

## Bioclimatic designs for the student housing of new University of Cyprus

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### ABSTRACT

The design for the new University of Cyprus campus is being developed in a series of six competitions, paralleling the six "phases" of construction. Awards are being made both to the best overall design, which then also determines the architectural firm responsible for that phase, as well as for the best bioclimatic design. This paper describes the first-prize winner in both categories for the second of this series of competitions, representing the first phase of student housing design. The whole study was carried out as an integrated approach, taking into consideration a very wide range of design choices and parameters, with a conscious focus on bioclimatic design. There was an effort to combine traditional wisdom, new technology, function and comfort, cost, natural environment and microclimate, energy saving, client program, and aesthetics. These were tailored to the particular requirements of the buildings. Energy-efficient design is used throughout, including careful and appropriate placement of insulation in relation to interior thermal mass. This is assisted by "smart-control" mechanical systems for heating and cooling. Daylighting is integral to the design, with energy-efficient supporting lighting systems. The designs also promote natural summer cooling ventilation, utilizing the prevailing summer wind direction as well as enhancing stack-effect ventilation.

### 1. INTRODUCTION

The design for the new University of Cyprus campus is being developed in a series of six competitions, paralleling the six "phases" of construction. Awards are being made both to the

best overall design, which then also determines the architectural firm responsible for that phase, as well as for the best bioclimatic design. This paper describes the first-prize winner in both categories for the second of this series of competitions, representing the first phase of student housing design. The presenter is the bioclimatic design consultant.

This design encompasses housing for 208 students. These are blocked into twelve individual buildings, consisting of four blocks of twelve rooms, four of twenty-four rooms, one of forty-eight rooms, and three houses with two for six persons and one for four, as well as a common space. This carries on the "village" scheme first established in Phase I (see the companion paper in this conference, Kyprianou and Aitken 1999).

The bioclimatic design is consciously integrated into the whole planning, siting and architecture of the scheme. There is an effort to combine traditional wisdom with new technology and aesthetics. In this context a range of parameters were considered, such as the natural environment, climate, microclimate, the building program, economics, symbolisms and aesthetics.

The siting of the buildings and treatment of open spaces utilizes the natural topography and environmental features. Most of the existing trees are to be preserved to provide wind protection and to assist the other natural cooling features.

The buildings are oriented on East-West axes, to provide for favorable winter solar gain, summer shading, year-round daylighting and natural ventilation. All blocks of buildings feature fixed external passive shading devices. In



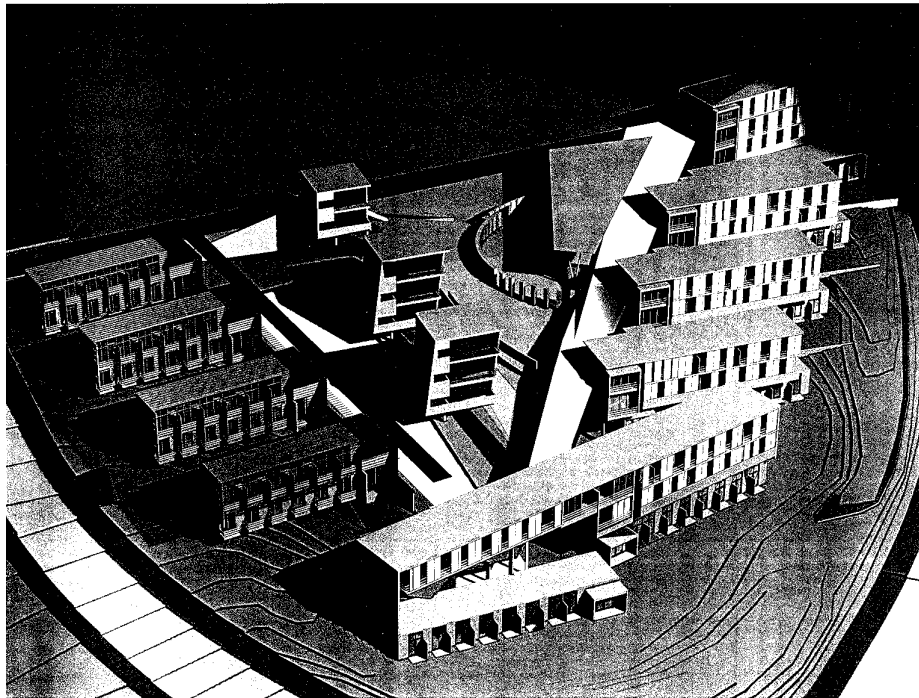


Figure 2: A model of the buildings, showing the stepping up from south toward north, at calculated distances, to achieve unobstructed solar access, as well as wind protection from the north in winter, for both the buildings and courtyards.

In the summer, recycled water trickles through the stones, providing coolness to the adjacent areas. The stone wall and columns are facing the western cool summer breezes so they enhance effectively the cooling of the open and semi-open sitting space. In the winter the stonework is not wetted so that it acts as a wall and columns for solar collection, storage and warmth of the space, which becomes a pleasant sunny courtyard.

Paving is also used as a measure against dampness, on the ground level, at the perimeter of the buildings, forming verandas for the ground level units. These paved surfaces are shaded in the summer, with the balconies above. In this way, possible glare and overheating resulting from reflection of the high summer sun are avoided.

Most of the existing vegetation is retained. The eucalyptus clusters are enhanced at the northern side with more trees for wind protection. At the east and west, tall Cypress trees allow the summer breezes through their bare lower trunk, whilst they intercept the low morning and afternoon sun in the summer with their compact vertical foliage.

Tree planting at other zones of the housing and open spaces defines site boundaries and courtyards in-between the buildings. It is used

to reduce air temperature and to provide shading for the parking space, which is sunken at a lower level, to isolate it visually and acoustically.

#### 4. THE BUILDINGS

The natural contours of the site are used to locate the buildings in an amphitheater configuration. They are stepping up from the south toward the north side, at calculated distances, achieving unobstructed solar access and wind protection from cold north winds for both the buildings and the courtyards. This is shown in Fig. 2.

The buildings on the West Side of the plot, due to the natural contours, are raised at a higher level. The space between the ground and the underside of the buildings is filled with loose rubble stones, encased in metal wire. In the summer it is wetted with water, enhancing the cooling effect of the westerly summer breezes (Fig. 4). Openings in the ground floor insulated and waterproofed slab, channel coolness into the rooms. The free flow of air towards all directions and through the gaps between the stones, under the floor slabs, dissipates coolness in the surrounding areas. It also avoids dampness and creation of mold. The wa-

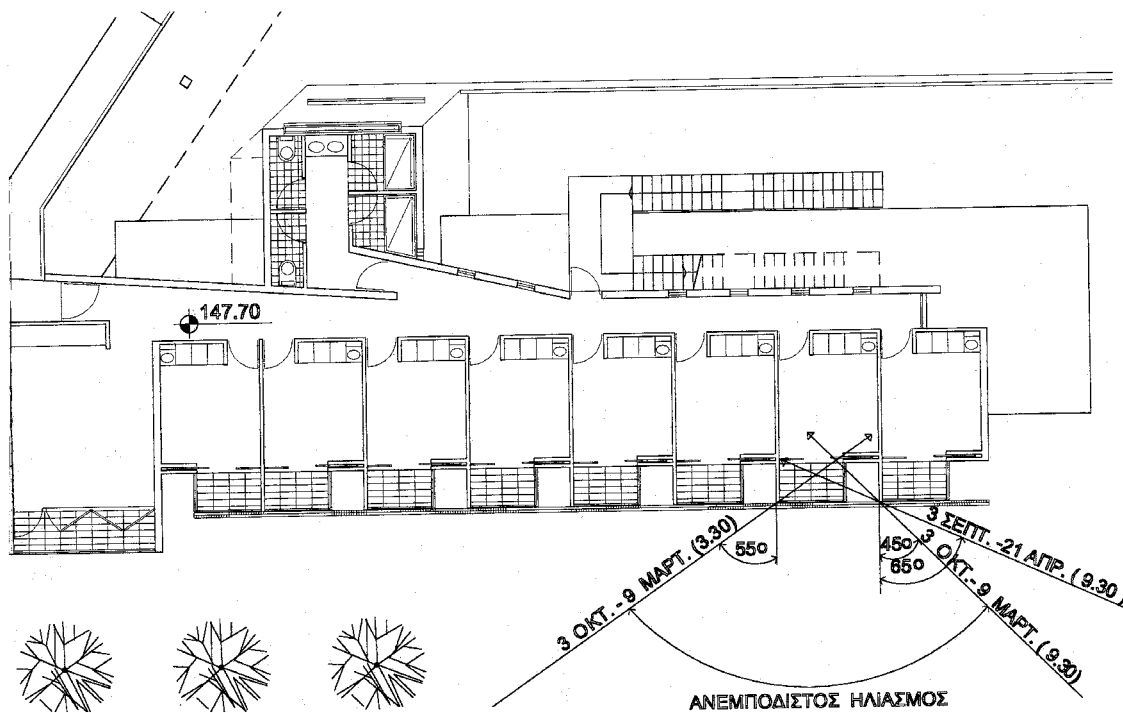


Figure 3: The elongated shape of the structures, with an east-west long axis, allows favorable solar orientation to all student living units and common spaces, in all buildings. Shown is the unobstructed solar access, sunrise to sunset, from the beginning of October to mid-March.

ter, which is used for the wetting of the stones, is collected in waterproofed metal trays and is recycled with the aid of a pump, for water conservation. The pumps are activated by an array of photovoltaic panels for solar energy utilization.

#### 4.1 Shape, Mass, Orientation, Layout and Openings

In all buildings, the shape, the mass, the orientation, the layout and the openings have been designed to meet the conditions of bioclimatic architecture.

The elongated shape of the buildings, with an east-west axis, has a maximum deviation of 17 degrees from the south, allowing favorable solar orientation to all student units and most common living spaces in all buildings. The collection of solar heat in the winter reduces energy for mechanical heating.

The east and west ends do not receive significant solar radiation in winter while in the summer they receive high amounts of unwanted solar radiation. This explains the chosen elongated east-west configuration, with minimal east

and west exposure. An orientation east of south exposes the units to more morning than afternoon sun and enables them to begin to heat earlier in the day (Fig. 2).

The sheltered spaces of balconies and verandas provide pleasant, private living spaces and an amenity in themselves, as well as preconditioning the exterior climate to make indoor comfort control more easily achieved. In winter they form warm sunny pockets. These, with their warm areas immediately outside the units expand the length of the usefulness of outdoor living areas, but the heating effect will provide additional benefit by creating a warmer climate outside the rooms, thereby reducing winter heat loss. In the summer, they shade the walls, the openings and surrounding ground and outdoor floor surfaces. This helps to keep the temperature of the outdoor air low, making natural ventilation more suitable and minimizing conductive heat gain through the walls.

The large south glazing is the source of solar gain in winter when the sun path is low and its warmth welcome. Unobstructed solar access is provided to all living units from sunrise to sun-

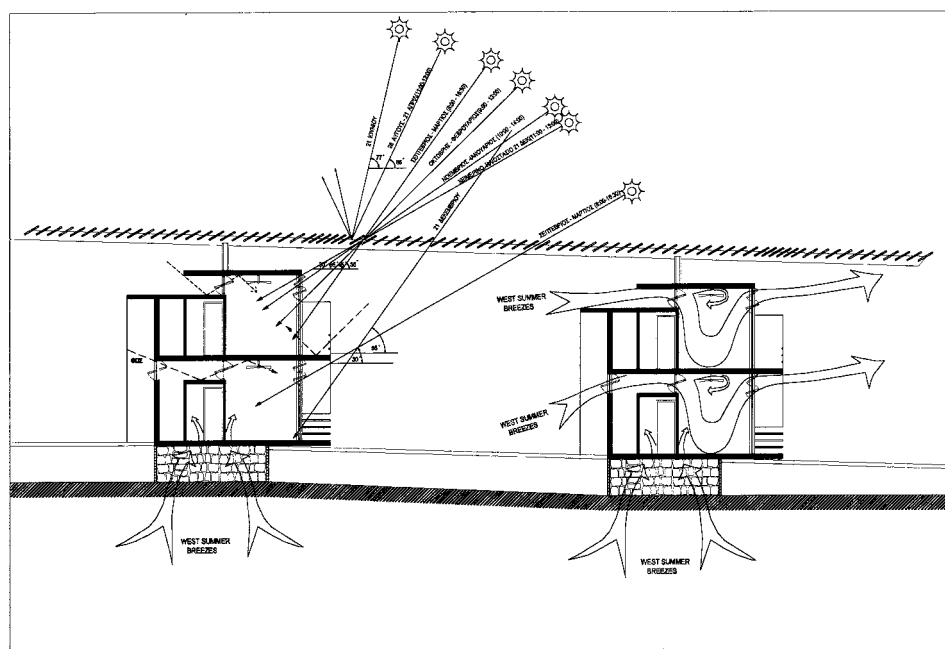


Figure 4: Section views showing, in winter, the sun penetration in the center of the day through the properly angled canopy slats. In summer, direct sun penetration is prevented by the slat angle and spacing. The narrow shape and placement of openings promote natural ventilation. Evaporative cooling from the underfloor wetted rubble stones provides additional summer comfort.

set, from the beginning of October to mid March. (This is shown in Fig. 3, on the next page.) The sun, in December 21, has a maximum altitude of 35 degrees and azimuth of 130 degrees.

During the summer, appropriately proportioned overhangs and vertical sidewalls provide solar protection. The horizontal overhangs provide solar protection from the high summer sun, from mid April until the end of August, at least from 11.00 to 3.30. The sidewalls intercept the low morning and afternoon unwanted sun for the rest of the times, during those months. Additional solar protection for the buildings on the East Side is provided by vertical external perforated sliding metal screens. For the buildings on the West Side, solar control is provided by an elevated horizontal shading lattice made out of metal slats at calculated angles for solar transmission in winter and protection in summer. The slats become denser above the top open balconies. Both types of solar protection allow airflow through them, to avoid overheating and encourage ventilation. (This is shown in Fig. 4.)

#### 4.2 Wind Protection – Limiting Heat Losses

The common bathrooms and toilets on the

northern side--which is the windward side of the structures--and the covered corridors extending as entryways to the rooms, collectively act as a buffer zone, providing wind protection and restricting heat losses. The corridors are fully partitioned from the heated zones. These decrease the temperature gradient across the partition between the heated living units and the unheated corridors and thus retard the rate of heat loss.

#### 4.3 Ventilation

The northern corridors of the housing units have openings to the west and east sides as well as on the top of the walls. The prevailing summer breezes, which are mainly from the west but occasionally northwest or southeast, enter the corridors within 30 to 45 degrees of the opening direction. These are the best conditions for the provision of cross ventilation, and they are favorable for the circulation of airflow in the corridors and into the rooms.

In addition, the range of the sizes and location of the opening (entrance doors, north and south top windows, balcony doors) offers flexibility. The occupants can regulate the opening part and in effect the potential for most beneficial ventilation according to the direction of

breezes and the desired flow of air.

The overhangs above the corridors and balconies direct the cooling breezes towards the opening. Through the top windows the air flows towards the ceiling, which is concrete and therefore has thermal storage mass, so that it retains the coolness of the night. In addition, the top openings offer safety as well as visual privacy. The ceiling fan (a program requirement) circulates the airflow, which otherwise would tend to stratify, distributing it to the entire room. (This is shown in Fig. 4).

#### 4.4 Daylighting

The linear layout of the building plans in a one room depth offers the potential for natural lighting from the two opposite sides, which is ideal for uniform visually comfortable lighting distribution without glare (again Fig. 4). Furthermore the top windows in combination with the glazed doors achieve a high daylighting factor, so it is possible for the occupants to regulate the intensity of the daylight according to their needs or desires.

The north top window openings offer uniform natural lighting, free of glare. Glare prevention is also offered by the use of overhangs, side fins and the overhead horizontal slatted shading device suspended over the west housing units. Furthermore, reduction of glare is provided by the sliding, perforated screens, which reduce the brightness of the glazed openings on the east housing units.

The reduction of extreme contrast is achieved with the use of soft light colors on the walls and ceilings, which give better distribution of the lighting.

## 5. CONSTRUCTION

All the buildings are reinforced concrete frame structures with infill panels of concrete blocks, which are locally manufactured. This type of massive construction, in addition to the concrete floor and roof slabs, offers time lag as well as thermal storage. This is of particular significance for the Cyprus climatic conditions, due to the characteristic of large diurnal fluctuations (5 to 25 degrees Celsius) and the potential inherent in mass for large solar contribution in winter and cooling in the night.

The walls are insulated externally with rigid

extruded polystyrene and rendered with plaster on plastic mesh painted white for sun reflection.

The concrete floor slabs are finished with screed and mosaic tiles, enhancing their thermal capacity. The concrete roof slabs are topped with lightweight concrete screed forming slopes for water collection, waterproofing membrane and insulation to intercept the summer solar radiation. A protection layer of white chipping acts as a reflecting surface, necessary for the reflection of the almost vertical summer sun-rays.

Double-glazing with low emissivity coating is used on all windows for limiting the heat losses in winter and heat gains in the summer.

## 6. CONCLUSION

All the buildings are sited, planned, designed and detailed to minimize the mechanical heating and cooling requirements.

The landscaping, the amphitheatrical siting of the buildings opening with large glazing to the south, and the use of appropriate shading devices ranging from overhangs, side walls, perforated screens and suspended metal lattice, ensure unobstructed solar access, wind protection in winter, exposure to breezes and solar protection in the summer.

The building plan with the living spaces facing south provide solar-oriented interior zones for maximum solar heat gain.

The corridors stretching at the back of the buildings and the low-use spaces of bathrooms and cupboards act as climatic buffers zones, shielding the entryways of the rooms from the cold northern winds, while in the summer they channel the cool summer breezes.

The openings are located for winter solar collection, cross ventilation and uniform natural lighting free from glare.

Special features such as the enclosing stone wall of the common courtyard, and the rubble stones under the west rows of buildings wetted in the summer for evaporative cooling and kept dry in winter for solar gains, enhance the bioclimatic performance of the buildings.

This award winning concept continues to demonstrate that designs for comfort, convenience and utility, within tight budgets, can still attain low energy consumption and low greenhouse gas emissions. The key to this, as it was

in the first winning competition, is the appropriate use of bioclimatic design principles in a holistic, integrated approach. These first two winning design phases (out of six) should now assure that the finished complete campus design will carry through with these principles. If it does, it will certainly be worthy of international architectural attention.

#### REFERENCES

Aitken, D.W. and A. Kyprianou, 1999. Bioclimatic Designs for the New University of Cyprus Campus, 1<sup>st</sup> Competition: Facilities for Science and Technology, this Proceedings.