A Tropical Grammar:
An Architectural Grammar for Hot Humid Climates

by

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Submitted to the Department of Architecture
in Partial Fulfillment of the Requirements for the Degree
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ABSTRACT

This thesis considers the viability of an architectural grammar based on traditional Caribbean architecture as an aid to designing climatically responsive architecture in hot humid climates.

It argues that since traditional Caribbean architecture is a successful response to the constraints of climate and resources, a grammar based on this architecture would produce designs with similar characteristics and therefore would still be relevant today. The purpose of focusing on the relationship between architectural form and energy use is to help designers understand the consequences of basic design decisions and to help them to use these issues positively to generate form.

In order to investigate this issue, a number of questions were addressed in the thesis. They were: What are shape grammars? What is appropriate design in hot humid climates? What is traditional Caribbean architecture and is it climatically appropriate? What would a tropical grammar look like and what would it produce? and How could it be used practically? A grammar was formulated based on a set of 16 traditional Caribbean houses and as a test, two new designs were generated.

Shape grammars, in their most basic form, are essentially a set of rules that if followed, will generate designs in the same family as the original set. Typically, they are used to study a particular architect's style or occasionally a building style.

This thesis states that shape grammars have two serious limitations which reduce their usefulness to designers. The first is that shape grammars focus only on physical form and the second is that they do not increase the user's understanding of the reasons for the grammar rules.

However, it was found that, in contrast, the process of developing or formulating a grammar (as opposed to using one) was exceptionally useful for developing a deep understanding of the architectural style or type.

The thesis concludes that architectural grammars can be a very useful and accessible tool for designers: 1. if they are able to go beyond physical form to include other architectural issues and knowledge; 2. if means are developed for presenting grammars which allow users to understand the rules, and not simply follow them; and 3. if methods are developed for analyzing and evaluating the designs that are generated by the grammar.

It also concludes that a grammar is a useful tool to familiarize designers with the most successful characteristics of traditional architectural vocabulary. The purpose of this type of grammar is not to copy or duplicate a style, but to learn from its practical solutions in order to create new combinations of form that would be appropriate to the conditions found today.

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4. A Tropical Grammar .................................................................... 83
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This thesis investigates the use of an architectural grammar based on traditional Caribbean architecture as an aid to designing appropriate architecture in hot humid climates.

This investigation attempts to bring together three interests that I have: tropical architecture that responds gracefully to its climate, tools for designing, and shape grammars.

I have long been interested in how buildings can respond to a climate. Having lived for a number of years in uncomfortably hot humid climates where the energy supply was unreliable and resources were limited, I became very much aware of the need for low-cost buildings that were comfortable in high temperature and high humidity and that did not rely on air conditioning systems. During these years, my admiration for the elegant solutions offered by traditional architecture in these regions grew and it became clear that they offered important lessons to the contemporary designer.

My second interest lay in how designers, especially those in developing countries, could be provided with tools to aid them in designing low-cost appropriate buildings that meet local needs. Unfortunately, it is not uncommon for architects (both foreign and national) who have been trained in northern countries to have difficulty adapting what they had learned to the radically different circumstances in developing countries. Designs that would have been perfectly adequate in another setting become expensive uncomfortable burdens to the occupants.

Shape grammars are a more recent interest. I understood what they were, but their practical purpose was unclear. I became interested in the question of how, or if, a shape grammar could be used to familiarize designers with the best characteristics of traditional architectural vocabulary that had been developed over the years for responding to hot humid climates. The intention was not to copy or duplicate this architecture but to learn from it in order to create new combinations of form that might be appropriate to the conditions found today.

In order to answer the question of whether an architectural grammar could be used as an aid to designers, a number of questions were considered. Each of the chapters focuses on the five following questions:
• What are shape grammars?
• What is appropriate design in hot humid climates?
• What is traditional Caribbean architecture and is it climatically appropriate?
• What would a tropical grammar look like and what would it produce? and
• How could it be used practically?

The first chapter reviews shape grammars. It describes what they are, their purpose and history, gives examples of grammars that have been developed in the past 15 years, explains the process of formulating a grammar, the role of computers, and the use of grammars in education and reviews the criticism of shape grammars.

The second chapter gives a brief review of the study of tropical architecture, characteristics of a hot humid climate, the concept of comfort and how it's quantified, and the design strategies or established architectural rules-of-thumb that have been developed for dealing with hot humid climates.

The third chapter looks at traditional domestic Caribbean architecture - its influences and similarities to other architecture in other parts of the world, house types, and a description of its characteristics. It demonstrates how the traditional house meets the climatic requirements of the region by comparing the design strategies described in the previous chapter with the characteristics of the traditional Caribbean house.

In the fourth chapter, an architectural grammar is formulated, based on a set of 16 houses (11 frame houses, 2 shop/townhouses, and 3 townhouses) found in the Caribbean. Though located in the Caribbean, these buildings are similar to other houses found in other parts of the world. The grammar rules are listed as well as the reasoning behind them. Finally, to test the grammar, two new designs are generated, using the grammar rules.

The final chapter looks at the practicality of using grammars as an aid for design - both its limitations and potential. It looks at some existing examples, the advantages and disadvantages of various media and suggests some ways of presenting grammars to enhance their usefulness.

The final chapter also makes some conclusions on grammars and their usefulness to the design process. It emphasizes that
grammars can be a useful tool if they are able to go beyond physical form to include other architectural issues and if they are presented in a form that makes them accessible and easy to use in daily practice.
1 SHAPE GRAMMARS

- Description
- Why shape grammars?
- History
- Examples
- Process of Developing a Shape Grammar
- Role of the Computer
- Use of Shape Grammars in Education
- Criticism of Shape Grammars
- Chapter Bibliography
Description

Grammars

A grammar is simply a set of rules for making useful arrangements from a set of elements. The results are usually two- or three-dimensional and can represent buildings, components, subsystems or other objects. A grammar may contain many or very few rules.

Grammars are based on the analogy between design and language. It is based on the premise that the process of designing a building is similar to the construction of a sentence, that is, architectural elements make up a vocabulary and can be put together according to certain rules of grammar. For example, not every combination of words would be considered a sentence; only those combinations of words that obey the rules of the language's grammar would be considered a sentence.

Several types of grammars have been developed. The most common is the shape grammar which produces geometric forms or shapes that can represent objects and are possible to talk about in functional terms. They have been used to describe and understand a wide range of architectural types or styles. Because a shape grammar defines a set of shapes, it is most successful with geometric forms.

Related closely to shape grammars are artifact grammars which “make the functions of components and subsystems explicit and derive functionally interpreted designs”. (Mitchell, 1992b) Rather than generating geometric shapes, artifact grammars produce designs that “contain knowledge of things work, how they can be assembled and how they can be used”. (Mitchell, 1992b) A practical architectural vocabulary would consist of realistically obtainable types of elements. In the simplest case, it might be the closed and limited kit of parts offered by a Froebel or Lego set, or the repertoire of an old-fashioned industrialized component building system. (Mitchell, 1992a)

Other types include color grammars, and structure grammars and relational grammars.

Types of Rules

There are three basic types of rules found in grammars:
1. **Simple Prescriptive Rules:** The simplest type is to show examples of "correct" and "incorrect" solutions or designs. Another approach is to give general prescriptive "should" or "must" rules.

2. **Replacement Rules:** Another approach is to give replacement rules, that is, options are given during the design process. For example, for a design for a clock tower, one can choose option A, option B, or option C.

3. **Recursive Rules:** The third type are recursive rules or replacement rules that are applied repeatedly. In this way, a very simple rule can produce a very large number of design possibilities.

### Approaches to Shape Grammars (Decision-making)

Designs are generated in shape grammar by applying rules to some initial shape. At any stage of the design generation, choices or decisions are made and the final design is a result of a particular series of decisions or choices made during the process.

There are two basic approaches to decision-making in shape grammars: top-down and bottom-up.

Top-down shape grammars start with abstract concepts that are broken down into a series of sub-problems which are then individually solved. Each stage of the design is broken into another level of sub-problems. For example, a top-down architectural grammar would start with an overall size and organizing grid and work down to room layout, entrances, and finally down to the details of walls, columns, doors, windows and exterior ornamentation.

A bottom-up grammar would work in the opposite direction, starting with the details and working into more abstract general concepts.
Both strategies have their advantages and disadvantages. In top-down design, sub-problems and therefore their solutions are limited by the previous decision. It may become necessary to move back up the framework and readjust the decisions at a higher level so that the subproblems at a lower level are redefined. In bottom-up design, the sub-problems are defined by the assembly of previous elements. It may at some point be impossible to combine the pieces to reach the desired result which may require moving back down to a lower level and reassembling elements in a different way. In reality, most grammars are neither top-down nor bottom-up, but are a combination of the two, permitting the designer to move up and down levels in both directions, exploring possibilities, as needed.

- Generation and Testing

A grammar that generates designs is made up of two mechanisms:

1. The generation mechanism. This consists of the elements, rules for how the elements are to be put together, and a control strategy for deciding what alternative to try next, and

2. A test mechanism. This tests if the rules have been followed correctly and the results meet the desired criteria.

Either or both the generation and testing can be done by computer program.

The intelligence or critical ability of the grammar can lie either in the generation or the test mechanism. If the generation mechanism is set up so that the results will always be what is desired, then the test mechanism will have little to do. In other words, it will get it right the first time. If, on the other hand, the critical ability lies in the test mechanism, the grammar can generate endless possibilities and the test mechanism evaluates and chooses the most acceptable ones according to its criteria.

Why Shape Grammars?

The primary purpose of any type of grammar is to increase our understanding of design. It is based on the belief that the more accurately or explicitly an object or system can be described, the better it will be understood and consequently, the better the discussion can be about that design. Simply describing an architectural style or type and showing a few examples does not promote understanding in the same way. It is claimed that full understanding can only occur when one can give rules to construct new instances of the style or type. (Stiny, Mitchell, 1980)

A well-formulated grammar describes architectural knowledge that is useful and practical and is put in a form that allows it to be applied in new situations (different sites, client requirements, and budgets). The grammar allows designers to generate new designs and it should indicate whether the new design will work and if it can be built. (Mitchell, 1992a).

Shape grammars are based on the view that design is a problem-solving activity that involves the process of generating a set of possible solutions and choosing the most acceptable one from that set. Therefore, in order to choose the best solution, it would be desirable to be able to specify all the known design possibilities. To specify this set of design possibilities or elements, one could:

1. catalogue all the possible elements in the set;
2. present one possible element and transform it to produce the other elements,
3. provide a computer program for generating all the elements of the set, or
4. provide a grammar for generating the elements of the set. (Gips, Stiny 1980)

Shape grammars are also based on the premise that architects already use a type of informal shape grammar when they design and that a shape grammar simply makes their method more explicit. They are said to have an architectural language or style because of their knowledge of shapes and materials and how to use them. This language can evolve as the architect learns to make use of new elements or new ways of using known elements. (Mitchell, 1990, Logic)

Using the rules of a shape grammar to construct designs are believed to have several advantages:
1. A few simple rules can be used to construct a multiplicity of complicated designs.
2. Rules open up new avenues or directions for design with a given vocabulary.
3. In order to define rules that can be used in shape grammars, ideas and knowledge about possibilities for design must be represented in an explicit and detailed way which gives a greater command of the language of design.
4. Rules shift the emphasis in design away from the individual to the language of design and allows the designer to use past experience in new situations.
5. Rules can be modified to define new languages of designs that reflect changing circumstances or incorporate new ideas. (Stiny, 1980b)

(Gips, Stiny 1980), (Hersey, 1992), (Knight, 1980), (Knight, 1990), (Koning, Eizenberg, 1981), (Mackenzie, 1989), (Mitchell, 1990), (Mitchell, 1992a), (Stiny, 1980b), (Stiny, Mitchell, 1980)

History

The point that many authors emphasize about shape grammars is that the idea is not new. The name may be relatively new – dating from the late 1970s – but the idea that plans, facades and designs can be generated from recipes, rules, prescriptions, or instructions have been circulating in the architectural world for hundreds of years.

Vitruvius, was one of the first to describe how to design a building. Palladio, Le Corbusier, Frank Lloyd Wright, and Christopher Alexander are all considered “paradigmatic” architects and architectural historians and theorists have long used the ideas of “language”, “vocabulary” and “syntax” to describe design. (Mitchell, 1992a)

Furniture design in the eighteenth century was based on guidebooks or catalogues published by the more prominent cabinet makers for the purpose of providing other cabinet makers with a wide variety of models on which to base their own designs. These catalogues were based on the belief that creativity is expressed by new elaboration on a given paradigm within a language, and not by innovation of new paradigms or novelty. Good design therefore was a reflection of the designer’s ability
to understand the language and to develop its potential in a refined way. (Knight, 1980)

Others thought that model designs could be useful for the non-designer as well as the designer. James Gibbs in his A Book of Architecture (a good example of replacement rules) stated that the book was written because he thought that ...

"...such a Work as this would be of use to such Gentlemen as might be concerned in Building, especially in the remote parts of the Country, where little or no assistance for Designs can be procured. Such may be here furnished with Draughts of useful and convenient Buildings and proper Ornaments; which may be executed by any Workman who understands Lines, either as here Defined, or with some Alteration, which may be easily made by a person of Judgment". (Gibbs, 1728)

(Gibbs, 1728), (Knight, 1980), (Mitchell, 1992a)

Examples

A number of grammars have been developed in the past 15 years, but by far the most common are shape grammars. Though shape grammars are considered to be most successful with geometric form because of their ability to generate shapes, they have also been successful with architecture because the shapes that are generated are interpreted as rooms, volumes and buildings. They have been used to analyze a variety of designs, including Hepplewhite chair backs, (Knight, 1980), Frank Lloyd Wright prairie houses (Koning, Eizenberg, 1981), Palladio villas (Hersey, 1992, Stiny, Mitchell, 1978a,b,c, Mitchell, 1990), Mughul gardens (Stiny, Mitchell, 1980), and Queen Anne Houses (Flemming, 1987).

Architectural grammars usually are developed to:
1. analyze styles or types of design, and
2. explore and generate completely new styles or types of design.
Though most authors stress the importance of the ability to generate new styles of types of designs, much of the work done to date has focused on the analysis of historic or contemporary styles.

Plates 79-80- Summer houses “in form of Temples” (Gibbs, 1728)
Figure 18. Rules to generate roofs. Queen Anne houses (Flemming, 1987)

Figure 1. Three Hepplewhite-style shield-back chairs attributed to Samuel McIntyre. Hepplewhite chairs (Knight, 1980)

Figure 23. A new Hepplewhite-style chair.
There are 6 stages to developing an architectural shape grammar.

1. The Corpus: The first step is to identify a corpus or a finite set of buildings from which the vocabulary will be derived. This corpus can be small or large but the choice of buildings in this set will influence the grammar - that is, a different set of buildings will produce a different vocabulary. This corpus could be a group of buildings by a particular architect such as the prairie houses of Frank Lloyd Wright (Koning, Eizenberg, 1981) or a type such as Queen Anne houses (Flemming, 1987).

2. Vocabulary: The next stage is to analyze and study the corpus and specify a vocabulary or elements of two or three-dimensional forms that make up the corpus. These elements are considered the building blocks for future designs. (Knight, 1990) (Stiny, 1980b)

3. Spatial Relations: Once the elements are identified, the
relationships between the elements or how they are combined are determined.

4. Rules: The next stage is to write the “rules” that specify how the elements can be arranged in a design.

Frank Lloyd Wright's Prairie Houses (Koning, Eizenberg, 1980)
5. Initial Shape: The initial shape is formed. The shape rules will be applied to this initial shape to construct designs. Another way of approaching the “initial shape” is to consider it as the starting point in the design - or in other words, where one starts in the design process. The initial shape can be a room (Flemming, 1987) or an element such as a fireplace (Koning, Eizenberg, 1981).

6. Shape Grammar: The initial shape, rules and vocabulary are combined together to define a language of design. This grammar represents a hierarchy or path of decisions that are made through the design process. One starts with the initial shape, applies the rules and obtains a design in the style defined by the grammar. With a grammar, one could reproduce one of the original buildings in the corpus or produce another one that would be completely different, but of the same family.

(Flemming, 1987), (Knight, 1990), (Koning, Eizenberg, 1981), (Mackenzie, 1989), (Stiny, 1980b)

Role of the Computer

To some, the use of computers is synonymous with shape grammars, but though they can be useful in some circumstances, they are not essential.

Computers are used because of their ability to calculate a huge number of permutations and combinations based on a set of rules. Because of a computer’s speed and thoroughness, some believe that a computer can apply rules, generate designs, and test them better than an unaided human being. (Hersey, 1992) Though many see the computer as a useful tool for generating the set of possible solutions, there are only very few who see the designs that are generated by a computer as a more “dependable” source of new designs. Even fewer feel that computer-generated designs are superior because the designer would no longer need to rely on “creative inspiration”, the “inventive flash”, or “individual genius”. (Stiny, 1980b).

A computer can undoubtedly produce an exhaustive list of possible designs far faster than a person ever could. However, if one considers it from an educational point of view, this may not be positive and could even be at odds with learning. In some circumstances, it could be preferable to not use computers and instead have the person apply the rules, generate, and test the
designs by hand.

Rather than an either-or situation, more interesting possibilities occur in combining computers and humans. Because a shape grammar is made up of both generative and testing rules, a computer could generate the designs by mechanically applying all the rules while a human inspects and tests the machine’s proposals. Or, a person could generate alternative designs, and a computer tests and evaluates the design. In a completely automated design process the computer would both generate and evaluate. In a completely manual system, the human would both generate and evaluate. (Mitchell, 1990)

(Hersey, 1992), (Mitchell, 1990), (Stiny, 1980b)

Use of Shape Grammars in Education

The most famous shape grammar, designed by Frederick Froebel, a nineteenth century educator, is well known to architects and designers because of its influence on Frank Lloyd Wright who was trained in this method as a child.

The method was based on a set of building blocks or “gifts”. The child plays with the blocks and is expected to design new forms

Figure 1. Froebel’s building gifts.

Froebel’s building gifts (Stiny, 1980b)
through trial-and-error. Success is measured by the child’s ability to discover new ways of putting the blocks together. The intention was to allow the child to learn to solve design problems by discovering the blocks’ properties and possibilities. (Stiny, 1980b).

More recently, George Stiny developed a program based on the Froebel blocks. This program has since been revised and expanded into a series of design exercises and is being used in the Design Theory and Methods area of the Architecture and Urban Design Program at UCLA. One part of the program is made up of exercises for developing shape grammars and the other for developing color grammars. (Knight, 1990)

They have found that the most exciting aspect of the exercises is that using simple shapes, design and coloring can be explored in a systematic and straightforward way. They also found that the designs generated in these exercises would not likely have been imagined using the conventional trial-and-error method. (Knight, 1990)

(Criticism of ShapeGrammars)

Shape grammars have their critics but much of the criticism seems to stem from a misunderstanding of their purpose and an overestimation of what they can do. Though shape grammars are meant to be an aid to designers, they are seen by some as a threat.

Much of the criticism is rooted in a fear that shape grammars are intended to replace architects and designers in the design process. Some see it in futuristic or “Brave New World” terms where one pushes a button and a machine mindlessly produces a final product with no human interaction and without proper consideration of site, user needs, or experiential concerns. Others fear that shape grammars take the “mystery” out of the creative process and consequently devalues the skill of the architect. Taken to the extreme, it is the fear that if the design process is made too explicit, then anyone could design and the role of the architect would disappear. Still others believe that good design must be completely novel and original and any design that is
based on established rules must therefore be suspect, a copy, uncreative and intrinsically poor design. And finally, some of the criticism of shape grammar is the disagreement with the analogy of shape grammars with language.

Though most of these particular fears are based on a misunderstanding of a shape grammar’s intention and ability, shape grammars do have their limitations and do not always live up to their promises. In order to take advantage of grammars in understanding architecture, it is useful to also understand their drawbacks.

- **Shape grammar vs. architectural grammar.** Shape grammars can be very limiting and somewhat dangerous when they look at architecture solely as a set of lines and shapes, completely ignoring some of the most important aspects of architecture, that is, of how the building is experienced by the user. Pure shape grammars focus strictly on form and ignore color, sensations, sound, and how it feels to move in and about a building. (Mitchell, 1990)

Though the ability to manipulate shape and physical form is absolutely essential in architecture, it is not everything. Those who focus grammars only on this one aspect ignore its potential for other areas. Rather than shape grammars, a more helpful tool for architects and designers would be an architectural grammar that would combine shape, form, color, function, structure, light, energy, budget, culture, social sciences, construction, materials and all the other considerations that go into a design of a building.

- **Impracticality for the Designer.** From a practical point of view, many of the shape grammars overemphasize the mathematical and programming aspect that is necessary for creating a flawless grammar. Unfortunately, when this happens, these rules become extremely difficult for the uninitiated to read and use. The rules must in rigorous but in the process they must not be made incomprehensible and thereby negating the original purpose of a grammar.

- **Rigid, Mechanistic and Unambiguous.** Shape grammars are sometimes described as overly rigid, mechanistic and lacking in ambiguity. This is considered by many to be a drawback because in real life architectural design is more often a complex process where rules must change as the design process unfolds.
• Process vs. Product. If the primary purpose of any grammar is to increase our understanding of design, it must be judged on those terms. Looking at the results of others’ shape grammars as well as creating one myself, it has become increasingly clear that from an educational point of view, the process of creating a shape grammar is far more beneficial than using a grammar that has been created by someone else. It is the process of formulating a grammar that one gains the deepest understanding of an architectural form.

The most serious flaw from a practical point of view is that when presented with the rules created by another person, the understanding of why the rules are that way are not explicit. One can follow the rules and manually rearrange the form but one’s understanding of the reason why one arrangement may be better than the other is not enhanced.

(Fleisher, 1992), (Mitchell, 1990)

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THE HOT HUMID CLIMATE

- History of "Tropical Architecture"
- Characteristics of a Hot Humid Climate
- Climatic Elements
- Selection of Materials
- Comfort
- Design Strategies
- Chapter Bibliography
The purpose of this chapter is to give a brief review of the climatic context of the grammar. It looks at the characteristics of the hot humid climate and the appropriate design strategies, suggested by the literature, that can be taken to cope with the climate.

**History of “Tropical Architecture”**

The first book on how to design buildings in the tropics, written in 1776 by a M. d’Albaret, described how buildings should be adapted in the West Indies. Interestingly, M. d’Albaret had never been to a tropical country himself and seemed to only be aware of the physical danger of earthquakes; no consideration was given to the comfort of the occupants in the design.

After this book, there is no record of any literature written on the subject of architectural design in tropical countries for another hundred years.

It was not until the 20th century that interest developed in adapting architectural solutions for tropical conditions. In 1931 the International Congress of Urbanism took place in Paris which was the first recorded gathering to discuss the problems of urbanism in the colonies in tropical regions.

During the 1940s, more bibliographical entries are found. These discuss both architecture in general in the tropics and specific problems faced by architects. Apparently in December 1941, the term “tropical architecture” was used for the first time in an article in *Pencil Points*. During this period, particular attention was given to adapting buildings to tropical conditions through environmental study and by observing “practical and ingenious means devised by permanent inhabitants throughout the region”. During this period, research involving construction materials for the tropics also began.

During the 1950s research and publications on the topic increased and in the 1960s the output increased even further. However, during the 1970s and even more so during the 1980s, there was a rapid decline in the number of books published.

Architectural historians mainly attribute the interest in tropical architecture to the development of colonialism in tropical regions since a large segment of England’s, Portugal’s, Spain’s and
France's colonial territories were in the tropics. Some claim that interest grew in this topic because Europeans had difficulty adapting to life there and the first step taken to overcome these difficult conditions consisted of "tropicalizing" European architectural styles.

(Rivera de Figueroa, 1980)

Characteristics of a Hot Humid Climate

"The tropics" is a geographic term and refers to a wide belt around the middle of the earth, between the Tropic of Cancer and the Tropic of Capricorn. This area contains nearly 40% of the total land surface of the earth.

Broadly speaking there are 2 basic types of tropical climates:

1. hot and humid; and
2. hot and dry.

Only the hot and humid climate will be addressed in this chapter and thesis.

Temperatures: Hot and humid climates have a temperature range from 64°F to 100°F (18-38°C) but temperatures are usually somewhere between 82°F and 86°F (28°C – 30°C). Vapor pressure is very high.

There is usually no great temperature difference between the seasons and night temperatures are close to daytime temperatures. The rainy season is very warm to hot and humid with nights as uncomfortable as the days.

Humidity: Humidity is high during most of the year and can vary from 55% to 100%; 75% is average.

Precipitation: Precipitation is quite high and can vary from 49” to 197” (1250 – 5000 mm). Some regions have little or no rain during the dry season and tropical downpours are common.

Sky condition: Some regions are fairly cloudy and hazy throughout the year while other areas have clear skies and bright sun more frequently. Sky glare is high.
Other: The high temperatures and high humidity encourage mosquitoes and other insects, the growth of fungi, rusting and rotting. Termites are common. Severe corrosion can occur in coastal areas due to the high salt content of the air. Hurricanes are also a serious seasonal hazard in some regions.

Consequences on design: A climate with these characteristics means that buildings and humans need protection from the rain and sun, but because of high humidity, air movement is important to help dry sweating skin and relieve discomfort.

All the literature stresses the importance of checking climatic data carefully in the specific area where the building will be located. They emphasize that a designer must be aware not only of the averages and range of the climate, but also the extremes.

(Atkinson, 1950), (Atkinson, 1960), (Fry, Drew, 1982), (Koenigsberger, 1973), (Konya, 1980), (Kukreja, 1978), (Rannells, 1952)

Climatic Elements

There are five meteorological or climatic elements that need to be considered and understood by the designer: 1. solar radiation, 2. air temperature, 3. wind, 4. humidity, and 5. precipitation. With an understanding of these elements, the designer can design a building that is able to counteract at least some of the least pleasant characteristics of the climate and use its benefits to the best advantage.

- Solar radiation

There are three ways in which energy can be transferred from one point to another: 1. radiation, 2. conduction, and 3. convection.

Conduction and convection are relatively slow but radiation is acts quickly and has the most effect on buildings.

Buildings receive heat directly from the sun and sky, and from reflected heat from the ground. The intensity of the solar radiation depends on the altitude of the sun and the amount of water vapor, dust and pollutants in the air.

The interior of a building is affected by the radiation when it enters windows and is absorbed by the internal surfaces and when it is absorbed by the outside surface, conducted through
Air temperature
Air temperature is determined mainly by the heating and cooling of the earth's surface. It is important for the designer to consider not only the mean maximum temperatures but also the monthly mean minimum which can give an indication of the day and night variations.

Wind
Wind is measured by its direction, speed, gustiness and frequency of calms. The direction of the wind always refers to the direction from which the wind is coming. The designer must determine the direction, speed and the daily and seasonal shifts of the prevailing winds.

Because the wind affects ventilation, it can be used for cooling, but the wind can also cause driving rain.

Atmospheric humidity
The term atmospheric humidity refers to the water vapor content of the atmosphere. For any given temperature, there is a limit to the amount of water that can be held as vapor and its capacity increases with temperature.

Precipitation
Precipitation occurs when moist air rises and cools, causing condensation and forming clouds. As the air continues to rise (and cool) the droplets form together and they fall as rain, snow, sleet, or hail.

It is important for the designer to not only know the total rainfall for each month but also the maximum amount for any 24-hour period in order to ensure adequate drainage from roofs and paved areas.

Selection of Materials
The amount of heat entering a building depends largely on the wall and roof materials. The characteristics of the materials that most effect the comfort of the occupants are:
2. THE HOT HUMID CLIMATE

- absorptivity/emissivity,
- insulation value, and
- thermal capacity.

**Absorptivity/emissivity:** Radiation that strikes a surface can either be absorbed by the material or reflected away from it. Absorptivity refers to the ability of the material to absorb heat and emissivity refers to its ability to reflect the radiation.

Darker colors tend to absorb solar energy more than light colors. Also, the lighter the color is, the more it will reflect the energy. Therefore, light colors are preferred for walls and roofs in hot climates because of the resulting lower temperatures inside the building. Both dark and light colors lose heat to the sky at equal rates.

**Insulation Value:** Insulation value refers to the material's ability to transfer heat.

Walls and roofs in hot climates should not transfer heat easily. Because air is one of the best insulators, materials made with air usually have low heat transfer values. Interior spaces within walls and roofs can be made even more resistant to heat transfer by covering the interior surface of the air space with highly reflective materials such as foil.

**Thermal Capacity:** Thermal capacity refers to the ability of the material to store heat. The higher the thermal capacity, the slower the temperature change through the material.

Where there is little difference between day and night temperature, walls and roofs with low thermal capacity are preferred.

*(Atkinson, 1950), (Konya, 1980)*

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**Comfort**

One of the most important requirements for human comfort is keeping the internal temperature of the body within a certain range, regardless of the temperature of the environment around it. This balance will depend on activity, acclimatization, clothing, air temperature, radiation, humidity and air movement.
The body attempts to maintain its internal temperature in warm weather by releasing heat through conduction, convection, radiation and/or evaporation.

A person with clothes does not normally lose much heat by conduction unless the body is in contact with cold materials that are good conductors.

The body exchanges heat with the surrounding air by convection. The amount of heat transfer will depend on the temperature difference between the skin and the air, and the amount of air movement.

Radiation can take place between the body and surrounding surfaces and will depend on the temperature difference between the skin and the surface.

When the air temperature is above 77°F (25°C), the clothed human body cannot get rid of enough heat through convection or radiation. At this temperature, the loss of perspiration (heat loss through evaporation) becomes the only means of cooling the body. The amount of heat that can be lost through evaporation depends on the clothing worn, the level of vapor pressure, and the amount of air movement.

The comfort of the human body in hot humid climates depends on the temperature of the air and surrounding surfaces, the relative humidity of the air, and air movement. The range of conditions under which comfort is experienced is called the “comfort zone”. Though the comfort zone is a subjective assessment of conditions, it does have a physical base.

Several researchers have tried to evaluate the effects of temperature, humidity and comfort and combine them into a
single value.

**Bioclimatic Chart:** Victor Olgyay devised the bioclimatic chart on which comfort zones can be determined. The chart plots the dry-bulb temperature and humidity and is position in the comfort zone is indicated. The chart also indicates how the zone can be shifted (e.g. through air movement, activity, etc.)

Schematic diagram of Olgyay's Bioclimatic Chart (Konya, 1980)

**Thermal Indices:** B. Giovani claimed that the Bioclimatic Chart was limited because it was based on the outdoor climate and not on the conditions within the building. He therefore developed an alternative method which involves an estimation of the expected indoor climate and suggests the suitability of ventilation, air temperature reduction and evaporative cooling. The resulting diagram has been called the Building Bioclimatic Chart.

**Mahoney Tables:** Because the methods used to analyze and solve climatic problems can be long and difficult, the Mahoney Tables were developed by the Department of Development and Tropical Studies of the Architectural Association. With this
method the more easily found climatic data (temperature, humidity and precipitation) is entered into simple tables which then formulate recommendations for preliminary architectural design. (Konya, 1980)

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<td>1</td>
<td>Protection from heavy rain necessary</td>
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Mahoney Tables (Koenigsberger, 1973)
Design Strategies

In response to the characteristics of a hot humid climate, the most important aspects of a building in these areas are its ability to provide shade, ventilation and protection from rain.

Ventilation is the most important consideration and the prime generator of architectural form in hot humid climates since air movement evaporates perspiration, causing a cooling effect on the skin. Ventilation is the most important factor when designing because shade can be provided by other means if necessary. Solar radiation is the next most important consideration for reducing the heat load on buildings.

When reviewing the design strategies for minimizing the unpleasant characteristics of a hot humid climate, it should be emphasized that compromise will almost always be necessary. It is a rare site that would permit all the strategies to be incorporated without any conflict.

Site

Layout: If buildings are placed in rigid rows, they should be separated by a distance of five to seven times the building height to ensure adequate airflow through them. A staggered or checkerboard pattern of placing the buildings will enhance air movement and the distance between buildings can be reduced. The resulting orientation and spacing will be a layout that is spread out with a relatively low population density.

Water drainage must be provided away from the house for run-off during intensive storms.
Lanscaping: Trees and shrubs should be placed carefully to promote air movement and provide shade.

Public Spaces: Public spaces with minimum walking distances and shaded areas are preferred.

**Building**

**Orientation:** The building should be oriented to the prevailing breezes to maximize air flow within the building.

The building should also be oriented to minimize solar radiation. This means that an elongated building’s axis should be generally in an east-west direction in order to reduce the surfaces exposed to the low sun angle in the morning and late afternoon. (Konya, 1980)

**Layout:** Buildings that are one room wide are preferred but they can be up to two rooms wide if openings are placed in the interior partitions that permit adequate air movement.

Individual buildings are preferred and should be somewhat elevated and elongated. The optimum proportion ranges from 1:1.7 to 1:3 on the east-west axis.

Shade protection should be provided on all sun-exposed sides, especially on the roof and the east and west facades.

Rooms that generate heat and moisture (e.g. kitchens and laundries) should be ventilated and separated or isolated from the main living areas.

**Safety:** Structures may need to withstand high velocity or hurricane-force winds. Attention must also be given to security, especially in high crime areas.

**Roofs**

**Design:** The roof should be watertight, insulated and reflect solar rays.

Wide eaves or overhangs of at least three feet (0.9m) are preferred to protect the walls from sun and rain and to reduce the glare
from the sky.

Roofs should be pitched to enable them to shed rain. Where there is no piped water, the rainwater from the roof may be the only source of water and therefore will need large gutters and rainwater tanks.

Flat thick roofs are not desirable and should only be used for buildings that are not used during the night (e.g. offices and schools) because of the time lag of the heat transfer. If a flat roof is necessary, a lightweight roof on top of the flat roof can be used to shade the roof below.

Materials: Materials that reflect rather than absorb radiation and which readily release the quantity absorbed are preferred. Light colors are best for this reason. Where there is little difference between day and night temperatures, materials with a low thermal capacity is preferred. Corrugated iron and asbestos sheets are generally poor materials for a roof.

Construction: Thermal and reflective insulation in the ceiling is the most effective means of reducing ceiling and room temperatures.

Walls
Design: All sun-exposed walls would be shaded by eaves, shades, horizontal screens (on north or south sides), vertical screens (on east and west sides), vegetation or overhangs.

Walls are used primarily for screening from insects and their wind penetration qualities rather than thermal barriers.

Interior and exterior walls should be of reflective light colors in order to minimize glare both inside and out.

Materials: Preferred materials are those that reflect rather than absorb radiation (low thermal capacity) and which readily release any absorbed heat. Wall materials should also not transfer heat easily.

Construction: Lightweight construction is preferred because the temperature range during the day and night is low. Lightweight structures cools down rapidly at night but also heat up quickly during the day so careful consideration of orientation
and shading is important.

**Openings**

**Design:** Windows need to let air in but keep sun and rain out. Glass windows are not usually desired because they allow solar radiation to enter but not escape (i.e. the greenhouse effect).

Windows should be shaded whenever possible.

Indoor air-flow patterns are influenced by the position and design of the inlet openings, overhangs and sun-shading devices. The direction of the flow can be directed by adjustable louvers and shutters.

**Size:** The window size and number should be maximized whenever possible to enhance air movement.
If windows are of unequal size and on opposite walls of a room, to increase the velocity of the air flow in the house, the smaller opening should face the on-coming wind and the larger opening should be away from the direction of wind.

**Placement:** Windows should be placed on the opposite walls of a room. Rooms that have one opening in one wall may average velocities of only 3.3% - 4.7% of the outside velocity, almost irrespective of the size of the opening. For two openings, placed in the same wall, average velocities range from 4.3% - 17.7% of the outside air velocity. When windows are located in two adjacent or opposite walls, average velocities range from 32% to 65% of the exterior velocity.

Widow sills need to be relatively low in order to enable air flow to be at body level.
2. THE HOT HUMID CLIMATE

Low window sills. (Slesin, 1985)

Foundations and Floors
Basements are impractical because of constant high humidity. Foundations must be protected from moisture, mold, fungus, termites, and other gnawing insects and animals.

Raised floors are preferred in order to facilitate inspection of termite attack to provide a shaded covered space.

Floor materials must be impervious to moisture.

### Chapter Bibliography

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Publication Details</th>
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<tbody>
<tr>
<td>Frommes, Bob</td>
<td>Fundamental Knowledge in Urban and Building Climatology</td>
<td>Standing Committee Urban and Building Climatology, IFHP. Austria. 1980.</td>
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3

TRADITIONAL CARIBBEAN ARCHITECTURE

- Introduction
- Influences
- History
- House Types
- Description
- Response to Climate
- Chapter Bibliography
Top photo: Eaves, Zanzibar, Tanzania
Bottom photo: Building 1869, Queensland, Australia
This chapter looks at traditional Caribbean domestic architecture and how it has been modified or adapted to suit the climate. Caribbean architecture has much in common with other regions and was selected because its architectural vocabulary can also be found in other parts of the world, particularly in Africa, Asia and Australia.

The architecture looked at in this chapter is considered folk, vernacular or traditional architecture. It focuses on the small house of the working or low-income classes in both rural and urban areas. The grander houses built by the wealthy are larger and more ornate with more expensive materials, but will have many of the characteristics of the more humble home.

A number of authors describe the advantage of studying traditional architecture... "Folk architecture usually answers the elementary demands of use, site, climate and materials more directly than buildings of greater architectural pretension." (Goodwin, 1942) It is also useful to study because of its "graceful proportions, sense of balance, and successful adaptation to the climate" and because these smaller houses continue to be built today. (Gosner, 1982). And finally some authors emphasize the lessons that are applicable today “…it is hoped that designers of new houses that appear will seek their inspiration in Bermuda’s older architecture. It is eminently appropriate to the climate and other local conditions, harmonious and in scale with the surrounds. It has the unity, charm and simplicity of an architecture that is the unaffected expression and natural outcome of environment and, from its simplicity, is entirely adaptable to modern requirements of Bermuda.” (Humphries, 1923)

The literature on Caribbean traditional architecture is not extensive but does give a good overview of the history and description of typical Caribbean architecture. Many of the books were written with the intention of recording the architecture before it was torn down and replaced by more contemporary structures and serve as a plea to respect and save some of the historical buildings that are deteriorating rapidly or disappearing altogether.

It is also pointed out by many of the authors that the Caribbean does indeed have a distinct and coherent architecture and a style
that is typical of almost all the islands in the region. They also highlight the similarities between Caribbean architecture and tropical architecture along the Gulf and Atlantic coast of the United States and the coastal areas of Central and South America. Though all have distinct characteristics, there is a style that unifies them that stems from colonialism, the climate, and their common history.

Geographically, the area that is being studied is a chain of islands that reaches from Florida to the north coast of South America. There are three major island groups: The Bahamas; the Greater Antilles (Jamaica, Cuba, Haiti/Dominican Republic, and Puerto Rico); and the Lesser Antilles (which include all the other islands from the Virgin Islands to Curacao). Bermuda is not part of the Caribbean but is often considered with the other islands because of its common history, trade, and climate.

Influences

Inarguably, domestic architecture of the Caribbean islands each have unique qualities, but what they have in common far outnumber their differences. There are many influences that shape a regional architecture but in the case of the Caribbean, the forces that had the greatest impact were: colonialism, inter-island contact, available building materials and skills, and the climate.

Colonialism: With colonialism came the architectural traditions of the homeland. These traditions had the greatest influence immediately following colonization when the first houses were limited to simple dwellings almost identical to those in their native countries.

Dutch Influence in Willemstad, Curaçao (Groll, 1990)
However, it was not long before national influences became blurred, and eventually the French, Dutch and English colonies had more in common with each other than their respective homelands. An architectural style was developed from borrowing elements from the different cultures and synthesizing them into a common regional style. Interestingly, architecture on all the islands was strongly influenced by the English, irrespective of the colonial government's nationality. One explanation for this was the popularity of Georgian builders' handbooks published during the 18th century.

In spite of the common style or architectural vocabulary in the region, there were and still are some characteristics that are identified with one or another colonizer. For example, the French brought dormer windows; the English developed the taste for porches and projecting roofs over the entrance; and the Spanish built very simple but tall forms using only doors and windows for ventilation.

Not all islands absorbed the architectural traditions from other islands and cultures to the same degree. Willemstad on Curaçao always maintained close ties with the homeland and therefore still show strikingly strong Dutch architectural traditions. Though some adaptation to the climate took place, the streets and architecture remain surprisingly similar to their counterparts in the Netherlands.

**Inter-island Contact:** One of the main explanations for the similarities between the architecture on the islands is the high level of contact between the islands. This occurred because of the constant wars and changing governments in the 18th and 19th centuries, but the greatest influence came from trade between the European countries as well as between the islands.

The level of inter-island contact is also evident from the differences between the urban and rural architecture. Because towns were based on trade, they were more international and therefore were more strongly influenced by other national architectural traditions than the more isolated rural plantation.

The contact and mixing of architectural tradition was also caused by the migration of the population from one island to another. Though the colonial government may have been of one nationality, it was not unusual for nationals of that country to be in the minority, with the majority made up of citizens from a
variety of countries.

Building Materials and Skills: Though the first colonizers attempted to duplicate the architecture from their native lands, they were forced to quickly adapt to local conditions in the choice of building materials and the building skills that were available to them. Brick was not available locally but came in as ballast with ships, and because of the limited supply, it was used more often as an accent. Wood, lime and local stone quickly became the more common building materials.

Building technique in the Caribbean is unique because though much of the architectural traditions were those of English rural architecture, these traditions were interpreted by shipwrights, rather than housebuilders.

Climate: All the Caribbean islands share a tropical climate, although rainfall can vary quite a bit from one island to another. The heat is moderated by the trade winds which blow most of the year.

Consequently, as architectural form was imported from Europe, it was also adapted to the local climate. The floor plan was simplified and oriented to face the direction of the wind in order to maximize its cooling effect. Open galleries or verandahs shaded the walls, again to keep the interior as cool as possible. Windows were large to encourage airflow and shutters were common to protect the windows and the interior from hurricanes and tropical storms.

(Hacworth, 1951), (Andel, 1985), (Coomans, 1990), (Gosner, 1982), (Groll, 1990), (Humphries, 1923), (Slesin, 1985)

History

The first colonists built their homes as replicas of English rural housing. A common form of construction was timber-framing (or half-timbered) consisting of upright posts either placed directly into the ground or on a horizontal beam. Diagonal timbers reinforced the structure. The spaces were then filled with a variety of materials, often a rubble masonry made of mortar and small chips of stone.
This technique was modified as timber quickly became scarce on the islands. Fortunately many of the islands have good sources of lime or shell that could be burned to produce mortar. A characteristic masonry construction was consequently developed called “tabby” or “Spanish walling”. In this technique a mixture of stone and mortar is poured into wooden forms. As each pouring sets, the forms are raised until the walls reach the correct height.

Climate was the other modifier of this type of medieval building; ovens were moved away from the main building to reduce the heat and possible risk of fire; windows were made slightly larger, and it was found that lower buildings were less vulnerable to hurricanes and earthquakes. In spite of the advantages of these changes, many settlers were reluctant to part with tradition, partly because it was the English tradition, and partly because of the prevailing belief in the ill effects of too much ventilation.

It was during the period of between 1750 and 1850 that considerable building occurred and what is considered traditional architecture was developed. The colonist imported the current fashionable architectural forms which were predominantly Georgian at the time, but these were soon modified for local conditions, creating a new regional architecture.

The introduction of classicism in the 18th century was important for the development of the “Caribbean style”. It was brought to the colonies by illustrated books in which classicism was presented in a more popular form, such as The Book of Architecture by James Gibbs, published in 1728. This book was very popular and Gibbs had a greater influence on the architecture in the region than any other architect in the 18th century. The presentation and details in these publications were simple and fairly easily adapted to a smaller scale, local materials, circumstances and climate.

In the beginning of the 19th century, houses with wooden verandahs, gingerbread trim and framing became the traditional architecture. Masonry became uncommon and the wood supply was exhausted on the islands. The importation of timber from America for frame construction became commonplace and resulted in the standardization of building. An industry producing complete wooden houses or parts developed quickly and sawmills mass-produced studs and joists which were shipped to the Caribbean region. New framing methods were also
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(Gibbs, 1728)
developed. In an 1880 catalogue, one manufacturer offered for sale 700 models of houses and parts as well as 95 machine-made balustrades, banisters, staircase posts, railing and front doors.

(Acworth, 1951), (Andel, 1985), (Bergsma, 1990), (Gibbs, 1778), (Gosner, 1982)

House Types

There are three types of buildings that are characteristic of the Caribbean region – the frame house, the shop/townhouse and the plantation house. All three are described but more attention is given to the frame house and the shop/townhouse because of its more modest size. The plantation house is always located in a rural setting; shop/townhouses are located in urban areas; and frame houses are found in both rural and semi-urban areas.

The Frame House

The frame house is by far the most common form of small house in the Caribbean. Though small, it is often architecturally distinctive; their forms vary between the islands but a certain style prevails.

Typical small frame house. (Slesin, 1985)

Typically the whole house is raised off the ground, sitting on a rock or concrete foundation. This permits the circulation of air underneath the floor and protects the structure from insect attack. Some of these houses are raised a full story on stilts; the open space underneath serves many of the functions of a porch, that is, providing a place for children to play or for laundry to dry.
The plan is rectangular, and in its simplest form, divided into two spaces with the entry located in the long wall. In the interior, all the rooms open onto each other so that there is maximum ventilation. Partitions often do not extend above the eaves, and the space between the top of the partition and the roof is sometimes filled with latticework.

Openings between rooms provide ventilation. (Groll, 1990)

The walls have many openings with sash windows and/or louvers (or jalousies) for coolness. Windows will often have heavy wooden shutters that can be closed during tropical storms. Inner casement windows are usually louvered, glass or a combination of both. Many windows are protected from the sun by 19th century “coolers” which can be wooden shield shaped like awnings or it can refer to enclosing the window in a projecting boxes, formed of louvers.
The walls are made of wooden posts with a top and bottom plate and braces in the corners. On the outside the posts are covered with clapboard or sometimes shingles. On the inside, the timber frame is usually left exposed.

The roof previously was thatch or shingled but is now almost universally corrugated metal. Gable or hip roofs are the most common and the pitch varies from one island to another.

Frame House (Slesin, 1985)

The house is easily expanded by building extra rooms onto the existing house, and can become quite large. It is also very common for these small houses to have a verandah attached to them, which is often highly decorated with wooden cutouts and gingerbread.

Kitchens and fireplaces were almost always separate and cooking takes place in a separate building in the yard.

Houses were expanded by building extra rooms onto them.
The small house was most frequently made of wood and often transportable. The transportable or "chattel" house has its roots in the plantation; it enabled the workers to live close to the fields being worked at the time. The tradition has been preserved and modular cabins with standardized dimensions that facilitate relocation continue to be built today.

The export of wooden pre-fab construction from America to the Caribbean resulted in a number of standard types. One
standard is a house with the length twice the width; the largest being 3 x 6 meters (10' x 20'). The facade was symmetrical with a door in the central axis and a window on both side. To enlarge the house, a second module was constructed behind the first.

The frame house has and continues to serve its purpose well and is still the popular dwelling of all the islands of the Lesser Antilles.

(Andel, 1985), (Bergsma, 1990), (Buisseret, 1980), (Gosner, 1982), (Slesin, 1985).

The Shop/Townhouse and Townhouse

The Shop/Townhouse: This building type is characteristic of the region and is the most common type of urban building in the Caribbean with only minor differences between the islands. This building form was so successful that it spread to mainland seaports such as New Orleans, Louisiana, Belize and the Guianas.
It is a combined shop and house; they are found lining the main shore street as well as nearby commercial streets. The shop is located on the ground floor, and made of masonry, with heavy double doors. On the upper floor lives the shopkeeper's family. The upper floor is usually either masonry or frame construction but has a much lighter, delicate appearance.

There are two types of shop townhouses: those with the lower and upper walls on the same plane, and those with the upper story extending out over the ground floor.

Irrespective of the type, the upper floor almost always had a balcony of iron or wood that extended across the entire front of the building, and if located on a corner, it would wrap around on both street fronts. When there was no balcony, the center window often extended to the floor with a railing across it. The balconies usually had roofs separate from the main building, though it is more common on the French islands to have the balconies covered by the main roof. The balconies were usually supported either by brackets of wrought iron or wooden posts.

The area underneath the balcony or overhang can be either a public sidewalk or an extension of the shop. If it is private, it often contains the stairs to the upper story. If not, the stairs will usually be located at the side of the building. Interior stairs are not very common, though they may have been added more
Like the frame or small house, the shop/townhouse would have a yard at the back where laundry, sanitary and cooking recently to older buildings.
facilities will be located.

The Townhouse: This type was built on the same model as the shop/townhouse with either balconies or overhanging second floors. These houses filled the remaining streets of a town, often mixing with the shop/townhouses. There was much variety among this house type - from the elegant residences of the wealthy planters and merchants to the more humble wooden structures of the working classes.

The townhouse can also be a single-story building on a solid masonry basement which is less than a full story and with a covered gallery or verandah on the front.

More common, especially in the English islands, is the two-story townhouse with double galleries or verandahs across the front and sometimes the back. The architectural treatment of the verandahs varies widely. They can be open with a simple rail, or have decorative supports of wooden latticework or cast iron, or have louvered panels at the ends, or be completely enclosed by

Townhouse, Port-au-Prince, Haiti (Phillips, 1977)
louvered panels, or by alternative louvers and sash windows.

Because of the lack of space and privacy in urban areas, the townhouses with galleries across the front are more likely to be screened from the street by louvered panels than the same building in a more rural setting.

**The Plantation House**

The “Great Houses” or “Plantation Houses” built by wealthy plantation owners are also distinctive to the Caribbean area and are characterized by a gallery or verandah on one or more sides of the building. Though it was not exclusively French, it reached its highest development in the French colonies. There is debate among architectural historians whether this house type originated in the Caribbean and spread northwards or if it followed the French south from Canada.

(Gosner, 1982). (Groll, 1990)

Coffee plantation house, Guadeloupe. (Slesin, 1985)

**Description**

The following summarizes the characteristics of small houses in the Caribbean region, and includes both frame houses and shop/townhouses.
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Town Planning

The earliest settlements had no planning and grew spontaneously near the protection of the fort. Kingston, Jamaica, was probably the first ‘planned’ town of the non-Spanish islands.

The streets were usually in a checkerboard pattern or grid. In most West Indian towns no ceremonial elements were added. Instead of the streets leading to main buildings and squares, the main street usually ran along the shore. It was the coastal street that was the most important because it was where the town’s trade was based. The area inland from the coastal road was usually reserved for housing. The streets that ran perpendicular to the shore road allowed the wind blowing from the sea to provide some coolness through the residential areas.

(Andel, 1985), (Bergsma, 1990), (Gosner, 1982)

The Site

The arrangement of the house on the site is described but in the literature there is almost no information on the size of typical urban or rural lots. The only information given is of original lots in Philipsberg, St. Martin which were divided in plots 40 feet square. (Andel, 1985)

The site is divided into three parts, each with its own function: the front facade, the house itself and the backyard.

The front is part of the house that links the private living space with the outside public world. It is emphasized by the often highly decorated facade and the verandah which provides a transition zone between the street and the house.

The house itself provides privacy and security for the family. The house is most commonly place lengthwise along the street, either on or very close to the lot line. In most cases, a passage alongside the house leads to the backyard.

The back yard is a family space where friends and relatives are received and where much of the housework is done. It is common to have a 10,000-20,000 liter cistern in the back which collects the rainwater from the roof. The kitchen is traditionally located in the back to avoid the risk of fire and to keep heat, smoke and smells out of the house. This area is also often used for raising chickens and rabbits, gardening, collecting rubbish, and washing and drying laundry. (Andel, 1985)
Plan
All houses have a rectangular plan. The simplest type consists of one room but more complicated ones have three to six rooms. The sizes of the houses vary but basic proportions generally range form 1:2 to 1:3. In many houses this proportion can change as additional rooms are added to the original structure.

(Andel, 1985) (Humphries, 1923)

The building is often only one room wide, to promote ventilation, but two rooms wide is usually the maximum found. Interior partitions often do not reach the ceiling. Instead, the solid partition stops at the eaves and a wooden grill or latticework continues to the ceiling.

Foundation/Substructure
The houses are built on a foundation made of stone, concrete or brick. Supporting elements are made of stone, or wood. The height of the substructure is usually 1/2, 1/3 or 1/4 of the story height, or it can be a full story.

(Andel, 1985) (Humphries, 1923)

Materials
Brick was first used in colonial buildings because the brick arrived as ballast in the ships. "Tabby" or "Spanish Walling" was soon developed to meet the demands of the building industry. Some brick was manufactured on the islands, but most of it was imported. Traditional buildings are usually wood or wood in combination with stone.

Wooden shingles imported from America was traditional at one time but this has largely been replaced by corrugated roofing sheets.

Wood is still one of the most important building materials in the area. In the past it was used almost exclusively but wood is now more often seen in combination with other materials such as brick, corrugated steel, and cement. Recently wood has been replace by cement because it is cheaper than imported wood.

Construction

As has been mentioned previously, the construction methods used in Caribbean housing owes much to the shipwright rather than the carpenter.

There are two typical timber exterior construction techniques:
1. The wall begins with a low wall 60 cm (24") high and 8-10 cm (3"- 4") thick. Openings in the wall are left where there are door openings. A wall plate is screwed to the wall and master posts, 8-10 cm square (3"-4") are placed at the corners of the building and frame the doors. In between are common posts, 2.10 m (7'-0") high. This makes the total wall height of 2.7 m (9'-0"). Posts are placed about 0.8 to 1 m (2'-8" to 3'-3"") apart.

2. The second method is similar to the first except that there is no low wall. Posts are wall height and attach directly to the floor plate.
There are also two methods for roofing:

1. The roof system is composed of trusses resting on wall plates. Each truss takes four 3 m (10'-0") beams. One 1-meter beam make up the king-post. Two 80 cm (2'-8") and two 30 cm (1'-0") shoulder brackets are used. A ridge beam and purlin connects the trusses on the top and the bottom. The purlins and trusses are supported from below.

2. The roof is made up of trusses which rest on the wall plates and support the rafters. The truss has a collar beam and king post.

(Berthelot, 1982)
Openings
The number of openings depends on the length of the facade. The corner bay is rarely open in English-speaking countries, though it is more common on the French-speaking islands. All rooms have at least one openings in each of their exterior walls. Facades with a verandah have many windows. Doors and windows may alternate, openings may be concentrated around
the door, or there may be a series of doors on the facade. There is considerable diversity between the houses.

Typical facades (Andel, 1985)

In the side facade, there are fewer bays than the front and usually only one or two openings. In one-story houses, the openings in the side facade are almost always windows, while in a two-story house, there may be a door that gives access to an outdoor staircase.

The lintels of doors and windows are always at the same level and are located just below the roof plate. Windows often are about half the height of the doors. The width of the doors and windows never vary within the house unless the width of the bays deviates.

Windows are both sash and casement; usually with some type of protective shutters.

(Andel, 1985)

- **Verandah**

  The verandah is part of the house, but is not usually part of the main structure of the building. It may be built during construction or added on at a later date. It is the dominant feature of the front facade. It serves as a transition zone between public and private space and shades the walls of the house from the sun.
A variety of window types. (Slesin, 1985)

Door and window with louvers and shutters (Goergler, 1984)
Houses with two stories usually have a verandah on the upper floor which is accessible by an exterior stair along the side or front of the facade, or occasionally by an indoor flight of stairs.
Verandah on a frame house. (Slesin, 1985)

Decorative Trim (Slesin, 1985)

(Slesin, 1985)
The spacing of the supports usually corresponds to the posts used in the construction of the house. Verandahs are usually the only part of the house that is decorated and will often have ornamental woodwork (gingerbread fretwork) and decorative patterns on the balustrade.

(Andel, 1985)

Roof
The roof is always pitched, often between 35° and 45°. Gable and hip roofs are by far the most common.

The roof frequently has a gutter system attached to it which leads to a large cistern and is especially common on islands that have a limited water supply.

Today, the roof is almost always covered with corrugated roofing sheets instead of the traditional shingles. Though this may be a cheaper alternative for the homeowner, it is noisier during heavy rain, and it requires a well-insulated ceiling underneath if the interior is to remain within the range of comfortable temperatures.

Roof spans are not usually large and rarely exceed 5.5 m (18 feet). Eaves usually project no more than 15 to 20 cm (6"-10"). This differs from the large projecting eaves in other hot tropical climates but makes sense in the Caribbean where hurricanes and strong winds could lift off a roof with large eaves.

(Andel, 1985) (Humphries, 1923)

Color
Paint is used to protect the wood against rain, humidity, drying sun, wind, and insect attack. It is also used as decoration with many houses painted in a combination of colors. English-speaking islands are known for their bright, sharp and lively colors. The walls are usually painted a light color (white, yellow, off-white, pale green or pink). Darker or more vivid colors (blue, brown, red, green, light blue or olive green) are applied on the shutters, verandahs, balustrades and columns. On some of the islands, the corrugated iron roof is painted red, likely as a reminder of the red clay tiles that were once used.

(Andel, 1985) (Berthelot, 1982) (Slesin, 1985)
Response to Climate

Much of the architectural vocabulary of the small Caribbean house has developed as a response to the climate. When compared to the “rules of thumb” or design strategies suggested by researchers in the previous chapter (2. The Hot Humid Climate), it is clear that the architecture in the region meets almost every strategy.

Ventilation is the most important consideration and the prime generator of architectural form in hot humid climates since air movement evaporates perspiration, causing a cooling effect on the skin. Ventilation is the most important factor when designing because shade can be provided by other means if necessary.

Protection from solar radiation is the next most important consideration for reducing the heat load on buildings.

The following section is a summary of the design strategies described in the previous chapter and demonstrates how the Caribbean house meets each one.
### Design Strategies

**Orientation:**
The building should be oriented to the prevailing breezes to maximize air flow within the building.

The building should be oriented to minimize solar radiation. This means that an elongated building’s axis should be generally in an east-west direction in order to reduce the surfaces exposed to the low sun angle in the morning and late afternoon.

<table>
<thead>
<tr>
<th>Traditional Caribbean House</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Houses in rural areas will more often be oriented to the prevailing winds. In urban areas, the house is more likely to be oriented to the street.</td>
</tr>
<tr>
<td>• Rural houses will more likely be oriented in an east-west direction. Again, in urban areas, the house is more likely to be oriented to the existing street.</td>
</tr>
</tbody>
</table>

**Layout:**
Buildings that are one room wide are preferred but they can be up to two rooms wide if openings are placed in the interior partitions that permit adequate air movement.

Individual buildings are preferred and should be somewhat elevated and elongated. The optimum shape ranges from 1:1.7 to 1:3 on the east-west axis.

<table>
<thead>
<tr>
<th>Traditional Caribbean House</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Houses are often one room wide, with the maximum width of two rooms. Interior partitions have openings and a latticework above it to encourage air movement within the house. Large open arched openings are common between rooms.</td>
</tr>
<tr>
<td>• The individual detached house is the standard. Attached houses are extremely rare. Even in densely populated urban areas, the house will have at least the space of a passageway between it and its neighbor.</td>
</tr>
<tr>
<td>• Houses are typically rectangular with proportions ranging from 1:2 to 1:3.</td>
</tr>
</tbody>
</table>

Shade protection should be provided on all sun-exposed sides, especially on the roof and the east and west facades.

<table>
<thead>
<tr>
<th>Traditional Caribbean House</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Shade is provided by trees, verandahs, window shades and awnings whenever possible.</td>
</tr>
</tbody>
</table>

Rooms that generate heat and moisture (e.g. kitchens and laundries) should be ventilated and separated or isolated from the main living areas.

<table>
<thead>
<tr>
<th>Traditional Caribbean House</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Kitchens, laundries and sanitary facilities are almost always located in a separate structure in the back yard of the house.</td>
</tr>
</tbody>
</table>

**Safety:**
Structures may need to withstand high velocity or hurricane-force winds. Attention must also be given to security, especially in high crime areas.

<table>
<thead>
<tr>
<th>Traditional Caribbean House</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Unlike other hot climates, eaves are reduced to a minimum to reduce the risk of roof damage during a hurricane.</td>
</tr>
<tr>
<td>• Louvered shutters are common which allow them to be closed at night for security reasons and yet still allow the air to flow through the house.</td>
</tr>
<tr>
<td>• Houses are no more than two stories high, and towers, cupolas, and parapets are rare to minimize damage from hurricanes and earthquakes.</td>
</tr>
</tbody>
</table>
Roofs:
The roof should be watertight, insulated and reflect solar rays.

- Roofs are well constructed. Traditional wooden shingles provided more insulation than the present-day corrugated metal roofing sheets which reflect solar rays but need extra insulation to prevent the heat from radiating into the interior.

Wide eaves or overhangs of at least three feet (0.9m) are preferred to protect the walls from sun and rain and to reduce the glare from the sky.

- Eaves are not large because of the risk of potential roof damage during hurricanes and strong winds.

Roofs should be pitched to enable them to shed rain. Where there is no piped water, the rainwater from the roof may be the only source of water and therefore will need large gutters and rainwater tanks.

- Roofs are always pitched, usually between 35° and 45°. Gutters are common, permitting the rainwater to be collected in cisterns.

Materials:
Materials that reflect rather than absorb radiation and which readily release the quantity absorbed are preferred. Light colors are best for this reason. Where there is little difference between day and night temperatures, materials with a low thermal capacity is preferred. Corrugated iron and asbestos sheets are generally poor materials for a roof.

- Wood is the traditional building materials which does not absorb radiation and readily releases the amount that it does. Walls are traditionally painted a light color with darker or brighter colors used for the trim (shutters, banisters, decorative woodwork, etc.).

- Concrete is becoming more common which is not as desirable as wood because of its higher thermal capacity.

- Corrugated roofing sheets are also less desirable than the traditional wooden shingles.

- The new materials require some adjustment in the design of the building, such as greater shading on the walls, and increased insulation in the roof.

Walls:
All sun-exposed walls would be shaded by eaves, shades, horizontal screens (on north or south sides), vertical screens (on east and west sides), vegetation or overhangs.

- Wall are traditionally protected by shades and awnings.

Walls are used primarily for screening from insects and their wind penetration qualities rather than thermal barriers.

- Wall have large and frequent openings to enhance air movement. All exterior walls of all rooms have at least one opening.

Interior and exterior walls should be in reflective light colors in order to minimize glare both inside and out.

- Walls are traditionally painted light colors (e.g. white, off-white, light yellow, pink, or light green).
Windows:
Windows need to let air in but keep sun and rain out. Glass windows are not usually desired because they allow solar radiation to enter but not escape (i.e. the greenhouse effect).

- The windows frequently are made without glass, but when they are, they are well shaded. Louvers are very common on windows because they permit the breeze to enter but keep rain out during storms. Glass is often combined with louvers.

Windows should be shaded.
- Windows are usually shaded, either by verandahs, awnings, shutters, or "coolers".

The window size and number should be maximized whenever possible to enhance air movement.
- The walls have frequent openings and are found on all sides of a room.

Windows should be placed on the opposite walls of a room.
- Rooms always have more than window and all exterior walls have at least one opening.

Widow sills need to be relatively low in order to enable air flow to be at body level.
- Window sills on poorer houses are approximately 1 meter (39") from the ground. Doors are often used in these houses instead of windows. Wealthier homes tend to have windows that are much taller, often the same size as a door.

Foundations:
Basements are impractical because of constant high humidity. Foundations must be protected from moisture, mold, fungus, termites, and other gnawing insects and animals.

- Basements are rarely built. Foundations are usually raised and open to allow for ventilation and to inspect for insect damage.

Raised floors are preferred in order to facilitate inspection for termite attack and to provide a shaded covered space.
- Foundations are always raised, and it is not uncommon for them to be one story high, providing covered place below the house.

Chapter Bibliography
Traditional Caribbean Architecture


3. TRADITIONAL CARIBBEAN ARCHITECTURE


4

A TROPICAL GRAMMAR

- Corpus
- Generative Rules
- Using the Grammar
Corpus

The corpus is the set of buildings from which the shape grammar is derived. A correctly formulated grammar should be able to reproduce all the buildings in the corpus, but more importantly, it should be able to generate new and different designs that are not included in the corpus, but belong to the same “family”.

The buildings that have been selected to make up the corpus are the typical house types found in the Caribbean. There are 11 frame houses, 2 shop/townhouses, and 3 townhouses.

The information on the frame houses came from measured drawings by Guadeloupe-based architect Jack Berthelot which are found in his book *Caribbean Popular Dwelling*, and in Slesin's *Caribbean Style*. The information on the shop/townhouse and townhouse is somewhat less accurate because only photographs were available and dimensions consequently had to be estimated.

The houses included in the corpus are presented on pages 86 to 92. In the remainder of the section, the houses are analyzed in terms of plan dimensions, ceiling heights, roof angles, door locations, door treatments, window locations and window treatments.
The Frame House

Puerto Rico

Trinidad
St. Lucia

Grenada

Antigua
The Shop/Townhouse

Shop/Townhouse, Port Antonio, Jamaica (Phillips, 1982)

Shop/Townhouse, Jamaica (Phillips, 1982)
The Townhouse

Townhouse, Barbados (Slesin, 1985)

Townhouse, Spanish Town, Jamaica (Gosner, 1982)
Townhouse, Guadeloupe (Slesin, 1985)
Plan Dimensions

FH - Frame House
S/TH - Shop/Townhouse
TH - Townhouse
Heights and Roof Angles

FH - Antigua

FH - Barbados

FH - Dominica

FH - Grenada

FH - Guadeloupe

FH - Martinique

FH - Montserrat

FH - Nevis

FH - Puerto Rico

FH - St. Barthélemy

FH - St. Lucia

FH - St. Vincent

FH - Trinidad

S/TH - Jamaica 1

S/TH - Jamaica 2

TH - Barbados

TH - Jamaica

TH - Guadeloupe

FH - Frame House

S/TH - Shop/Townhouse

TH - Townhouse
Door Locations

FH - Frame House  S/TH - Shop/Townhouse  TH - Townhouse
Door Treatments
Window Treatments

Antique
Puerto Rico
Dominica
Grenada
Monterey
Havana
Barbados
Trinidad
St. Lucia
St. Vincent
St. Barbados
Jamaica
Generative Rules

This section describes the generative rules that make up the tropical grammar. The rules are based on a corpus of traditional Caribbean single-family homes - 11 frame houses, 2 shop/townhouses and 3 townhouses. Technically, the rules should only reflect those examples found in the corpus. However, occasionally rules that reflect typical Caribbean architectural elements but that are not found in the corpus are included. These additional rules are marked with an asterisk (*).

Unless noted otherwise, the rules apply for all the house types. If they are type specific, they are marked with FH (frame house), S/TH (shop/townhouse) or TH (townhouse). Because detailed information was not available for the shop/townhouse and townhouse, the rules pertaining to these two types mainly focus on the verandahs, windows, doors, stairs and other information that could be derived from the photographs and drawings.

The rules are broken down into 3 sections: massing, openings and construction. Massing covers building shape and dimensions, the site, room sizes and arrangements, roofs, substructures and stairs. The section on openings reviews the rules for walls, doors and windows and construction states the rules for framing, materials, technique and decorative trim.

For each section the general description of the rule is given, followed by the rule as an equation, and then followed by a brief reason for the rule.

In order to aid understanding of the generative rules, three fonts are used. A serif font is used for describing the rule, italic is used for listing the rules, and a gray box surrounds the reasoning behind the rules.
MASSING

Building Shape and Dimensions

- Dimensions

The overall shape of the buildings is rectangular [1]. The length ranges from 5.0 m (16'-5") to 9.0 m (29'-6") [2]. Widths range from 2.7 m (8'-11") to 6.0 m (19'-8") [3]. Average length and width is 6.75 m (22'-2") and 4.6 m (15'-2") respectively.

The length/width ratio varies from 1.09 to 3.0 [4]. The average is 1.56.

**Rules:**

1. \( 5.0 \text{ m} (16\text{-}5\text{")} \leq \text{building length} (l.bld) \leq 9.0 \text{ m} (29\text{-}6\text{")} \)
2. Width \( (w.bld) < \text{Length} (l.bld) \)
3. \( 2.7 \text{ m} (8\text{-}11\text{")} \leq \text{building width} (w.bld) \leq 6.0 \text{ m} (19\text{-}8\text{")} \)
4. \( 1.09 \leq \text{Length/Width Ratio} \leq 3.0 \)

The width and length of the building varies with the number of room. The maximum width is 6.0 meters (2-3m rooms) in order to permit air movement through the building.

The Site

There was insufficient information available in the literature for formulating a rule for the lot size and shape.

The building on an urban site is set either on the street lot line or within 1.0 m (3'-3") of it [5]. In a rural setting, the house will be set back much farther from the road. The building can be set with either its length

sidewalk/street

>1.5 m

<1.0 m
or width side facing the street [6]. On at least one side of the building, the distance between the side lot line and the house (including any exterior stair) must be large enough for a passageway to the backyard, e.g. a minimum of 1.5 meters (5'-0") [7].

Rules for an urban site:

[5] 0 ≤ bld.setback ≤ 1.0 m (3'-3")
[6] lsd.bld // street or wsd.bld // street
[7] 1.5 m (5'-0") ≤ sd.passage

The building is placed close to the front of the site, next to the street in order to maximize the space at the back of the house where household activities take place. Also in the back are the kitchen and sanitary facilities. Placing the building close to the street also facilitates social contact between the occupants sitting on their verandah and those on the street.

The first priority for orientation is for wind; the longest side of the building should face the prevailing winds. The second priority is shade; the building's length should be oriented along the east-west axis. These two priorities may be more easily met on a rural site. However, in urban areas, the building will be oriented to the lot lines; the length of the building will either be parallel to the street or at 90°.

Room Types, Sizes and Arrangements

- Types

The houses consist of three basic types of rooms all of which are rectangular in shape –

1. primary rooms;
2. secondary rooms; and
3. verandahs.

- Sizes

Primary Room: The primary room is the largest room. The first phase of a house is usually built with one or more primary rooms.

The length of the primary room varies from 3.0 m (9'-10") to 8.0 m (26'-3") [8]. The average length is 4.41 m. The width is always less than the length [9] and varies from 2.0 m (6'-7") to 3.5 m (11'-6") [10]. The average width is 2.21 m. The length to width ratio has a range from 1.00 to 2.67 [11]; the average is 1.51.
Upper story rooms generally reflect the size of the room below it. Occasionally frame houses have a second floor, in which case the room above it would be the same size as the room below it [12*]. The only exception is the shop/townhouse or townhouse which sometimes has upper floors that overhang the front facade by up to 1.8 m (6'-0") [13].

Rules:

**Primary Room**

[8] \[3.0 \text{ m} \ (9'-10") \leq \text{length of primary room (l.pr)} \leq 8.0 \text{ m} \ (26'-3")\]

[9] \[\text{Width (w.pr)} < \text{Length (l.pr)}\]

[10] \[\text{Width (w.pr)} = 2.0 \text{ m} - 3.5 \text{ m} \ (6'-7" - 11'-6") \ [\text{avg. 2.98}]\]

[11] \[1.00 \leq \text{Length/Width Ratio} \leq 2.67\]

[12*] FH: length and width of upper primary room = length and width of lower primary room

[13] S/TH or TW: width or length of upper primary room = width or length of lower primary room + (0 - 1.8 m)

The primary rooms are the largest because they are the first-built rooms and therefore must be multi-functional (living, sleeping, storage, etc.). As the family gets larger and wishes to expand, the new (secondary) rooms are usually smaller because they are normally used as bedrooms. The primary rooms either continue to be used for sleeping and living or they are used exclusively as living areas.

The smallest dimension of the room's width (2.0m) (6'-7") is dictated by the size of a bed or the space needed to lie down. The largest dimension of the room's width (3.5m) (11'-6") is dictated by the length of the timber that was ready available. The smallest dimension of the room's length is again dictated by the size of a bed. It's largest dimension is dictated by the size of the lot and the ability to arrange furniture and activities within the space.
Secondary Room: The secondary room is always smaller than the primary room [14]. Secondary rooms are often but not always built as additions at a later stage.

The length of the secondary room is equal to the length of the primary room or the width of the primary room [15] and ranges from 3.0 m (9'-10") to 4.5 m (14'-9"). The width of the secondary rooms is always less than the length [16] and varies from 1.8 m (5'-11") to 2.5 m (8'-2") [17]. The average width is 2.2 m. The length to width ratio of secondary rooms range from 1.18 to 2.25 [18] with an average of 1.5. Upper secondary room are usually the same size as the room below it [19].

Rules:

Secondary Room
[14] Width of secondary room (w.sr) < width of primary room (w.pr)
[15] Length of secondary room (l.sr) = length of primary room (l.pr)
or
   Length of secondary room (l.sr) = width of primary room (w.pr)
[16] Width of secondary room (w.sr) < length of secondary room (l.sr)
[17] 1.8 m (5'-11") ≤ width of secondary room (w.sr) ≤ 2.5 m (8'-2")
[18] 1.18 ≤ length/width ratio ≤ 2.25
[19] length and width of upper secondary rooms = length and width of lower secondary rooms

The secondary rooms are smaller than the primary room because they are built as additions and usually have more limited functions, e.g. they are most often used as bedrooms.
The smallest dimension of the room's width $(2.0 \text{m}) (6'-7'')$ is dictated by the size of a bed or the space needed to lie down. The largest dimension of the room's width is dictated by the dimension of the adjoining room.

**Verandah:** Verandahs are covered with a roof and vary in width from $1.2 \text{ m} (4'-0'')$ to $1.8 \text{ m} (6'-0'')$ [20]. The width of the verandah is always less than its length [21]. The length can be equal to either the length of the building, the width of the building, the perimeter of the building, or the length or width of a primary or secondary room [22].

**Rules:**

**Verandah**

[20] $1.2 \text{ m} (4'-0'') \leq \text{width of verandah (w.\text{vr})} \leq 1.8 \text{ m} (6'-0'')$

[21] Width of verandah (w.\text{vr}) $< \text{length of verandah (l.\text{vr})}$

[22] Length of verandah (l.\text{vr}) = length of the building (l.\text{bld}) or

$= \text{width of the building (w.\text{bld}) or}$

$= \text{perimeter of the building (p.\text{bld})}$

$= \text{length of a secondary room}$

The verandah is part of the house but not usually part of the main structure; this allows it to be built at a later stage. The verandah is one of the most prominent features of the house and usually is the only part that is decorated. Not only does the verandah shade the walls which keeps the house cool, but it serves as a transition zone between the private house and the public street.
The minimum width dimension of 1.2 m (4'-0") is dictated by the space needed to place a chair. The maximum dimension is dictated by the spanning ability of the timber.

**Arrangements**
A house can consist of one of the following four combinations:
1. primary room(s);
2. primary room(s) + secondary room(s);
3. primary room(s) + verandah; or
4. primary room(s) + secondary room(s) + verandah.

The maximum number of rooms along one side of the building is two [23].

Rules:
[23] 1 ≤ no. of rooms (#.rm) // one side of building (w.bld) ≤ 2

The number of rooms is limited to two in order to permit air circulation through the house.

**Primary Rooms:** All buildings have at least one primary room [24]. The primary room is usually found either singly, or in a linear arrangement of either two or three units. When arranged in multiples, the rooms may be attached either on the length side or the width side [25].

[24] No. of primary rooms (#pr) ≥ 1
[25] length side of primary room adjoins the length side of the second primary room.

\[
\text{lsd.pr} // \text{lsd.pr} \\
\text{or} \\
\text{the width side of the primary room adjoins the width side of the second primary room} \\
\text{wsd.pr} // \text{wsd.pr}
\]

The rooms are attached in a linear arrangement to simplify and facilitate construction and future additions.
Secondary Rooms: Secondary rooms are optional [26]. The secondary room can be placed on the either the length or width side of the primary room [27]. All secondary rooms are attached on the same side of the primary rooms [28]. The secondary rooms must fill the full length or width of the building [29].

Rules
[26] No. of secondary rooms (#sr) ≥ 0
[27] If the width side of the primary room adjoins the width side of the next primary room, then the length side of the secondary room adjoins and equals the length side of the primary room.
   If lsd.pr // wsd.pr, the lsd.sr // and = lsd.pr
   or
   If the length side of the primary room adjoins the length side of the second primary room, then the length side of the secondary room adjoins and is equal to the width side of the primary room.
   If lsd.pr1 // lsd.pr2, then lsd.sr // and = wsd.pr

[28] Width length of the secondary room adjoins the width of the next secondary room.
   wsd.sr1 // wsd.sr2 // wsd.sr3 ...

[29] No. of secondary rooms (#sr) = no. of primary rooms (#pr)

The secondary rooms are added on the same side and the full length of the building, most likely to facilitate construction.

Verandah: Verandahs are optional on the building. [30] Verandahs are placed on either the full length of the building or the full width of the building or encircle the complete building or it can substitute 1 secondary room [31]. The length side of the verandah faces the street or front of the site [32].
4. A TROPICAL GRAMMAR – GENERATIVE RULES

Rules:

[30] No. of verandahs (#vr) = 0 or 1
[31] Verandah (vr) // length of building (l.bld) or
Verandah (vr) // width of building (w.bld) or
Verandah (vr) // perimeter of building (p.bld) or
Verandah (vr) substitutes (§) one secondary room (1 sr)
[32] Length side of verandah (l.vr) // street or front of site.

For ease of construction, the verandah extends the whole length or
width of the building or is the size of a secondary room. The purpose
of the verandah is to shade the wall and to provide an indoor/outdoor
space for the house that also acts as a transition between public and
private space.

The diagram above illustrates some of the possible alternative arrangements.
Ceiling Heights and Roofs

**Primary Rooms:** The ceiling height for all primary rooms in a building are equal [33]. The ceiling height of primary rooms range from 2.4 m (7'-11''0 to 3.0 m (9'-10'') [34]. The average height is 2.6 m (8'-8'').

Roof angles range from 270 to 490 [35]; the average is 42°. Roof types for primary rooms are: gable or hip [36].

**Rules:**

[33] Ceiling height of primary room$^1$ (cl.pr$^1$) = ceiling height of primary room$^2$ (cl.pr$^2$) = ceiling height of primary room$^3$ (cl.pr$^3$) ...  
[34] 2.4 m (7'-11'0 ≤ ceiling height of primary room (cl/pr) ≤ 3.0 m (9'-10'')  
[35] 27° ≤ roof angle primary room (ra.pr) ≤ 49°.  
[36] Roof type (rtftp.pr) = gable or hip

The ceilings are relatively high because of the belief that higher ceilings are cooler. This is true if the roof is uninsulated (which it often was) but is less important if the ceiling is well insulated.

The roofs are sloped to permit the rapid removal of rainwater and to direct it to the gutters where is often collected for household use. The steep slope of the roof also enablesthe ceiling to be even higher (it often reaches the tie beam on the truss).

**Secondary Rooms:** The ceiling height for all secondary rooms in a building are equal [37]. The ceiling height of secondary rooms range from 2.2 m (7'-3'') to 2.7 m (8'-10'') with the average 2.5 m (8'-2'') [38]. Secondary rooms usually have shed roofs, but occasionally gable roofs are used [39]. Shed roofs slopes range from 6° to 14° [40], with an average of 9°. Gable roofs slopes are approximately 43° [41]. The roof of the secondary room(s) may be under the roof of the primary room but since they are not usually built at the same time, they are often.
separate structures [42]. If the roof on the secondary roof is gable, the height of the ceiling will be the same as the ceiling height in the primary room [43]. If the roof of the secondary room is a shed roof, the ceiling height and the rise of the slope of the roof is lower than the ceiling height of the primary room [44].

Rules:

4. A TROPICAL GRAMMAR - GENERATIVE RULES  |  109 |

Rules:

[37] Ceiling height of secondary room $^1 (cl.sr^1) = cl.sr^2 = cl.sr^3 \ldots$

[38] 2.2 m (7'-3") $\leq$ cl.sr $\leq$ 2.7 m (8'-10")

[39] Roof type (rftp.sr) = shed or gable

[40] $6^\circ \leq$ shed roof angle (ra.sd.sr) $\leq 14^\circ$

[41] Roof angle of gable roof (ra.gb.sr) = 43$^\circ$

[42] Roof type (rft.sr) $=$ or $\neq$ roof type of primary room (rft.pr)

[43] If roof type (rft.sr) = gable, ceiling ht. of primary room (cl.pr) = ceiling ht. of secondary room

[44] If roof type (rft.sr) = shed, ceiling ht. of primary room (cl.pr) $>$ Ceiling ht. of secondary room (cl.sr) + roof ht. of shed roof (ht.sh.sr)

The roof type can be gable or shed, depending on the span and the preference of the homeowner.

Ceiling heights for secondary rooms with a shed roof are lower than primary rooms because they are usually built as a second roof and which must be lower than the main roof. If the roof is a gable, the ceiling height can be the same as the primary room.

The slope of shed roofs is quite low because of the roof having to fit under the main roof. The slope of a gable roof will be close to the roof slope of the primary room.

Verandah: The ceiling height for verandahs range from 2.2 m (7'-3") to 2.5 m (8'-2") [45]. Verandahs always have shed roofs [46]. Their roof angles are quite shallow, ranging from $6^\circ$ to $18^\circ$ [47], with an average of $9^\circ$. Because the verandah is attached to the wall of the primary room and/or secondary room, the ceiling height and the roof height of the verandah is less than the ceiling height of the primary or secondary room [48].

Rules:

[45] 2.2 m (7'-3") $\leq$ ceiling ht. of verandah (cl.vr) $\leq$ 2.5 m (8'-2")

[46] Roof type (rftp.vr) = shed
Substructure

Types and Sizes:
There are three types of floor levels — low, high or 2-story [49]. In the past, foundations of frame houses often consisted of rocks placed at the corners of the building. However, more permanent materials such as stone or concrete are always used today.

Houses that have low substructures can have one story above it [50] and their height ranges from 10 cm to 60 cm (4"-24") above ground level [52]. High substructures have one story raised one story off the ground level. The ground level can be either left open or enclosed with shutters or screens. Foundations in this case are usually wooden poles or concrete pillars. The height from the ground to the first floor range from 2.2 m to 2.7 m (7'-3"-8'-11") [53]. Two-story substructures are low and support two stories [51]. They range in height from 10 to 60 cm (4"-24") [54].
Rules:
[49] Substructure type = low, high or two-story
[50] If no. of stories = 1, substructure type is low or high
[51] If no. of stories = 2, substructure type is two-story
[52] Substructure low type height (sub.ht) = 0.1 m – 0.6 m (4” – 24”)
[53] Substructure high type height (sub.ht) = 2.2 m – 2.7 m (7’-3” – 8’-11”)
[54] Substructure 2-story type height (sub.ht) = 0.1 m – 0.6 m (4” – 24”)

Buildings are raised off the ground to allow for ventilation and to inspect for insect damage. Floors that are raised one story provide a covered area below the house. Two story structures permit more living space in a smaller area which is especially important in urban areas.

Low Stairs

Types:
There are three main types of stairs for buildings with a low substructure. The first (type 1) is a simple block step-up, the second (type 2) is a set of stairs with 2–3 risers leading directly to the door, and the third (type 3) is a set of stairs with 2–3 risers and a landing at the top [55]. The number of risers depends on the height of the substructure and some low substructures do not require a stair [56].

Rules
[55] If substructure type is low, then low stair type = 1, 2, 3 or none
[56] No. of stairs/risers (#rsr) = low substructure height/0.20m

The type of stair will depend on the budget of the homeowner and the height of the substructure. The simplest type is often a single concrete block. If the substructure is very low (e.g. 20 cm or less), usually no stair is used (e.g. on the ground floor of a shop/townhouse).
4. A TROPICAL GRAMMAR – GENERATIVE RULES

Sizes
Low - type 1 stairs range from 10 cm (4") to 30 cm (12") in height [57]. The height of low types 2 and 3 are equal to the height of the substructure [58]. Low type 2 and 3 stairs have risers that vary between 15 cm (6") and 24 cm (9.5") [59].

Widths of all low stair types are approximately 1.0 m (3'-3") but can vary from 0.9 (3'-0") to 1.2 m (4'-0") [60]. Stair or tread depth is between 20 (8") and 30 cm (12") [61].

Rules:
[57] \[10 \text{ cm (4")} \leq \text{total stair height of low type 1 (ht.str1)} \leq 30 \text{ cm (12")}\]
[58] \[\text{Total height of low type 2 or 3 (ht.str 2) (ht.str3)} = \text{height of substructure (sub.ht)}\]
[59] \[\text{Height of risers (ht.rsr)} = \frac{\text{substructure height (sub.ht)}}{\text{No. of risers (#rsr)}}\]
[60] \[0.9 \text{ m (3'-0")} \leq \text{stair width (w.str)} \leq 1.2 \text{ m (4'-0")}\]
[61] \[20 \text{ cm (8")} \leq \text{tread depth (d.trd)} \leq 30 \text{ cm (12")}\]

The height and number of stairs will depend on the height of the substructure. The width will depend on the preference of the owner and the height of the stair; stairs usually tend to be somewhat wider as the height rises. Bannisters are optional on low stairs.

Placement/Location:
The stairs are usually placed directly in front of the door, either placed against the door opening or with a verandah between the stair and the door. Occasionally type 2 and 3 stairs are placed at right angles to the door or away from the door. [62] [63] The stairs are always visible from the street.

If a house had a type 3 stair, it would have only one; the others would be either type 1 or 2 [64].
### 4. A TROPICAL GRAMMAR – GENERATIVE RULES

<table>
<thead>
<tr>
<th>low type 1</th>
<th>low type 2</th>
<th>low type 3</th>
</tr>
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<tbody>
<tr>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
</tr>
</tbody>
</table>

#### Rules:

[62] \(\text{stair (str) } // \text{door (dr)}\) or

\(\text{stair (str) } // \text{verandah (vr)} \times // \text{door}\)

[63] \(\text{angle of stair approach (°str.app)} = 0° \text{ or } 90°\)

[64] \(\text{No. of type 1 stairs (#str.11)} \geq 0\)

\(\text{No. of type 2 stairs (#str.12)} \geq 0\)

\(0 \leq \text{no. of type 3 stairs (#str.13)} \leq 1\)

The stairs are always placed against the front door if there is no verandah. If there is a verandah, it is placed close to the front door to minimize the distance between it and the entrance. Only occasionally is it placed at the end of the verandah – usually when there is not enough space on the site for the stairs.
High Stairs

- **Types:**
  High stairs are used with high and 2-story type substructures [65]. There are five main types of exterior stair used for the second story. There are three straight stairs- direct (hst.1), landing (hst.2), and split (hst.3), as well as L-shaped (hst.4) and T-shaped stairs (hst.5).

- **Sizes:**
  The overall height of high stairs and the number of risers depends on the height of the substructure [66] [67][68]. Risers vary between 15 and 24 cm (6"-9.5") [69] while the treads are between 20 cm and 30 cm (8"-12") [70]. Stair widths range from 0.9 to 1.8 m (3'-0"-6'-0") but 1.2 m (4'-0") is most common [71].

**Rules:**
[65] If substructure type = high or 2-story, then high stair type = hst.1, hst.2, hst.3, hst.4 or hst.5
[66] If substructure type is high, the total height of high stairs (ht. hstr) = height of substructure (sub.ht)
[67] If substructure type is 2-story, the total height of high stairs (ht.hstr) = substructure height + ceiling height of ground room.
[68] No. of stairs/risers (#rsr) = total height of high stairs (ht.hstr)/.20m (8")
[69] Height of risers (ht.rsr) = total height of high stairs (ht.hstr)/No. of risers (#rsr)
[70] 20 cm (8") ≤ tread width (w.trd) ≤ 30 cm (12")
[71] 0.9 m (3'-0") ≤ stair width (w. h str) ≤ 1.8 m (6'-0")

The height of the stairs will depend on the height of the substructure. The width will depend on the preference and budget of the owner. The style of stair will depend on the size of the site, and the preference of the owner. Railings will always be used for high stairs.
■ Placement/Location:
High stairs are usually placed directly in front of the door, either placed against the door opening or with a verandah between the stair and the door. They are also sometime placed at the side of the house [72]. They can approach the house either directly or at right angles to the entrance [73].

Rules:
[72] high stair (h. str) // door (dr) or
high stair (h. str) // verandah (vr) // door (dr) or
high stair // building side
[73] angle of stair approach (° str. app) = 0° or 90°
The stairs are placed next to the door or if there is a verandah, as close as possible to the front door in order to minimize circulation space on the verandah. The placement also depends on the preference of the owner as well as on the amount of space on the site between the house and the street. Like the low stairs, the high stairs are always visible from the street. Shop/townhouses usually have their exterior stairs on the side of the building in order to maximize the public space in front of the store.
Traditionally, walls are made of wood framing with the posts usually between 0.8 m (2'-8") and 1.0 m (3'-3") apart [74]. The bays or panels are usually all the same width within a house [75]. Between the posts are either full walls or openings which can be either a door or a window [76][77]. Therefore, the width of the openings is always the width of the panel or bay [78].

The number of bays in the facade of the building depends on its length and the bay size [79]. This is also true for the number of bays in the side facade [80].

The precise size of rooms also depends on the bay size [81] and usually vary from 3 to 10 bays [82]. Every room with an exterior wall has an opening. Room walls with 5 or less panels or bays will have at least one opening [83]. Rooms with 6 or more bays will have at least two openings [84].

The placement of the openings also depends on the number of bays in the room. In odd-numbered panel walls, the opening is most frequently placed in center panel, though occasionally it is also placed in the end panels [85]. In even-numbered panel walls, the door opening is most often placed in either of the two most central panels [86]. When there is more than one opening, they can be placed in any order, but evenly spaced in more frequent.

In buildings with two stories, the number and placement of the openings are usually the same in both the lower and upper story [87].

[74] 0.8 m (2'-8") ≤ panel width ≤ 1.0 m (3'-3")
[75] panel width1 = panel width2 = panel width3 = panel width4 ...
[76] panel type = full wall, 1/3 height wall, or opening
[77] opening type = door window, or none
[78] opening width = panel width
[79] No. of panels in bld. length = building length/panel width
[80] No. of panels in bld. width = building width/panel width
[81] No. of panels in exterior wall = wall length/panel width
[82] 3 ≤ no. of panels per exterior wall (#wl pnl) ≤ 10
[83] If no. of panels = 3-5, no. of openings ≥ 1
[84] If no. of panels >5, no. of openings ≥ 2
[85] If no. of panels = 3, 5, 7, or 9, and if no. of openings = 1, the
opening is placed in panel no. \((\text{no. of panels}/2)+.5\)

[86] If no. of panels = 4, 6, 8, or 10, and if no. of openings = 1, the opening is placed in panel no. \((\text{no. of panels}/2)\) or \((\text{no. of panels}/2) + 1\)

[87] No. and placement of openings in lower floor = No. and placement of openings in upper floor.

The number and placement of openings in the rooms are some of the most important decisions in terms of comfort for the occupants. The general approach is to maximize the opening size and number whenever possible to enhance air movement. All exterior walls of all rooms should have at least one opening in it; larger rooms will have more than one opening. These openings can be doors or windows. If there is only one opening per wall, it is usually centered in order to permit air to move through the middle of the room.

The openings of 2-story buildings will be balanced with the same number and position, but not necessarily the same type. For example, door openings may be placed on the ground floor but windows are used on the second floor.

### Doors

■ Types:
There are many styles of doors used. Seven examples are shown below. The doors are usually paneled, louvered, or combinations of the two. Sometimes there is no door, in which case shutters are always used to close the opening. [88] There are also three types of door swings: single, double or triple [89].

[88] door type = none, panel, louvered, panel/louvre or glass/panel.
[89] door swing type = single, double or triple

The type of door will depend on the context and the preference of the owner. Doors with glass would usually be located in the shade (e.g. on a verandah) to prevent solar heat gain inside the house. Doors with glass would also have shutters to protect them during storms and for security. Solid panel doors might be used more where security is an issue.

The type of door swing will depend on the width of the wall panel, the preference of the owner and the amount of space available for the door swing.
Sizes:
Door openings range from 0.8 to 1.5 m wide (2'-8"–5'-0") [90] and usually depends on the width of the wall bay or panel (see rule 76) with 0.8 and 1.0 m the most common sizes. However, specialty doors, such as the shop doors on the ground floor of a shop/townhouse, tend to be larger in order to permit the movement of goods and people [91].

The most common widths are 0.8, 1.0 and 1.2 m (2'-8", 3'-3", 4'-0"). Single doors are usually 0.8 or 1.0 m (2'-8", 3'-3") [92]. Double doors are usually 1.0 or 1.2 m (3'-3", 4'-0") [93]. Triple swing doors are always 1.2 m (4'-0") or more wide [94]. Door heights ranges from 2.2 m to 2.5 m (7'-3"–8'-2"), but the most common is 2.2 m (7'-3") [95].

Rules:
[90] 0.8 m (2'-8") ≤ door opening (dr. opn) ≤ 1.5 m (5'-0")
[91] If house type is shop/townhouse, 1.2 m (4'-0") ≤ width of doors on lower floor ≤ 1.5 (5'-0")
[92] If door swing type = single, door width (w.sgl.dr) = 0.8 or 1.0 m (2'-8", 3'-3")
[93] If door swing type = double, door width (w.dbl.dr) = 1.0 or 1.2 m (3'-3", 4'-0")
[94] If door swing type = triple, door width (w.trp.dr) ≥ 1.2 m (4'-0")
[95] Door height (dr.ht) = 2.2 m (7'-3")

The width of the door will depend on the wall panel width, the door swing type and the use of the door. Residential doors are usually the width of the wall panel but specialty doors such as those used in the ground floor of the shop/townhouse will be much wider to allow the movement of goods and customers.
Shutters
Door openings frequently have shutters in addition to doors. Three main types include panel, plank and louver [96]. The height of the shutters are equal to the height of the doors [97] and their width is half the width of the door opening [98].

[96] Shutter type = panel, plank, louver, solid or none.
[97] Shutter height (sht.ht) = door height (dr.ht)
[98] Shutter width (sht.w) = door width/2

The shutter type will depend on the level of security needed, the door type it protects, the intensity of storms experienced and the preference of the owner.

The height of the shutters is always the height of the doors and the width is half of the door opening.
Placement/Location:
Doors are used for moving in and out of the house as well as ventilation. Except in the simplest one-room house, a building would have at least 2 entrances – a “front” and “back” door [99]. Many even simple buildings have more than 1 back door. All houses would normally have only one door/entrance on the street side [100]. Doors are only used when they are adjacent to a verandah, stairs or the ground [101].
4. A Grammar - Generative Rules

Rules:
[99] $2 \leq \text{total number of exterior doors (}\#\text{ext.drs)}$
[100] Number of "front" doors (\#fnt.drs) $\geq 1$
[101] Door // verandah, ground or stairs

All houses would have at least 2 doors (a "front" and a "back" door) with even small houses often having more.

For safety, a door must always open onto a verandah, the ground or a set of stairs.

Windows

Types:
There are many types of doors used in Caribbean architecture. Seven of the types found in the corpus are shown below. Window types are plain, paned (2-, 4-, 6- or 12-pane), decorative (short or tall), louvered and combinations [102]. Windows can be sash or casement [103]. Shutters are frequently added to the window to protect it from tropical storms. Shutters are only added to exposed windows, that is, they would rarely be on the windows protected by a verandah unless the house had originally been built without a verandah. Shutter types are louvered, panel, and plank [104].
4. A GRAMMAR – GENERATIVE RULES

Rules:
[102] window type = louvered, pane, plain, decorative, or combination
[103] window opening type = sash or casement
[104] shutter type = louver, panel, or plank.

The choice of window type depends on the amount of shade, the amount of security needed and the preference of the owner. Glass windows in particular should be shaded to prevent solar heat gain. Louvered windows might be preferred when air movement is desired even though windows may need to be closed.

The choice of sash or casement windows depends on the preference of the owner, the amount of air movement desired, and the amount of space available for the window swing.

Sizes:
The range of dimensions of window openings are identical to common door openings: 0.8 m (2'-8'"), 1.0 m (3'-3'"), and 1.2 m (4'-0'"")[105].

The top of the window is always level to the top of the door [106]. Window height is often 1.2 m (4'-0'") with the sill height at 1.0 m (3'-3'"). Window sill can also be at 0.6 m or 0 (floor level) [107].

Rules:
[105] Window width = 0.8, 1.0, or 1.2 m
[106] Top of window = top of door
[107] Window sill height = 0, 0.6 (2'-0'") or 1.0 m (3'-3'"")

Window width will depend on the width of the wall panel. The top of the window is always at the same level of the top of any door. The height of the window will depend on the preference of the owner and the amount of air movement desired within the room.
Shutters:
Windows frequently have shutters. The three main types are panel, plank, and louvered [108]. The height of the shutters are always equal to the height of the windows [109] and the shutter width is half of the window width [110].

Rules:
[108] Window shutter type = panel, plank, louver, or solid.
[109] Window shutter height = window height
[110] Window shutter width = window width/2

The choice of shutter type will depend on the preference of the owner, the amount of air circulation desired, the type of window it protects, the intensity of storms experienced and the amount of security needed. The height of the shutters is always the same as the window height and shutter width is always half of the window width.

Placement/Location:
Windows are used to provide ventilation and light in the building. The rules for placing windows are those for placing openings (see rules 74–87). Typical rules are: every exterior wall of every room will have at least one opening – either a door or window and that windows on the ground floor will be placed in the same location in the second floor. Unlike doors, windows can be placed in any location i.e. they do not have to be placed next to the verandah, ground or stairs.
CONSTRUCTION

Materials

The choice of materials in traditional Caribbean houses were and continue to be dependent on availability and the homeowner's budget.

**Foundations**: The materials for foundations need to be strong and resistant to moisture, mold, fungus, and termites. The usual choice for the foundations and substructure of the buildings were (and still are) stone, concrete or concrete blocks [111]. Occasionally wooden columns are used, especially in houses with the first floor raised one story.

**Walls**: Traditionally walls were wood framing. Originally wood was available locally but the supply soon disappeared and Caribbean islands have since depended on importing standardized timber from other countries. Recently concrete block has become more common because of the expense of importing timber [112].

**Roofs**: The roof structure is timber [113]. Roof coverings can be tile, wooden shingles or corrugated metal sheets [114].

**Rules:**
[111] Foundation materials = stone, concrete, or concrete block.
[112] Wall materials = wood framing, or wood framing with insulation, or concrete block with shading and insulation.
[113] Roof structure material = timber
[114] Roof covering material = wooden shingles, tiles, or corrugated metal sheet.

The choice of building materials will depend largely on their local availability and their cost.

Foundation materials will depend on the materials that are available locally.

Preferred wall materials are those that have a low thermal capacity and do not transfer heat easily. If concrete block is used, walls must be shaded and/or insulated.

Preferred roofing coverings are those that have a low thermal capacity and do not transfer heat easily.
Method

Whenever possible, walls and roofs should use lightweight construction (e.g. wood framing) [115]. If lightweight construction is not possible, effort must be made to design the walls so that they are protected with shade and have sufficient insulation.

There are two wall construction methods used: type one with the low wall at its base and type two with the timber frame attached to the floor plate [116].

There are also two main types of truss for gabled roofs: type 1 with a collar beam, and type 2 with a king post [117].

The roof/ceiling should always be well insulated [118].

Rules:

[115] Wall construction method = lightweight or heavy construction

If wall construction method = heavy, wall construction → insulation

[116] Wall frame method = type 1 or 2

[117] Roof truss method = type 1 or 2

[118] Roof construction method → insulation

Insulating the roof which receives the maximum amount of solar radiation, will prevent the heat from radiating into the room and heating the air inside.

Insulating the walls, especially east/west unshaded walls will prevent the heat from transferring into the room.

The choice of the wall frame and roof truss method will depend on the tradition in the area and the availability of materials.
Walls are usually painted a light color [119] with darker colors on the shutters, verandahs, balustrades and columns [120]. Walls are one color while two colors can be used for the trim.

**Rules:**

[119] **Wall color (1)** = white, off-white, pale yellow, pale green, or pink
[120] **Trim color (1 or 2)** = blue, brown, red, green, light blue, or olive green.

<table>
<thead>
<tr>
<th>Wall colors are lighter to reflect solar radiation. Darker colors are used in smaller amounts for accent.</th>
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**Decorative Trim**

Decorative trim is usually limited to the front of the house where it can be seen from the street [121].

The trim is usually wood fretwork, lattice, or geometric arrangements on the verandah railings. Fretwork is found along the fascia of the verandah roof. The style or type is almost unlimited - but is usually lathed shapes, cut-outs or lattice [122]. It's height is usually no more than 30 cm (12") [123].

The railing height on a verandah is approximate 1/3 of the adjoining room, usually 80-90 cm (2'-8"-3'0") [124]. The width between verandah columns is usually the same or twice the width of the panels of the adjoining room [125]. The choice of pattern of railing panel is almost infinite, but simple geometric forms are the most common, with combination of horizontal, vertical and diagonal shapes.

**Rules:**

[121] **Fretwork // verandah facia**
[122] **Fretwork type = lathed, cut-out, or lattice**
[123] **20 cm (8") ≤ fretwork height ≤ 30 cm (12")**
[124] **80 cm (2'-8") ≤ railing height ≤ 90 cm (3'-0")**
[125] **Railing panel width = wall panel width or 2 x wall panel width**

The purpose of the trim is to add individuality to the house. Fretwork also provides more shade to the walls while still allowing air movement through it.
The railings and trim on the verandah serve the same function of expressing individuality; it also marks the edge of the public/private territory, prevents furniture and occupants from falling off the edge and allows air circulation through it.

The choice of pattern for the fretwork and the railing panel will depend on the materials available, the skill of the carpenter, the preference of the owner and the budget available.
The purpose of an architectural grammar is to generate designs. The set of total possible designs to come out of a grammar is very large (hundreds in the case of this grammar) and will contain those in the original corpus as well as new ones. The newly generated designs will all be unique to the original corpus but will clearly belong to the same “family”.

The rules could be put into a computer program which would then generate all the possible designs. They could also be generated manually – which, though much slower, would produce the same results.

In order to test the rules, sketch designs were generated following the series of rules that were formulated for the grammar. One was to produce a frame house on a semi-urban site and the other was a shop/townhouse on an urban site.

As mentioned in a previous chapter, the process of using grammar rules are usually described as top-town or bottom-up, but in reality, middle-out is a more accurate reflection of the design process. The rules were set up as a top-down (see diagram on next page) but when put to use, they did not follow the strict path of the rules (see diagram on following page). Rather than beginning with the overall building site, the designer began at the room sizes, placed them on the site, checked with the overall building shape and then skipped down to ceilings and roofs.

On the following pages for each of the two sketch designs are – a brief description, sketches of the house and a list of the design decisions that were made during the process, as the rules were followed.
Design 1 – Frame House

The first design was for a house on a semi-urban lot—12 m by 20 m. The first phase was to have 2 primary rooms (3.5 m x 4 m) and verandah (1.8 m wide, full length). A second phase was planned for two additional secondary rooms (3 m x 4 m). The building was placed 1.5 m from the street lot line, and 2.0 m from the side lot lines. The site’s axis was north/south and the breeze also came from the south.

When the decision of the wall panel width was taken, the initial room size had to be adjusted. The primary rooms became 4.5 m x 3.6 m, the verandah became 1.8 m x 9.0 m, and the secondary rooms became 4.5 m x 2.7 m. Consequently, the building had to be shifted on the site and distance from the side lot lines became 1.0 m and 2.0 m.

It was decided that the openings would be large and numerous as possible and no exterior shutters would be necessary. Louvered casement windows were used and an exterior door was placed in every room.

The low stairs were placed within the verandah and steps were provided to the doors in the two secondary rooms.
### Test Design 1 — Frame House

<table>
<thead>
<tr>
<th>Type of Decision</th>
<th>Rules</th>
<th>Decision Made</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MASSING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room size</td>
<td>8–22</td>
<td>2 rooms @ 3.5 x 4.0 m&lt;br&gt;verandah 1.8 m width&lt;br&gt;secondary rooms (3 x 4 m) (2nd and 3rd phase)</td>
</tr>
<tr>
<td>Room arrangement</td>
<td>23–32</td>
<td>width side to width side</td>
</tr>
<tr>
<td>Building shape (check only)</td>
<td>1–4</td>
<td></td>
</tr>
<tr>
<td>Location on site</td>
<td>5–8</td>
<td>length side along street; 1.0 m setback from street line; kitchen and sanitary facilities near back lot line</td>
</tr>
<tr>
<td>Roof type</td>
<td>36, 39, 42, 46,</td>
<td>Gable on primary rooms, shed on verandah, shed on future secondary rooms</td>
</tr>
<tr>
<td>Roof slope</td>
<td>35, 40–41, 47,</td>
<td>Gable - 40°, verandah - 10°, secondary rooms - 8°</td>
</tr>
<tr>
<td>Ceiling height</td>
<td>33, 34, 37–38,</td>
<td>2.6 m primary room&lt;br&gt;2.2 m secondary room&lt;br&gt;2.3 verandah</td>
</tr>
<tr>
<td></td>
<td>43–45, 48,</td>
<td></td>
</tr>
<tr>
<td>Substructure</td>
<td>49–54</td>
<td>low type&lt;br&gt;height: 0.6 m</td>
</tr>
<tr>
<td>Stair type</td>
<td>55–61</td>
<td>type 2&lt;br&gt;stair height: 0.6 m&lt;br&gt;number of risers: 3&lt;br&gt;tread height: 0.2 m&lt;br&gt;stair width: 1.0 m</td>
</tr>
<tr>
<td></td>
<td>65–73 (n.a.)</td>
<td></td>
</tr>
<tr>
<td><strong>OPENINGS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall panel width</td>
<td>74, 75,</td>
<td>0.9 m (Therefore...&lt;br&gt;primary room: 5 panels x 4 panels – new room size: 4.5 m x 3.6 m&lt;br&gt;secondary rooms: 5 panels x 3 panels - new room size: 4.5 m x 2.7 m (recheck building size and placement on site)&lt;br&gt;verandah: 2 panels x 10 panels</td>
</tr>
</tbody>
</table>
| Number, type and Location of Openings | 76–87, 99–100 | Length primary rooms: panels 1,5,- solid; panels 2, 4, - window; panel 3 - door.  
Width side: panels 2,3, - window  
Verandah: 2 panels on side open, remainder 1/3 height. |
<p>| Door type                 | 88             | louver/panel                                                                   |</p>
<table>
<thead>
<tr>
<th>Type of Decision</th>
<th>Rules</th>
<th>Decision Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door swing</td>
<td>89</td>
<td>double</td>
</tr>
<tr>
<td>Door size</td>
<td>90-95</td>
<td>height: 2.2 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>width: 0.9 m (panel width)</td>
</tr>
<tr>
<td>Door shutters</td>
<td>96-98</td>
<td>none</td>
</tr>
<tr>
<td>Stair placement</td>
<td>62-64</td>
<td>End of verandah (west side)</td>
</tr>
<tr>
<td>Window type</td>
<td>102-103</td>
<td>louver, casement</td>
</tr>
<tr>
<td>Window shutter</td>
<td>104, 108-110</td>
<td>none</td>
</tr>
<tr>
<td>Window size</td>
<td>105-107</td>
<td>width: 0.9 m (panel width)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sill height: 0.6 m</td>
</tr>
<tr>
<td>CONSTRUCTION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall materials</td>
<td>111</td>
<td>wood frame</td>
</tr>
<tr>
<td>Foundation materials</td>
<td>112</td>
<td>concrete</td>
</tr>
<tr>
<td>Roof structure</td>
<td>113</td>
<td>timber</td>
</tr>
<tr>
<td>Roof covering</td>
<td>114</td>
<td>corrugated metal</td>
</tr>
<tr>
<td>Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wall construction</td>
<td>115-116</td>
<td>type 1 (low wall)</td>
</tr>
<tr>
<td>roof construction</td>
<td>117-118</td>
<td>type 1</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wall color</td>
<td>119</td>
<td>pale yellow</td>
</tr>
<tr>
<td>trim color</td>
<td>120</td>
<td>blue, pale blue</td>
</tr>
<tr>
<td>Trim</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fretwork location</td>
<td>121</td>
<td>verandah facia board</td>
</tr>
<tr>
<td>Fretwork type</td>
<td>122</td>
<td>lattice</td>
</tr>
<tr>
<td>Fretwork height</td>
<td>123</td>
<td>10”</td>
</tr>
<tr>
<td>Railing height</td>
<td>124</td>
<td>0.9 m</td>
</tr>
<tr>
<td>Verandah panel width</td>
<td>125</td>
<td>1.9 m (2 x panel width)</td>
</tr>
<tr>
<td>Verandah panel style</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Design 2
– Shop/Townhouse

The second design was for a shop/townhouse on a narrow 10 m by 20 m lot. The lot was oriented in a north-south direction and the wind also came from the south. The building was to have two floors - 4 rooms per floor. The ground floor was to be used as a store. Upstairs was to be the family house. Both floors had 2 larger primary rooms and two smaller secondary rooms. The upper floor also had an overhanging verandah which shaded the entrance of the store.

The house was centered on the lot with 2 meters on each side - enough to allow for some air movement as well as space for the exterior side stair and a passage to the back yard. The building width was 6 m and its length was 11 m. The building was oriented in on a north/south axis which was not preferred from a climatic point of view but the lot size and orientation prevented other alternatives. Consequently, openings were maximized and windows were shaded.

The two primary rooms were each 6 m x 4 m and the secondary rooms were 3 x 3 m. The verandah was 1.5 meters wide and stretched across the front facade.

The windows on the ground floor have louvered interior casement windows and solid shutters that can be closed at night for security. Upstairs are louvered windows. On the verandah that faces the street, the windows and walls are louvered for ventilation and privacy. Two windows on the sides and four in the front of the verandah can be opened or closed according to need.
## Test Design 2— Shop/Townhouse

<table>
<thead>
<tr>
<th>Type of Decision</th>
<th>Rules</th>
<th>Decision Made</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MASSING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room size</td>
<td>8-22</td>
<td>2 primary rooms @ 6.0 x 4.0 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>verandah 1.5 m width</td>
</tr>
<tr>
<td></td>
<td></td>
<td>secondary rooms (3 x 3 m)</td>
</tr>
<tr>
<td>Room arrangement</td>
<td>23-32</td>
<td>length side to length side</td>
</tr>
<tr>
<td>Building shape (check only)</td>
<td>1-4</td>
<td></td>
</tr>
<tr>
<td>Location on site</td>
<td>5-8</td>
<td>length side along street; no setback from street line; 2.0 m on each side of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the house; kitchen and sanitary facilities near back lot line</td>
</tr>
<tr>
<td>Roof type</td>
<td>36, 39, 42, 46,</td>
<td>Gable on primary rooms, shed on verandah, shed on secondary rooms</td>
</tr>
<tr>
<td>Roof slope</td>
<td>35, 40-41, 47,</td>
<td>Gable - 26°, verandah - 10°, secondary rooms - 7°</td>
</tr>
<tr>
<td>Ceiling height</td>
<td>33, 34, 37-38, 43-45, 48,</td>
<td>2.8 m primary room</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 m secondary room</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 m verandah</td>
</tr>
<tr>
<td>Substructure</td>
<td>49-54</td>
<td>2-story type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>height: 0.1 m</td>
</tr>
<tr>
<td>Stair type</td>
<td>55-61 (n.a.)</td>
<td>high stair type - straight split</td>
</tr>
<tr>
<td></td>
<td>65-73</td>
<td>stair height: 2.4 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>number of risers: 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>riser height: 0.2 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tread depth: .25 m</td>
</tr>
<tr>
<td>OPENINGS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall panel width</td>
<td>74, 75,</td>
<td>1.0 m (Therefore...</td>
</tr>
<tr>
<td></td>
<td></td>
<td>primary room: 6 panels x 4 panels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>secondary rooms: 3 panels x 3 panels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>verandah: 1.5 panels x 6 panels</td>
</tr>
<tr>
<td>Number, type and Location of</td>
<td>76-87, 99-100</td>
<td>Length upper primary rooms: panels 3,4 opening</td>
</tr>
<tr>
<td>Openings</td>
<td></td>
<td>louver doors, panels 2, 5 louver panels, panels 1, 6, solid; panels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper primary width side - panels 2,3 louvered windows, 1 door.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper secondary rooms: panel 2 louvered window</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower primary, 1.3 m shop doors, width side</td>
</tr>
<tr>
<td></td>
<td></td>
<td>panels 2,3 shuttered windows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower secondary rooms - panels 2,3 shuttered windows</td>
</tr>
<tr>
<td>Type of Decision</td>
<td>Rules</td>
<td>Decision Made</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Door type</td>
<td>88</td>
<td>Shop front: 1.3 solid shutter doors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ground floor secondary rooms and upper entrance door: panel/louvered doors</td>
</tr>
<tr>
<td>Door swing</td>
<td>89</td>
<td>double</td>
</tr>
<tr>
<td>Door size</td>
<td>90-95</td>
<td>height: 2.2 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>width: 1.0 m (panel width)</td>
</tr>
<tr>
<td>Door shutters</td>
<td>96-98</td>
<td>solid downstairs</td>
</tr>
<tr>
<td>Stair placement</td>
<td>62-64</td>
<td>exterior west side</td>
</tr>
<tr>
<td>Window type</td>
<td>102-103</td>
<td>louver, casement</td>
</tr>
<tr>
<td>Window shutter</td>
<td>104, 108-110</td>
<td>downstairs: solid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>upstairs: none</td>
</tr>
<tr>
<td>Window size</td>
<td>105-107</td>
<td>width: 1.0 m (panel width)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sill height: 0.6 m (upper floor)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sill height: 1.0 m (ground floor)</td>
</tr>
</tbody>
</table>

**CONSTRUCTION**

- **Materials**
  - **Wall materials**: 111 wood frame
  - **Foundation materials**: 112 concrete
  - **Roof structure**: 113 timber
  - **Roof covering**: 114 corrugated metal

- **Method**
  - **Wall construction**: 115-116 type 2
  - **Roof construction**: 117-118 type 2

- **Color**
  - **Wall color**: 119 white
  - **Trim color**: 120 green, yellow

- **Trim**
  - **Fretwork**: 121-123 n.a.

- **Railing height**: 124 n.a. (louvered panels)

- **Verandah panel width**: 125 1.0 m
Chapter Bibliography


Grammars in Practice

- Process vs. Product
- Choice of Media
- Examples of Grammars
- Another Approach
- Summary and Conclusions
- Chapter Bibliography
This chapter considers how architectural grammars could be used in practical terms for assisting the design process. It considers grammars as a process and a product, discusses the advantages and disadvantages of different presentation media, and gives some examples of grammars that have been produced for a non-academic audience. Finally, it suggests ways of how grammars could be put into a usable form so that they could be used by both design professionals and students.

Process vs. Product

When considering architectural grammars as a tool for both practice and learning, there are two very different ways of approaching the subject. The first is to look at the process of formulating a grammar and the second is using an already completed grammar as a tool. There are advantages and disadvantages to both approaches.

Having gone through the process of developing a grammar for this thesis, it is difficult to imagine a method that surpasses it for developing an understanding of a subject. The process of having to prescribe rather than simply describe the architectural form, style or type forces a greater rigor which results in a much deeper understanding. However, it is also a very time-consuming process and does not necessarily increase the user's ability to evaluate the generated designs other than in terms of whether it meets the rules.

In cases where developing a grammar may be impractical because of time or where there is a need to evaluate and compare the new designs, an already-formulated grammar could be used in conjunction with a method for comparing designs. If this method is used, it is essential to present it in an informative and understandable way to convey the necessary information.

Choice of Medium

How a grammar is presented to users and what it is able to do will depend on the medium chosen. Three media are briefly discussed here - paper, wood and computers.

Paper (The Grammar as Paper Rules)
The simplest and most usual method of presenting a grammar is
to write it down and paper and have the user follow the rules to generate new designs. However, if this medium is used, it is important to write the rules as clearly as possible and to have the reasoning or explanation for the rule accompany it (e.g. Appendix 1). Even more helpful would be an additional graphic description of the process that the user will go through. An example of written rules and the explanation for them is a summary of the rules written for the grammar developed for this thesis which can be found in the appendix.

The advantage of using pen and paper is that it is the simplest and requires the minimum resources. Though not usually done in most grammars, it can quite adequately explain the reasoning behind the rules, simply by having the reasons accompany the rules.

The disadvantage of this method is that comparison between or evaluation of the generated designs is not easy. Though the user will know if the rules were followed, it becomes more difficult to choose between possible acceptable designs. For example, if one had to choose between three designs which follow the rules and fit the design brief for a particular situation, how would one know which will be the least expensive or provide the greatest amount of breeze in hot weather? Certainly, these could be worked out manually, but it would be time-consuming and discourage quick comparisons.

Wood (The Grammar as Building Blocks)

The grammar that has been formulated in this thesis could be made into a set of blocks or kit of parts that could be put together in different ways to generate designs. In addition to the blocks of room and roof elements, it would be useful to be able to add more detail such as having different types windows, doors, stairs and trim that could be attached to the blocks.

The advantage of using a set of blocks is that in addition to being fairly inexpensive and easy to use, it would permit designers to model possibilities in three dimensions rather than sketching them in two or three dimensions. It could also be preferred to a computer program if the user is unable or uncomfortable manipulating 3-d images on a computer screen.

The most serious disadvantage of blocks is that though the grammar may encode important architectural information, it is
not able to convey this information to the user who would not be aware of the rules or the reasoning behind them. The blocks would strictly limit the discussion to physical form only and it would not allow comparison between two equally grammatically correct designs. From a practical point of view it would also likely be difficult to design a system or kit that would only allow itself to be arranged in "correct" ways.

- Computer (The Grammar as Computer Program)
Though more expensive than paper or wood, the computer as a medium offers the widest opportunities for making a grammar a useful tool for designers.

There are two main approaches for using the computer as a design and learning tool. The first sees the computer as an interactive textbook for tutoring. It breaks the subject into facts and often emphasizes rote learning. The second approach sees the computer as an expressive medium which provides exploratory environments and allows the learner (and teacher) to explore a subject which leads to discovery and learning.

Neither approach is right nor wrong but some subjects lend themselves to one approach rather than another. Learning to type, for example, would not be a subject where the most effective learning method is discovery; in this case, practice and drill is more appropriate. Design on the other hand lends itself to an exploratory approach because it allows the user to build and integrate different aspects or pieces of knowledge as they need it.
The computer's greatest advantage is its flexibility which allows different levels of information to be made available when it is needed by the user. The user can choose to work with a "black" or "transparent" box, that is, they can choose to work with more limited information or delve deeper in to subject and work with much more complex and complete information. Of course, its ability to calculate quickly also makes it very useful for evaluating designs whether it be from a cost or energy point of view.

Examples of Grammars

The following are examples of how grammars, as products, have been used for presenting styles or types of architectural form using different media.

To date, most grammars have been written for an academic audience rather than the professional, student, or general public. They have also usually been limited to the printed page with many (but not all) describing the rules in a more mathematical form. In spite of a grammar's ability to generate form through the use of the rules, few authors have developed their grammars into a computer program.

Planmaker and Facademaker

George Hersey and Richard Freedman's Possible Palladian Villas (Plus a Few Instructively Impossible Ones) has, in addition to the text, an accompanying diskette with two computer programs - Planmaker and Facademaker. The program allows the user to design Palladian villas by applying the rules described in the book. In Planmaker the user types in the dimensions of the desired plan and the program generates plans to fit the dimensions. With Facademaker the user can also create facades of Palladian villas by choosing elements from a menu which includes 4 roof types, 16 facade styles, 4 bases, and 14 stair styles. The authors state that the designs can also be generated manually by following the rules in the book.

The authors explain that they decided to have a computer design the Palladian villas rather than doing it themselves simply because of its "ability to calculate a huge number of permutations and combinations based on Palladio's rules. Because of the rapidity and completeness with which it can apply these rules, it can test them on a far wider and firmer basis than could an unaided human being. With the disk containing Planmaker and
Screen views of Planmaker and Facademake (Hersey and Freedman, 1992)
Facademake, our software for creating plans and facades, anyone can sit down in front of a Macintosh and generate thousands of Palladian villas. The ultimate number is probably circumscribed only by the operator’s patience.” They also state that another advantage of the computer is that it “excludes unconscious human prejudice” and eliminates imitators of Palladio who “stray very far from his architectural code”.

Hersey and Freedman’s computer program is interesting because they have actually done what many others have only suggested and they have succeeded in putting it into a very easy-to-use format. The program does exactly what it is supposed to do — it generates Palladian look-alike villas using a computer program.

However, using the program quickly demonstrates its limitations as a design tool (though to be fair, this may not have been their main objective). The user can indeed create thousands of Palladian villas but the problem is that the user’s understanding is not increased as the designs are generated. Is one design preferable over another, and if so, why? There is no indication of what rules are being used (unless the user reads the book) or why those rules exist. The user’s role becomes one of pushing the buttons, rather mindlessly watching the program generate designs and the process quickly becomes very uninteresting.

The Facademake and Planmaker programs are actually very similar to the blocks and rubber stamp kits that will be discussed next. Though the technology would permit much greater possibilities, the program does not take advantage of them and actually ends up being a stricter high-tech version of blocks or rubber stamps.

To be truly useful to designer, a computer program must do something more than produce imitation buildings. It must bring to it an understanding which in Hersey and Freedman’s case is done through reading the book, and not the computer program.

Archiblocks
The other example of a shape grammar that has been produced for the general public is Archiblocks by Bower Studios. It is a set of building blocks in “architecturally correct styles” that include Greek, Roman, Japanese, Santa Fe, Renaissance and Frank Lloyd Wright. These blocks are a scaled-down version but still in the family of the well-known Froebel blocks used by Frank Lloyd Wright as a child. Their advantage is that they permit much more interaction than the Hersey/Freedman program and are
The Wright stuff in Archiblocks

Archiblocks – building blocks in architecturally correct styles that include Greek, Roman, Japanese, Santa Fe, Renaissance and now Frank Lloyd Wright – were originally conceived as children’s toys. That they are, but owner/designer Ron Bower estimates that now “75 percent are bought for adults,” to use as decoration, wall sculpture, curios, and yes, adult toys. Sized from a ¼-inch cube to 8-inch columns, priced from $39 per set to $300, some come in a wooden box with plexiglass front, for displaying your architectural creations. If you order now from Bower Studios, 300 Main St., Vergennes, VT 05491, (802) 877-6868, fax (802) 877-3631, they’ll guarantee Christmas delivery.

source: Boston Globe

meant to be played with and used to explore ways of putting together the elements to produce new designs. It is a much more creative and interesting activity for the user, however its major drawback is that though the user has the elements they do not know the rules for combining them – arranging the forms becomes an interesting but rather arbitrary process.

Rubber Stamps

Another grammar is a set of rubber stamps called Fun With Architecture. The kit is made up of a set of 36 basic shapes that the user can put together to generate designs. It is interesting to find in the booklet that accompanies the kit that it very explicitly describes itself as a shape grammar...

"Architecture is like a language. In a written language, letters make words, words make sentences, and sentences make paragraphs. If they are thoughtfully arranged, they communicate ideas.

Architectural works in a similar way. Small elements are combined to make parts of a building like walls and roofs. These parts are then combined to make a whole building, which communicates in its own way. This is the language of architecture.

The stamps in this kit are the equivalent of letters and words. They are the architectural building blocks that make up buildings. You will easily recognize some of them as pieces of buildings. Others will look like simple geometrical shapes."
The rubber stamps are similar to the blocks (though limited to two dimensions instead of three) because they permit the user to use the “kit” to explore possibilities and generate designs rather than a machine. However, like the blocks, it also fails to convey any rules or reasoning for assembling the shapes and does not consider any issue other than physical form.

Another Approach

The choice of medium used to present a grammar clearly depends on the resources available and the particular needs of the user, but by far the most flexible medium with the greatest potential for making a grammar useful is the computer.

Computer programs have been written that, using a grammar’s rules, generate all the possible designs. A more rewarding approach from a user’s point of view would be to design a computer program that would allow the user to generate designs using the grammar, be aware of and understand the reasoning behind the rules, and permit the user to quickly evaluate many possible designs in terms other than solely form (e.g. energy, ease of construction, cost, etc.).

This program could combine several approaches depending on the needs of the user. In the first approach, the program generates the designs but the user has a variety of tools available
Possible modeling systems to accompany program.

to help select and evaluate the design. The second approach would have the user generate the design, perhaps used in conjunction with blocks or a kit of parts to assist in the modeling. Design decisions would be made following the rules but based on the particular design situation or context. The designs generated in this way could then be evaluated in terms of cost, energy, etc.

This combined approach takes advantage of the computer's flexibility which allows the user to concentrate only one some aspects of the design if desired. The program could also be designed to provide background information to explain and illustrate the basic principles and reasoning behind the rules.

An example of how one small part of the program could be used to help make design decisions is a program developed for Wolverine Technologies, a manufacturer of exterior building materials. An interactive point-of-sale kiosk was developed that allows customers to experiment with different color schemes
and to see the results. The program has drawings of several different styles of houses. At the side of the screen are the parts of the house (siding, windows and doors, trim and corner posts, facias, porch trim, porch skirt, and gables). Under it are 14 colors of paint. The user clicks on variations of the house parts and colors to experiment with different color combinations. Though simple, it is very effective for weighing alternatives and arriving at a decision. (Josephson, 1992)

Other parts of the program that could be developed would be similar to those used to predict the building's performance such
as construction cost, operating cost, comfort, energy consumption, lighting conditions, how easily it can be used, etc. Professor Murray Milne at UCLA has suggested that what is needed by designers are design tools which he defines as “a piece of software that is easy and natural for architects to use, that easily accommodates three-dimensional representations of the building, and that predicts something useful about the building’s performance". (Milne)

Another useful feature of this program would allow the user to “walk through” the building under consideration. This is a very important feature because it would allow the designer to experience and evaluate the physical form before it was built. With the computer the designer again could also work at different levels of complexity from the very detailed to the very broad.

Certainly a problem with these very complex programs is that it is all too easy for the user to get lost, to not get an overview or not see how parts are related. Care in the design to prevent this from occurring.

This computer program as described does not exist but the parts that make it up do – there are CAD programs, evaluation programs, walk-through programs, presentation programs, etc. What would be needed is a means of tying them together. The result would be a complex program and care would have to be taken when designing it to ensure that the user does not get lost or confused when using it.

### Summary and Conclusions

The overall objective of this thesis was to examine architectural grammars and to evaluate them in terms of usefulness for designing appropriate architecture in hot humid climates.

The methodology used for exploring this question was to review shape grammars that have been created, examine the principles for designing in hot humid climates and investigating traditional Caribbean architecture. A grammar was then formulated, based on a set of 16 houses and as a test, two new designs were generated. The exercise of creating a grammar was especially useful to illustrate its strengths and weaknesses. Finally, grammars that have been produced for the public rather than an
academic audience were reviewed and suggestions were made for ways of presenting grammars to make them a more practical and useful tool for designers.

Since the primary purpose of any grammar is to increase our understanding of design, it must be judged on those terms.

Most grammars that have been produced to date have been shape grammars, based on a particular architect’s style or occasionally a building style. Shape grammars have two serious limitations which reduce their usefulness for a designer. The first is that, as the name suggests, shape grammars focus only on physical form. Though certainly the ability to manipulate form is an essential skill for a designer, architecture is much more. The second limitation is that a grammar on its own does not provide information on the reasons for the rules that make up the grammar. Without this information, there is no understanding and the designer is reduced to a simple generator of look-alike designs. If this information was made explicit, the designer could choose to ignore some rules or add others that might be more applicable in certain contexts. This would increase the ability of the designer to design instead of being limited to simply reproducing or recreating someone else’s style.

However, in its favor, as a tool for learning about and gaining an understanding of an architectural type or style, the process of developing (as opposed to using) a grammar is unsurpassed. The need to go beyond description of a typology into prescription forces a much greater rigor which results in a deeper understanding. This process though, is also very time-consuming which could reduce its usefulness in a professional or educational setting.

In its usual form, shape grammars have some limitations but these can be overcome fairly easily, allowing the grammar to become an extremely useful tool for designers. These limitations could be overcome in three ways, all of which are interlinked.

The first change would entail also including other practical architectural knowledge in the grammar. Though physical form is important, so are many other aspects which should be incorporated into the grammar. These issues may include assessment of comfort, cost, performance, experience, light, sound, and function.
Secondly, ways must be developed for presenting grammars which allow users to understand the reasoning behind the rules, not simply follow them. This could be done using both words and graphics. This is essential in order to allow the designer to intelligently break the rules when necessary which would result in a better design. The goal should be for the user to be a participant in the design process not just the recipient of the generated designs.

Thirdly, methods for analyzing the designs that are generated by the grammar should be incorporated that would permit the user to quickly evaluate many possible designs in terms other than solely physical forms (e.g. energy use, ease of construction, cost, etc.).

These improvements could be implemented using a variety of technologies, but a computer program has the greatest potential. Because of its speed of calculation, flexibility and ability to selectively present and consider one or more aspects of a design as well as the relationship between them, it offers the widest opportunity for making a grammar a useful tool for designers.

In relation to designing climatically responsive architecture for hot humid climates, a grammar is a useful tool because it is based on traditional Caribbean architecture which was intended to maximize the comfort of the occupants given the resources available and the conditions of climate, site and use. Traditional Caribbean architecture offers practical architectural solutions and therefore, a grammar based on this architecture will produce new designs with the same characteristics. These considerations are still relevant today because there is a need for housing that does not rely on air-conditioning but creates comfortable conditions for the inhabitants with minimum investment, maintenance cost and energy, using simple building methods and materials and which reflects local needs and conditions.

An architectural grammar that focuses on the relationship between architectural form and energy use helps designers to understand the consequences of their most basic design decisions and helps them to use these issues to generate form rather than simply accommodating them. An architectural vocabulary and grammar based on Caribbean architecture is also applicable to other regions with similar climates and could easily be adapted to more closely reflect local architectural practices.
Chapter Bibliography


Appendix

Summary of Grammar Rules
Room Types, Sizes and Arrangements

Primary Room
[8] 3.0 m (9'-10") ≤ length of primary room (l.pr) ≤ 8.0 m (26'-3")
[9] Width (w.pr) < Length (l.pr)
[10] Width (w.pr) = 2.0 m - 3.5 m (6'-7" - 11'-6") [avg. 2.98]
[11] 1.00 ≤ Length/Width Ratio ≤ 2.67
[12]*FH: length and width of upper primary room = length and width of lower primary room
[13]*S/TH or TW: width or length of upper primary room = width or length of lower primary room + (0 - 1.8 m)

Rules

1] 5.0 m (16'-5") ≤ building length (l.bld) ≤ 9.0 m (29'-6")
[2] Width (w.bld) < Length (l.bld)
[3] 2.7 m (8'-11") ≤ building width (w.bld) ≤ 6.0 m (19'-8")
[4] 1.09 ≤ Length/Width Ratio ≤ 3.0

Explanation

The width and length of the building varies with the number of room. The maximum width is 6.0 meters (2 - 3m rooms) in order to permit air movement through the building.

The building is placed close to the front of the site, next to the street in order to maximize the space at the back of the house where household activities take place. Also in the back are the kitchen and sanitary facilities. Placing the building close to the street also facilitates social contact between the occupants sitting on their verandah and those on the street.

The first priority for orientation is for wind; the longest side of the building should face the prevailing winds. The second priority is shade; the building’s length should be oriented along the east-west axis. These two priorities may be met on a rural site. However, in urban areas, the building will be oriented to the lot lines; the length of the building will either be parallel to the street or at 90°.

The primary rooms are the largest because they are the first-built rooms and therefore must be multi-functional (living, sleeping, storage, etc.). As the family gets larger and wishes to expand, the new (secondary) rooms are usually smaller because they are usually used as bedrooms. The primary rooms either continue to be used for sleeping and living or they are used exclusively as living areas.

The smallest dimension of the room’s width (2.0m)(6'-7") is dictated by the size of a bed or the space needed to lay down. The largest dimension of the room’s width (3.5m)(11'-6") is dictated by the length of the timber that was ready available. The smallest dimension of the room’s length is again dictated by the size of a bed. It’s largest dimension is dictated by the size of the lot and the ability to arrange furniture and activities within the space.
On a two-story building, the overhang both shades the walls and the entrance to the shop.

**Secondary Room**

[14] Width of secondary room (w.sr) < width of primary room (w.pr)

[15] Length of secondary room (l.sr) = length of primary room (l.pr)
   or
   Length of secondary room (l.sr) = width of primary room (w.pr)

[16] Width of secondary room (w.sr) < length of secondary room (l.sr)

[17] 1.8 m (5'-11") ≤ width of secondary room (w.sr) ≤ 2.5 m (8'-2")

[18] 1.18 ≤ length/width ratio ≤ 2.25

[19] length and width of upper secondary rooms = length and width of lower secondary rooms

The secondary rooms are smaller than the primary room because they are built second and usually have more limited functions, e.g. they are most often the bedroom.

The smallest dimension of the room’s width (2.0m)(6'-7") is dictated by the size of a bed or the space needed to lay down. The largest dimension of the room’s width is dictated by dimension of the adjoining room.

**Verandah**

[20] 1.2 m (4'-0") ≤ width of verandah (w.vr) ≤ 1.8 m (6'-0")

[21] Width of verandah (w.vr) < length of verandah (l.vr)

[22] Length of verandah (l.vr)
   = length of the building (l.bld) or
   = width of the building (w.bld) or
   = perimeter of the building (p.bld)
   = length of a secondary room

The verandah is part of the house but not usually part of the main structure; this allows the it to be built at a later phase. The verandah is one of the most prominent features of the house and usually is the only part that is decorated. Not only does the verandah shade the walls which keeps the house cool, but it serves as the transition zone between the private house and the public street.

The minimum width dimension of 1.2 m (4'-0") is dictated by the space needed to place a chair. The maximum dimension is dictated by the spanning ability of the timber.

**Arrangements**

[23] 1 ≤ no. of rooms (#.rm) // one side of building (w.bld) ≤ 2

[24] No. of primary rooms (#pr) ≥ 1

[25] length side of primary room adjoins the length side of the second primary room.
   lsd.pr // lsd.pr
   or
   the width side of the primary room adjoins the width side of the second primary room
   wsd.pr // wsd.pr

The number of rooms is limited to two in order to permit air circulation through the house.

The rooms are added in a linear arrangement to simplify and facilitate construction and future additions.
Secondary Rooms
[26] No. of secondary rooms (#sr) ≥ 0
[27] If the width side of the primary room adjoins the width side of the next primary room, then the length side of the secondary room adjoins and equals the length side of the primary room.

If lsd.pr // wsd.pr, the lsd.sr // = lsd.pr
or
If the length side of the primary room adjoins the length side of the second primary room, then the length side of the secondary room adjoins and is equal to the width side of the primary room.

If lsd.pr1 // lsd.pr2, then lsd.sr // & = wsd.pr

[28] Width length of the secondary room adjoins the width of the next secondary room.

wsd.sr1 // wsd.sr2 // wsd.sr3 ...

[29] No. of secondary rooms (#sr) = no. of primary rooms (#pr)

Verandah
[30] No. of verandahs (#vr) = 0 or 1
[31] Verandah (vr) // length of building (l.bld) or
Verandah (vr) // width of building (w.bld) or
Verandah (vr) // perimeter of building (p.bld) or
Verandah (vr) substitutes (j) one secondary room (1 sr)
[32] Length side of verandah (l.vr) // street or front of site.

Ceiling Heights and Roofs
[33] Ceiling height of primary room1 (cl.pr1) =
ceiling height of primary room2 (cl.pr2) =
ceiling height of primary room3 (cl.pr3) ...
[34] 2.4 m (7'-11"0 ≤ ceiling height of primary room (cl/pr) ≤ 3.0 m (9'-10")
[35] 27º ≤ roof angle primary room (ra.pr) ≤ 49º.
[36] Roof type (rftp.pr) = gable or hip

The secondary rooms are added on the same side and the full length of the building, most likely to facilitate construction.

For ease of construction, the verandah extends the whole length or width of the building or is the size of a secondary room. The purpose of the verandah is to shade the wall and to provide an indoor/outdoor space for the house that also acts as a transition between public and private space.

The ceilings are relatively high because of the belief that higher ceilings are cooler. This is true if the roof is uninsulated (which it often was) but is less important if the ceiling is well insulated.

The roofs are sloped to permit the rapid removal of rainwater and to direct it to the gutters where is often collected for household use. The steep
Ceiling height of secondary room^1 (cl.sr^1)
  = cl.sr^2 = cl.sr^3 ...
[38] 2.2 m (7'-3") ≤ cl.sr ≤ 2.7 m (8'-10")
[39] Roof type (rftp.sr) = shed or gable
[40] 6° ≤ shed roof angle (ra.sd.sr) ≤ 14°
[41] Roof angle of gable roof (ra.gb.sr) = 43°
[42] Roof type (rft.sr) = or ≠ roof type of
  primary room (rft.pr)
[43] If roof type (rft.sr) = gable, ceiling ht. of
  primary room (cl.pr) = ceiling ht. of
  secondary room
[44] If roof type (rft.sr) = shed, ceiling ht. of
  primary room (cl.pr) > Ceiling ht. of
  secondary room (cl.sr) + roof ht. of shed
  roof (ht.sh.sr)

[45] 2.2 m (7'-3") ≤ ceiling ht. of verandah
  (cl.vr) ≤ 2.5 m (8'-2")
[46] Roof type (rftp.vr) = shed
[47] 6° ≤ roof angle of verandah (ra.vr) ≤ 18°
[48] Ceiling ht. of verandah (cl.vr) + roof
  height of verandah (ht.sh.vr) < ceiling ht.
  of adjacent room (cl.pr) or (cl.sr).

Substructure type = low, high or two-
story
[50] If no. of stories = 1, substructure type is
  low or high
[51] If no. of stories = 2, substructure type is
  two-story
[52] Substructure low type height (sub.ht) =
  0.1 m - 0.6 m (4"-24")
[53] Substructure high type height (sub.ht) =
  2.2 m - 2.7 m (7'-3"- 8'-11")
[54] Substructure 2-story type height (sub.ht) =
  0.1m - 0.6 m (4"-24")

If substructure type is low, then low stair
  type = 1, 2, 3 or none
[56] No. of stairs/risers (#rsr) = low
  substructure height/0.20m

The slope of the roof also enables the ceiling to be
even higher (it often reaches the tie beam on the
truss.

The roof type can be gable or shed, depending
on the span and the preference of the homeowner.

Ceiling heights for secondary rooms with a shed
roof are lower than primary rooms because they
are usually built as a second roof and which
must be lower than the main roof. If the roof is a
gable, the ceiling height can be the same as the
primary room.

The slope of shed roofs is quite low because of
the roof having to fit under the main roof. The
slope of a gable roof will be close to the roof slope
of the primary room.

The roof type of a verandah is always shed
because of its narrow width. The slope of shed
roofs is quite low because of the roof having to
fit under the main roof.

Ceiling heights for verandahs are lower than
primary rooms because they are usually built as
a second roof and which must be lower than the
main roof.

Buildings are raised off the ground to allow for
ventilation and to inspect for insect damage.
Floors that are raised one story provide a covered
area below the house. Two story structures
permit more living space in a smaller area which
is especially important in urban areas.

The type of stair will depend on the budget of
the homeowner and the height of the
substructure. The simplest type is often a single
concrete block. If the substructure is very low
(e.g. 20 cm or less), usually no stair is used (e.g.
on the ground floor of a shop/townhouse.
The height and number of stairs will depend on the height of the substructure. The width will depend on the preference of the owner and the height of the stair; stairs usually tend to be somewhat wider as the height rises. Bannisters are optional on low stairs.

The stairs are always placed against the front door if there is no verandah. If there is a verandah, it is placed close to the front door to minimize the distance between it and the entrance. Only occasionally is it placed at the end of the verandah—usually when there is not enough space on the site for the stairs.

The height of the stairs will depend on the height of the substructure. The width will depend on the preference and budget of the owner. The style of stair will depend on the size of the site, and the preference of the owner. Railings will always be used for high stairs.

The stairs are placed next to the door or if there is a verandah, as close as possible to the front door in order to minimize circulation space on the verandah. The placement also depends on the preference of the owner as well as on the amount of space on the site between the house and the street. Like the low stairs, the high stairs are always visible from the street. Shop/townhouses usually have their exterior stairs on the side of the building in order to maximize the public space in front of the store.
The number and placement of openings in the rooms are one of the most important decisions in terms of comfort for the occupants. The general approach is to maximize the opening size and number whenever possible to enhance air movement. All exterior walls of all rooms should have at least one opening in it; larger rooms will have more than one opening. These openings can be doors or windows. If there is only one opening per wall, it is usually centered in order to permit air to move through the middle of the room.

The openings of 2-story buildings will be balanced with the same number and position, but not necessarily the same type. For example, door openings may be placed on the ground floor but windows are used on the second floor.

The type of door will depend on the context and the preference of the owner. Doors with glass would usually be located in the shade (e.g. on a verandah) to prevent solar heat gain inside the house. Doors with glass would also have shutters to protect them during storms and for security. Solid panel doors might be used more where security is an issue.

The type of door swing will depend on the width of the wall panel, the preference of the owner and the amount of space available for the door swing.

The width of the door will depend on the wall panel width, the door swing type and the use of the door. Residential doors are usually the width of the wall panel but specialty doors such as those used in the ground floor of the shop/townhouse will be much wider to allow the movement of goods and customers.
Door height \( (dr.h) = 2.2 \text{ m (7'-3'\)}} \)

Shutter type = panel, plank, louver, solid or none.

Shutter height \( (sht.h) = \text{ door height (dr.h)} \)

Shutter width \( (sht.w) = \text{ door width/2} \)


2 \leq \text{ total number of exterior doors (ext.drs)}

Number of “front” doors \( (#fnt.drs) \geq 1 \)

Door // verandah, ground or stairs

Window type = louvered, pane, plain, decorative, or combination

Window opening type = sash or casement

Shutter type = louver, panel, or plank.

Window width = 0.8, 1.0, or 1.2 m

Top of window = top of door

Window sill height = 0, 0.6 (2'-0") or 1.0 m (3'-3")

Window shutter type = panel, plank, louver, or solid.

Window shutter height = window height

Window shutter width = window width/2

Foundation materials = stone, concrete, or concrete block.

Wall materials = wood framing, or wood

The shutter type will depend on the level of security needed, the door type it protects, the intensity of storms experienced and the preference of the owner.

The height of the shutters is always the height of the doors and the width is half of the door opening.

All houses would have at least 2 doors (a “front” and a “back” door) with even small houses often having more.

For safety, a door must always open onto a verandah, the ground or a set of stairs.

The choice of window type depends on the amount of shade, the amount of security needed and the preference of the owner. Glass windows in particular should be shaded to prevent solar heat gain. Louvered windows might be preferred when air movement is desired even though windows may need to be closed.

The choice of sash or casement windows depends on the preference of the owner, the amount of air movement desired, and the amount of space available for the window swing.

Window width will depend on the width of the wall panel. The top of the window is always at the same level of the top of any door. The height of the window will depend on the preference of the owner and the amount of air movement desired within the room.

The choice of shutter type will depend on the preference of the owner, the amount of air circulation desired, the type of window it protects, the intensity of storms experienced and the amount of security needed. The height of the shutters is always the same as the window height and shutter width is always half of the window width.

The choice of building materials will depend largely on their local availability and their cost.
framing with insulation, or concrete block with shading and insulation.

[113] Roof structure material = timber
[114] Roof covering material = wooden shingles, tiles, or corrugated metal sheet.

[115] Wall construction method = lightweight or heavy construction
   If wall construction method = heavy, wall construction – insulation
[116] Wall frame method = type 1 or 2
[117] Roof truss method = type 1 or 2
[118] Roof construction method – insulation

[119] Wall color (1) = white, off-white, pale yellow, pale green, or pink
[120] Trim color (1 or 2) = blue, brown, red, green, light blue, or olive green.

[121] Fretwork // verandah facia
[122] Fretwork type = lathed, cut-out, or lattice
[123] 20 cm (8") ≤ fretwork height ≤ 30 cm (12")
[124] 80 cm (2'-8") ≤ railing height ≤ 90 cm (3'-0")
[125] Railing panel width = wall panel width or 2 x wall panel width

Foundation materials will depend on the materials that are available locally.

Preferred wall materials are those that have a low thermal capacity and do not transfer heat easily. If concrete block is used, walls must be shaded and/or insulated.

Preferred roofing coverings are those that have a low thermal capacity and do not transfer heat easily.

Insulating the roof which receives the maximum amount of solar radiation, will prevent the heat from radiating into the room and heating the air inside.

Insulating the walls, especially east/west unshaded walls will prevent the heat from transferring into the room.

The choice of the wall frame and roof truss method will depend on the tradition in the area and the availability of materials.

Wall colors are lighter to reflect solar radiation. Darker colors are used in smaller amounts for accent.

The purpose of the trim is to add individuality to the house. Fretwork also provides more shade to the walls while still allowing air movement through it.

The railings and trim on the verandah serve the same function of expressing individuality; it also marks the edge of the public/private territory, prevents furniture and occupants from falling off the edge and allows air circulation through it.

The choice of pattern for the fretwork and the railing panel will depend on the materials available, the skill of the carpenter, the preference of the owner and the budget available.
Bibliography


Knight, Terry W. “Designing with Grammars”, Environment and Planning B. 1990?


