CLIMATICALLY RESPONSIVE ARCHITECTURE

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Abstrak

The process of architecture design is a complex exercise. Involving interactive relationships between parameters of diverse nature and varying magnitude. Yet, it is the prime generator of architecture as we see and experience. It exercises control on both the teaching and practice of the profession. Various ideas have dominated architectural thought in this century. The fundamental issue of energy as an embodiment of the natural environment has not been a basic paradigm of design. Since building is a product of a process that starts at the board of an architect. A logical approach based on quantitative assessment leading to qualitative decision in the design making process. A design tool enabling decision making at the conceptual and final design stage is developed and presented as a design guide matrix.

Keyword: climatic design guide

INTRODUCTION

Architecture and Bioclimatic Design

Bioclimatic design has indeed come a long way, but unfortunately at the same time it still has a long way to go before it is to be universally accepted by architects and the others members of the design and not just a fad that will blow away with all the other " isms" that have come and gone. The reason is that architects are basically trained to exercise only eyes. An architect "envisages" space or a new situation, he does not feel it with any of his other senses, so these senses become dormant and he gradually loses the many hidden dimensions of architectural creation which are vital to the notion of bioclimatic design. Let me only mention what to me are the three most fundamental one although sound, smell and touch are not less important (Tombazis, 1995).

Time, which has been called the fourth dimension architectural space, is of importance because every object cannot exist but in time. The notion of time gives life to an object and relates to seasonal and diurnal patterns and thus to climate and the way that a building behaves or should be designed to couple with and not antagonize nature. It further relates to the dynamics nature of a building in contrast to the static image that we have created for it.

Air, is a second invisible but important element. We create space and pretend that it is empty, oblivious of the fact that is both surrounded by and filled with air. Air in its turn, due to air movement which is generated by either temperature or pressure differences, is very much there and alive. Relation with the movement of air should be building shapes, sections, heights, orientations and the size and positioning of openings.

Light and in particular daylight, is a third important element. Architecture can not exist but with light and form the time we have been able to substitute natural light with artificial lighting, many building an a lot of architecture has become poorer so, it is not an exaggeration to say that the real form giver to architecture is not the architect himself but light and that the architect is but the form molder.

An architect, during the process of design should take separate walks through the plans and sections of what he is putting down on paper or computer screen and each time visualize how what he is designing is being affected by time, air and light. There exists there in so much to see that would be hidden to the untrained eye for ever and so much to be influenced by, that the end product cannot but become richer and more complete. Architect which is sensitive to **site, sustainability, climate**, the teaching of **simplicity** and **beauty** to be learn from the common sense lessons of the vernacular and the needs and aspirations of human beings is in itself so comprehensive and fulfilling that there is little else to be added.

Sustainable Architectural Reality

One of the drawbacks of “agenda 21” is that it list, in catalogue fashion, the problems and issues of sustainability, without any grading of their relative importance or urgency: as such it is a confusing puzzle that leaves the individual reader to draw his own conclusions as to what are the priorities for the future. One of the principle problems resulting from non sustainable forms of development are the changes being caused to the atmosphere resulting in changes to the balances of heat flux between the sun , the earth and deep space. The specific make up of atmospheric gases cause a : greenhouse effect” tempering heat flow and temperature variations on earth maintaining average temperature of 15-35°C over large areas of the globe, forming the basis of life and global ecology as we know it. Action of man are increasing the concentrations of “greenhouse gases” in the atmosphere, reducing heat loss to deep space, and increasing global temperatures. It is now accepted that these changes in the atmosphere are the principle cause of changes in global temperature. There is a clear increase of average global temperature of 1°C from 1880-1980, and while not a reliable long term statistical guide, there is a clear 1°C increase in average temperatures over the last 15 years.

How are we going to achieve architectural sustainability? Certainly not through following “conventional” western design patterns, copying stylistic fashions, or adopting in appropriate technological fixes from other climates, regions, or cultures. The real solutions must come from within:

1. Create diverse and locally adapted solutions to development
2. Use of locally available, appropriate resources, in conjunction with local climatically responsive design solution
3. Design for local social customs, conventions and aspirations
4. Avoid easy, ready made ideas and solutions, use original thinking
5. Conserve non renewable energy-limit its use to highly efficient, essential functions, design out the need for massive consumption
6. Introduce incentives for energy efficient, climatically responsive developments, through use of building energy comfort performance standard, progressive taxing of increased energy consumption on a per m2 (for public and commercial buildings) or per unit (for residential building).
7. Apply energy performance ratings to equipment and systems that are an integral part of building function i.e. fridges in residential buildings.

These are just a selection of ideas, approaches, concepts that are fundamental to a sustainable approach to development of the built environment.

METHOD AND DISCUSION

Climatically Responsive Scientific Process of Design

The relationship between built form and the environment should become the driving force behind this scientific process, based on a scientific methodology. The tool of analysis available allow critical performance and evaluation of built and overall space network. It seems logical to develop a process almost in the form of an algorithm which will help find the optimal form/solution for a given set of requirements and constrains. Evidently based on a design hypothesis it is possible to generate a set of solution through this process/algorithm. From this set of solutions the optimal solution can be arrived at. However, the reverse is not true. Given a case (the design hypothesis) and a rule (the simulation model) one may obtain by deductive inference the unique possible result (the performance characteristic of the given hypothesis). If instead, one defines the required result (the performance characteristics) there does not exist a mode of inference by which, using a given rule (a specific algorithm) one may determine unique the case (the design solution).

The idea of climatically responsive design is to modulate the conditions such that they are always within or as close as possible to comfort zone. The ambient condition over twenty four period is shown by the line A. For a majority of the time it is outside the comfort zone. Modulations introduced by the landscape, built form, envelope, materials and other control measures brings the conditions within the comfort range throughout the twenty four cycle. This is the goal of climatically responsive design. However, unlike industrial manufacture, designing is not a linier process. Parameters are inter related and inter active. Often they need to be considered simultaneously and in a cyclical manner. Any process of design must therefore allow for this flexibility and dynamism. This process and the design tool is put forth in the manual accompanying this paper.

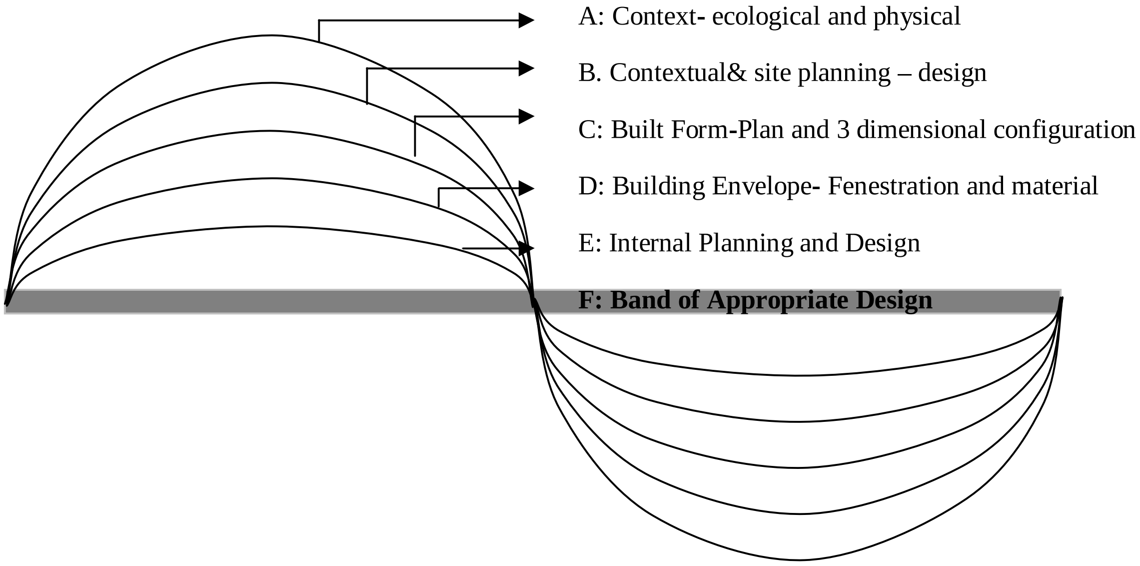

Figure 1. The ideal of climatic design (Adopted from Prof.Arvan Krishan)

Climatically Responsive Architecture an Integrated Approach

The basis of our attempt at climatically responsive design involves considering the climate in every aspect of the building and built environment. Our First task is to put forth these various aspects in logical sequence. In effect, we are dissecting the design into its constituent elements, so that we can act upon each is turn. The sequence proceeds from macro level details to micro level details. The design sequence that is thus generated is as follows:

1. Landform
2. Vegetation type and pattern
3. Water bodies
4. Street widths and orientation
5. Open spaces and built space
6. Ground character
7. Plan form
8. Plan elements
9. Roof form
10. Fenestration pattern and configuration
11. Fenestration controls
12. Walls
13. External color and texture
14. Internal layout and partitions
15. Internal finishes

A qualitative study of these modulations, at each level, is an essential pre-requisite to climate design. Each level is explained in terms of its climate implication, the conceptual understanding there of and its effect on the building design (table 1). The various levels together provide an extensive understanding of the interaction of the building and the micro climate. To enable the qualitative and quantitative analysis of landform the energy balance at the surface should be analyzed and consequent effect of this be taken into account in the design process.

CONCLUSION

The information given in the paper is linked together into a comprehensive "design aid" by design tool. It helps in the formation of a conceptual design strategy. However, it is also linked to the qualitative and quantitative information. It thereby draws the reader into a more comprehensive and precise understanding of the requirements. An underlying sentiment of this work is the desire to focus all analysis and calculations towards the design input. The idea is to optimize the input of the designer and to direct the output of the aid into clear pointers for design. As result the design aid package seldom requires the designer to know much more than the basic climatic condition and the latitude of the place. Only at advances stages of design is more specific data required.

REFERENCE

Bansal, 1994, *Passive Building Design Handbook of Natural Climatic Control*, Elsevier Science
Koenigberger, 1986, *Climatic Design: Manual of Tropical Housing and Building*
Krishan A, 1995, *Climatically Responsive Efficient Architecture*
Tombazis,1995, *Architecture and Bioclimatic Design*

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Table 1: Climatically responsive architecture an integrated approach

Level	Parameters	Climatic implication	Theoretical understanding	Building design
Landform	Air temperature Air movement	Cooler air tends to collect in depressions or dips in land. However, slopes and depressions lead to different levels of air temperature and air movement at different parts of the site.	Cool air has higher density than hot air. As a result cool air is heavier and tends to settle down in depressions while hot air rises.	Even in humid climate we might be forced to place our building in a depression. If so we can take other measures to mitigate the effect. A study of the different levels to enhance or suppress the effects of decision taken at earlier levels
Vegetation pattern	Air movement Radiation Humidity Daylight	Vegetation and trees in particular very effectively shade and reduce heat gain. They increase humidity levels. They also cause pressure differences thereby increasing and decreasing air speed or directing air flow.	Plant, shrubs and trees absorb radiation in the process of photosynthesis. As a result they actually cool the environment. Threes and hedges also affect air flow. Thick vegetation can effectively cut it off. On the other hand careful placement of trees can direct and increase air speeds	In warm humid regions vegetation can be employed to maximize air flow. However, if they are not planted carefully they would end up reducing air speeds
Water body	Radiation Air temperature Humidity	Water absorbs relatively large amount of radiation. They also allow evaporative cooling. As result, during the daytime areas around water bodies are generally cooler	Water has a relatively high latent heat of evaporation as well as specific heat. So, when water evaporates by the movement of air, it cools the air. This is evaporative cooling.	In warm humid climate water bodies are best avoided. The minimal benefit provided by evaporative cooling would be off set by the heightened humidity levels.
Street width and orientation	Radiation Daylight Air movement	The amount of direct radiation received on the street is determined by the street width. The orientation affects the time of the day when the radiation is received.	The street width to building height ratio determines the altitude up to which solar radiation can be cut off.	In warm humid climate the primary need is for air movement. Streets should therefore be oriented to utilize the natural wind pattern. Modulating the street width and orientation can very effectively control solar radiation received.
Open space	Radiation Air flow	Open space have to be seen in conjunction with the built form. Together they can allow for free air movement and increased heat loss or gain	An open area, especially a large one allows more of the natural climate of the place to prevail. So obviously, large open spaces allow for freer air movement. The built pattern is also important. It can increase, decrease and modify air speeds	In humid climate s buildings should preferably not be attached to one another. Streets and the open spaces should be oriented with respect to wind pattern. The open spaces and the tunnel effect can be used to maximize air flow within the complex
Ground character	Radiation Daylight Humidity	Depending on the ground surfaces, incident radiation would be either absorbed, reflected or stored and re radiate later.	The lighter the color and smoother the surface the more the reflectivity of the material. The darker the surface and the rougher it is the lower the reflectivity	In humid condition ground character is of consequence only when it can absorb moisture
Plan form	Radiation Air movement Daylight	The perimeter to area ration of the building is an important indicator of heat loss and gain. It therefore plays a role in ventilation, heat loss and heat gain	In the case of radiative gains or losses, the perimeter is crucial factor. However, it goes without saying that a large building would have a greater perimeter than very small building. To be able to make a real comparison we need to consider the perimeter to area ratio and not just the perimeter	In warm humid climate the prime concern is plan form for maximizing air movement. Here too. Minimizing the perimeter to area ration is useful as minimizes heat gain
Plan element	Air movement Radiation Air temperature	Water bodies and vegetation help cool a space by evaporation and the absorption of heat. Water bodies and green house also aid in space heating. Courtyards and in certain cases wind	Water bodies are effective means of evaporative cooling. It has already been seen that vegetation can absorb radiation. Courtyard and verandahs can lead to very air	In humid climates courtyards and verandahs aid in ventilation. Wind catchers, objects of must interest, may also be employed. However, they have to be used with

Level	Parameters	Climatic implication	Theoretical understanding	Building design
	Humidity Daylight	tower cause heat loss and enhance ventilation.	structures especially when seen in conjunction with the fenestration.	care.
Roof form	Radiation Air movement Daylight	The roof can be used as a source of daylight	By varying the roof projections with respect to the building width pressure differences between the windward and leeward side could either be increased or decreased	In warm humid climate natural ventilation is very desirable. The building should, in such a case, have its longest dimension perpendicular to the direction of air flow. Further, the roof overhangs and pitch should be as high as possible. This would result in the maximum pressure difference and consequently maximum air flow
Fenestration pattern	Radiation Air movement Daylight	The fenestration pattern and configuration involve the area, shape, location and relative positioning of the windows. This would affect the air movement, daylight and glare indoors.	That the area of the opening should affect air movement and daylight is understandable. After all, it directly affects the amount of light and breeze allowed in.	In warm humid climates fenestration area should be large to facilitate ventilation. Large overhangs would be desirable in cutting of diffuse solar radiation. The fenestration height should be such that there is a good distribution of air flow over the human body. Lower ciil levels might therefore be preferable
Fenestration orientation	Radiation Air movement	The orientation of the fenestration determines the amount of radiation incident on the opening. The orientation with respect to the air pattern could increase or decrease natural ventilation.	Orientation with respect to solar geometry has been dealt with earlier. To obtain a good distribution of air flow within a building the wind direction and inlet to outlet direction should not be the same.	In humid climate they should be within 45 degrees of the perpendicular to the direction of air flow. The inlet and outlet should not be in a straight line in order to maximize air flow
Fenestration Control	Radiation Air movement Daylight	Glazing, shades, light selves, fly wire nets and the cross sectional area of the window can be important control	Glazing, the most commonly used control devices, traps solar radiation. Light shelves are horizontal projection in a window. Flywire nets are intended as control devices for insect.	In warm humid climate window shades are not so much of an issue since solar radiation is largely diffuse. Fly wire net are all the more necessary due to the insect that thrive under theses conditions. The major need. That of increased ventilation can be achieved by modifying the window section
Walls	Radiation	As in the case of roofs, wall materials are a major factor to consider in heat flow studies	There is more to walls than just their material. Cavity wall with air spaces of about 5 cm between the two layers reduce heat transmission.	In warm humid climate wall should have a low thermal capacity
External color and texture	Radiation	The surfaces characteristic affect heat transmission into the building	The color of a surface affects its reflectivity and therefore the heat absorbed. The surface texture could vary from smooth to rough.	In warm humid climates again the aim would be to minimize heat gain. Light colored and rough surfaces and therefore preferable
Internal finishes	Radiation and daylight	Under certain conditions it would also affect heat loss	The reflectance of internal surfaces would affect daylight level indoors.	Internal reflectance's should be as per the desired daylight condition