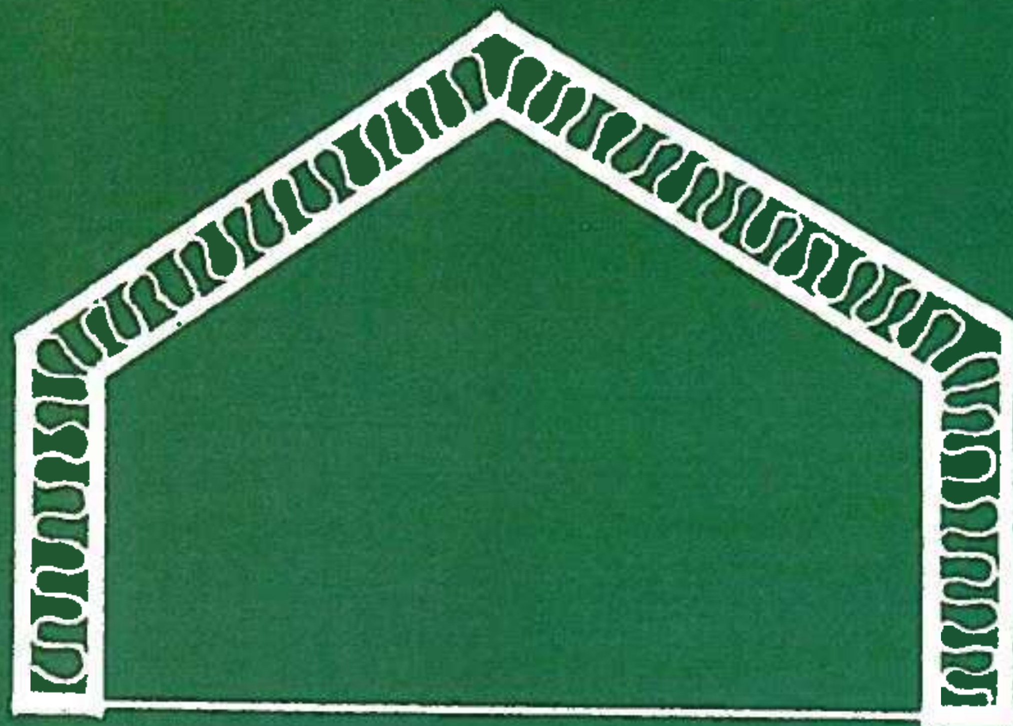
Chapter 4
Air Conditioning



Air Conditioned Houses

Many people find their personal lifestyle comfort requirements or their specific site requires mechanical air conditioning. Air conditioning of a house will increase the operating costs; however proper design can minimize these costs by insulating against the heat gain and by limiting outside air infiltration.

Air Conditioned Systems

As explained earlier, if the environment can maintain a controlled humidity and temperature range, then a comfort zone can be achieved. Currently there are several different means or mechanical systems that can be installed in dwellings to obtain this control.

An air-conditioning system is the assembly of equipment for the purpose of controlling the interior climate to meet the requirements as desired for a given conditioned space. To meet these requirements, the processes involved are the changes in temperature and humidity as well as cleanliness and distribution of air. For the tropics, the main functions are cooling, ventilating, filtering, exhausting and recirculation of air. Where the air conditioner is run a portion of each day the heat from the equipment can be recovered to provide free water heating. Systems that are commonly in use include direct expansion system, chilled water systems and window air conditioners.

Constant volume central systems with direct expansion have generally performed well when properly designed. Window air conditioning units are usually haphazardly located and inferior in overall air conditioning quality and dehumidification capability.

Use of chilled water fan-coil air-conditioning systems in extremely humid areas should be carefully analyzed prior to their use. They have a low dehumidification capability and are difficult to maintain in a satisfactory temperature-relative humidity relationship.

"Economy cycle" options should be avoided. In cold climates these can reduce cooling energy consumption by shutting down refrigeration machines and circulating outside air through air-conditioned space when the outside air temperature drops below 70F (21.1C). With the high humidity of the tropical island outside temperatures seldom drop low enough without also having high humidity, thus the "economy cycle" merely provides a needless avenue for invasion of humid outside air. Leakage through the economy cycle dampers when not in use increases the workload of the air conditioner under normal operation.

Cooling coils and air handling equipment may be located within the building to eliminate weather damage and deterioration.

The current standard of measuring capacity of air-conditioning equipment is the British Thermal Unit per hour (BTU/hr) which is a measure of heat. Air-conditioning capacity is often described in terms of tons or the amount of horsepower developed by its compressor motor. A ton of refrigeration means the equivalent of the cooling effect of melting one ton of ice in 24 hours. Manufacturers have established standards for rating and testing their units in BTU with a one ton air-conditioning unit removing 12,000 BTU per hour.

Maintenance

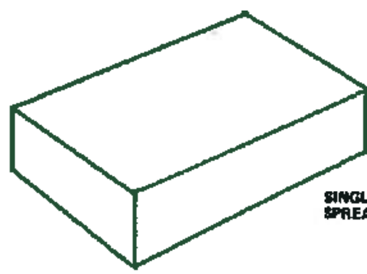
To achieve the maximum efficiency and minimum power consumption in an air-conditioning system, the equipment must operate in good working order. The following is a list of simple maintenance items. Poor maintenance leads to inefficient energy consumption and higher utility bills.

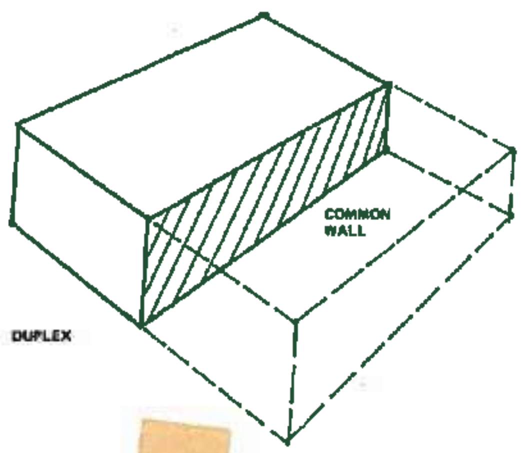
Keep air filters clean.
Keep coils clean to allow for efficient heat transfer.
Maintain proper refrigerant charge: A low charge will cause equipment to run for longer periods to achieve necessary temperature.
Follow equipment manufacturer's recommended maintenance program.

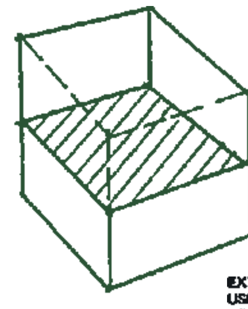
Building Envelope

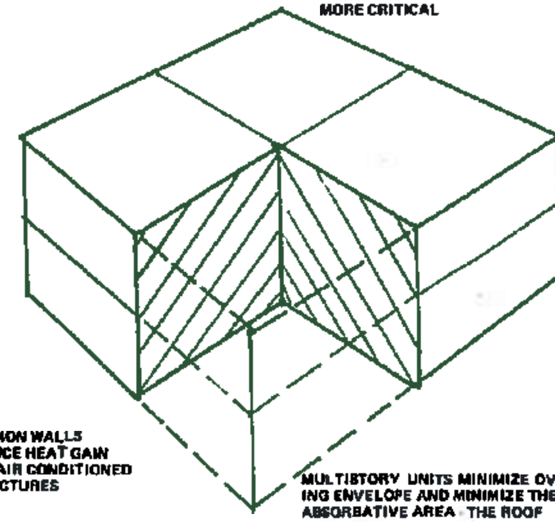
For energy conscious and economical design of an air-conditioned home, the building envelope must minimize heat gain from the outside and decrease infiltration of hot-humid air. This means a minimum roof and wall area. Doors and windows should be minimized on the windward and leeward side, and weather sealed to decrease infiltration. Orientation should be so walls face directly north, south, east and west. The preferred orientation and configuration for natural ventilation, facing east-northeast, will result in approximately 10 percent more heat load. Storage and seldom used areas can be placed on exterior walls to provide additional air space insulation.

Compact arrangements of houses into duplexes or townhouses can decrease exterior walls and reduce solar heat gain and infiltration.









Landscaping should be dense to provide shade, but also close to the building to avoid breezes heating the building through convection or disturbing the surface air films. Hedges and vines will even provide some insulation by the still air between their leaves.

All cracks at windows, doors and walls should be sealed, to prevent outside air from entering the inner space, and cooled air from escaping to the outside. Vestibules at the exterior doors will also reduce the infiltration of outside air.

Sunshine through windows can create extremely high heat gain in the interior atmosphere. Eliminating this heat gain reduces extra loading on the air-conditioning system. A practical solution is to provide extra exterior shades on the windows or glazed areas so that at any particular time the glazed area will not be affected by the sunshine. Drapes and blinds also perform this function, though less effectively.

Heat Gain

For tropical islands with relatively moderate exterior temperatures, the amount of energy required to cool the interior air temperature is relatively small. However, the heat load generated by the unshaded sun through the building structure is another matter. The cooling loss through the floor is minimum, so it can be disregarded. The heat gain through the roof and walls, however, is quite high. If the structure is not insulated the heat gain not only occurs during the daytime but also lasts late into the evening, because concrete and masonry retain this heat and continue to transmit it to the interior. The amount of energy required to offset this heat gain is extremely high. Provision of insulation is therefore important to block this heat gain.

In analysis, a house can be divided into imaginary zones or rooms and the assumption made that no heat load will transfer between them. Desired R values of the proposed construction are chosen (i.e., R=2 for windows, R=20 for roof, R=4 for wall).

The square footage of interior surface areas is multiplied by the associated U value (1/R value) giving the British Thermal Units per hour per degree Fahrenheit (BTU/Hr/F) of gain. These are then added for the total.

For a residence, an air infiltration of one air change an hour is assumed; this allows for leaks. Multiply the volume in cubic feet by the heat capacity of air, 0.018 BTU/Hr/F to find the infiltration heat gain.

These figures for walls, roof and infiltration are added to get total BTU/Hr/F. For our island the total gain is multiplied by 10, the difference between the desired interior design temperature, 78F (25.6C) and outside climate design criteria temperature of 88F (31.1C). (Note that an interior design temperature of 75F (23.9C) may be desirable for some individuals.) The resultant figure is the approximate sensible heat load required in BTU per hour. Sensible heat is energy resulting from a change in temperature. For the total cooling capacity used for selecting an air-conditioning unit, the sensible load is multiplied by a factor of 1.3 to include potential latent heat (the additional energy necessary to condense some of the water vapor and decrease the relative humidity to within the comfort zone). This is the primary requirement for sizing an air-conditioning system. Additional calculations may be necessary for areas with heavy occupant load or equipment use. Professionals may recommend slightly lower latent load factors depending upon their experiences with prior installations. Times of the day may be considered separately.

The local building codes may not force the owners of existing residences to provide insulation. However, for new construction our island's building code requires that if the residence is to be air conditioned it must conform to Chapter 53 of the Uniform Building Code. This requires new structures to meet the minimum heat gain standard of R=3.33 for walls, R=20 for roofs, and R=2.67 for floors.

A vapor barrier should be provided on the warm side of the insulation. This will block moisture accumulation within the wall, that reduces the insulation thermal resistance value and contributes humidity to the interior space. Usually the vapor barrier can most effectively be applied on the exterior of the building in the nature of a paint finish of low vapor permeability in conjunction with an interior paint finish of greater permeability. Insulation materials should be moisture-resistant such as foamglass or foamed plastic. Use of organic fiber insulation materials and those with organic backings should be minimized because of vulnerability to insect infestation and decay. Certain types of insulation such as polyurethane give off noxious gases in case of fire. Other types, such as polystyrene have revised requirements limiting their interior use due to potential melting and flame spread. Use of either polyurethanes or polystyrenes on interiors should be carefully scrutinized and limited to code complying systems.

Exterior mold growth is an increased problem on air-conditioned buildings. Projecting structural members like overhangs, eyebrow cantilevers and projecting fins can provide a thermal bridge through the building envelope to the interior cooler temperature. This can cause more heat load to the interior and condensation and mold problems on the exterior. Uninsulated metal doors and windows or door frames can also create this problem. The solution is to carefully place full insulation and provide frames with built-in thermal breaks.

Insulation

Insulation installed on the roof or in the walls of a building will save money; however, because insulation can represent a significant investment to the home owner or businessman, a decision to purchase and use insulation cannot be made simply because energy is saved. It does not make good economic sense to spend, for example, $3,500 to insulate a house or business if over the lifetime of the investment, only $1,000 in energy cost savings is realized.

In recent years, all types of energy users, including architects, other design professionals and builders have examined their investment in energy conservation measures such as insulation in terms of the economic return on these investments.

There are several types of insulation commonly in use locally. Two of the most common types are polyurethane foam and fiberglass batt. Whatever type may be under consideration, several characteristics are common to all types, and must be evaluated when making an intelligent, economically sound decision regarding insulation:

What are the thermal characteristics of the materials?

What thickness is economically practical?

Where should the insulation be placed to achieve the greatest savings?

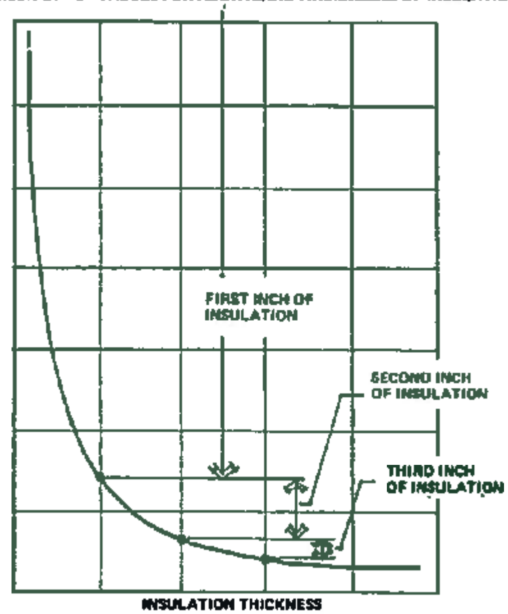
Very often these questions for specific conditions can be answered completely only by a qualified architect or other design professional; however, every energy user should understand the general principles involved.

The resistance of insulation to heat penetration is measured in terms of "R" value. The larger the R value, the better is a material's insulating properties. Polyurethane foam and polyurethane board have an R value that ranges from 5.8 to 7.7 per inch. Fiberglass batt (or blanket) has an R value of 3.67 per inch. A detailed list of R values for a wide variety of materials is included in the appendices.

Polyurethane insulation is available in board stock or can be sprayed on a roof surface on site. It is available in practically any thickness desired. Fiberglass batt can be obtained in a number of thicknesses, three inches or more is common.

One inch of insulation added to an otherwise uninsulated surface produces a dramatic decrease in heat conduction; a further reduction realized by the addition of a second inch is much smaller. The incremental value gained from the second inch is smaller. Two inches, therefore, will not save twice as much money.

COMPARISON OF "U" VALUES FOR ADDITIONAL THICKNESSES OF INSULATION.



THE SPECIFIC FIGURES ARE FOR POLYURETHANE BOARD WITH AN "R" VALUE OF 7.1

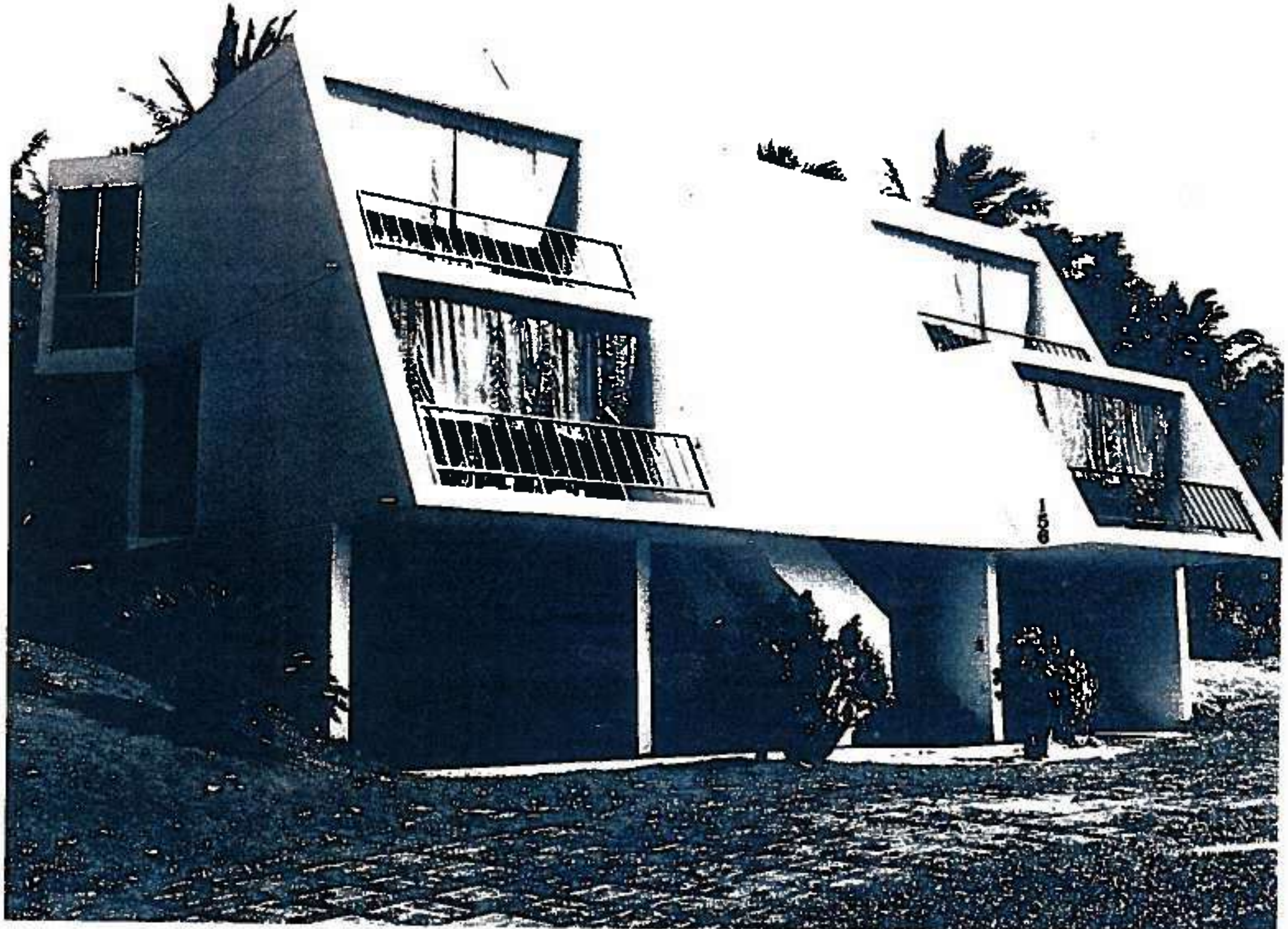
The precise determination of the maximum economic benefit, of course, depends on the construction of the particular surface to be insulated, current material cost and projected utility costs. An economic analysis formula applicable to insulation and other energy saving expenditures is included in the appendices. Currently in a tropical environment, one to two inches of urethane foam is most cost effective. Three inches of fiberglass batt is usually most effective.

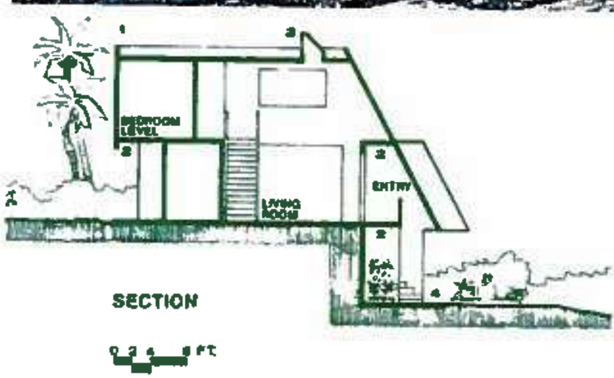
Placement of insulation where it will stop the most heat from reaching an air-conditioned space is vital. In most cases, this means that the roof of a building has the first priority for insulation, simply because a roof is usually exposed to the sun for a longer daily period than any other building surface.

Air Conditioned Residences

The following houses have been designed for air conditioning in the tropics and incorporate the principles previously discussed:

Private Residence
Perez Acres
Sunrise Villa





1. Spaces stacked vertically minimize building envelope and heat gain.
2. Overhangs to maximize shade.
3. Clerestory skylight for daylighting.
4. Building tucked into slope.

Perez Acres Townhouses

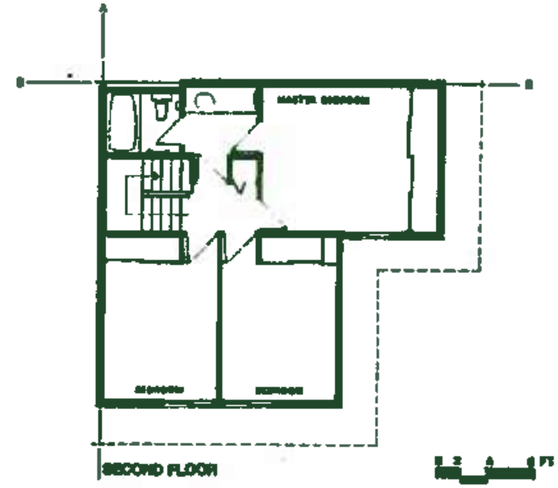
Located on a site covered with lush tropical vegetation, this development takes maximum advantage of existing terrain and surrounding foliage.

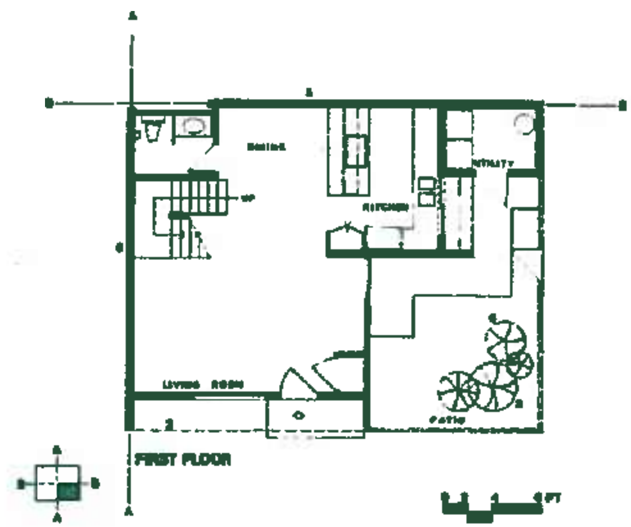
The houses are good examples of proper configuration for air-conditioned structures. They are compact and well-shaded. Four townhouses, each two story, are housed in quadplex structures. This compact organization minimizes overall building envelope by stacking the floors, thus reducing roof area, and by use of common walls. The structures further reduce heat gain by carefully controlling the amount of window area and by shading devices: overhangs, canopies and trellises. The windows are either fixed glass panels or sliders which seal well against air infiltration.

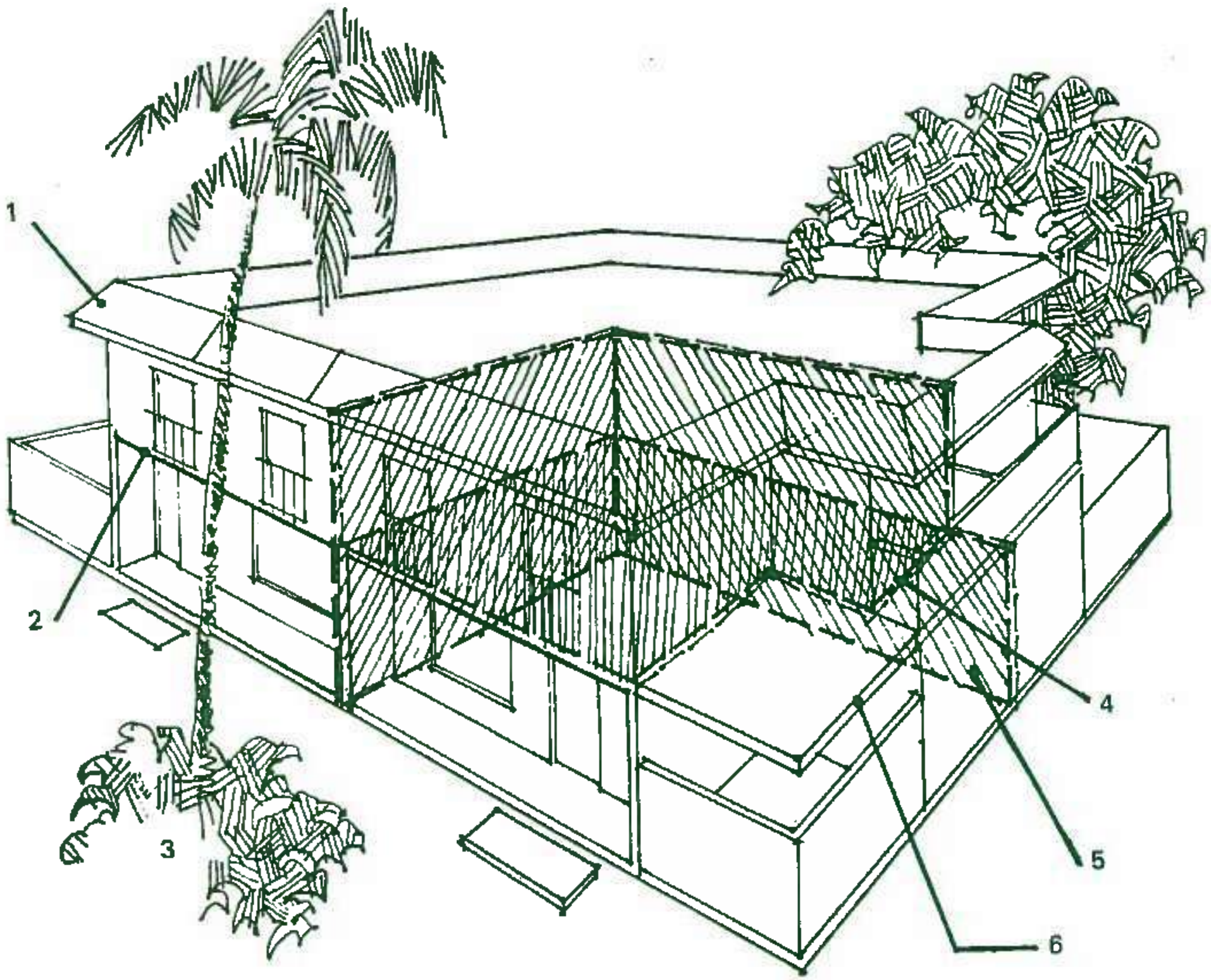
The central air-conditioning system is a direct expansion type and the interior ductwork is kept to a minimun.

The structures are precast concrete walls with precast prestressed concrete slabs. The effect of the relatively low "U" value of the walls is minimized by eliminating most of the direct sun. The roofs have a white reflective covering.

Project: Perez Acres Townhouses, Yigo, Guam
Architect: Alfred A. Yee & Associates, Inc. and
Courtland Paul-Arthur Beggs & Associates
Contractor: Tumon Village Construction Co.
Construction Date: 1975-76







PEREZ ACRES TOWNHOUSES

MINIMIZING THE BUILDING EVELOPE TO MINIMIZE ENERGY CONSUMPTION FOR AIR CONDITIONED STRUCTURES

1. Roof overhang for shade protection
2. Second floor projecting for further shading
3. Vegetation adds extensive shading
4. Second floor stacked for minimum building envelope
5. Common walls reduce exterior perimeter
6. Trellis for further shading

Sunrise Villa

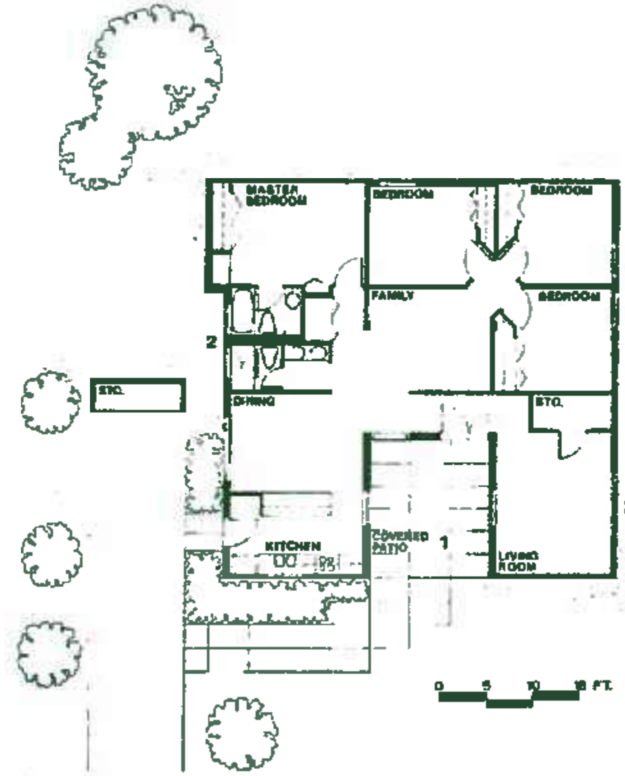
The development consists of 1800-square foot, four bedroom houses. The houses are centrally air conditioned throughout with overall building planning carefully controlling window placement and insulation values.

The buildings have concrete roofs with 1-inch sprayed on polyurethane insulation underneath with gypsum board interior wall surface.

The plan centers around an exterior entrance court. The court is covered with a redwood trellis and provides soft indirect light to the surrounding spaces whose windows face the court. Perimeter windows are shaded by redwood slatted suncreens that also double as security and typhoon protection when lowered.

A direct expansion 3-ton central air-conditioning system is used along with a solar hot water system.

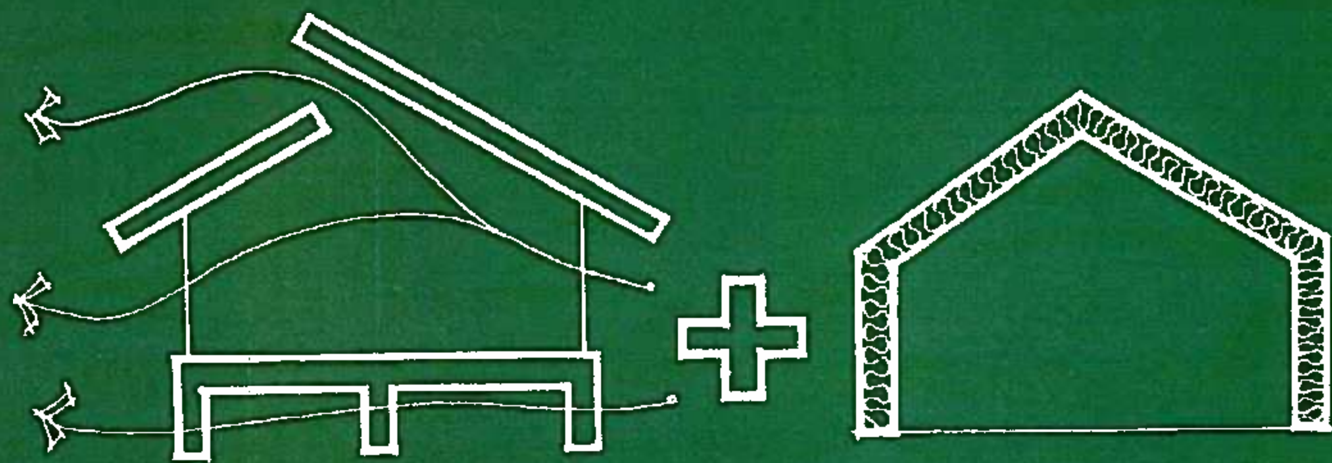
Project: Sunrise Villa
Architect: Frederick E. C. Sun, Architect, AIA
Contractor: Sun's Enterprises
Construction Date: 1981



1. Entrance court with trellis.
2. Sunscreens at perimeter windows.

SUNRISE VILLA - Exterior entrance court with trellis provides shading and indirect interior light. Slatted sunscreens shade perimeter windows.

Chapter 5
Partial Air Conditioning

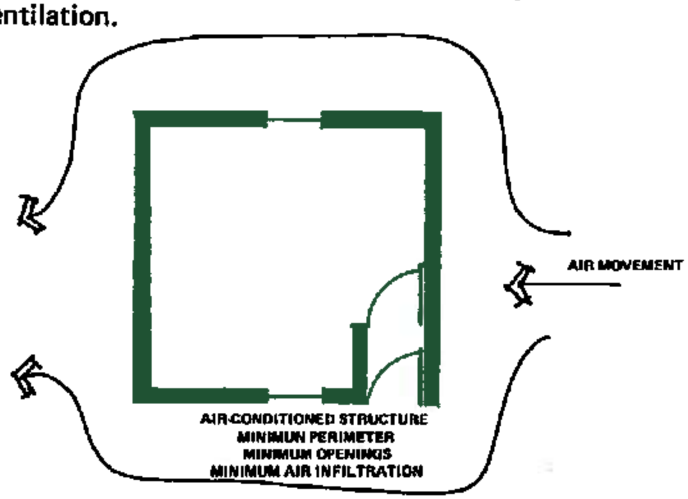


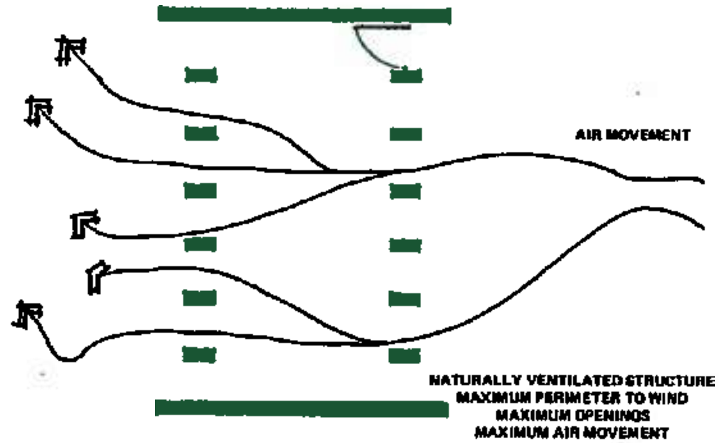
Partially Air Conditioned Houses

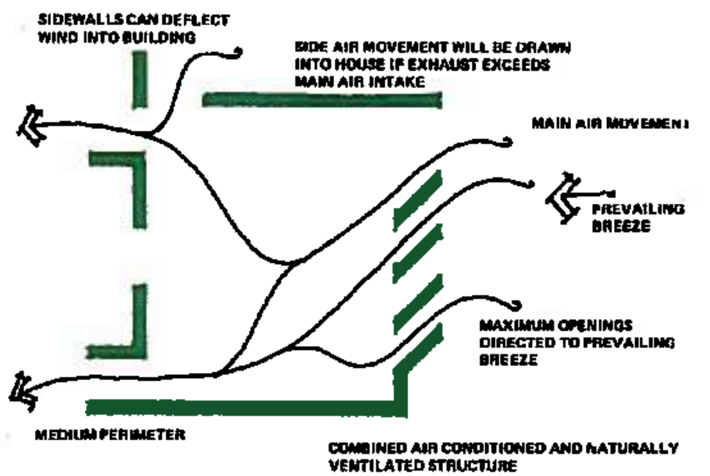
Some people want the advantages of both naturally ventilated houses and air-conditioned houses. This can be accomplished by air conditioning only a partial area of a house such as bedrooms, library and den; or by air conditioning only a partial amount of the time such as during the hottest season.

Notable structures to use the practical concept for the tropics of partial air-conditioning have been hotels. Many hotels lobbies throughout the Pacific Basin are naturally ventilated, while the individual rooms are air conditioned. This saves on overall utility costs, increases rapport with the naturalness of the tropics while sacrificing little actual comfort. Residential design can employ the same ideas.

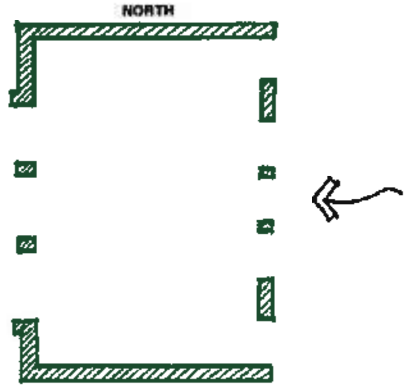
In an air-conditioned house openings are minimized to reduce heat transfer and infiltration. In a naturally ventilated structure openings are maximized for maximum ventilation. In a partially air-conditioned facility, key design factors are strategically locating openings, maximizing on the characteristics of air movement and using the best of available technology, especially gaskets, seals and other forms of weatherproofing. With proper use of these factors, a design can come close to the ideal combination of air conditioning and natural ventilation.



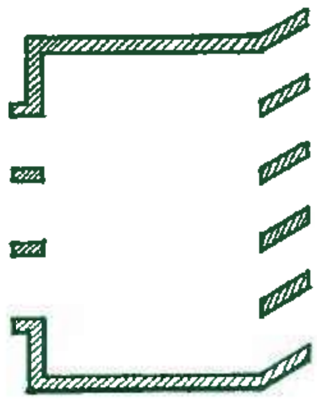




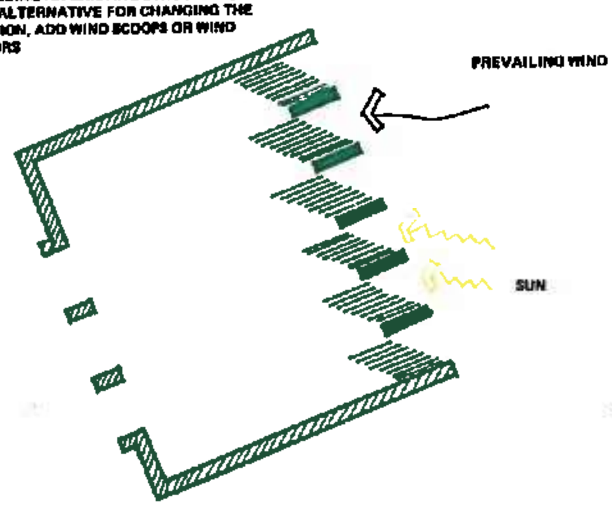
Window locations should be carefully considered. Just as in a naturally ventilated structure, openings must be orientated to accept the prevailing breeze. They should, where possible, provide ventilation at different levels, but particularly low and in the seating height zone. Wind scoops both vertical and horizontal can be used to encourage the maximum wind to enter the openings so that the total window area can be minimized. These are particularly useful when the prevailing breeze also comes from an undesirable sun angle location such as the east. By use of walls and fins, a wind can be canted 10 to 20 degrees and in so doing provide sun screening while maintaining proper ventilation.



CONCENTRATED WINDOWS ON WINDWARD SIDE AND ON LEEWARD SIDE FOR EXHAUST

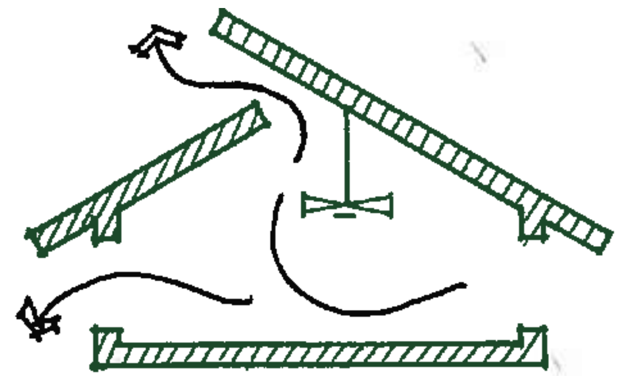


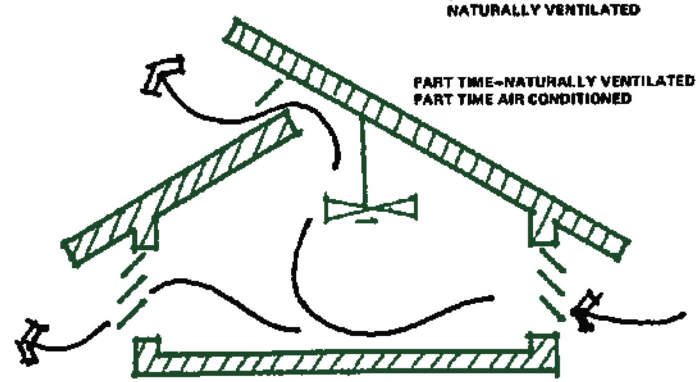
IF REMODELING AN EXISTING STRUCTURE, OR AS AN ALTERNATIVE FOR CHANGING THE ORIENTATION, ADD WIND SCOOPS OR WIND DEFLECTORS



IF THE PREVAILING BREEZES ARE FROM THE EAST, IDEALLY ORIENTATE THE BUILDING NORTH OF DUE EAST

Location of ports at the top and leeward side of the house are also critical. These will literally help suck the air through the house, thus the openings in the house can be reduced provided the leeward openings exceed windward openings.

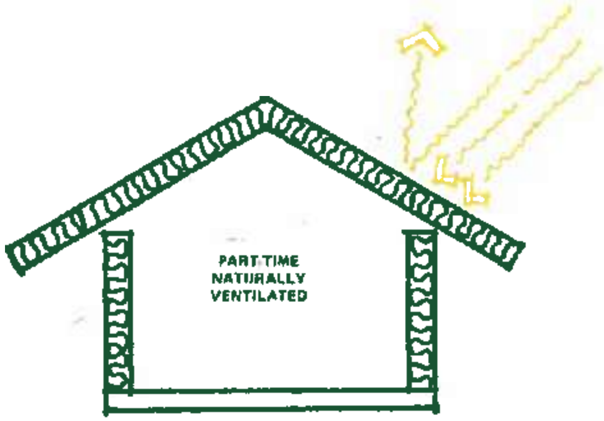


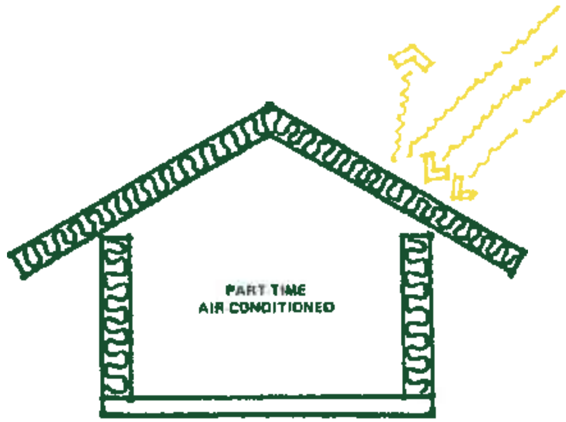


A PART-TIME AIR-CONDITIONED DWELLING SHOULD HAVE CEILING FANS AND BOTH SHOULD HAVE UPPER EXHAUST OPENINGS FOR RISING HOT AIR. HOWEVER, THE PART-TIME AIR CONDITIONED HOUSE NEEDS OPENINGS THAT CAN BE CLOSED COMPLETELY AND ARE WELL-SEALED. PROJECTING CLERESTORY WINDOWS WORK WELL WITH BOTH.

Insulation in walls and ceiling is important for both air-conditioned and partially air-conditioned plans. The less solar heat load the better, whether the space is air conditioned or naturally ventilated. The areas that are to be air conditioned will be required to have walls of R=3.33 and a roof of R=20 to meet the building code.

The openings must have good seals and only moderate amounts of sealing perimeter. The sealing perimeter is the overall length between each operable window element and the surrounding frame or other opening part. The larger the sealing perimeter, the





A PART-TIME AIR-CONDITIONED SPACE SHOULD BE AS WELL-INSULATED AND VAPOR SEALED AS A FULL-TIME AIR-CONDITIONED SPACE.

greater the chances for air infiltration through poor seals. While jalousie louvers are good for naturally ventilated structures, they are marginal to poor for a house that on occasion must be sealed shut. When a large perimeter for the numerous blades and poor seals between blades, jalousies are not airtight and allow infiltration of damp, warm air, or the escape of cool air-conditioned air.

The amount of effective open area per window area needs to be maximized. Windows generally have lower insulation values than walls and allow penetration of more exterior radiation than opaque surfaces. Window systems that provide 85 to 95 percent clear opening such as awning, projecting, pivoted and casement types are preferable to windows with much lower percent of clear opening such as sliding windows (46 to 30 percent clear openings).

Other factors, including cost, must be considered. Sliding windows are frequently less expensive than other types. Some sliders, particularly the full-length glass sliding doors, work nicely into a functional design. To further limit infiltration, vestibles should be included at doors to better contain the conditioned air when the exterior doors are used.

Weather conditions, especially humidity, must also be considered. The goal is to make the house comfortable with natural ventilation for as long as possible.

Partial Air Conditioning — Time Wise

To alternate the cooling method of a space on a daily basis may often be difficult. With a large amount of water vapor in the air, the air quickly feels humid, and when the air conditioner has been operating it feels damp and chilly. The thermostat kick-on and kick-off points must be set closer to maintain comfort. For instance, in a dry space for the tropics (40 to 60 percent humidity) an air-conditioning unit can have five degrees between kick-in (80 degrees) and shut-off (75 degrees). Occupants will feel the difference but probably will not experience discomfort. However, if the humidity is 80 to 90 percent, 80 degrees may seem too hot and 75 degrees too cool. This can be partially overcome by not blowing the conditioned air directly on the body.

Over a period of air-conditioning operation the moisture is extracted from the air and a reasonably closed space will reach the 50 percent humidity zone. As such, conversion to air conditioning may be designed for seasonal change. During the cooler, dry months natural ventilation can be used; during the rainy season the air conditioner can be used, though at not too great an expense because with the rain comes the clouds and less solar radiation.

Sometimes people may fare better than their possessions in the tropics. Air conditioning may be useful to reduce mildew and rust during the rainy season.

Another reason for adaptable spaces is a change in the number of occupants. Occasional use by groups of people, one dozen to two dozen upward, will alter the cooling demands of a space. The comfort zone the owner is accustomed to may not fit a house full of guests, and on such occasions he may want to "dry out" the space for a day or so prior to an "event."

Not all characteristics of alternating use are favorable. The materials in the house are subjected to more damp/dry cycles and vapor pressure from inside to outside will vary, causing moisture to transfer through walls in different rates and directions. Most of the time this is predictable and insulated exterior walls minimize such a problem.

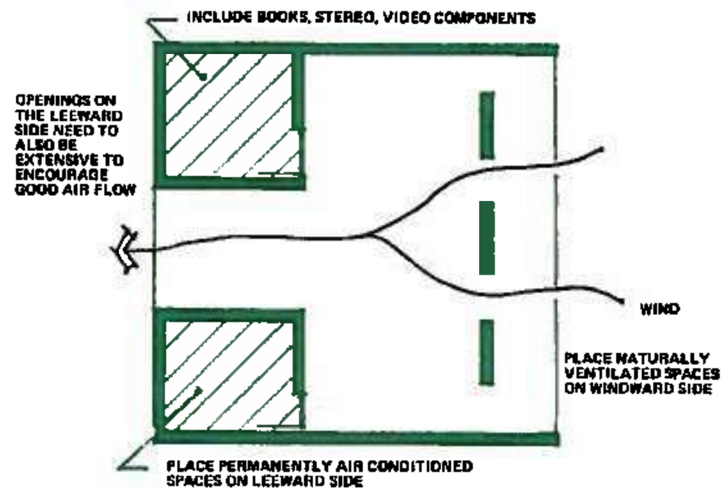
Shifting from air-conditioning to natural ventilation if done frequently must be done carefully. The changeover should be done slowly to allow cooled surfaces of books, clothes and walls to warm up to air temperature before ventilating large amounts of humid air on them. This will avoid condensation of moisture on the cool surfaces. After the surfaces reach air temperature, ventilation over them should be kept high for a short period of time for better evaporation of any condensation.

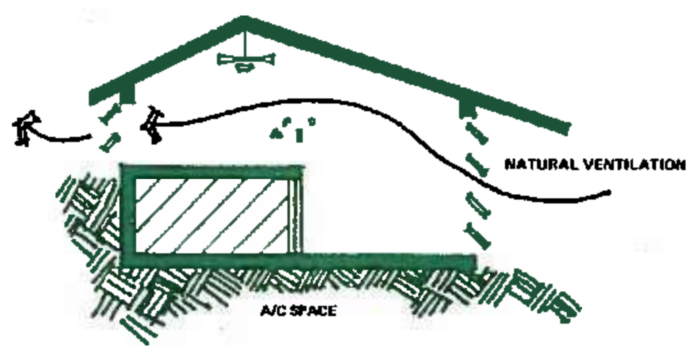
Fans of various types can be introduced to "push" the comfort zone whether natural ventilation or air conditioning is in use.

The rotational use of natural ventilation and air conditioning is certainly not new to motorists in the tropics. During the hot part of the day the car's windows are up and the air conditioning is on. In the cooler evening and early morning, the windows are open, the sun roof is vented and the air conditioning is off. The concept is similar, but the house doesn't have the luxury of the 35 to 45 mile per hour wind whistling by.

For the fixed use arrangement where portions of the house are naturally ventilated and others permanently air-conditioned, many of the same principles apply.

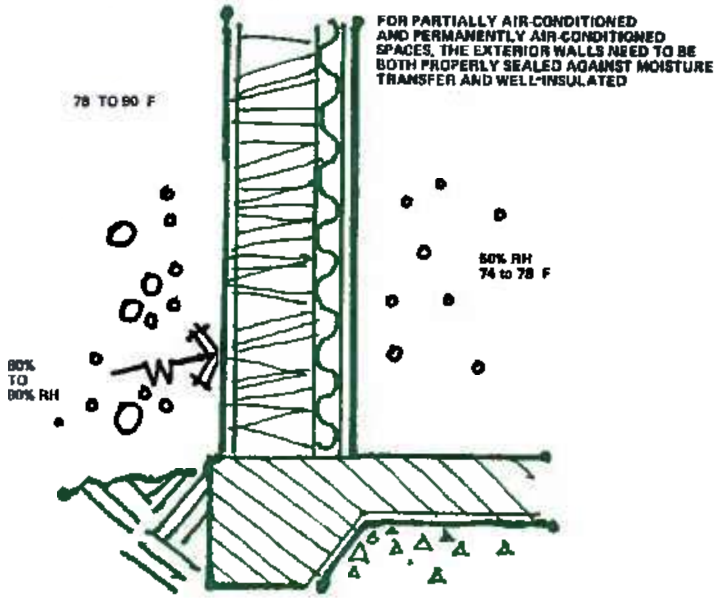
Orientation of the spaces become even more critical, with the naturally ventilated spaces located on the windward side and air-conditioned spaces tucked into protected areas.



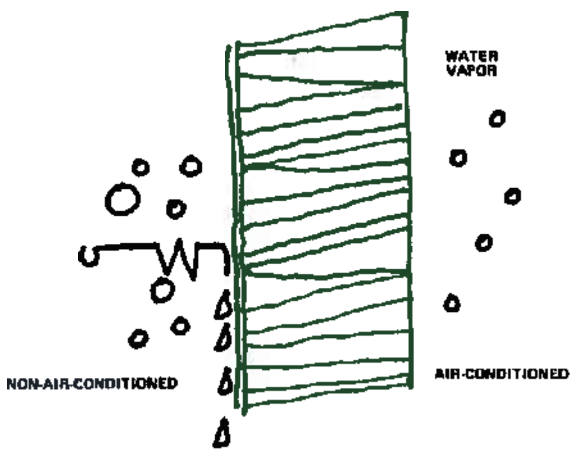


FOR TWO-STORY STRUCTURES NESTLED INTO HILL SLOPES, PLACE AIR-CONDITIONED SPACES WHERE MORE NATURAL INSULATION FROM ADJACENT GROUND OCCURS AND WHERE CROSS-VENTILATION IS MORE DIFFICULT

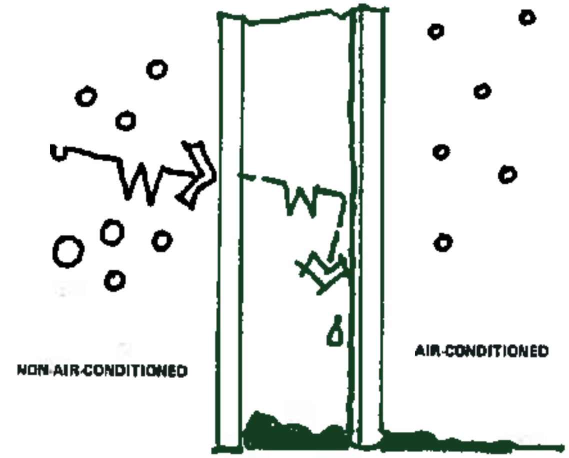
If only portions of the house are air conditioned, the partition between the air-conditioned and non-air-conditioned spaces must have a vapor barrier to avoid condensation and fungus growth at the non-air-conditioned side and to avoid humidity contribution to the air-conditioned space.



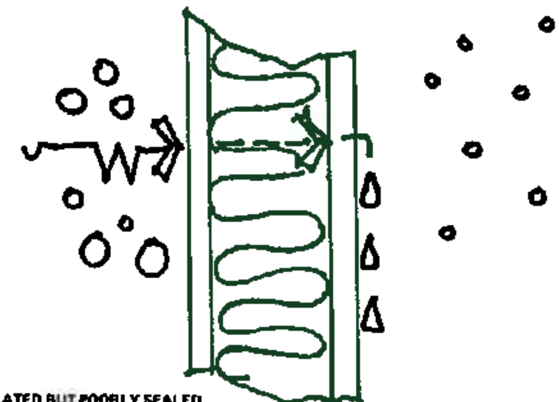
FOR PARTIALLY AIR-CONDITIONED SPACES THE WALLS BETWEEN AIR-CONDITIONED SPACES AND NATURALLY VENTILATED SPACES NEED TREATMENT SIMULAR TO THE EXTERIOR WALLS OF AIR-CONDITIONED STRUCTURES.



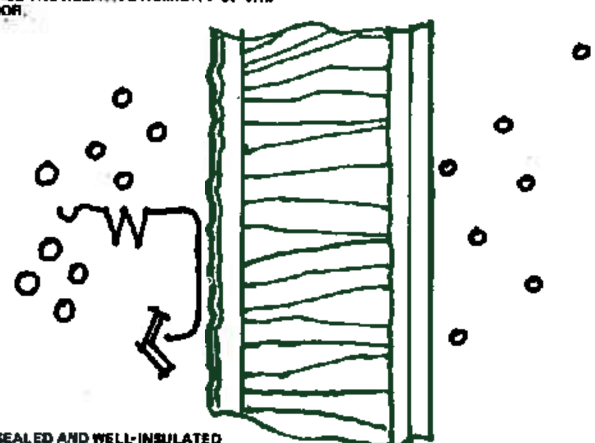
WELL-SEALED BUT POORLY INSULATED WALL. CONDENSATION (AND FUTURE MOLD) ON NON-AIR-CONDITIONED SIDE OF WALL



POORLY INSULATED WITH SEAL (MOISTURE BARRIER) IMPROPERLY LOCATED AT INTERIOR OF WALL



WELL-INSULATED BUT POORLY SEALED THE COLD TEMPERATURE IS NOT TRANSFERRED. THE WATER VAPOR SIMPLY TRAVELS THROUGH UNTIL IT BECOMES COLD ENOUGH TO CONDENSE OR INCREASE THE RELATIVE HUMIDITY OF THE INTERIOR.



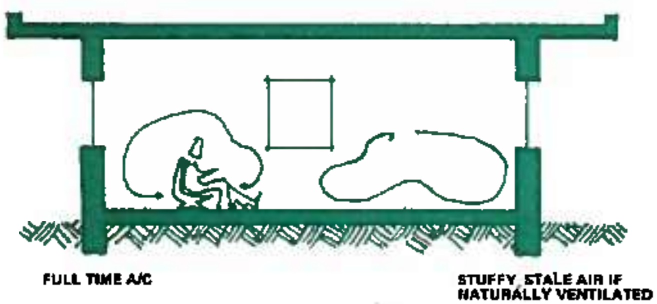
WELL-SEALED AND WELL-INSULATED MOISTURE DOES NOT PENETRATE. COLDER TEMPERATURE DOES NOT REACH EXTERIOR WALL AVOIDING CONDENSATION

Which areas need air conditioning vary with the individuals. Many people want to sleep with air conditioning but want the rest of their activities to occur in naturally ventilated spaces. Others want the air-conditioning in the areas of heavy activities, the kitchen or the game room but do not require it in more restful areas.

Books, stereos, home computers and linens require drier more stable surroundings and can be gathered into areas already air conditioned for human comfort.

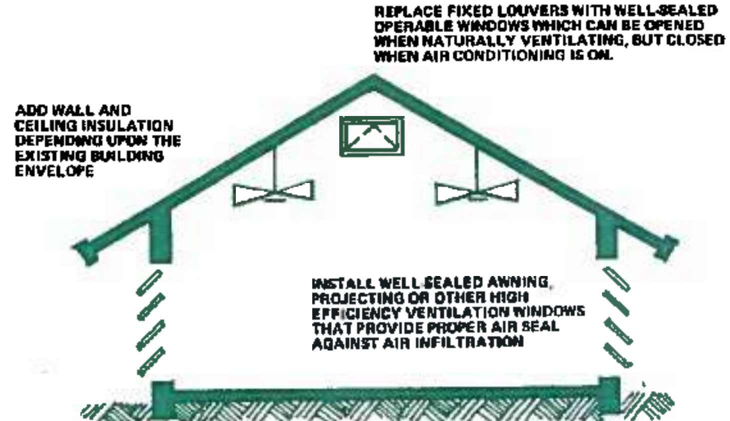
The two types of mixed air-conditioned and naturally ventilated spaces can also be combined. Bedroom areas permanently air-conditioned can be combined with central spaces on an optional rotating basis. The additional cost of the air-conditioning equipment can be minimized with compact duct design and energy efficient systems.

MANY PEOPLE FREQUENTLY TRY TO CONVERT HOUSES DESIGNED FOR AIR CONDITIONING TO NATURAL VENTILATION AND VICE VERSA. EACH CHANGE SHOULD BE CAREFULLY PLANNED TO AVOID IMPROPER AIR INFILTRATION OR IMPROPER QUALITY OR LOCATION OF AIR FLOW.



CHANGED TO PART-TIME AIR CONDITIONING

FULL TIME NATURALLY VENTILATED



CHANGED TO PART-TIME AIR CONDITIONING

IN ALL CASES, ADD ROOF INSULATION, CEILING FANS AND VAPOR BARRIERS IF CURRENT CONDITIONS ARE INADEQUATE.

Partially air-conditioned and naturally ventilated spaces are more prone to accumulation of dust. This needs to be considered in the design of horizontal and sloping surfaces. Handrail design and louvered blinds are two examples that can be coordinated to minimize dust problems. Handrails with horizontal balustrades will collect much more dust than with vertical balistrades. Similarily horizontal blinds will collect more dust than vertical blinds.

For partially air-conditioned and naturally ventilated areas, radiation from adjacent surfaces is a major factor effecting the comfort of a space as explained in the design criteria section. Cool, dense materials, tile, marble, stone, etc., literally cool a space and its occupants. A combined arrangement encourages tile floors with area rugs rather than wall-to-wall carpet. In the areas which are almost always air-conditioned, wall-to-wall carpet is fine. Carpet certainly can be used in naturally vented spaces, but selection of materials must be carefully handled. Avoid organic materials. Hemp backing or natural fiber underlayment padding should be avoided; use synthetics throughout.

Sound buffers are more important for privacy and comfort in a partially opened space. Closed spaces should be the private areas. Street and surrounding areas should be buffered with landscaping. Spaces that need privacy between them should be spread out as much as possible. For example, put the children's bedrooms on one side and the master bedroom on the other side.

Partially Air Conditioned Residences

The following houses have combined naturally ventilated spaces with air-conditioned spaces. They have been designed to properly blend the two systems.

Ruth House
Deal Residence

Ruth House

A variety of naturally ventilated and air-conditioned living spaces demonstrate effective planning and design at a cliffline site. The house adapts to the steeply sloping site in a multi-level plan with major spaces oriented to take full advantage of the tradewinds, sunlight and a panoramic view of the ocean and the city lights below.

The house faces northeast, away from the street, to take full advantage of the prevailing breezes which rise up the slope and provide natural shading for the large expanse of uncurtained windows. The living, dining and kitchen areas, as well as a loft guest room which doubles as a home office, are naturally ventilated and organized as an open plan flowing together without the separation of walls and doors. Accessible at ground level from the street, the living areas are elevated one-story, at the rear (view side) of the house.

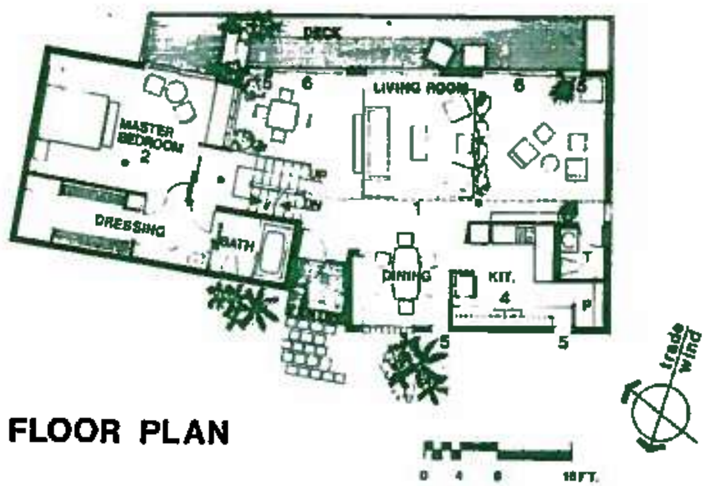
Air movement throughout these spaces is achieved by a combination of windows and tinted sliding glass doors which stretch across the viewside of the house. The eight foot wide sliding glass doors ensure maximum ventilation and provide access to the exterior terrace. Operating metal louver windows provide precise day-long control of the wind flow. The louvers are strategically located to provide continuous ventilation including times of the day when the house is secured. Louver windows are also placed at the front of the house to maximize privacy from the street and effectively provide for sun control. Additional light is brought to the interior by glass block at the dining area and a skylight over the stairway.

The entire living area is distinguished by a high sloping ceiling which follows the contour of the hillside. High clerestory windows on the downwind side facilitate a constant air flow through the house. The high ceiling creates space for the open loft guest room which overlooks the main living area.

Travertine marble flooring provides a constant coolness to the touch and an easy-to-maintain permanent surface. Walls are painted a cool grey to provide the psychological cooling and provide a neutral backdrop to accent furnishings.

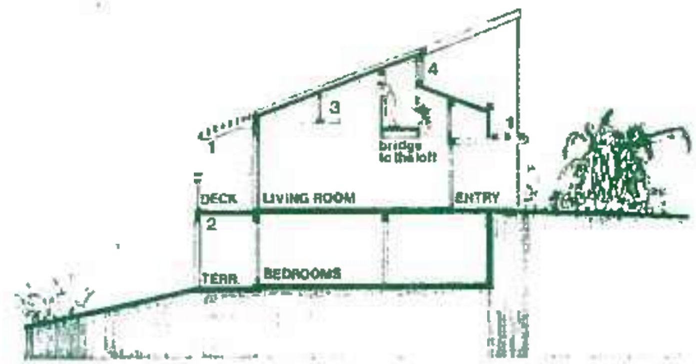
Furniture is grouped in islands away from walls with suspended ceiling fans above to augment the air flow. The fans, however, are required only a few days during the entire year.

1. Naturally ventilated living room, dining area and kitchen.
2. Air-conditioned master bedroom.
3. Openings orientated to prevailing breeze.
4. Kitchen located on leeward side for exhaust of cooking heat.
5. Operable louvers on both windward and leeward sides for continuous cross-ventilation.
6. Large sliding glass doors provide maximum ventilation.



FLOOR PLAN

Ceiling fans provide additional air movement when required. High ceiling facilitates better air movement. Also note large sliding glass doors and louvers for varying degrees of cross ventilation.



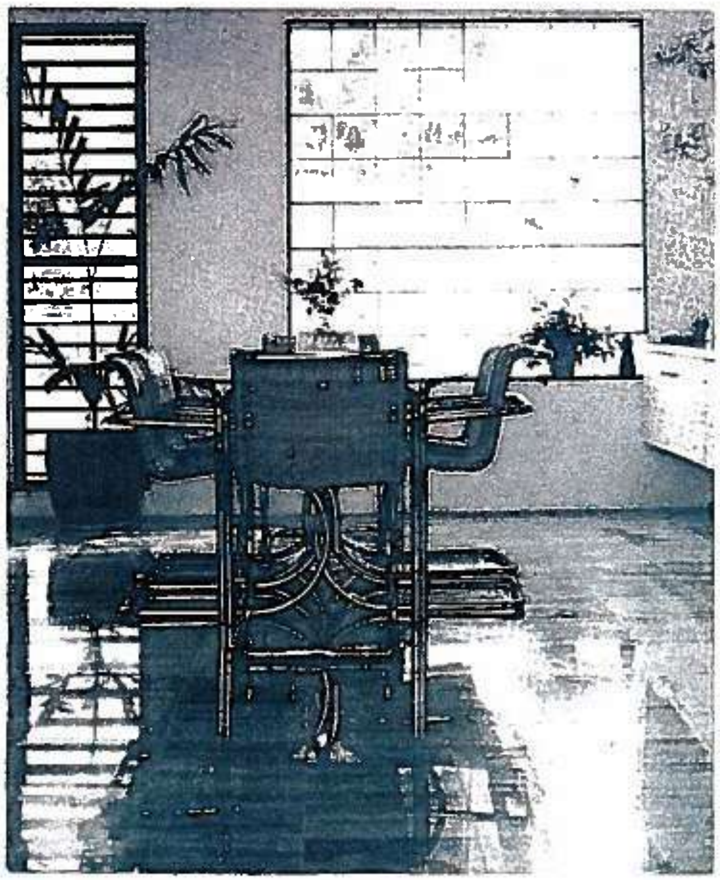
SECTION

0 4 8 16FT.

1. Trellis for sun control.
2. Terrace canopy for sun control.
3. High interior spaces for air movement.
4. Clerestory louvers on leeward side for warm air exhaust and a well distributed interior air movement.

Bedroom areas are separated from the living areas for maximum privacy and these areas are air conditioned. Air conditioning of carpeted bedroom and closet areas is considered a practical necessity by the owner to ensure sleeping comfort and guard against the effects of humidity to items such as clothing and books.

The master bedroom, located a half-level above the living areas, overlooks these areas through interior windows. These windows and the sliding glass doors leading to the terrace provide the option for natural ventilation. Blinds on bedroom windows and sliding



Marble floors provide cool radiating surfaces. Glass block minimizes heat gain from west wall while providing daylighting. Full height louvers provides for natural ventilation.

doors are used primarily to control light. Walk-in-closet, dressing and bathroom areas are located along the west wall to provide a buffer against heat gain from the afternoon sun. Other bedrooms are located on the lower level with direct access to the landscaped grounds. Because the house is set into the hillside, these rooms are partially underground and insulated by the earth.

The house is constructed of masonry and reinforced concrete. Roofs are insulated by means of polyurethane insulation spray applied on the underside of the roof slab and faced with gypsum wallboard.

Project: Residence for Mr. & Mrs. Mark Ruth
Architect: Taniguchi-Ruth, AIA & Associates
Contractor: Greenland Enterprises
Construction Date: December 1980

Trellis and wood on windward side. Well-shaded windows. Elevated terrace with a variety of tropical landscaping.

Deal Residence

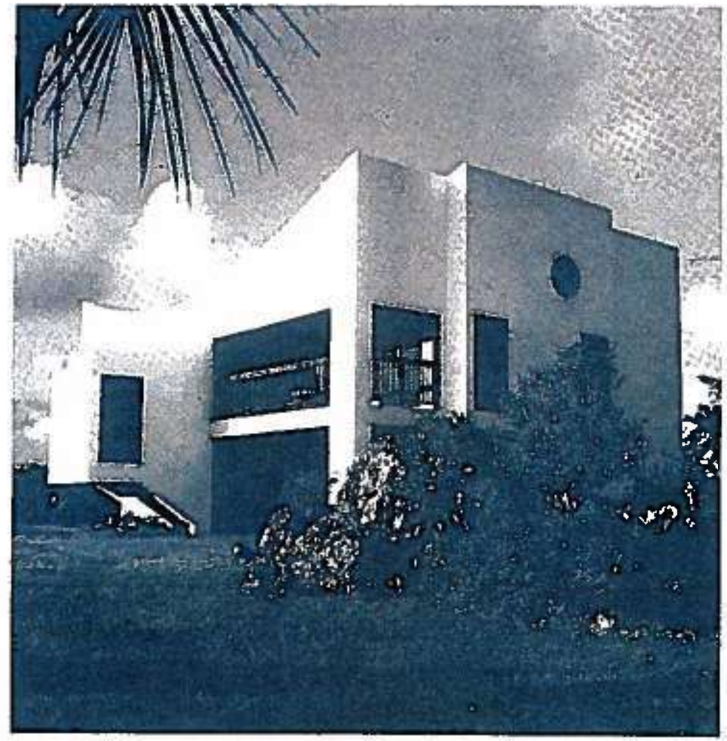
The house takes advantage of its elevated site on the windward side of the island for both excellent views and fine breezes. It is orientated toward the tradewinds providing natural ventilation for the main activity spaces. The dining and living room areas have maximum openings on the windward and leeward sides. The bedroom spaces are air-conditioned. These are more enclosed and sheltered on the east and west elevations. Ocean views are from the sunrise porch side with inland mountain views from the sunset side.

The upper floor is a three-bedroom residence and the lower level a two-bedroom apartment.

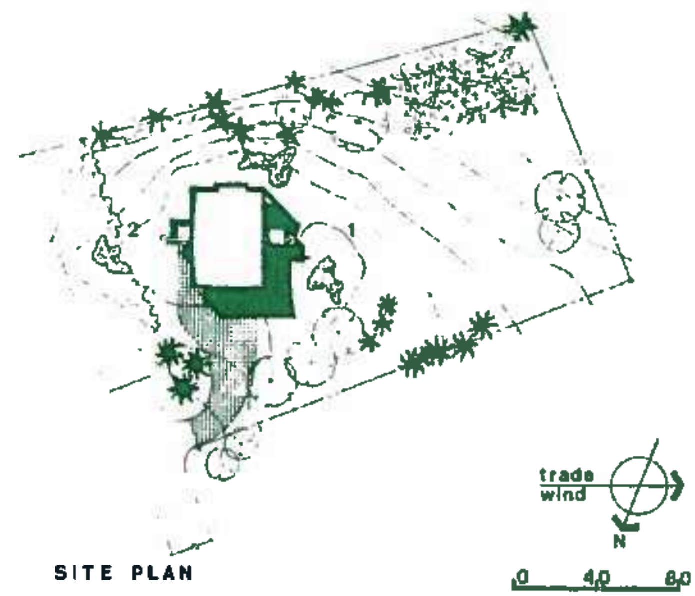
Interiors employ natural marble floors, loft ceilings and ceiling fans. Primary windows are full height glass jalousies.

The surrounding cool surfaces and abundant breeze create extremely comfortable interior spaces with interior ceiling fans used only on rare calm days.

Project: Residence for Mr. & Mrs. Allan Deal
Talofofo, Guam
Architect: Allan H. Deal, AIA
Contractor: Allied Construction Co.
Construction Date: 1974

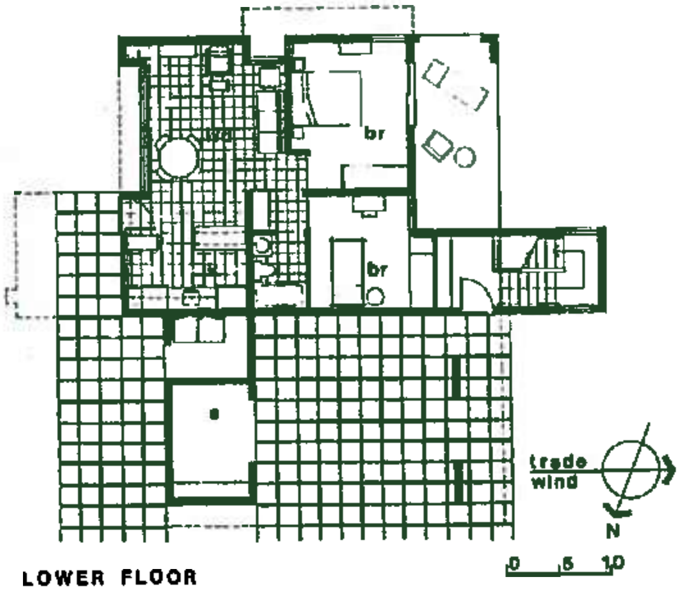


DEAL RESIDENCE-PARTIALLY AIR CONDITIONED SUNSET PORCH, LEEWARD SIDE

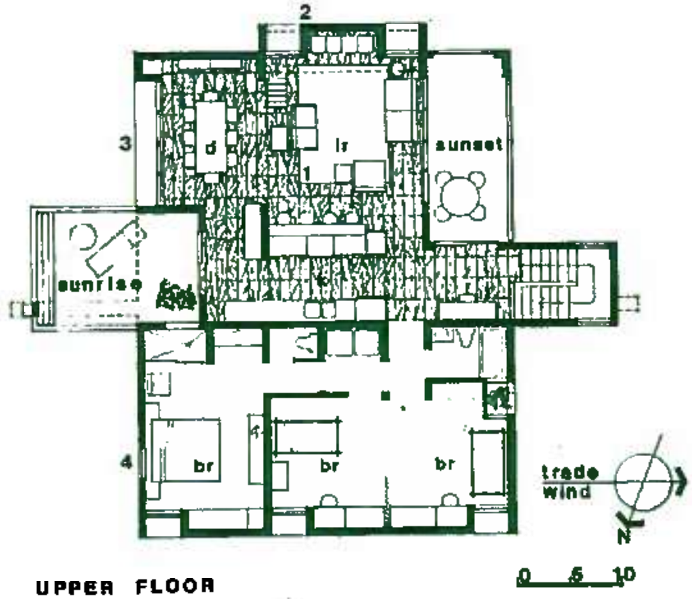


SITE PLAN

1. Location at hill crest maximizes the wind.
2. Landscaping helps channel the wind through the house.



LOWER FLOOR



UPPER FLOOR

1. Marble floors provide cool floor surfaces.
2. Dining and living room spaces are naturally ventilated.
3. Openings on windward and leeward sides maximized for naturally ventilated spaces.
4. Air-conditioned spaces located on north with minimal east-west openings.

SECTION

1. Glass jalousie windows for cross ventilation throughout.
2. Ceiling fans for additional air movement.
3. Spaces stacked vertically for reduced exposure and heat gain.

Chapter 6
Other Techniques