SEMINAR ON CLIMATE-CONSCIOUS CONSTRUCTION
Lecture of ir. Ronny Lobo, April 4, 2007

1. INTRODUCTION

Climate-conscious construction in my opinion is designing and building in such a way that a maximum comfort of man is reached, using as many natural climate properties as possible and minimize mechanical aids. Comfort can be defined as the total physical and mental wellbeing. The climate in Curaçao is a real challenge for the architect who is not satisfied with the replacement of a bad design by mechanical tools. This implies an ethical attitude toward the architectural design. This does not mean that in this modern world we can solve the comfort problem only with natural resources, where these are insufficient. But from a good architect it may be expected that he gets the optimum out of the natural possibilities. Unfortunately, I note that this ability in most cases is lacking. Fortunately, it appears that the current global concerns regarding the use of traditional natural resources for power generation improves the awareness of the people.

During the past decades, we more and more forgot how to make the best use of the natural climate characteristics. This is typically caused by the easy use of mechanical means, duplication of construction methods from countries with a different climate and the easy accessibility of books, magazines and now the Internet and the greater mobility of people. This causes our local building tradition to continue to degenerate. Because our natural resources are becoming scarcer, we must quickly turn the tide. From an ethical perspective, we need to ensure the best indoor climate by maximizing the structural use of passive possibilities to regulate this, so mechanical means may be limited or even unnecessary.

In my talk I will first make an analysis of the climate in Curaçao, determine the criteria for thermal comfort, and then elaborate on the structural controls thereof, such as orientation of buildings on the sun and the wind and use of materials in relation to the heat exchange of buildings and their environment. Finally, I will make a critical analysis of the use of mechanical aids such as air-conditioning and artificial lighting.

2. THE CLIMATE OF CURACAO

Curaçao is located in the Caribbean Sea at 12 degrees north latitude and as such in the tropics. Tropical climates can be essentially divided into three types:
1. Warm, humid equatorial climates;
2. Hot and dry desert or semi desert climates;
3. Composite or Monsoen climates.

The climate in Curaçao is most consistent with a subgroup of group 1, the so-called warm moist island climates, but with little precipitation.

The climate is primarily determined by the following:
1. air temperature;
2. humidity;
3. wind;
4. sunshine and clouds;
5. rainfall.

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Data on these properties are collected and published monthly by the Meteorological Department Curaçao (MDC, www.meteo.an).

Air temperature.
The average temperature is 27.8 degrees Celsius on Curaçao. The hottest months are June to October, with September being the hottest month with an average temperature of 32.5 ° C. The coldest months are December to March, with February being the coldest month with an average temperature of 26.6 ° C. The average temperature is 30.8 ° C with an average fluctuation of 4.5 ° C.

Humidity.
The average relative humidity is 77.7%. This moisture largely determines our sense of comfort. In general, a high-humidity is not pleasant.

Wind.
Although we learn in school about the northeast trade wind, the wind in Curaçao mainly comes from the east. The prevailing wind measured by the MDC between 1971 and 2000 was 87 degrees to the north, so almost east. The average wind speed on the island is 7.1 m / s. It is obvious that for comfort natural ventilation by the wind is very important. A higher wind speed causes a greater evaporation, which means better cooling. The wind is a constant feature of our climate, free of charge.

Sunshine and clouds.
The average percentage of sunshine is 70%, with a cloud coverage of 40%. The sunshine causes the heat load on buildings to be converted in the radiation temperature of the roof and exterior walls.

Rainfall.
The rainy season in Curaçao is from October to December. The average annual rainfall between 1971 and 2000 amounted to 553.4 mm, which is much lower than in the normal warm humid climates (eg, Paramaribo, Suriname with an average of 2800 mm per year). For the climate in Curaçao the rainfall is not significant. The rainfall is characterized by a large amount of rain during a short period of time.

Vegetation.
Because of the low rainfall, the island is mostly dry and natural vegetation is limited. Vegetation gives evaporation, which is accompanied by cooling of the air.

3. COMFORT

The main task of an architect, besides making beautiful buildings, is perhaps creating a pleasant indoor climate. The users of a building often judge the quality of a design from their physical and emotional comfort. This experience contributes to our opinion about the house we live in, the school in which we receive our education or the office or factory in which we work. The level of thermal comfort depends on external factors such as air and radiant temperature, relative humidity and air velocity but also on personal factors such as age, gender, type of clothing, physical condition and type of work. To determine the thermal comfort certain standards are used. For example, the average temperature of the ceiling may not be more than 4.5 ° C higher than room temperature, while the average air and radiation temperature may never exceed 28 ° C.

The index for thermal comfort is 21 ° C, which is much lower than the average air temperature of 27.8 ° C in Curaçao, as previously mentioned. Since the thermal comfort is dependent on the

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combination of relative humidity and associated temperature, there is an index for the maximum and minimum temperature, at a certain humidity. For the relative humidity of 70% in Curaçao, these are limited to 22 ° to 27 ° C during daytime and 17 ° to 21 ° C in the evening. These temperatures are also lower than the average in Curacao. This means that if we do not make use of mechanical equipment to decrease the temperature, the ventilation by the wind is extremely important to somewhat satisfy the above mentioned standards.

4. ORIENTATION OF BUILDINGS TO CONTROL HEAT LOAD AND VENTILATION

We all know that every day the sun rises in the east and sets to the west. The position of the sun relative to a building at a particular time of day can be determined with a so-called solar orbit diagram, where the height and angle can be read for each day of the year and any hour of the day. For each latitude this diagram is different. For Curaçao, we use a solar orbit diagram for 12 ° latitude. Because the highest position of the sun occurs on June 22nd, while the lowest position of the sun is on December 22nd occurs, we will use these dates for the extreme values with regard to the insolation.
As the sun rises in the east and sets in the west, the east and west facade of a building are most heated, next to the roof that receives the most solar energy. Limitation of the heat load on facades can best be achieved by large roof overhangs around the building, to ensure that the exterior walls of the building are in the shade most of the daytime. In addition, the longest walls of the building are preferably oriented east-west, while the east and west elevations must be minimized. For example, a rectangular floor plan that is oriented east-west in a house with the bedrooms on the shady side. This is opposite to the preferred orientation for natural ventilation by the wind, as we shall see later.

In most cases the greatest thermal load on a building is the direct radiation of glass surfaces. This may significantly raise the internal temperature. This is known as the greenhouse effect, the radiation of heat through the window, once entered, is trapped. To prevent this, there are four variables that a designer has at his disposal:
1. orientation and size of the windows;
2. interior, curtains;
3. special glass;
4. outdoor blinds.

Indoor blinds and curtains are not an effective means to regulate solar radiation. These indeed stop the radiation, but they themselves take up the heat and can therefore become very hot. A small portion of the heat absorbed is returned to the outside, while a considerable portion is released to the indoor air to through convection. The reduction of solar radiation by indoor blinds on a window with single glazing is therefor only 17%.

With so-called heat absorbing glass a reduction of approximately 32% can be achieved. There are several types of glass, such as heat-reflecting and light-sensitive glass, but in general, these types of glass are rather expensive. Moreover, an improper application of this glass may cause more problems than it solves. So I think we should not fall back too quick to on these technical solutions. Much better is the application of external sun protection in the form of horizontal elements above the windows, or horizontal louvres on the glass surface. We can also make vertical elements which form a horizontal shading. An example of an architecture where the architect completely surrenders to technical means is the SVB building on Pater Euwensweg. Immediately opposite is the expansion of the St. Elisabeth Hospital of Ben Smit, where the measures concerning the climate determine the architectural form.

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Ventilation and air movement.
Natural ventilation and air movement are structural assets because they are not dependent on any added energy or mechanical installation. They have three functions:
1. The introduction of fresh air;
2. cooling by convection;
3. psychological cooling.
There is an essential difference between the three. The first two are called *ventilation* while we consider the last separately as *air movement*.

The following aspects may be distinguished from the inner air flow, both with regard to the pattern and the speeds:
a. Orientation;
b. external factors;
c. cross ventilation;
d. location and size of openings;
e. controllability of the openings.

Considering the prevailing wind from the east a north-south longitudinal axis for a building is the most ideal, with the main facade surfaces directed towards the east where the wind can enter the building and to the west where the wind exits the building. This does not correspond with the most ideal location in terms of radiation from the sun. A rotation of 45 degrees with respect to the wind can, however, offer a solution. It has been found that this does not cause less air flow. On the contrary, the distortion often causes higher wind speeds. Rotation of a building on the site, with spaces at an angle of 45 degrees with the street, can also make a building spatially interesting. Proper orientation of a building with respect to the wind must always be preferred. It is more difficult to correct poor ventilation due to a wrong orientation. In order to prevent the air on its way through the building heating up too much, we have to make sure that this path is as short as possible. For a good cross ventilation it is important that the wind can enter the building, but also exit. The openings on the west should preferably be larger (min. 40% of the wall surface) than those on the east (at least 20% of the wall surface), which creates a better pull. The cross ventilation should take place on body height.

5. MATERIALS AND CONSTRUCTION

Walls.
To avoid the heat load on the walls these should be:
1. as little as possible directly hit by the sun through a correct orientation, and the use of large roof overhangs which are as low as possible for optimal shading.
2. easy to isolate;
3. be composed of lightweight materials with a low heat-absorption capacity;
4. reflective, painted in light colors; using dark colors in our climate is fatal.

In the regular building tradition on Curaçao exterior walls are often made from 10 or 15 cm thick solid concrete blocks. In order to achieve a better insulation, and a lower heat absorption, we can use hollow blocks.

Windows.
Windows should be large and able to open completely. Windows with fixed glass should be avoided

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wherever possible. The widely used single or double sash windows are not recommended.
To ensure that we can continue to ventilate when it rains, the use of movable horizontal louvres is recommended.

Roofs.
These should preferably:
1. have a reflective surface;
2. constructed as a double layer with an air space in the middle;
3. consist of lightweight materials with a low heat-absorption capacity; this also applies to the ceiling;
4. be well insulated, for example, by an insulating blanket on the ceiling, provided with a highly reflective film to the upper side;
5. have large overhangs.

6. MECHANICAL MEANS.

In many cases, e.g., for modern office use, mechanical cooling of spaces is necessary. In housing people often consider air conditioners necessary for safety reasons (they do not dare to sleep with open windows on the ground floor). Schools sometimes choose to cool the classrooms because of traffic noise. In all cases we must always consider what portion of a building necessarily has to be mechanically cooled and during what time. We must determine what part we want to simply cool to have more comfort. Waiting rooms in public buildings and lobbies in hotels e.g. usually need not be cooled, provided they are well situated on the wind and thus can be naturally ventilated. Sometimes ceiling or floor fans, which consume much less power than an air conditioner, can provide sufficient cooling. The degree of sophistication of the ventilation or cooling equipment is often a socio-economic issue in which we must make a value judgment about the degree of comfort that we want and what we have to pay for this. Unfortunately there are too many examples of misguided and energy-intensive cooling of spaces, sometimes caused by poor building design or changed use. We all know examples of large places for worship of religious groups, built in the shape of poor sheds badly insulated, where excessive energy consuming air conditioning units with a lot of noise are trying to cool the faithful. While in the past we would not even think of cooling a church. Often the cooling equipment is not carefully designed based on the design of the building and the location thereof on the site.

The different heat load from the sun on differently oriented facades demands a separate temperature control for cooling the rooms on these facades. Also the varying wind conditions along the walls can influence the heat or cold transport through the façade construction. Finally, in my opinion the users must become more critical to deal with the integration of air conditioning equipment in the architecture of a building. The indiscriminate placement of condensing units and cooling pipes against the wall has taken unacceptable proportions, both in terms of the beauty of buildings and as regards the cooling requirements.

Lighting.
The lighting of buildings should be considered critical. The use of natural light which is still the best light that we know, must be included as a part of the total illumination of buildings during the day. Energy wise, it is advisable to start from a common illumination with a low luminance combined with workplace lighting. Thus we concentrate the light at the spot where it's needed most. In offices it is further recommended to use motion switches to turn the light off automatically if there is nobody in the room.

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Epilogue.

In this lecture I have tried to indicate that climate-conscious building, that should be the natural thing to do on our island, more and more remains to be desired, and should be put on the right track again. I want to thank the organizers for the initiative to this seminar, combined with the workshop tomorrow afternoon. I was honored to be a speaker in this seminar.

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