with a central core but each unit has two exposures thanks to a bump out of the middle four units.

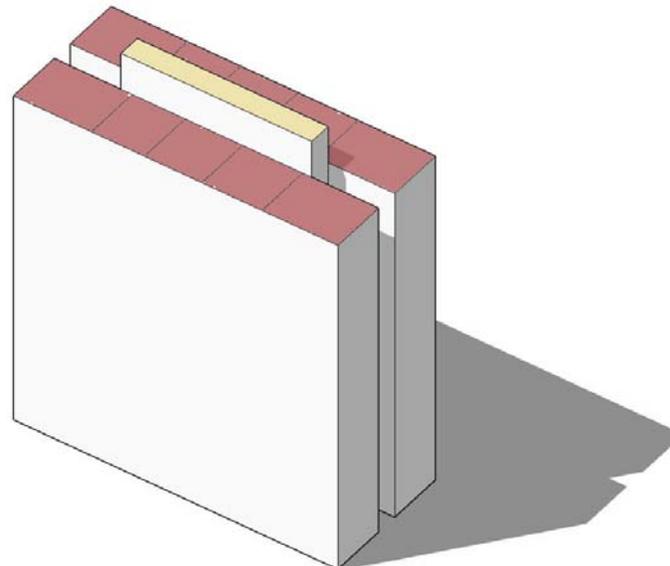


This single loaded high rise type has multiple cores allowing more units to have two full exposures while the bump out allows the other units better cross ventilation.

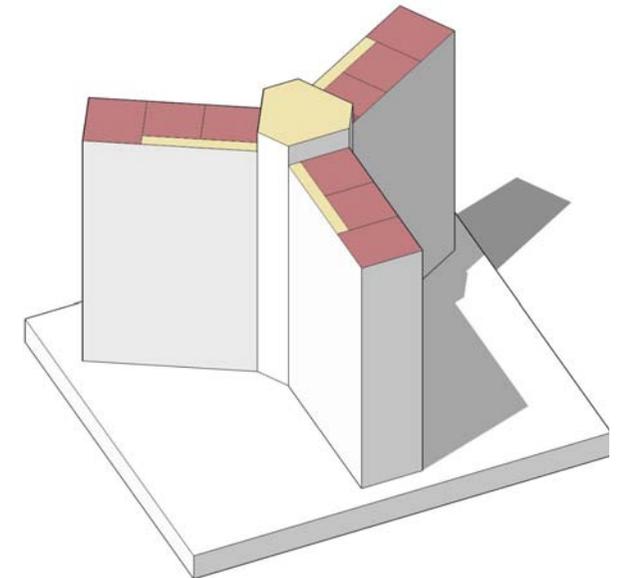
■ Unit
■ Circulation



The four unit high rise type allows three exposures for each unit increasing ventilation possibilities.



This double loaded high rise creates a third exposure for the end units and an atrium can be added to promote stack ventilation in the middle units.



This building type allows good wind access to all three wings of the building, but must be thoughtfully integrated into the urban design.

Representative Photos



Miami Beach, USA

- 6. Wide Streets
- 8. Wide Sidewalks
- 10. Short, Walkable Streets



Miami Beach, USA

- 1. Ventilation Corridors
- 6. Wide Streets
- 7. Shady Streets
- 9. Hierarchy of Streets



Miami Beach, USA

- 7. Shady Streets
- 8. Wide Sidewalks
- 14. Deep Overhangs



Miami Beach, USA

- 2. Interweave Buildings with Greens

Captions correspond to well executed techniques evident in the photos



Hanoi, Vietnam

- 2. Interweave Buildings with Greens
- 6. Wide Streets
- 7. Shady Streets
- 8. Wide Sidewalks



Hanoi, Vietnam

- 2. Interweave Buildings with Greens
- 7. Shady Streets
- 8. Wide Sidewalks
- 11. Outdoor Rooms



Hanoi, Vietnam

- 2. Interweave Buildings with Greens
- 6. Wide Streets
- 7. Shady Streets
- 8. Wide Sidewalks



Hanoi, Vietnam

- 2. Interweave Buildings with Greens
- 7. Shady Streets
- 8. Wide Sidewalks
- 11. Outdoor Rooms
- 14. Deep Overhangs

Captions correspond to well executed techniques evident in the photos



Sao Paulo, Brazil

7. Shady Streets

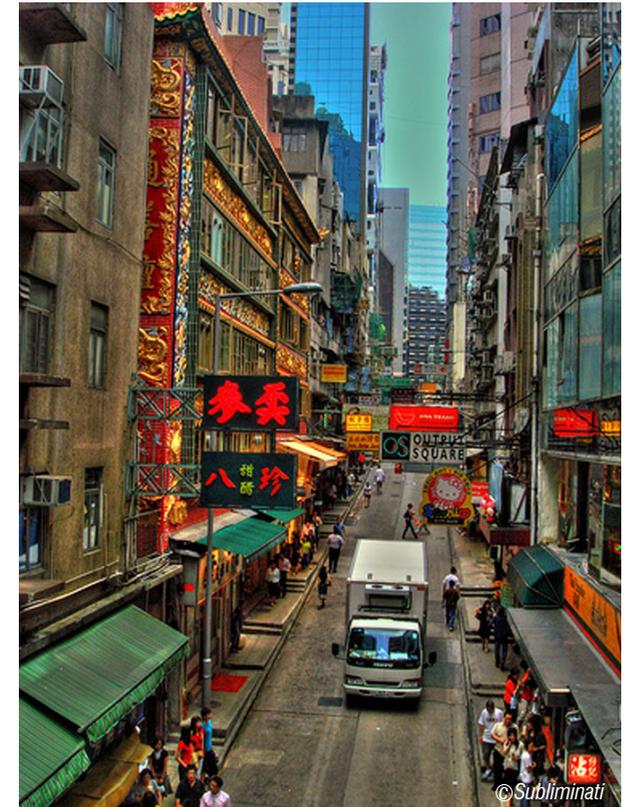
* Note the short crossing distance from curb to curb



Sao Paulo, Brazil

8. Wide Sidewalks

*Note the diversity of plant types and sizes



Hong Kong

14. Deep Overhangs

* Note how tall buildings and narrow streets create an urban canyon that reduces ventilation but can facilitate shading

Captions correspond to well executed techniques evident in the photos



Hong Kong

6. Wide Streets

*Note the mix of transportation options available on one street which can help combat the heat island effect



Teresina, Brazil

- 1. Ventilation Corridors
- 6. Wide Streets
- 7. Shady Streets
- 8. Wide Sidewalks



Teresina, Brazil

- 2. Interweave Buildings with Greens
- 6. Wide Streets
- 8. Wide Sidewalks



Singapore

- 1. Ventilation Corridors
- 2. Interweave Buildings with Greens

Captions correspond to well executed techniques evident in the photos



Singapore
8. Wide Sidewalks
11. Outdoor Rooms
12. Deep Overhangs



Singapore
11. Outdoor Rooms
12. Cool Courtyards
14. Deep Overhangs



Singapore
7. Shady Streets
10. Short, Walkable Streets
14. Deep Overhangs

*Note that the building extends to the curb but the sidewalk is under the arcade



Havana, Cuba
7. Shady Streets
8. Wide Sidewalks

Captions correspond to well executed techniques evident in the photos



Port Louis, Mauritius
2. Interweave Buildings with Greens



Limon, Costa Rica
2. Interweave Buildings with Greens
6. Wide Streets
14. Deep Overhangs



Nassau, Bahamas
2. Interweave Buildings with Greens
14. Deep Overhangs



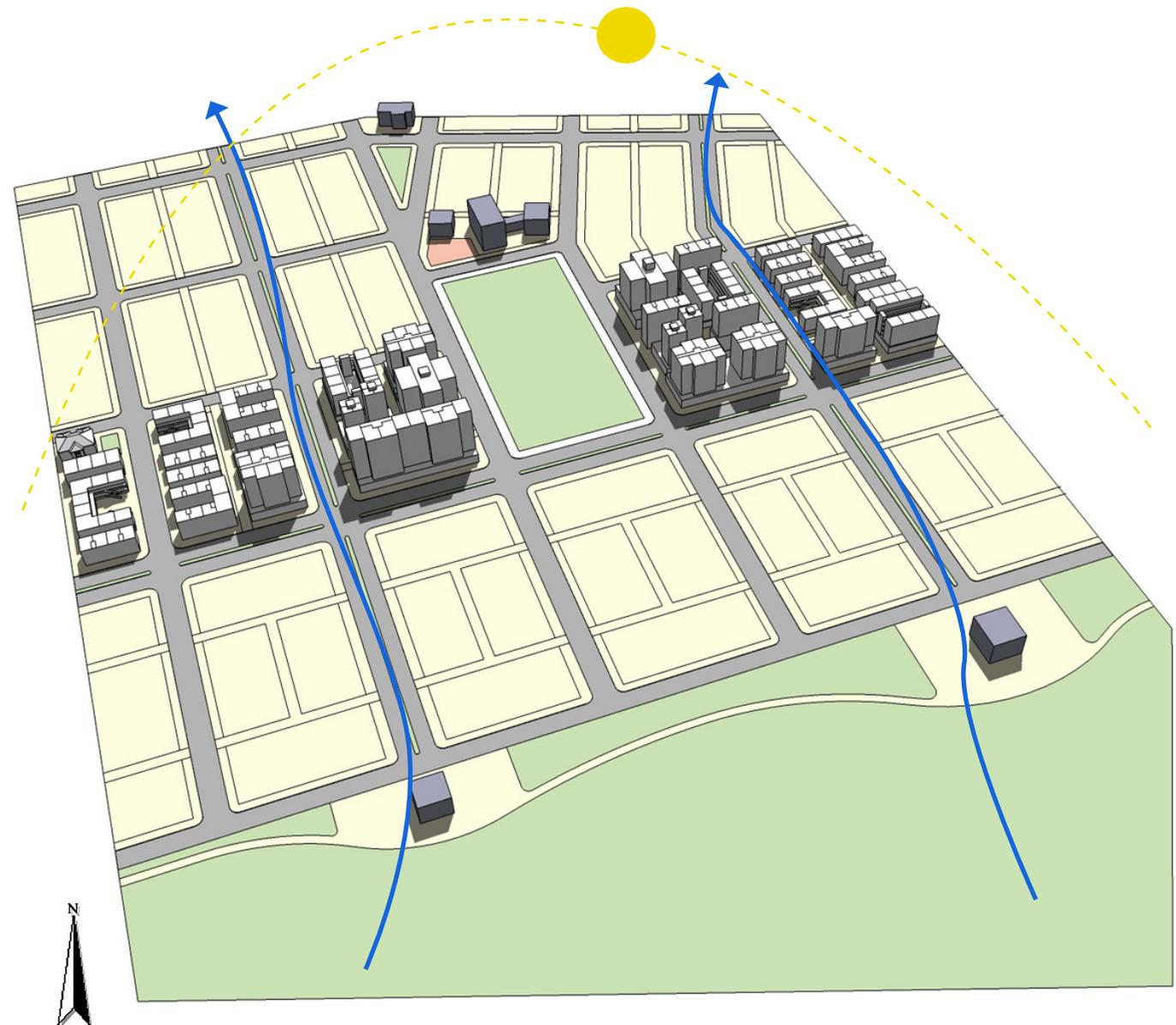
Nassau, Bahamas
6. Wide Streets
14. Deep Overhangs

Captions correspond to well executed techniques evident in the photos

Application

This diagram illustrates how the principles, techniques, and components can all work together to create a robust urban environment, which responds to the climate. The Transect-based planning shown here illustrates the highest density at the center with density decreasing away from the center. The blue buildings represent civic buildings, placed to be terminated vistas. This diagram assembles select components discussed earlier, in accordance with the techniques, which are listed here:

- 1. Ventilation Corridors** - wind brings cool air from the undeveloped land to the south up wide avenues
- 2. Interweave Buildings with Greens** - there are a number of greens at different scales
- 3. Block Orientation** - blocks are oriented so that buildings' short sides face east and west
- 4. Breezy Streets** - gridded network is rotated 20° from south for wind to move through city
- 5. Lot Disposition** - buildings are placed on lots so as to direct air flow
- 6. Wide Streets** - streets are designed with 1:1 ratios at the narrowest with taller buildings placed on wider streets
- 8. Wide Sidewalks** - sidewalks are 4.5 - 6 metres wide
- 9. Hierarchy of Streets** - streets operate in a clear network with four different street types
- 10. Short, Walkable Streets** - blocks are between 85 - 97 metres by 115-150 metres



At a closer scale, more techniques are evident:

7. Shady Streets - street trees, awnings, and colonnades provide shade for pedestrians

12. Cool Courtyards - courtyards are wide to allow wind access

13. Permeable Buildings - building types from “Urban Components” maximize ventilation in all units

14. Deep Overhangs - the north side of the buildings should have deep overhangs and all street level facades have overhangs providing shade

The application of these techniques must occur at all scales, including at the scale of the building, for an urban environment to be successful and comfortable. The thoughtful compilation of urban planning principles, climatic techniques, and urban components can and should lead to a healthy, sustainable, enjoyable, urban environment.



Conclusion

This document is an overview of sound urbanism and community building techniques in tropical climates. In many cases, what makes urban areas successful and beautiful are principles that apply all over the globe irrespective of climate; principles such as a network of streets, walkable neighbourhoods with a mix of uses and house types, parks and plazas for residents to enjoy, and well detailed and designed streets and buildings. But while these principles are applicable everywhere, there are a number of ways that urban areas should be designed specifically for a tropical wet and dry climate.

Sustainable urban areas are a collection of components that work together to create a robust system of pedestrian-oriented environments. The way in which the building sits on its lot and relates to the street, the width of the street and the way it is detailed, the lot size and block structure all work in concert to create these environments. Urban design can have a profound impact upon the usability of a building and can help to reduce the need for mechanical cooling in a tropical climate. By properly orienting streets, buildings can be sited to reduce their solar heat gain. By creating a wide network of streets, buildings have better access to stronger breezes that provide cross ventilation. All elements of the city, from the street network to the window awnings, combine to create comfortable environments, both physically and psychologically, in response to local climate.

Next Steps

Planning for sustainable communities in tropical climates requires a balanced combination of i- development planning and ii- building techniques, in order to effectively mitigate the impacts of heat and humidity on human comfort and productivity. Development planning should encompass the physical design of new neighborhoods and communities, as well as the ongoing evolution/redevelopment of existing ones, within a rational regional framework, and building techniques should encompass and address the architectural methods and construction codes applied to the structures within these developments.

To be most effective, the physical design of communities, and the architecture of the buildings in them, must reinforce one another to measurably reduce the amount of energy required to maintain the daily processes and activities essential to life in urban areas. The sustainable tropical city is one that considers the relative value of regionally-scaled design strategies and locally-scaled building designs. As this Design Guide illustrates and confirms, the most significant impacts on tropical sustainability (either positive or negative) come first from the urban plan and second by the architecture that reinforces these impacts.

As outlined within this document, that means ensuring that the basic neighborhood structure:

- Is configured to support mixed-use, in a compact, walkable, and robust street network
- Has the ability to accommodate alternative transportation modes, such as bicycles and transit
- Provides for community and civic institutions and amenities, such as public parks and playgrounds, libraries and post-offices, etc., to be conveniently located within the community fabric, and
- Has a fundamental layout, orientation, composition, and scale of the street and block structure is consistent with the underlying principles of climate-sensitive design for the region and climate in which the project or community is intended to be built.

The “next steps” for the City of Cairns to ensure the proper outcome involve three strategies:

1- Explore and document existing precedents, both urban and architectural:

Traditional forms of community development often demonstrate the most effective examples of how to respond to climatic considerations through urban form, including wide streets and parks, or other open spaces, evenly distributed throughout the urban fabric to facilitate air movement and to reduce the heat island effect. Or, streets aligned to allow and encourage building orientations which maximize the potential for cross-ventilation, while minimizing low-altitude solar heat gain (early

Traditional building types and styles often pre-date mechanical cooling and ventilation, and were typically designed and sited to maximize the cooling effects of prevailing winds, while minimizing heat gain through the use of appropriate building materials, shading devices, landscaping, etc. Well designed newer buildings are often designed to work with both natural and mechanical climate moderating techniques, and optimize around the specific attributes of both. For instance, they use mechanical cooling during times in which it is very difficult to achieve optimal psychrometrics standards solely through the reliance on natural air circulation, but they still employ specific techniques to reduce thermal heat gain through the use of shading devices, natural lighting, enhanced insulation and solar reflectivity, etc.

2- Analyze existing Building and Zoning Codes for unintended impediments to realizing Tropical Design standards:

Existing building codes may complicate the implementation of Tropical Design Standards by pursuing single-minded objectives at the expense of more climate-sensitive building and design strategies. For instance, wind-load design criteria, without an accompanying shading quotient, may discourage the use of brise-soleil, awnings, or other such sun control devices, by only considering one aspect of climatic design considerations, cyclonic events, without considering the broader, and more continuous, implications of solar heat loading. Building materials, designed to minimize maintenance concerns in the harsh tropical climate, may preclude the use of more organic materials, such as painted wood, which may have thermal characteristics more conducive to climate-sensitive design.

To help ensure that a full palette of tools and techniques, supportive of climate-sensitive tropical design, are available to local builders and architects, existing building codes should be carefully evaluated relative to the strategies identified in this document, to help identify and modify any code requirements that may be working at cross-purposed to this objective.

3- Initiate Changes to existing Zoning and Building Codes to facilitate climate-sensitive community development outcomes:

Develop form-based codes (FBCs) and design guidelines which encourage and enable desirable outcomes, as a matter of policy. Such codes should be based upon the proven and documented strategies outlined in this document, and should represent a balanced and comprehensive understanding and appreciation of the role of both urban form and community settlement patterns, as well as architectural massing and form (typologies), and building technologies, to achieve a more consistently sustainable form of development, that minimizes the consumption of natural resources, and the output of greenhouse gas emissions, while allowing for a comfortable and productive human habitat.

The plan on the following page illustrates the climatic “opportunities and challenges” at Mount Peter. Proper application of the techniques and principles presented herein can provide for cost effective and sustainable community development outcomes across the study area. A detailed analysis of the existing micro-climate will need to be undertaken to validate the initial findings and assumptions depicted on the plan to insure these outcomes.

Structure Planning: Tropical Design Principles

