SOLAR PASSIVE ARCHITECTURE IN THE TROPICS
THE TROPICS
Area between tropic of Cancer and Capricorn - 50,000 square km = 1/3 of the planets surface, accounting for more than 1/3 of the global population
More than 100 countries lie within this zone and most of them on the way of becoming industrialized with increasing energy consumption
Energy consumption in Asia/Africa per capita is about 0.5 tons of oil equivalent (TOE)
Latin America is about 1.0 TOE
Europe is about 3.5 TOE
United States of America is 8.0 TOE
Passive solar systems use architectural elements in buildings to take advantage of natural cycles of sunlight and other elements in order to reduce the costs of building heating and cooling, without using mechanical elements. If mechanical elements are used, then the system is termed “active solar”

- Florida in USA is a developed area in the tropical zone where 47% of the total energy is used in buildings and 35% is used in transport and 90% of this energy used is electrical.
- Brazil a developing country uses 42% of its energy in buildings
- Most countries in the tropics have a history of sustainable buildings and it is called “Vernacular architecture”.
- In hot dry regions with hot days and cold nights the vernacular design had developed a perfect balance between

1. Shading and Day lighting
2. Natural ventilation and heat storage

- In hot humid regions

1. Natural ventilation
2. Shading Systems
With the introduction of air conditioning architecture became independent from climate – “birth of pure aesthetics” – “Clearly expressed pure forms wrapped in glass” -
Result – increased energy consumption globally........of electrical energy mostly generated with fossil fuel. And architecture loses its “sustainability”
Architecture and Urban design have tremendous impact on energy efficiency and sustainability of societies.

The principle concepts are similar for residential and commercial buildings but the approaches are different.

• In residential buildings the low tech approach can prevail for most buildings, due to cost structure and more active user behavior.

In commercial buildings the more technical approach would be successful because of higher initial investment and more passive user behavior.

Providing thermal comfort to the user in a building is essential – without it the body gets stressed and the efficiency of the immune system suffers significantly.

ISO 7730 and ASHRAE accepts some form of acclimatization by specifying a higher temperature range for the summer – Temp 22.5-26 °C at 60% RH

Prevailing air conditioning temperatures in most office building in the tropics is 18-22 °C while outside temperature is 30-40 °C creating thermal stress for the human body while changing ambiance- main reason for the “summer flu”
The idea of climate responsive design is to modulate the conditions such that they are always within or as close as possible to the comfort zone.

Identification of the climatic zone

Identification of local / unique weather conditions and features

Collection of Climatic data for the last decade

Study of site specific features
TO MAKE CLIMATE AN INTRINSIC PART OF ARCHITECTURAL DESIGN VARIOUS PARAMETERS HAVE TO BE CONSIDERED AS DESIGN CRITERIA.

RELATIVE HUMIDITY

AIR TEMPERATURE AND MOVEMENT

SHADING DAY & LIGHTING

RADIATION RECEIVED

INTERNAL MATERIALS AND FINISHES

MICRO-CLIMATE
High relative humidity conditions in hot humid zones create high discomfort even with temperatures between 28-35 °C.

The few ways to deal with high humidity with little or no mechanical / electrical means:
• prevent the prevailing breeze to pass over water bodies before entering buildings.
• not have too much vegetation/ground cover too close to the buildings that would increase the RH with trans-evaporation
Natural Ventilation is the most essential element in Hot-Humid zones, and this can be achieved with optimization of the following:

Orientation: by conventional wisdom one would assume that the highest pressure on windward is generated when the long façade is right angle to the wind direction but it has been found (Givoni-'63) that wind angle of 45 ° increases the average indoor air velocity and provides a better air distribution.
Optimum solar orientation and the optimum wind orientation may not coincide

In the tropics the north-south orientation is preferable for sun exclusion but mostly the winds are easterly. So 45 degree orientation resolves this contradiction.
Proper ventilation starts with sustainable planning on the urban scale

- Ventilation canyons created on the urban master-plan
- Improvement of microclimate with landscaping measures
- Lowering air temperature and potential radiation by shading and evaporative cooling
- Provide ventilation channels towards the buildings

Within buildings in areas of low wind speed the following should be avoided:

- Wind shadows created by obstructions upwind—with shrubs, trees and fences
- Sitting of larger buildings in the windward directions

Wind velocity can be increased by

- Velocity gradient increased by rough ground surfaces
- Creation of wind walls at the downwind sides
- Create funneling with upward projecting eves
INTRODUCTION OF SOLAR VENTS:

DUE TO DIFFERENTIAL TEMPERATURE (THE SLAB AT THE TOP OF SOLAR VENT HEATS UP THE AIR AND DRAWS IT TO THE OUTSIDE CREATING NEGATIVE PRESSURE, INCREASING THE AIR FLOW FROM THE OUTSIDE) WITHIN A GIVEN SPACE, ONE CAN INCREASE THE WIND SPEED WHICH IS ESSENTIAL FOR COMFORT IN HOT AND HUMID CLIMATE. IN THE SUMMER AS THE WIND SPEED IS LOWER, THIS TECHNIQUE HELPS IN PROVIDING EVAPORATIVE COOLING BY DRYING THE SWEAT ON THE SKIN.
Roof vents to allow the hot air that rises to escape also creates negative pressure to increase the air movement in the room.

Use of fans during the hottest part of the day would reverse this by drawing the hot air under the ceiling and re-circulating it.
-Creation of courtyards as cool air traps
Creation of transition spaces for lowering the air temperature before it enters the building

Planting of ground and tree cover to reduce reflected ground radiation
Cross ventilation and position of openings:
Lack of cross ventilation in buildings

Windward opening with no outlet-no effective ventilation
Pressure built up in the room similar to front of the building

Leeward opening with no inlet

Oscillating pressure conditions may cause “buffeting”

Air movement can be directed by proper location the openings:

Inlets and outlet to be located according to the location of most used areas of a room and the time of usage.
Shading and day lighting: is a major issue in the vernacular architecture in the tropics. Because of the intense sky glare, in spite of careful orientation it is difficult to cut down on the glare.

Mesh screening helps to cut the glare and light shelves allow a more diffused lighting conditions. Day lighting can also act as heating systems due to the thermal aspect of day light.
Shading methods:-

- Projecting horizontal shelves
- Balconies
- Eves and porches
- Roof overhangs
- Inset windows
- Horizontal louvers
Egg crate louvers

Awnings

Vertical louvers

Louvered brackets

Louvered awnings

Horizontal fins

Architecture Dept: Auroville
Building Centre
This figure quantifies the impact of shading on different types of glazing:
1. un-shaded and shaded against direct radiation
2. shaded against direct and diffuse radiation

This shows the impact of shading devices and the relatively small impact of double glazing on overall heat load.
Shading from rain and sun.

Shading from one or the other is not difficult but both together is not easy.

Movable and adjustable shades allow flexibility.
Radiation and heating:

- Conduction – heat intake through walls and roof...lower U value in building materials

- Solar radiation – heat intake from opaque surfaces, solar heat gain from transparent surfaces (windows)....paved and surfaced area in direct sun around buildings. Un-shaded glazed windows especially on the east and western facades.

- Heat exchange – heat from movement of air.

- Internal heat gain – heat output from people, lamps, computers and appliances

- Evaporation – from surfaces (sweat, walls and plants)
materials and finishes:
• Construct building with low thermal capacity materials and if possible use light weight construction
Roof shading, reflective surfaces and insulation
Internal materials like furniture and furnishings can store heat making it uncomfortable. In high humid conditions even with temperatures between 25-35 °C evaporation of small quantity of moisture from the body would form a saturated air envelope preventing any further evaporation. In these conditions thick fabrics, warms colors and non-absorbent surfaces add to the uncomfortable feeling.
Micro Climate: Depending on the ground surface incident radiation would either be absorbed, reflected or stored to be re-radiated later. In hot climates ground surfaces should be minimally paved and trees that can relied on for full foliage year around should be used for shading.

Pergolas, shading devices and climbing plants on cheap frames can be quite effective.
NEW REGIONALISM

To progress in the area of sustainable development we have to change our paradigm of “Architecture”.

What we need is a new architectural approach “the new regionalism” that respects the climate and the culture of the region and therefore creating an ecological and cultural sustainability in the built environment.

Instead of the international, modern and post modern styles of the last century which respected neither climate or the regional cultures we should use the tools of globalization and communication to improve co-operation and research.

The faceless and resource devouring cities, buildings and lifestyles can not only be avoided but the existing ones can be changed. Respect of one’s own and other’s environment, culture and climate will inevitably lead to sustainability.