European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'10)
Granada (Spain), 23th to 25th March, 2010

Bioclimatic parameters in the design of contemporary buildings: the proposal for the new Town Hall of Deryneia, Cyprus

A. Michael[1], C. Hadjichristos[1], F. Bougiatioti[2] and A. Oikonomou[3]

[1] Department of Architecture, Faculty of Engineering,
University of Cyprus
75 Kallipoleos Avenue, P.O.Box 20537, Nicosia, 1678, Cyprus
Phone number:+ 357 22661130, Fax number: + 357 22667429, e-mail: **aimilios@ucy.ac.cy, hadjichristos@ucy.ac.cy**

[2] School of Architecture, National Technial University of Athens, Athens, Greece,
e-mail: **fbougiatioti@yahoo.com**

[3] Department of Architecture, University of Patras, Rio - Patras, Greece,
e-mail: **aineias4@yahoo.com**

Abstract. This study presents the process of the design proposal for the new Town-Hall of Deryneia, Cyprus. Deryneia is a "divided" municipality since 1974 and for this reason the proposed building had to satisfy, apart from the afore-mentioned environmental and architectural demands, the need to express symbolically the political situation. The aim of the study is to evaluate the thermal behaviour, of the proposed architectural design both qualitatively and quantitatively with the use of software. More specifically, this evaluation concerns the thermal behaviour of the building shell, the passive heating and cooling strategies that are integrated to the design, as well as the achieved daylighting conditions. Daylighting conditions are analysed with the use of software for both overcast (winter) and clear (summer and intermediate seasons) sky conditions, in order to evaluate the influence of the roof skylights.

Key words

Energy efficiency, bioclimatic design, building shell, thermal comfort, public buildings.

1. Introduction

Public buildings in general can help inform and educate the public on environmental issues and energy efficiency. At the same time, public buildings constitute city landmarks, and, especially if they are selected by a competition jury, their design and construction tend to follow, to some extent, contemporary architectural trends. Town halls are buildings, which house administration, information, exhibition and recreation activities, and aim at providing the general public with assistance concerning various aspects of local administration. As such their design seeks to combine the demand for standing out as symbols of the democratic processes, with the need to create a healthy and welcoming interior environment for both employees and visitors that will ultimately promote and enforce the relationship between the citizens and the local administration. In the last years, the continuously growing concern for climate change and environmental degradation has inevitably lead to the introduction of bioclimatic and environmentally-friendly design principles to the already complex and demanding architectural design of public buildings. This led to the high-quality design projects, such as the London City Hall [1] (Foster + Partners, 1998-2002) and the Bologna Civic Offices [2] (Mario Cucinella Architects, 2003-2009), which incorporate passive heating and cooling, daylighting and renewable energy sources features that aim at minimizing conventional energy consumption.

For the new Deryneia Town Hall, the competition brief [3] (Municipality of Deryneia 2008) asked for a building that would actively comply with the principles of sustainable development as stated by the Brundtland Commission. A building in which comfortable thermal and visual comfort conditions and interior air quality would be achieved primarily with careful bioclimatic design, which would have reduced energy demand for heating, cooling (< 30 kWh/m^2) and lighting (< 8 kWh/m^2) and where the proposed building materials would assure the maximum possible longevity with the least possible maintenance. It is important to note that there was an additional prerequisite that practically excluded the integration of high-tech energy conservation elements, stating "that the environmental performance of the building should derive mainly from the simplicity and rationality of the architectural design". It was this last point of the competition brief that actually defined in whole the design proposal that is presented in this paper and received an honourable mention in the homonymous Cypriot Architectural Competition.

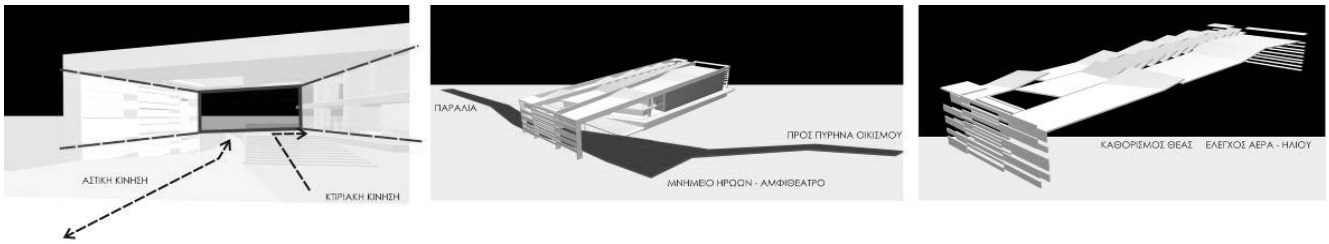

Fig. 1. Architectural design principles of the proposal.

2. Architectural design principles

A. Integration to the existing urban fabric

Deryneia is a small (7500 inhabitants), coastal town situated at the eastern part of the island of Cyprus (Latitude 35.1N, Longitude 34E), near the city Famagusta. Since the Turkish invasion in 1974, a large part of Deryneia (75%) falls within the occupied zone, and the town has been deprived of its contact with the sea and Famagusta (Municipality of Deryneia 2008)

The proposed project for the new town-hall of the semi-occupied community of Deryneia seeks to create new connections while strengthening the existing ones (Fig. 1). The building frames the occupied coast, visually connecting the here and there, past and present, presence with absence. The urban passage through the building connects the town centre, the heroes' memorial and the open-air theater with the coastal zone. The building shell (epidermis) regulates its contact with the environment, the view and the climatic elements, sun and wind (Fig.2).

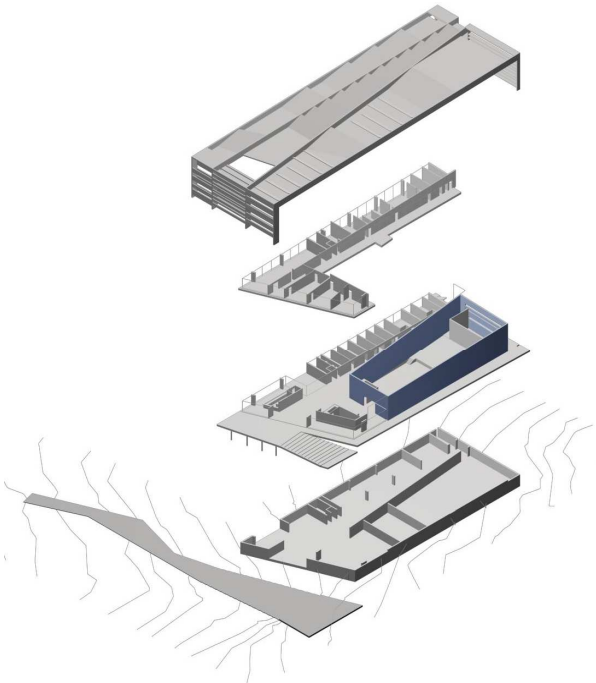

Fig. 2.The building shell of the design proposal.

B. Functional organisation and design of open spaces

The goal was to create a welcoming large yet sheltered open space that can reflect the symbolic and administrative character of the building and then arrange the interior spaces on two main levels and a basement for secondary uses.

The access from the street to the ground floor (level $\pm$0.00) is achieved through a spacious exterior staircase (Fig. 3). The entrance space leads to an open, central atrium space with transparent boundaries and clear functional organisation. The dynamic relationship between the interior spaces and the surrounding environment is accomplished through extensive glazed surfaces which are nevertheless protected with the appropriate shading device each time.

The central atrium space is the main connecting and unifying element, acting as a movement distributor, and at the same time allowing the immediate perception of the building's structure both functionally and symbolically. The multi-purpose hall is separated from the other building functions and is in direct functional contact with the exhibition space, which is placed close to the building exterior facade in order to achieve the best possible projection (Fig. 4).

The floor (level $\pm$3.95) includes solely office-spaces. The connection with the ground floor is achieved through a central, open staircase placed in the atrium, and two closed stairwells. The design of the individual open spaces promotes flexibility and functionality.

The surrounding space of the building constitutes an integral part of the proposed design. It allows the easy access and free entrance of the citizens to the building, and forms its immediate open space. As part of the open spaces, the entrance area is the main space for gathering and social interaction.

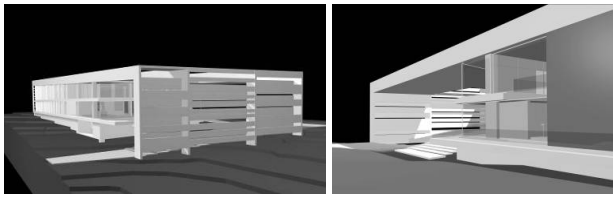

Fig. 3. Three-dimensional aspects of the building.

Fig. 4. Ground floor plan of the building and open spaces.

C. Construction and materials

The building is constructed of reinforced concrete framework, very similar to the current building practice in Cyprus. The vertical supporting elements, the majority of which are share walls, are placed on a grid, which corresponds to the functional organisation of the plan and the need to provide adequate seismic protection. The horizontal surfaces are 45-cm concrete slabs, which ensure the diaphragmatic function of the horizontal surfaces and, at the same time provide significant thermal mass.

3. Bioclimatic design and environmental approach

A. Climatic analysis

The environmental approach of the design proposal is directly linked to selected bioclimatic design principles, which were derived from the climatic analysis of the area. Due to the lack of detailed, local climatic data, an hourly weather data file for Deryneia was generated with the Meteonorm software [4] and was then used in the Weather Tool software [5] in order to create climatic charts and psychrometric diagrams.

The climate of Deryneia is characterised by mild winters and warm winters. Consequently, during the heating period, the contribution of solar radiation to the passive heating of the interior spaces and the reduction of conventional energy consumption for heating is very important (Fig. 5). During the hot, summer period, the climate is characterised as warm and humid, and the selected bioclimatic strategies are primarily efficient shading and natural ventilation, as well as exploitation of the building's high thermal mass (Fig. 6).

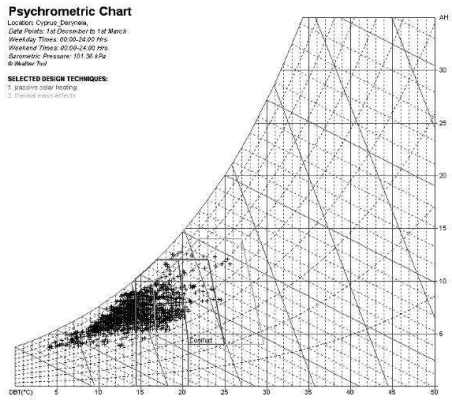

Fig. 5. Psychrometric diagrams for the heating period with selected bioclimatic strategies. (Weather Tool v.2.0)

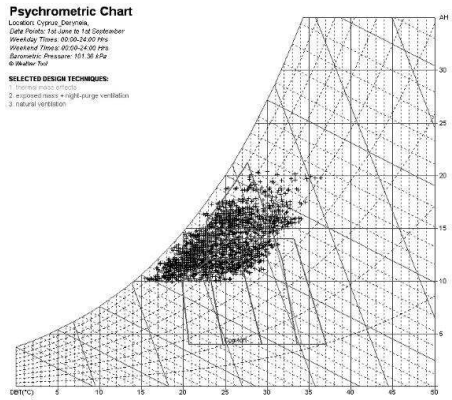

Fig. 6. Psychrometric diagrams for the cooling period with selected bioclimatic strategies. (Weather Tool v.2.0)

The applied bioclimatic strategies form an integral part of the architectural design, and, in a passive way and thus compliant to the competition brief, provide improved thermal and visual comfort conditions. The building shell is formed by elements of appropriate geometric characteristics, which ensure winter southern insulation, provide adequate summer shading, enhance natural cross-ventilation and stack effect and contribute positively to the acoustic performance of the design (Fig. 7).

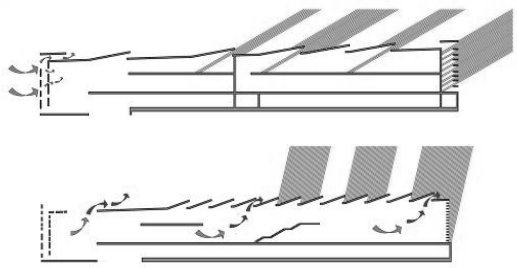

Fig. 7. Bioclimatic behaviour of the building shell during the heating and cooling period.

B. Heating period – Passive solar heating

Given the fact that the building site does not allow the design of a building with a main axis running from east to west, the exploitation of the year-long favorable southern orientation is achieved through the design of the building shell and the creation of the central, atrium space.The southern sun is directly introduced to the atrium space and the office spaces through various south-facing skylights, which contribute to passive heating, improvement of thermal comfort conditions and energy conservation (Figures 8 and 9).

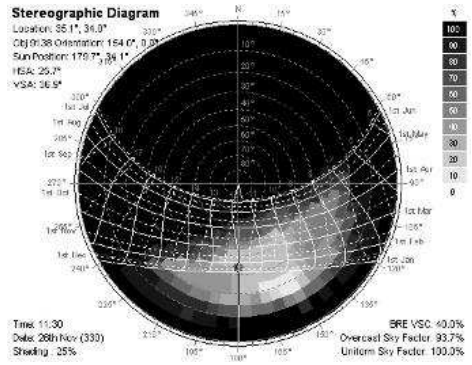

Fig. 8. Shading mask. (Ecotect v.5.5)

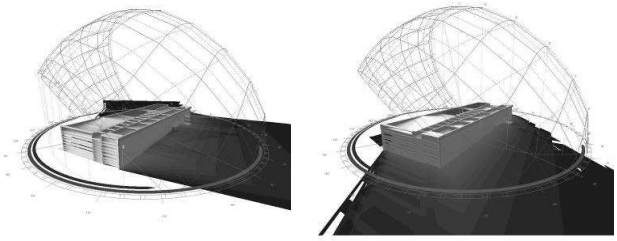

Fig. 9. Shadow range for the winter and the summer. (Ecotect v.5.5)

C. Cooling period – Shading, Cross-ventilation, Night-time ventilation

During the cooling period, the shading of the glazed surfaces of the building mainly depends on their orientation. East-facing surfaces are shaded by external, vertical, reflective louvers, which block solar radiation, whereas the south-facing skylights are shaded from direct solar radiation by their proper structure and geometry. The south-facing façade of the central atrium is shaded by external horizontal louvers. In order to further minimize thermal loads, the multi-purpose hall is placed in the west in order to act as a buffer space.

The enhanced natural ventilation of the building is primarily achieved with its placement at an angle to the prevailing winds. The central atrium space plays an important role in the overall ventilation of the building during the summer, as the opening of the skylights promotes stack ventilation (Bernoulli effect). The same principle applies for the office spaces on the upper storey. There is also the possibility of cross-ventilation, which is promoted with operable ventilation openings placed on the partitions separating the office spaces and the atrium. During night-time, when environmental temperatures are lower, increased ventilation rates assure the adequate cooling of the building's thermal mass (concrete slabs and building shell).

D. Daylighting

The daylighting analysis was performed with the combination of Ecotect [6] and Desktop Radiance [7] and was based on isolux contour diagrams and daylighting simulation of selected interior views. The analysis (Figures 10 and 11) shows that daylighting levels and distribution are adequate, even with overcast sky conditions, as a result of the appropriate choice of vertical and roof openings in combination with the external shading elements.

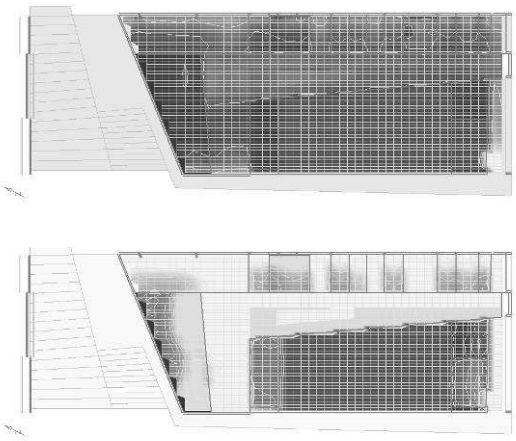

Fig. 10.Daylighting analysis (isolux contours) of the upper storey, a. December 21st, 12:00, overcast sky conditions and b. June 21st, 12:00, clear sky conditions. (Ecotect v.5.5, Desktop Radiance v.1.02)

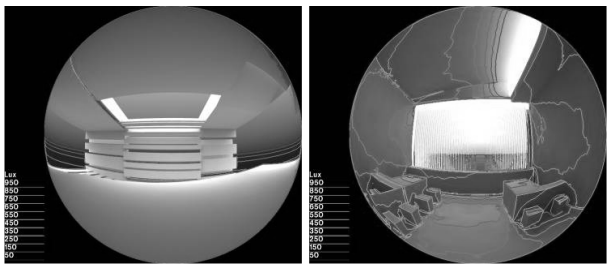

Fig. 11. Daylighting analysis and simulation of: a. the entrance area, b. a typical upper-storey office space. (Ecotect v.5.5, Desktop Radiance v.1.02)

E. Materials and building techniques

The bioclimatic approach to the design of the new Deryneia town-hall also includes the selection of materials and building techniques.

Reinforced concrete, the main building material, has low maintenance needs and can be recycled, both in terms of the steel reinforcement (recycled steel) and the concrete mass (production of second-hand aggregate). The other metal parts of the building (aluminium window frames and external louvers) can also be recycled without down-cycling. The applied building technique for the interior spaces is mainly based on dry-wall construction, which allows the dismantling rather than the demolition of the building, and employs elements of low embodied energy and low maintenance cost.

F. Microclimatic modification

The surrounding open space is appropriately designed in order to improve both summer and winter microclimatic conditions. The existing trees are preserved and the proposed vegetation involves local or indigenous plants which are able to with-stand local summer conditions (increased temperatures and lack of water). Irrigation needs are partly covered with the collection of rainwater in an underground reservoir.

G. Renewable energy sources and energy management

The building's electricity demands is covered by a photovoltaic installation placed on the flat roof. For the efficient energy management of all the functioning systems, a Building Management System (BMS) is proposed in order to monitor exterior environmental conditions and adjust the functioning systems accordingly.

The surrounding open space is appropriately designed in order to improve summer microclimatic conditions. The existing trees are preserved and the proposed vegetation involves local or indigenous plants, which are able to with-stand local summer conditions (increased temperatures and lack of water). Irrigation needs are partly covered with the collection of rainwater in an underground reservoir.

4. Conclusions

Public buildings in general and town hall in particular, can help inform and educate the public on issues of environmental protection and energy efficiency. For this reason, their design and construction is of utmost importance.

The presented design proposal for the new Deryneia town hall tried to fulfil, in the best possible way, the afore-mentioned needs and demands. The project shows that it is possible to combine the principles of bioclimatic and environmentally-friendly architecture with the need for contemporary architectural design. For this to happen, designers have to take into consideration issues of climate, landscape and materials from the first stages of the design process. The proposal has to be continuously reviewed and validated in terms of thermal and visual comfort in order to design the spaces and define the details of systems and components.

While initially exited with the emphasis the competition brief put on environmental issues, the design team has sadly observed that the committee's emphasis in judging the proposals shifted significantly to the formal and the fanciful, qualities which are not necessarily negative by themselves but are rendered so if they tend to displace other perhaps more vital qualities.

Acknowledgement

The authors would like to thank architects Vassilis Ierides, Maria Kouppi, Maria Xenophontos, of IMA Architectural Practice, and the students of architecture George Kallis, Savvas Anastasiou and George Tryfonos, of the Department of Architecture, Faculty of Engineering, University of Cyprus.

References

[1] Foster and Partners, [Online] Available, *http://www.fosterandpartners.com*
[2] E-architect, [Online] Available, *http://www.e-architect.co.uk/town_hall_buildings.htm*
[3] Municipality of Deryneia, 2008. Architectural competition for the construction of the new Deryneia Town Hall. Competition Brief. Deryneia, Cyprus: Municipality of Deryneia.
[4] Meteonorm software, v.6.1, Meteotest, [Online] Available, *http://www.meteotest.ch, http://www.meteonorm.com.*
[5] Weather Tool software, v2.0, Square One Research PTY Ltd., [Online] Available, *http://www.squ1.com.*
[6] Ecotect Tool software, v5.5, Square One Research PTY Ltd., [Online] Available, *http://www.squ1.com.*
[7] Desktop Radiance, v1.02, Lawrence Berkeley National Laboratory, [Online] Available, *http://radsite.lbl.gov/deskrad*.