Bioclimatic approach in designing tower office buildings

Tarek Farghaly and Hassan Abdel-Salam
Department Of Architecture, Faculty Of Engineering, Alexandria University, Alexandria, Egypt

This research presents a concise overview of a recent environmental trend in architecture: the "Bioclimatic Approach", with particular emphasis on its impact on contemporary design of tall office buildings. As a new approach in architectural thought, the bioclimatic philosophy has been looking into ways in which the environmental conditions could be selectively employed as to provide design improvements as well as design features. The Bioclimatic Approach reviewed here represents a wave of buildings that are inspired by environmental and green concerns, and have a clear strategy for environmental management. The research consists of six main parts. First the underlying concerns about energy efficiency, building design and operation are reviewed. The second part reviews the topic of energy efficiency in relation to design issues. Third, an overview is presented of the progressive development of office buildings. The fourth part explains the basic design principles of the Bioclimatic Approach. In the fifth part, lessons from recent examples of tower office buildings, and current literature, are revealed. Part six concludes a general prospect of the concept, and considerations towards an overall approach of environmentally responsive design of office buildings.

يتناول هذا البحث أحد المداخل البيئية لتصميم المباني الإدارية المرتفعة المخصصة كمباني للمكاتب ، و هو ما يعرف بمصطلح (Bioclimatic Approach) . يعتبر هذا المدخل المعاصر أن الظروف البيئية يجب أن يتم تناولها بحيث توجه و تحدد عملية التصميم و عناصره. و تترجم الأفكار الجديدة و المتلاحقة وعيا و أبعادا للتعامل مع البيئة و خصوصا السعي لإيجاد استراتيجية للتحكم في الظروف الداخلية للمنشأ ، مع مراعاة ترشيد استخدام الطاقة و النظم الاصطناعية المكلفة. يستعرض البحث المواضيع الرئيسية المتعلقة بمجال حماية البيئة و الموارد الطبيعية، و مدى ارتباطها بالتصميم ، و بالتالي كيفية دمجها و تكاملها مع الفكر و الإبداع المعماري في إطار متواصل . و ذلك استكمالا للنظر في الطفرة التي شهدتها عمارة أبراج المكاتب و التي ترجع في المقام الأول إلى التغيرات الجوهرية في مضمون العمل المكتبي . و مفهوم الإدارة و دخول عدد كبير من المعدات و الأجهزة الإلكترونية و شبكات المعلومات في إطار العمل المكتبي. يتكون البحث من ستة أجزاء . الأول هو تعريف بالاهتمامات الخاصة بالنواحي البيئية و تصميم و تشغيل المباني . الجزء الثاني يقدم شرحا لعلاقة التصميم بموضوع ترشيد الطاقة و المعالجات الخاصة بالمناخ . ثالثا يستعرض البحث المراحل الأساسية في تطور الفكر التصميمي لمباني المكاتب. الجزء الرابع يحوى تحليلا لمبادئ و أهداف المدخل البيومناخى للتصميم . و يقدم الجزء الخامس بعض الدروس المستفادة من الأمثلة و التجارب الموجودة في هذا المجال . يختتم البحث في الجزء السادس بالخلاصة وموجز للاعتبارات اللازمة لتطوير المدخل البيئي و توجيه تصميم مباني المكاتب نحو فكر اكثر مسئولية تجاه البيئة و متطلباتها.

Keywords: Bioclimatic approach, Office buildings, Environmental design, Energy-smart buildings, Exclusive design.

1. Introduction

1.1. *Environmental concerns and human comfort*

A sustainable architecture has become a term generating widespread attention and interest. With the Twentieth Century drawing to a close, this term has rather turned into a "keyword", which in many ways refer to an architectural design attitude appropriate to the demands of the next Millennium. One major demand among these is the need to embrace a strategy for minimising environmental degradation, while encouraging a sense of well being. This has initiated a relentless quest among architects and designers to develop advanced building prototypes, which are also informed by nature, sensitive to its fragile eco-system, and with minimum detrimental impact. The Bioclimatic Approach is primarily founded on, and continuously builds upon this notion.

The issues that must be addressed in the design of contemporary bioclimatic buildings and settings are essentially threefold: energy,

Alexandria Engineering Journal Vol. 39 (2000), No. 6, 937-958

health and well-being, and sustainability [1]. According to Jones, there are two aspects to the issue of energy in building design: how it can be used efficiently, and what form it should take. Energy conservation is as much about choosing the appropriate form of energy at the appropriate time, as it is about saving that energy. A building consumes energy in a number of ways, and they all should be studied and analysed in order to formulate a comprehensive strategy for efficiency and rationalism. However, this concise research particularly emphasises the energy consumed in the post-occupancy stage. Such portion of energy is used in running a building and its occupants equipment and appliances, and is therefore referred to as "Operating Energy".

Operating energy is the form of energy that has been given most consideration by recent research in the field. Accordingly, an energy-efficient building is primarily perceived to be a structure which looks to reduce this kind of consumption. Since energy use in buildings is closely tied to the climatic conditions in which they are located, the measures taken to minimise it will vary from one locale to the other. The basic requirements are however fairly uniform. Particularly in the case of office buildings, where interior functions are almost the same universally. Most buildings will require seasonal cooling or heating, and most will need good light levels for the activities taking place within them to be conducted satisfactorily. Nevertheless, achieving comfort will vary considerably, since the perception of comfort differs between individuals, groups, and cultures. It will also vary according to the activities taking place in different parts of the building, whether sedentary or active, and the psychological frame of mind of the occupants. Thus the *comfort criteria* will have to be set according to the local framework.

Defining goals for individuals comfort and convenience is an important but extremely difficult task for an architect to do. People comfort needs vary one from another, and the perception of comfort varies between seasons and with the degree of control that individuals have in maintaining it. It has been said that occupants will inevitably want to alter the targets the building systems are set to achieve. In the context of Bioclimatic building design, more explicit emphasis is put on the elements of control intended to deliver comfort, those directly regulated by the users themselves [1]. Surveys have shown that this will make occupants carry out their tasks within significantly wider comfort tolerances than those without control. The reason for this is at once physiological and psychological.

As Jones asserts, any building acts as an intermediary between conditions on the outside, which are often widely changing, and the requirement for a relatively stable interior environment. Towards this end, bioclimatic design needs to bring many factors into play, whilst striving to conserve energy. The most effective way is to design the building to exploit natural forces - sunlight, wind, and daylight - to greatest effect, and to harness the beneficial attributes of the climate, without resort to mechanical systems.

2. Energy efficiency and design issues

According to Jones [1], a building needs to be carefully balanced to reduce excessive solar heat when the weather is hot, whilst fully utilising solar radiation when the weather is cold. It should also allow abundant daylight to enter the building but guard against glare, excessive solar gain and excessive heat loss. Jones adds that architects need to ensure that plenty of natural ventilation is provided when the weather is hot or humid, and that the building can also be sealed but adequately ventilated when heated artificially. Finally, the building fabric should be used to absorb and release heat on a daily cycle, whilst being sufficiently insulated to provide thermal stability.

Several measures are available to designers. They primarily have to do with optimising orientation, finding a balance between sun-shading and sun-penetration. Also, the design of openings ought to provide a balance between natural air admission and elimination, and ensure a leak-free building.

Further measures involve understanding the thermal performance of materials, planning the interior to mitigate extreme thermal fluctuation, and landscaping to create complementary external conditions.

Combined together, the above measures are being adopted by architects, which increasingly seek a bioclimatic approach to design office buildings, with a view to achieve environmental control, human comfort, simultaneously with the chief objective of energy efficiency.

Architects have long been trying to make buildings less wasteful, in terms of energy consumption, and many attempts were primarily oriented to help ease energy-related problems. Yet, it has been noted that many buildings still barely meet many energy standards. According to recent surveys, this is due to several reasons. Developers seek to minimise initial costs, and lenders favour known technologies, like mechanical equipment, over efficient ones, e.g. passive solar design. A counter argument is forwarded by Fells [2]. He asserts that by using currently proven technology, energy usage could be reduced by 20 percent, with a payback period of less than five years. Further measures should be encouraged, such as careful design and insulation, use of energy-efficient lighting and glazing, installation of better controls leading to more efficient energy management, the use of computerised energy-management systems, and the installation of modern and efficient appliances. In addition, substantial rewards for energy-smart buildings are to be established, in order to entice providers to adopt the concept.

On a general level, buildings could be classified into two categories, depending on their physical design, and the manner in which they deal with external or natural conditions. Indeed, the typological difference should be taken into consideration in the early stages of design and decision-making regarding the physical form and operation processes. The first category is called "*Exclusive Design*", where the overriding concern is to isolate the internal environment from the exterior. This means to restrict the form and nature of the building envelope. For example, an ultimate exclusive building could be the typical deep-plan form, with highly insulated interior and minimal or no openings.

The second category is often described as "*Selective Design*". As evident in its name, a selective design is more interactive with the surrounding environment. It has a more complex form, system of openings, and its envelope has greater permeability, transparency and complexity, because it admits and harnesses exterior conditions, as well as ambient energy sources [3].

A comparative review of both categories can reveal basic differences between them, and thus presents further insight into the potential of each, and their appropriate applications in the context of bioclimatic design. The specific characteristics of exclusive mode and selective mode could be summarised in the following issues [3], also refer to Table 1.

- In the case of "*Exclusive Mode Buildings*", the interior environment is automatically controlled and predominantly artificially air-conditioned. The building form is usually compact, and functions are spatially condensed with a view to minimise the impact of external conditions upon the internal environment. The building orientation is of little relevance, and openings are restricted in size. Energy consumption in this mode is high, with a constant quantity, usually from generated sources.
- With regard to the second type : "Selective Mode Buildings", the interior environment is controlled through a combination of automated and user-operated means. Indoor lighting and air-conditioning are achieved by a variable combination of natural and artificial sources. The building form is more loose and diverse, in order to maximise the use of ambient energy. The building orientation is a crucial factor, and window sizes on different facades vary accordingly. Solar controls are required to avoid overheating in hot seasons. The power required in this mode is supplied through a combination of both ambient (natural), and

Table1. Comparative overview of characteristics for the two design modes of office buildings: the *exclusive mode*, and the *selective mode* [4].

Building mode	Exclusive mode	Selective mode
Interior Environment	Environment is automatically Controlled and predominantly Artificial	Environment is controlled by a combination of automatic and manual means and is a variable mixture of natural and artificial
Building Shape	Shape is compact, seeking to Minimise the interaction between Exterior and interior environments	Shape is dispersed, seeking to maximise the use of ambient energy
Orientation	Orientation is relatively Unimportant	Orientation is a crucial factor
Openings	Open windows are generally Restricted in size	Window sizes vary on different facades. Solar controls are required to avoid seasonal overheating
Energy Source	Primarily from generated sources And is used throughout the year in a relatively constant quantity	A combination of ambient and generated. The use is variable throughout the year with peak and free-running periods

generated energy. The consumption is variable throughout the year, depending on seasonal conditions, and indoor comfort requirements.

3. Progressive development of office buildings: an overview

Office buildings as a distinct type of buildings have gone through several stages of development and mutation. The most significant period is considered to be the recent decades. During the early part of the twentieth century, the central urban office building was an object between five and seven storeys in height, with either banking or shop space at the ground floor and daylit office space above. Most buildings were relatively small and shared common walls with their neighbours.

Environmental control was by means of natural ventilation, and when needed steam or hot-water central heating. Artificial lighting was basically regarded as night-time substitute for daylight [3]. A significant stage in the development of office buildings came with the idea of 'putting the lightwells on the outside'' by adopting a cruciform plan for the main office floors. Thus maximising the daylight the building received was made possible by increasing the distance between itself and neighbouring buildings, and by eliminating the lightwell altogether. The increased importance of daylight and sunlight considerations led to further developments after World War II, which ended in 1945. The emphasis was still on natural lighting, with the move towards opening up the urban fabric. A maximum height of ten storeys was considered to be adequate for all requirements.

The slab-on-podium form of the latter half of the years 1950s achieved the first major innovation in design and construction technology. This was the acceptance into common practice of the curtain-walling idea. This transformed the outer skin of the building from a heavyweight membrane with 'punched' apertures into a transparent film wrapped around the structural form, with any opaque areas being lightweight infill panels.

The shortcomings of this stereotype drew attention to problems of environmental control in office buildings for the first time. Several aspects were questioned, such as the conjunction of large areas of glazing, lightweight structures and hitherto unheard-of building heights. In addition, forms which maximised the surface area of the enclosure, and the effects of daylighting legislation, which reduced the amount of protection from direct sunlight that is enjoyed by closed packed buildings, all conspired to produce apparently severe solar heat-gain problems. They often produced intolerable environmental conditions and much effort has been dedicated to the solution of the 'problem' ever since [3].

In one sense it may be argued that the air-conditioned glass skyscraper is the most successful production of the construction industry in the twentieth century. Following the inspiration and ideology of Mies van der Rohe projects for glass skyscrapers in the early 1920s, its very presence in every city of the developed world, regardless of the climate, symbolises the ability of technology to overcome nature. Within the powerful economy of the multinational corporations, which are the most frequent occupants of skyscrapers, the extravagant use of energy which these structures inevitably require is rarely important. In spite of this, some of the most interesting contributions to the development of an alternative vision of environmental design have been made through office design.

In response to the environmental shortcomings of the early slab-on-podium buildings, attention was drawn to the previously little-explored attractions of air conditioning. This was quickly followed by a growing interest in deeper plans with a high degree of artificial control over the total environment. The organisational properties of the form were realised with the coming of the open-plan office. Full air conditioning was used, heating in winter and cooling in summer.

Along with open-planning came increases in illumination levels to provide a bright environment in deep spaces, and attention was drawn to new problems of noise control in large spaces [3].

This form led to high running costs for the environmental control systems, and by implication high energy consumption. Further refinement followed until the concept of 'interior balance' emerged, in which an optimum relationship is sought between levels of environmental provision, and the means by which they are achieved and maintained. In this form illumination levels are specified that maximise 'visual performance', and also demand a large number of light fittings to be installed. The heat from these is then utilised to provide the bulk, if not all, of the heating input into the building during the winter. Temperatures are controlled within fine limits and the ventilation rate selected is a careful compromise between the needs of occupants for the renewal of the air which they breathe and the need economically to maintain the thermal balance of the building [3]. Since the exclusion of external noise is recognized as an additional problem in central urban areas, it was further justifiable to support decisions to control the size of windows and to seal them. All of the above issues were studied as to achieve indoor balance, by controlling the effects of natural light and heat, and simultaneously regulating the use of artificial lighting and air conditioning.

4. Basic design principles of a bioclimatic approach

A brief review of the key aims is necessary in order to justify the need to design office buildings with climate. They would certainly support the argument for such an environmental approach, and at the same time, give a clearer insight on what subsequent measures are necessary. According to the broad view presented by Yeang [4], the aims include the following:

1. *Low costs:* as a result of decreasing energy consumption in the operation of the building. This can be by as much as 40 percent of the overall life-cycle energy costs of the building. Significant savings in operational costs would justify the incorporation of climatically responsive design features despite higher initial capital costs;

2. *Contact: providing:* the building users with the opportunity to experience the external environment. As a result, turning away the blandness of spending their working hours over a significant part of the day in an otherwise artificial environment that remains constant throughout the year; and

3. *Environmental gains:* reducing the overall energy consumption of the building by the use of passive structural devices. Savings in operational costs derive from less use of electrical energy that is usually derived from the burning of non-renewable fossil fuels. The lowering of energy consumption would further reduce overall emission of waste heat.

Within this quest to incorporate environmental issues into the design approach, precise design elements are to be considered. They include:

a. Relationship of vegetation to building: Buildings might be regarded as being simply massive concentrations of man-made objects, extracted and produced all over the biosphere, piled up and assembled at certain locations. The result is a significant increase in inorganic mass placed at these points. This needs to be balanced by an equally significant increase in planting and vegetation compatible with the location. As discussed by Yeang [4], there are three ways to relate buildings and planting theoretically:

- Juxtaposition: one material is placed next to the other, as in the use of planter boxes;
- Intermixing: combining or interspersing of large areas and quantities of vegetation with inorganic areas or surfaces; and
- Integration: seamless intermeshing of inorganic and organic material.

b. Physical articulation: atrium layout. Large multi-storey transitional spaces might be introduced in the central and peripheral parts of the building as air gaps and atria. These would serve as middle-ground zones located between the interior and the exterior. An atrium should not be totally enclosed, but rather be placed as to create such notion of an in-between space. Their tops could be shielded by a louvered roof to encourage wind-flow through the inner areas of the building. These may also be designed to function as wind scoops / catchers to procure natural ventilation to the inner parts of the building.

c. Service core. Service core position is of primary importance in the design of tall buildings. The service core not only has structural function, it also affects the thermal performance of the building, and it determines which parts of the peripheral walls will become openings and which parts will comprise external walls. According to a classification by Yeang, core positions fall into three types: central core, double core and single-sided core. A double core has many benefits with both cores on the hot sides of the building, they provide buffer zones, insulating internal spaces, and hence minimising air-conditioning loads.

d. External walls. External walls should be regarded as permeable, environmentally interactive membranes with adjustable openings. The external wall should have moveable parts that control and enable cross-ventilation for internal comfort, and provide solar protection [4].

5. Lessons from recent examples

Built in recent years, several examples are worth reviewing, in order to analyse and understand how different designers have approached, and further developed the concept of Bioclimatic Design. There are many lessons to be learned from recent experience in building high-rise office buildings, as well as from other experiments with energy-efficient buildings. Though perceptions and attitudes vary considerably among concerned architects, clients, and users of the selected examples, the basic concerns and remedial measures are found to be broadly shared, and theoretically valid at the universal level.

Informed by climate, orientation, and energy use, a series of bioclimatic skyscrapers, designed by Ken Yeang in Malaysia, Fig. 1 show how these concerns can be applied. The crucial factors that make of these office buildings a user-friendly experience are all functions of the bioclimatic schedule. Discerning design decisions on orientation result in elements such as lift cores (usually naturally ventilated and daylit) acting as solar shields; plan shaping to reduce insulation; natural ventilation options for the office spaces related to 'thin' plan forms and the incorporation of painted balconies and recesses together with eggcrate and louvre solar shading [5].

Originally developed in the temperate climate zones, the air-conditioned glass tower continues to be exported indiscriminately around the world. However, concern for energy use has resulted in an architectural form far removed from the received image of a "modern" office block. A good example of this recent shift is in Harare, Zimbabwe Fig. 2. Within the central business district a new office building manifests the alternative image of office blocks suitable for hot zones. The architects Pearce Partnership, and the developer opted for a bioclimatic design, and were initially convinced that the building should, as far as possible, be ventilated, heated and cooled by natural means [6].

Using computer simulation of heat gains, air flows, and temperature gradients, engineers Ove Arup sought to devise an alternative passive services strategy. The principal aim was to provide ventilation, since Harare's climate effectively reduces the need for an elaborate heating system. Certain parameters were established, concerning the building mass (to be as heavy as possible, with much of this exposed internally), the external walls (shielded from direct sunlight) and the windows (to be small and not exceed 25 percent of the exposed surface area). In addition, windows were to be sealed to avoid unpredictable temperature fluctuations and all ventilation was to be ducted [6].

The enormous thermal mass of the building is used to regulate the air temperature. Immediately above the first floor, a service storey contains the large low-speed air intake fans that provide forced air to the offices above. The ducts supply plenum chambers under the office floors and the offices themselves via grilles below the windows.

The hollow floor structure serves to increase the rate of heat transfer to and from the mass. As the concrete temperature is expected to remain at around 20 degrees C, this mechanism can be used alternately to cool air during the day and heat it during the cool nights. Exhaust air from the offices enters high level bulkheads parallel to the core and then moves horizontally to vertical extract shafts. Eventually, the slow moving ass of waste air is discharged from the building through roof-level chimneys [6].

Richard Rogers states that "Architecture of the twenty-first century will be more and more informed by ecological limitations and possibilities. Problems of pollution and quality of life will directly affect both the cities and the buildings. We have to use less energy, which is not just more economical but is also important in terms of pollution. Architecture will become therefore more informed by the wind, by the sun, by the earth, by the water and so on. This does not mean that we will not use technology. On the contrary, we will use technology even more because technology is the way to optimise and minimise the use of natural resources. We embrace technology as long as it is well used" [7].

Rogers' Turbine Tower Project is an example of a building which is designed to generate energy from renewable sources Fig. 4 The idea was to accept the possibility that the buildings could supply sufficient energy for themselves. Maybe some energy could be put into the general energy system and not just used for heating and ventilation. The building is sometimes like a windmill that creates energy. Since this was to be a tall building, Rogers shaped the building to encourage air to come past curved walls. If enough velocity of oriented wind could be gained in the right direction, inserted propellers could start to create sufficient energy. The building has glass on the long side of the building which is responsive to energy so that it can become translucent or opaque in color. The building becomes more like a plant-in the sense that it responds to nature [7].

As shown in many current examples, ambient wind could be explored as a design influence and feature. Wind-gust velocities at the upper parts of tall buildings might be incorporated as free energy in the buildings design. This has been proposed by some designers in order to increase the cross-ventilation opportunities to the inner parts of tall buildings. It is also suggested that such an environmental factor could provide new opportunities for sculpting design features, and producing new images and aesthetic vocabulary [4].

Rogers further supports this view [7] by mentioning that such an attitude will tend to change the design language away from the structurally expressionistic buildings, towards a language where the building is a response to nature and the occupants who use it inside. He remarks that this concept is more organic, but in a different sense of the word than the way architects used it fifty

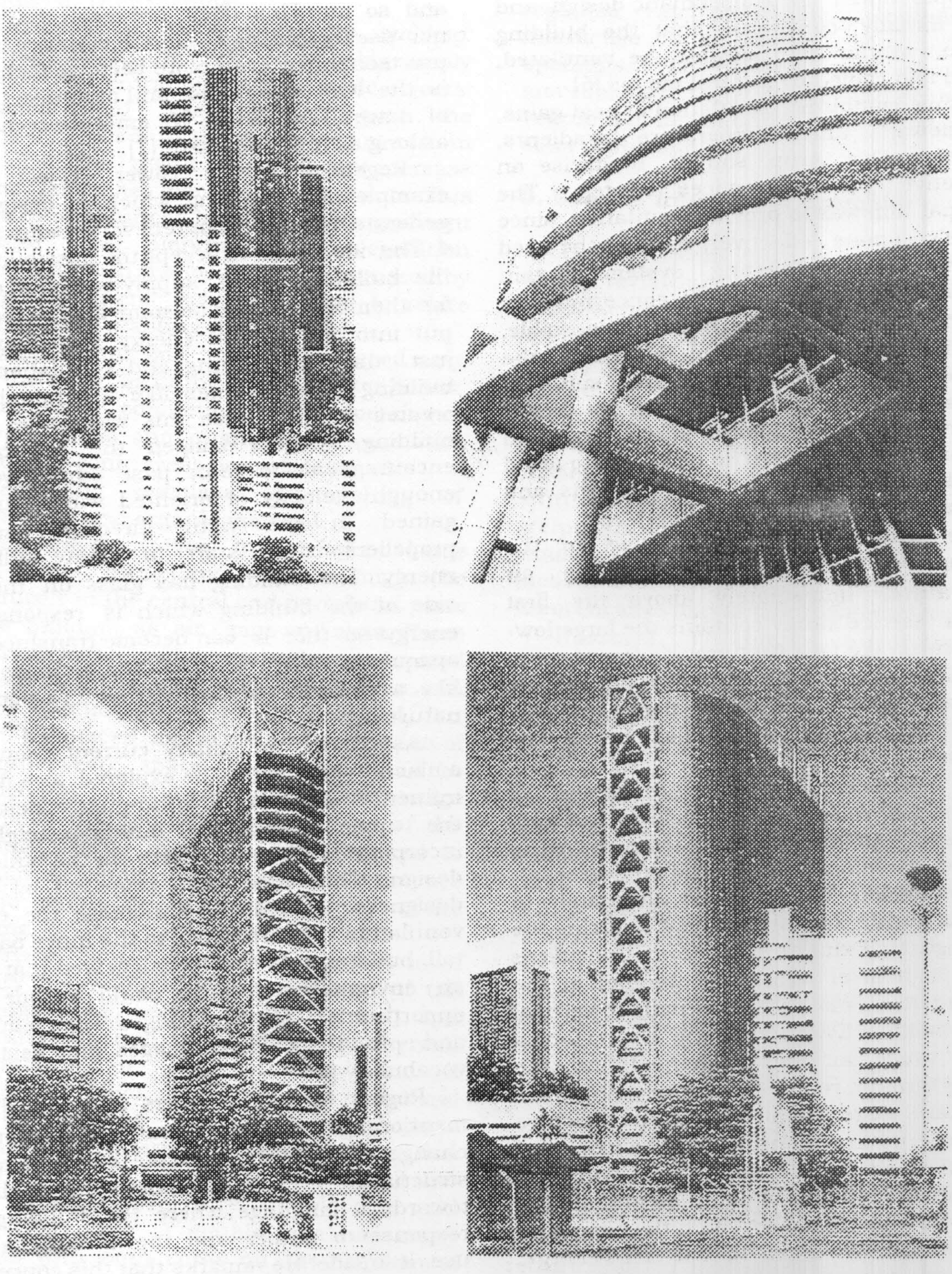

Fig. 1. A series of bioclimatic skyscrapers, designed by Ken yeang in malaysia, shows how climatic concerns can be applied. discerning design decisions on orientation result in elements, forms and recesses, plan shaping, and natural ventilation options. above: central plaza tower (left), menara boustead (right). below: menara budava tower [5].

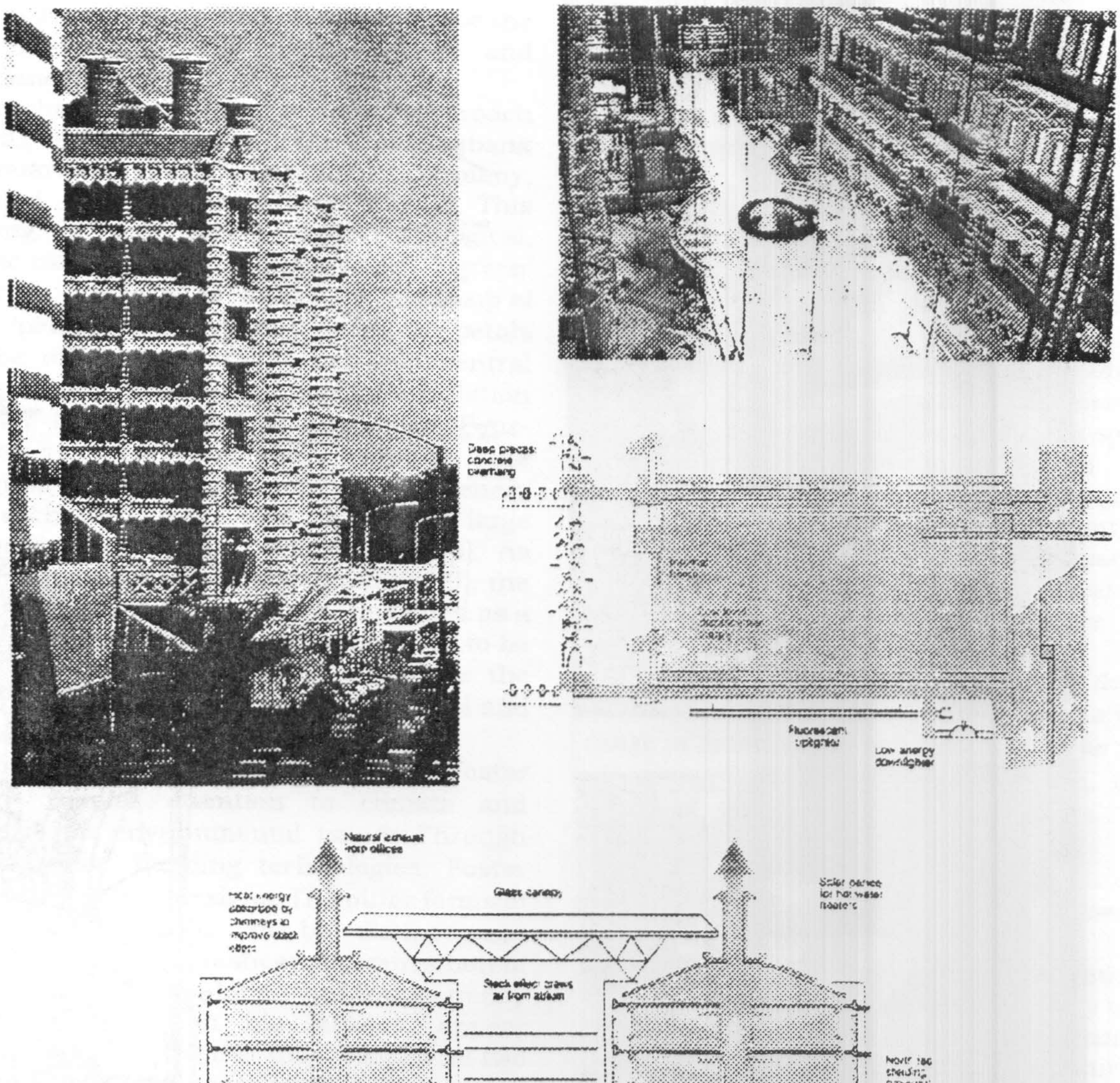

Fig. 2. An alternative image of office blocks suitable for hot zones: mixed development in central harare, zimbabwe. pearce partnership opted for a bioclimatic design, whereby a building should, as far as possible, be ventilated, heated and cooled by natural means, all reflected in the physical design. sections through a typical office and the building, showing general energy management principles [6].

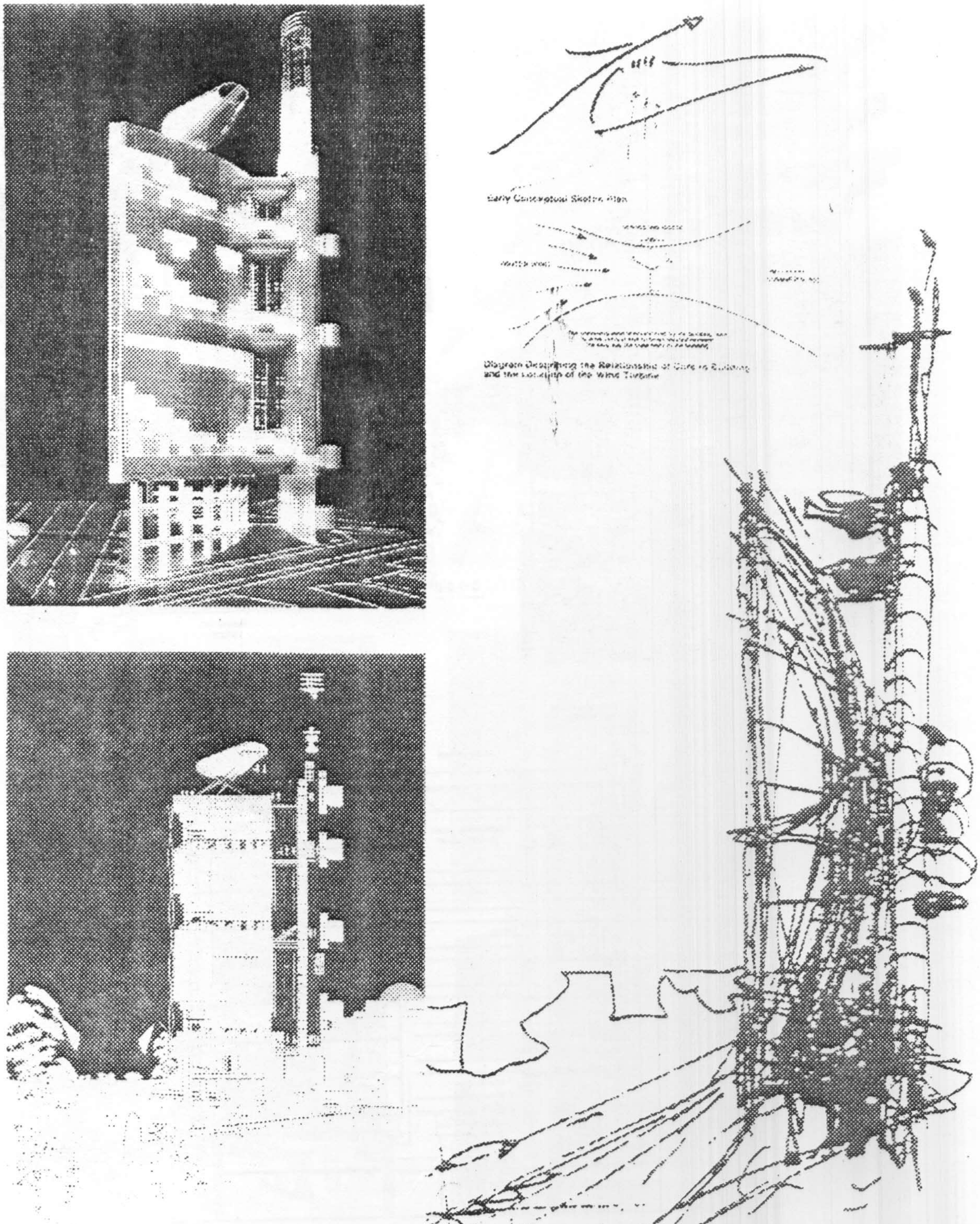

Fig. 3. The turbine tower project by richard rogers : an example of a building which is designed to generate energy from renewable sources. model, view and early conceptual sketches describing the wind turbine mechanism [7].

years ago. Buildings have been developed to fight nature, to keep nature out, and now the aim is rather to use nature and simultaneously give to nature.

Another example of a sound approach towards energy matters is the Commerzbank Headquarters, in Frankfurt, Germany, designed by Norman Foster Fig. 5 This building is the world's highest ecological, symbolically and functionally 'green' structure. Its form is triangular, made up of three 'petals' and a central stem; the petals are the office floors, the stem a great central atrium which provides a natural ventilation chimney for the inward-looking offices. Four-storey-high gardens spiral around the triangular plan giving a view of the greenery from each work place and eliminating large expanses of unbroken office space [8]. As explained in a review of this building [9], the "hanging gardens" had to be imagined as a veritable green lung: the vegetation was to be so luxuriant as to be able to provide the building at all times with sufficient cool and humid air even without air-conditioning.

Other examples designed by Foster display similar attention to climate and emphasis on environmental issues. Through energy-saving building technologies, Foster produces pioneer designs. The outer forms of buildings are seen to be distinct and spectacular, with sophisticated composition of walls and roofs, articulation and transparency . Glass surfaces on his facades, appear entirely seamless, while they consist of two glass skins using new construction systems and computer-controlled blinds. The physical properties of the double glazing are those of a thermally insulated wall. Air conditioning, heating and cooling are performed by systems based on water cycles, which operate at low cost and make brilliant use of thermal laws. Through a combination of inexpensive power stations and sun collectors on roofs, Foster makes current buildings which are electronically steered self-sufficient units [10].

6. Conclusions

The purpose of this research has been to present a broad review of the concept of Bioclimatic Design, with particular emphasis on its application in the field of tall Office Buildings. The discussion and multiple views presented above, have helped introduce the theme, and present further insight into its scope and characteristics. Significantly, a new potential emerges in favour of shaping a unique direction in contemporary architecture, which is more sensitive towards the environment as well as the needs of users. Within this context and as a specific title, the term "Bioclimatic" has been established to describe such an approach to building design which is inspired by nature. It applies a sustained logic to every aspect of a project, focusing on optimising and using the environment, in an interactive but responsible way.

The logic or rationale underlying design-decisions and feature-selection, cover a broad range of determining conditions such as :

- Setting: The building site, location, form, mass, orientation, local climate, and geographical conditions;
- Economy: cost, capital and running expenses, funding, productivity, savings, and competency;
- Construction: Techniques, methods, materials, embodied and grey energy which are consumed in the manufacture of components and construction respectively;
- Building Management: Control systems operating in the building and its interior environment, natural versus mechanical means, and practical requirements;
- Building physics : Properties, dynamics, ordering and correlation; and
- Individual health and well-being: Occupational considerations, utility, performance, comfort requirements and productivity.

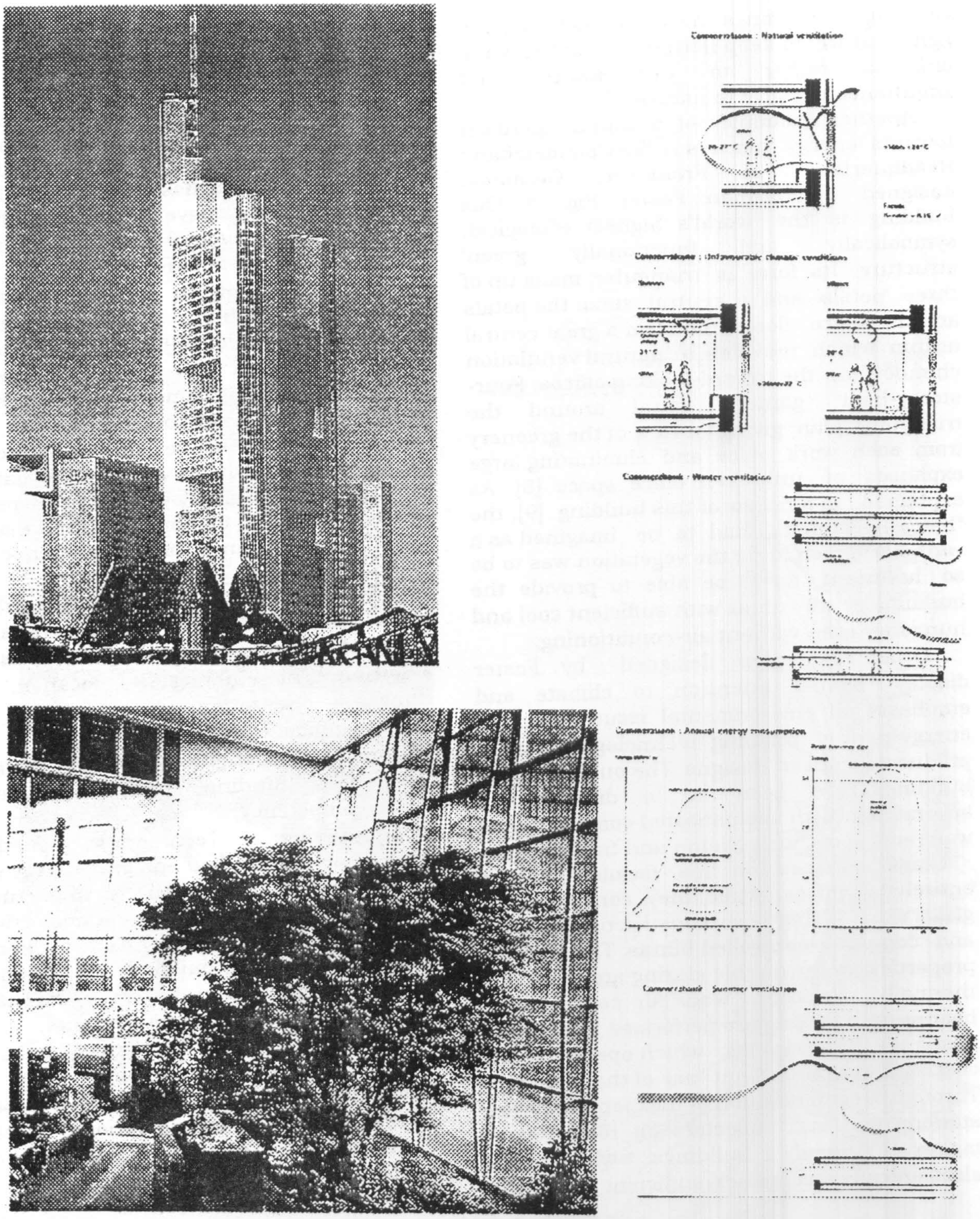

Fig. 4. Commerzbank headquarters in Frankfurt, Germany, designed by Norman Foster is the world's highest ecological, symbolically and functionally 'green' structure. exterior and interior views and diagrams of principles of climatic control and environmental management through ventilation and hanging gardens [9].

The Bioclimatic Approach is not only suggesting a new style, but rather presents an overall design philosophy and comprehensive strategy, which further serves the environmental protection purpose. The above six issues should be carefully considered by designers, as the search continues for a novel vision, role, and responsibility for architects towards nature and the environment. A radical re-evaluation of the way office buildings are designed, constructed and managed is essential. Problems and concerns ought to be addressed, spreading awareness about the current environmental degradation, and unnecessary abuse. Subsequently, viable solutions need to be formulated for the benefit of both users, patrons and most importantly the environment. Trade-offs, combined strategies, and middle solutions will also be taken into account, especially in particular contexts such as the developing Countries, where development is operating on limited budgets, and economical considerations are focal to the process. Here a middle-ground concept is needed, between exclusive and selective modes, or perhaps a combination of both, which allows designers to further explore environmentalism and energy efficiency issues in competitive and creative ways.

Bioclimatic Architecture needs to be accorded further priority, and receive attention and support both politically and economically. If bioclimatic office towers, recently constructed world-wide were not able to compete on a commercial level, they simply would have not gained patronage or been built in the first place. That they have, is proof that the existing order can be challenged, and more environmentally-responsible ideas are becoming embraced and accepted. The process of educating clients and building users not to expect sleek, sealed glass towers or air-conditioned absolutes, is an urgent necessity, and one in which architects have an important part to play.

The bioclimatic trend is expected to continue, and in its course develop new ways by which innovative design can be linked to nature. New projects are likely to display higher levels of integrity between form, function, and energy matters. With regard to tower office buildings, the main target should be to expand the existing standard agenda of work efficiency, as to incorporate, the primary objectives of energy efficiency, environmental sensitivity, management technology, human well-being, and process sustainability.

References

[1] David Lloyd Jones, Architecture and the Environment: Bioclimatic Building Design, London, Lawrence King Publishing (1998).

[2] Ian, Fells " Energy Conservation ", Electronic Arcticle on Microsoft Encarta 99 Encyclopaedia, New York , Microsoft Corporation (1998).

[3] Dean Hawkes, The Environmental Tradition: Studies in the Architecture of Environment. London, E & F N Spon. (1996).

[4] Kenneth. Yeang, Bioclimatic Skyscrapers. London , Artemis London Limited (1994).

[5] Ivor Richards, "Vertical Visions", in The Architectural Review, Special Theme: Sustainable Architecture, London, Emap Construct, Vol. CC(1195), pp. 66-67 (1996).

[6] Catherine Slessor, "Critical Mass", in The Architectural Review, Special Theme: Sustainable Architecture, London, Emap Construct, Vol. CC (1195), pp. 36-40 (1996).

[7] Yukio Futagawa, (editor). Richard Rogers, GA Document Extra, Vol. 02. Tokyo, A.D.A. EDITA Tokyo Co. Ltd. (1995).

[8] Peter Murray, and MaryAnne. Stevens, (editors). New Urban Environments : British Architecture and its European Context , Munich, Prestel - Verlag (1998).

[9] Manuel Cuadra, " Headquarters of a Bank in Frankfurt ", in Domus , Milan, Domus Academy, (798), pp. 20-26 (1997).

[10] Otto Riewoldt, New Office Design, London, Lawrence King (1994).

Received November 1, 1999
Accepted Augusts 17, 2000