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Construction Design and Sustainability in Architecture: Integrating Environmental Education in the Architectural Studies.

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Abstract. Based on the modern interpretation of architectural education at university level, architectural design is developed within the multidisciplinary nature of the area, at various levels of analysis, at all scales of the project. The present paper underlines the necessity of integrating technology courses with design and sustainability issues. In clarifying this, the respective pedagogical approach, followed at the Department of Architecture of the University of Cyprus, in the courses of construction in timber, reinforced concrete and steel, as well as in the main architectural design coursework with emphasis in technology, is discussed.

As regards the building technology component within the architectural education, the application of the respective technical knowledge, obtained through lectures and exercises, in a design project is of major importance. The design project is organized within a studio or micro-studio, and becomes the major assignment of each respective construction course. A necessary component for a successfully-integrated design is the iterative realization of an architectural aim, the design vision that binds every element of the design of different scales together. In this way, construction design substitutes the merely more empirical act of "architectural design" throughout the integration process.

The sustainability component of the designs in the studio or micro-studio refers to the bioclimatic, construction and energy-efficient design. The investigation and application of all aforementioned aspects ensures the comprehensive environmental approach in the creation of the built-up spaces, underlying at the same time, the importance of integrated design in the studio or micro-studio.

Key words

Architectural education, Multidisciplinarity, Sustainability, Integrated design, Energy efficient design.

1. Introduction

The technological and scientific development, particularly during the last century, had a decisive role in the evolution of the construction industry. The result of this progress has been the dependence of building constructions from any climate conditions and at the same time the use of heating systems, cooling, air and lighting systems [1-3]. All of the above have had a negative impact on the natural environment and the threat of an energy crisis has appeared.

The realization that each building unit is a system interrelated to the environment, bound with it and subjected to the various seasonal and daily climate changes, has brought about the introduction of environmentally-responsible building design.

The University of Cyprus, Department of Architecture, responding to the challenges of the Environmental Sensitive Architecture, has included in construction design courses (construction in timber, reinforced concrete and steel) as well as in the main architectural design coursework with emphasis in technology, research fields, which correspond to the sustainability in architecture. It particularly referred to three thematic directions: bioclimatic architecture, energy in architecture and ecological aspects in building, covering an important part of the multi-dimensional field of environmental design approach in architecture.

2. Bioclimatic Design

Bioclimatic design refers to the incorporation of nature elements in architecture design, aiming at the improvement of comfort conditions – thermal, visual, acoustic comfort, indoor air quality – of the inhabitants of the building and the minimization of energy consumption. The term refers to the joining of the terms, life (Greek: βίος, bios) and climate, indicating an approach which introduces qualitative parameters (anthropocentric view) in architectural design. It is related to the application of a series of strategies in architectural design, which refer to passive heating and cooling, as well as to the obtainment of natural lighting and improvement of microclimatic conditions of the surrounding environment.

A. Solar Gains by Exploiting the South-Facing Orientation

Direct solar gains are the main strategy of bioclimatic design during the winter period. Design projects that have south-facing elevations are much benefited from the incoming solar energy, through both the building envelope and the appropriate openings (Fig. 1). Spaces with no south-facing openings may receive solar energy from the roof through specially-designed openings or other architectural solutions.

Fig. 1. Design Project, Construction in Reinforced Concrete, SS08.

B. Solar Spaces

The incorporation of solar spaces at the building envelope of design projects maximizes the function of collection, storage and transfer of solar energy to the interior of buildings. To avoid overheating of the interior during the summer period, the arrangement of solar spaces is appropriately sun-protected and it additionally affords openable glazed windows.

C. Heat Losses Buffer Spaces

In order to improve heat distribution and to reduce the heat losses of the building envelope, a thermal zone is used as a heat losses buffer space, consisting either of the placement of spaces with lower energy requirements in the North that do not have any direct solar gains, or of the construction of a north-facing double-skin façade (Fig. 2). In cases where the entry points are located in the direction of prevailing winds, the use of entry lobbies can significantly reduce the penetration of air inside the buildings.

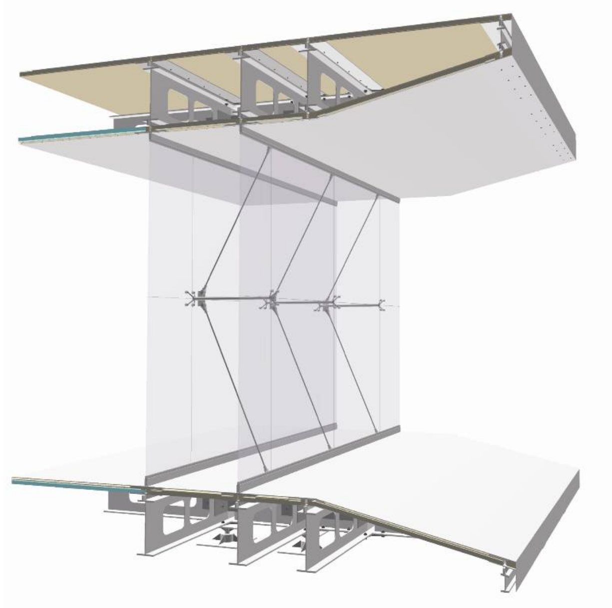

Fig. 2. Design Project, Architectural Design Studio VI – Architectural Technology, SS09.

D. Sun Protection via Appropriate Exterior Elements

Sun protection is achieved through the use of appropriate exterior architectural elements at the glazed facades of the design projects. The design proposals incorporating linear cantilevers, fixed or mobile, horizontal or vertical elements that provide shade, reduce the direct solar radiation (Fig. 3). In addition, the sun protection elements contribute to the normalization and filtration of the natural lighting, which enters the interior space.

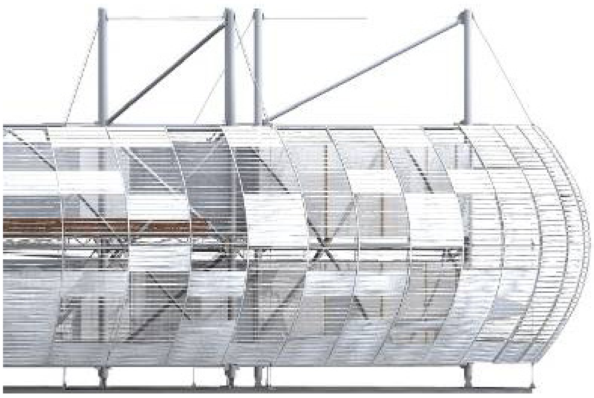

Fig. 3. Design Project, Architectural Design Studio VI – Architectural Technology, SS11.

E. Cooling of the Building Envelope

Suitable openings in the building envelope ensure controlled cross ventilation and controlled importation of fresh air in the interior of the building. Specially-designed openings enable the removal of hot air to the outdoor environment during the summer period (Fig. 4).

Fig. 4. Design Project, Construction in Steel, FS08.

F. Exploitation of Natural Lighting

The penetration of natural lighting is ensured through the glazed surfaces of the building envelope. In spaces with large depth, a satisfactory solution is the placement of openings or light-tubes in the roof (Fig. 5a & b).

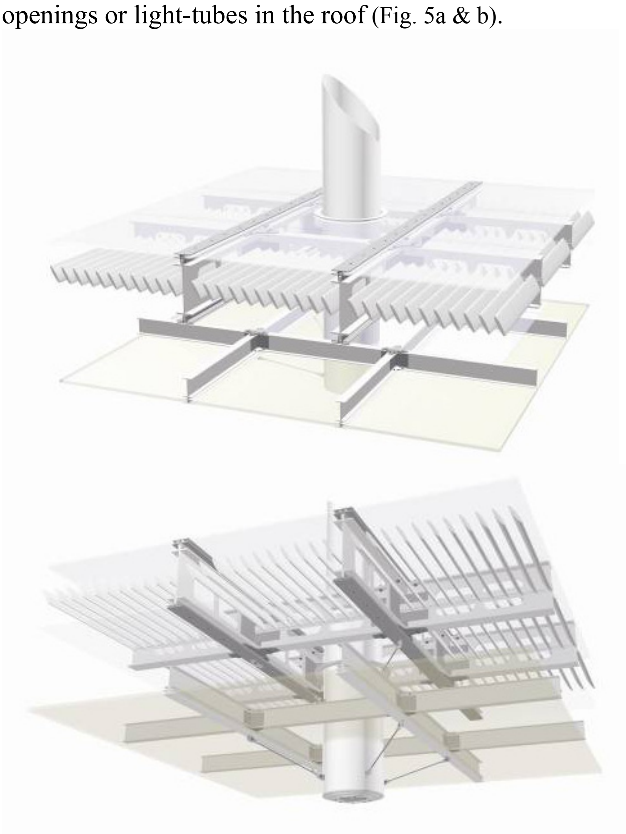

Fig. 5a & b. Design Project, Architectural Design Studio VI – Architectural Technology, SS09.

The distribution of natural lighting is also influenced by the configuration of the interior and the reflections of the surrounding surfaces within the building. Large openings provide visual connections as well as the possibility of physical connections with the external environment and nature.

Energy savings from the appropriate use of natural lighting contributes significantly to the reduction of energy consumption in buildings, while reducing unwanted heat gains in the summer period caused by technical lighting.

G. Atria, Courtyards and the Immediate Environment

The formation of the atria, courtyards and the immediate environment, concerning the vegetation and the existence of the water features, constitutes an essential mean of passive design in architectural design proposals. The vegetation forms a natural protected environment, which reduces the high temperatures during the summer period, shades the building envelope and reduces the abrupt changes in humidity. Besides shading, vegetation can also prevent, filter or divert the air flow, thus affecting the internal ventilation of buildings (Fig. 6).

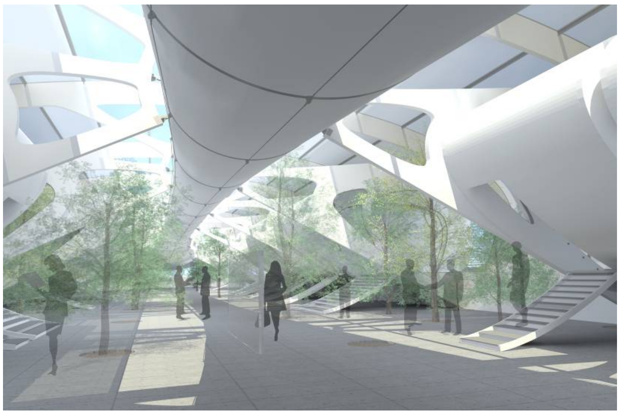

Fig. 6. Design Project, Architectural Design Studio VI – Architectural Technology, SS08.

The suitable use of materials on floor surfaces (thermal inertia, color), contributes to the development of microclimatic conditions, affecting the air temperature of the immediate environment. The existence of water features in atria, courtyards and in the building's surrounding areas provides evaporative cooling and results in the decrease of the high temperatures during the summer. The relationship of the built environment and the natural environment, beyond the improvement of microclimatic conditions and consequently the comfort conditions, also provides a pleasant visual incentive with significant effects on the emotional and psychological state of the users of the building (Fig. 7).

Fig. 7. Design Project, Architectural Design Studio VI – Architectural Technology, SS08.

The application of the principles of bioclimatic design in students' design proposals contributes dynamically to the procedure of building envelope creation and dynamically defines the compositional outcome of the architectural proposals in terms of morphology, construction and structure.

3. Construction design

The materiality of the design proposal constitutes a significant part of an architect's education. The selection of appropriate building materials and the application of modern manufacturing technologies, directly affects the architectural expression of the building.

A. Materiality of Construction

The environmental approach to design refers to the selection of appropriate building materials to minimize the ecological footprint of the building (Figs 8 & 9).

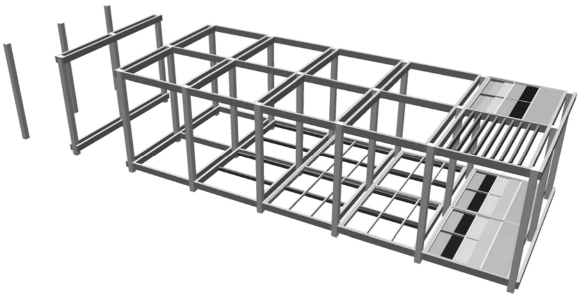

Fig. 8. Design Project, Construction in Timber, FS07

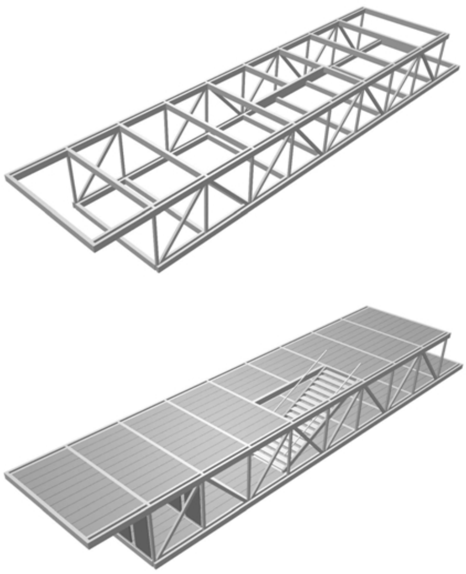

Fig. 9. Design Project, Construction in Timber, FS08

The attempt to reduce the environmental damage, apart from the use of appropriate building materials (Low emission CO_2, low embodied energy) refers to the use of appropriate building techniques (drywall techniques, assembled constructions) and techniques that allow re-use of a part of construction materials of the building (recycled without downgrading the quality of materials), (Fig. 10).

Fig.10. Design Project, Architectural Design Studio VI – Architectural Technology, SS08

B. Construction Systems and Building Envelope Details

The application of contemporary construction systems refers to the construction mentioned in the main construction options for ensuring adequate thermal protection of the building envelope – double-glazing technologies, double-skin facades (Fig. 11a & b).

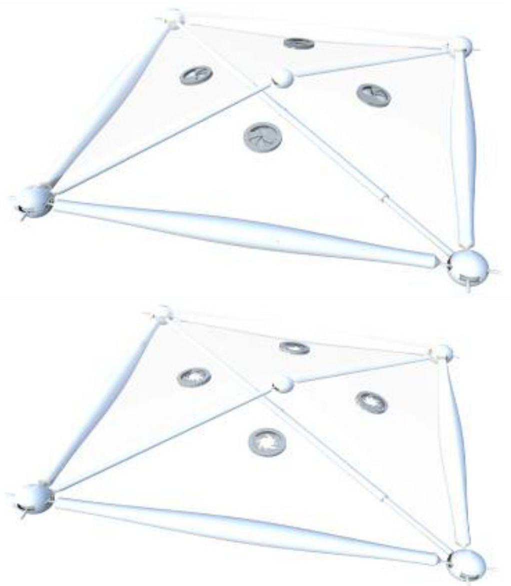

Fig. 11a & b. Design Project, Architectural Design Studio VI – Architectural Technology, SS11

The appropriate construction details design adds value to the final construction product and increases the effect of the contribution of construction design to the enrichment of the building image (Fig. 12).

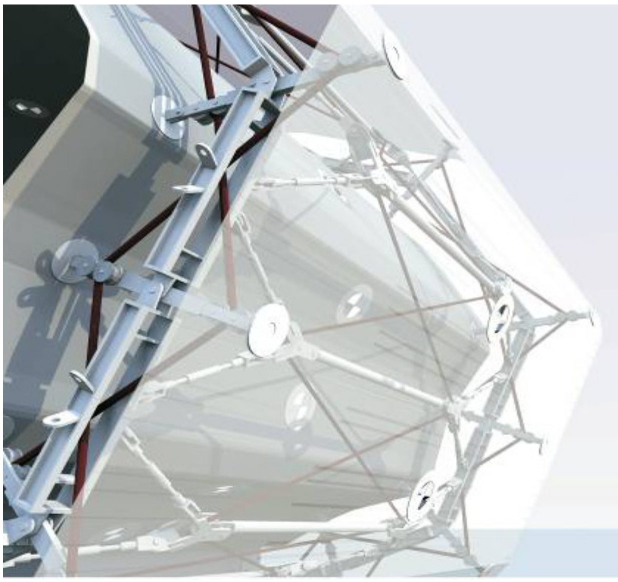

Fig. 12. Design Project, Architectural Design Studio VI – Architectural Technology, SS10

4. Energy Design

Energy design refers to the minimization of energy consumption of the building envelope, the use of appropriate technical supporting systems for air-conditioning (heating, cooling and ventilation) and lighting, and to the installation of advanced monitoring equipment for controlling and providing management of the technical systems. Furthermore, the energy design refers to the installation of systems exploiting renewable energy sources, such as systems utilizing solar radiation, soil thermal inertia and, more rarely in building applications, wind energy.

A. Technical support systems

The electromechanical installations support the function of the building by providing water supply and drainage, electricity supply (lighting, strong and weak stream), air conditioning (heating, cooling and technical ventilation) etc. The integration of technical systems – inside and outside of the building – and the ensuring of appropriate routes for the buildings networks constitute a multi-dimensional design subject (Fig. 13).

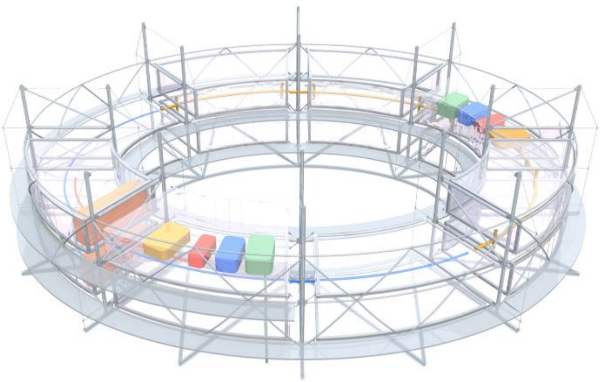

Fig.13. Design Project, Architectural Design Studio VI – Architectural Technology, SS11

Technical equipment is selected primarily based on the criteria of users' safety, the efficiency and effectiveness of the devices, both for operating and maintenance expenses. Their integration within the architectural design allows for their harmonious coexistence with the building and therefore, their display as an aesthetic element of the building.

B. Renewable Energy Sources

The integration of systems using renewable energy sources in the building envelope is directly related to the compositional design process and significantly affects the expression of the architectural product. The integration of solar photovoltaic modules or solar hot water panels, drastically impacts the building envelope of the design proposals (Fig. 14).

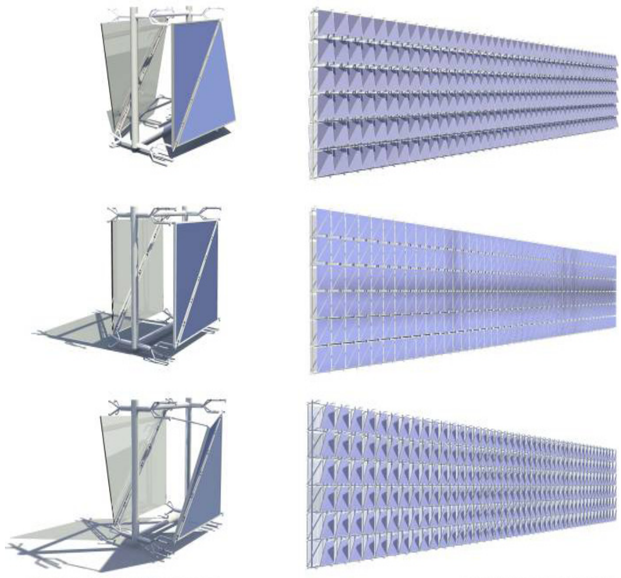

Fig. 14. Design Project, Architectural Design Studio VI – Architectural Technology, SS10

In the same way, the use of wind energy through wind generators producing electricity, defines the concept of the architectural design (Fig. 15).

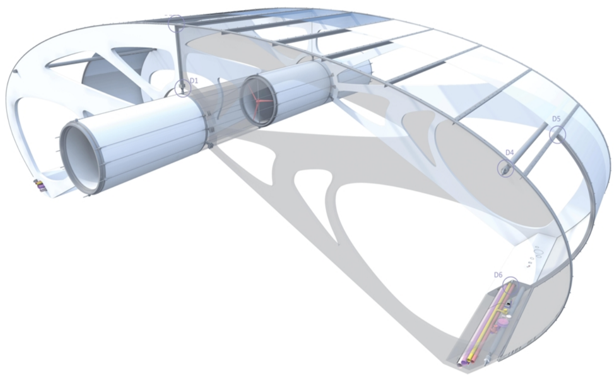

Fig. 15. Design Project, Architectural Design Studio VI – Architectural Technology, SS10

5. Conclusion - Outcomes

The simultaneous investigations of the three pillars that contribute to the environmental approach of architectural design enables a holistic approach to the issue concerning the improvement of the comfort conditions of the indoor spaces, reducing energy consumption and preventing environmental consequences.

In particular, the application of the bioclimatic design principles aims to ensure adequate living space and to improve the users' comfort conditions. The field of bioclimatic design is directly integrated into the process of architectural design.

The alignment of the building envelope with the constant environmental changes and the ability to face dissimilar climatic conditions may constitute the most complex and challenging requirement of bioclimatic design. In the design projects presented, the application of bioclimatic design principles has dynamically contributed to the production process of the building envelope and has defined the architectural composition (concept, form, materiality, construction, etc.).

The construction substance and the materiality of the building constitute an integral part of the architectural proposal, with significant contributions to the issues of energy consumption and CO_2 emissions reduction and thermal protection of the building's envelope. From this perspective, the environment is recognized as a finite precious resource and conscious limitation of any negative influence on it is attempted. Construction design and the design of construction details, directly affects the morphological expression of each architectural proposal.

Finally, energy design aims to ensure the appropriate technical support of the building and to minimize the use of conventional energy sources. The investigation of the integration of renewable energy sources and technical systems into the building envelope adds value to the architectural design and offers opportunities to investigate and redefine the contemporary architectural expression.

The investigation and application of all aforementioned aspects ensures the comprehensive environmental approach of built-up spaces, evidencing the importance of integrated design in architectural education.

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