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

International Conference on Renewable Energies and Power Quality (ICREPQ'11)
Las Palmas de Gran Canaria (Spain), 13th to 15th April, 2011

Integrated Interdisciplinary Design. The Environment as Part of Architectural Education

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Abstract. Interdisciplinary architectural design plays a significant role in education and research at the Department of Architecture at the University of Cyprus. Interdisciplinary design with emphasis in technology is applied in the main studio of the final semester of the first three years core studies, whereas the design of the building requires a holistic, integrated development, in respect to the functions, form, structure, construction and energy efficiency. The final fifth year of studies requires a research based design development. Theoretical investigations and a state of the art documentation on specific subjects of interest form the basis for a parallel or subsequent, in any case rather nonlinear development of the design thesis. The analysis of the two main directions of interdisciplinary design, the holistic integrative design and the research based design, applied at different program levels at the Department of Architecture at the University of Cyprus, reveals in terms of the environmental aspects of the design specific similarities and different technological potentialities achieved herewith.

Key words

Architectural Education, Integrated Interdisciplinary Design, Sustainability.

1. Introduction

While the key importance of the act of design in architectural education and practice is indubitable, based on the contemporary interpretation of architecture, an integrated approach to design may be conducted within the multidisciplinary nature of the area, with one common horizontal connecting element, namely the architectural design intentions and aim [1-3]. International applications, based on a timely re-adaptation of intervention of technological parameters and in particular of the significant areas of the structure, construction and environmental systems in the architectural design, have succeeded in a timeless quality of the built up result through the optimized tuning between the desirability of the building form and functional spaces with the structure, materials and construction [4]. Furthermore an interrelation of technology with architecture from an early design stage enhances the achievement and application of respective technological innovations, while aiming at the improvement of individual or multiple architectural parameters within the holistic design context. In this respect two independent or interdependent directions may be followed:

- The integration of the design vision, structure, construction and environmental systems to form the architectural design syntax – design driven technological developments.
- The interactive architectural design process through innovative technology systems applications – technological developments driven design.

Based on four recent architectural studio design examples at different stages of the Diploma studies with emphasis on technology – two at the sixth semester of the 4-years B.Sc. in Architecture and two at the final Diploma year (fifth year), supervised by the authors at the Department of Architecture at the University of Cyprus, the paper examines the architectural-technological potentialities in the sustainability of the designs, made possible by applying the specific design-syntax. The design case studies indicate the way that advanced interdisciplinary design based research supports the development of the initial architectural aims on one side, leading thus to technological innovations and the way that design may be influenced by environmental considerations and aims on the other side, i.e. technology transfer within architecture.

2. Design Methodology

In Schools of Architecture, relevant courses on construction, structures and environmental design constitute the area of architectural technology. Pedagogically, the interrelation of the technology courses with design is implemented at the Department of Architecture at the University of Cyprus through integrated interdisciplinary design, with the final main architectural design of the three years core of undergraduate studies in architecture with emphasis on technology and Diploma project designs in the respective area. The practice of the interdisciplinary design approach at the University of Cyprus is based on the belief shared by the authors that design may be developed based on the respective syntax of technology. In this frame the design refers to all scales of the project: From the urban- to the building-scale, up to the detail.

The integral development and the application of technological parameters in the design are based on the main areas of the morphology that corresponds to the surrounding environment and results from the functionality of the building, the construction, geometrically and structurally directly related to the structure and responsible for the interrelation of the interior spaces, the building envelope, of non minor importance for the skin and of-course the external appearance of the building, and the energy efficiency, as regards possible spatial configuration and the integration of the technical supporting systems of the building. The structure supports the framework of design, all areas of the integral development, without constituting a self aimed component. In all cases sustainability issues play a significant parameter of the final design results. In addition, necessary connecting element is the search for and the iterative resisting realization of the architectural aim, the design vision that interconnects the different scales of design and levels of analysis, through construction design.

The schedule of development of the applied design methodology may refer at first place to the time management of development of the different areas and scales of design, rather than the technology driven direction of design, as described in the introduction of the paper. In this sense, both directions may be followed: from the development of the building to the construction elements and vice-versa. In all cases, an analysis is conducted initially of the urban and environmental conditions at the site, functional configurations of the building and construction issues. The aim is the formulation of a driving design concept, thus the setting-up of an architectural vision, the development of a general morphology of the building or its elements and a preliminary coordination among form, function and construction. Subsequently the design concept is further developed, in its architectural, structural, construction and energy efficiency sections. This implies:

- The determination of the functional zones, as derived from the construction typology, the users circulation, the functional requirements of the spaces, their natural and technical lighting and ventilation.
- The preliminary design of the structure as regards the system developed and materials applied.
- The construction design of the building elements up to large scale, structure, building envelope and interior elements.
- The preliminary development of the energy efficiency concept, the incorporation of the technical installation elements of the building and verification of sustainability issues of the design.

In the first case, interdisciplinary design with emphasis in technology is applied in the main studio of the final semester of the core studies, whereas the design of a building with an area of about 2000 m^2 requires a holistic, integrated development, in respect to the functions, form, structure, construction and energy efficiency. The supervision of the design groups of two to three students is conducted by the first two named authors. Advice is given in two interim reviews by a structural engineer and a mechanical engineer, the third named author. Since the students possess by then fundamental knowledge in the different areas of the integrated approach, these can be considered at equal levels within each stage of an almost linear construction design development, as regards architectural scale, as well as transfer and promotion of the originally design vision set, through means and expression of technology. In the present paper, two selected design examples of the sixth main studio coursework clarify the methodology of integration of environmental aspects of design, further enabling design driven innovations; a design of an intelligent building envelope, composed of a spatial hybrid steel structure and photochromic glasses, enclosing an open space with vegetation and functional areas, above and below ground, and a design of a multilayered building envelope with rotating triangular transparent photovoltaic elements, air regulators and double glasses, for the peripheral circulation zones and the open plan in the centre.

In the second case, two diploma design examples, accomplished in 2010 and supervised by the first- and third named author, describe the formulation of the "problem", the respective interdisciplinary design methodology followed and the generation of new related fields for further investigations; a design of sustainable, light-weight mega-buildings on water with integrated wave turbines below, at a distance of 1.5 km offshore, and a design of sustainable adaptable fiber polymer satellites with photovoltaic units, at a height of about 500 m above ground level, that also serve as modular tower units on ground. In both examples, environmental issues and energy regeneration techniques determine the overall architectural results.

3. Holistic Integrative Design

In the Spring-Semester 2008 the development of a Centre of the Cyprus Platform for Research and Technology in Building Engineering was required, to be followed two years after by a Research Centre for Advanced Mobility

Technologies, with total area of about 2.000 m^2 each. The brief of the buildings included entrance areas, exhibition-, multipurpose-, library-, seminar-, conference rooms, research spaces and technical supports. In both cases the buildings were expected to comprise symbolically a prototype of technological advancement of contemporary structures, aesthetically and morphologically, as well as through the interactive development of the functions, construction and energy efficiency.

The first design example, situated within the commercial area of the centre of Nicosia, the capital of Cyprus, consists of a building envelope developed in the longitudinal axis, enclosing the autonomous functional units. The main functions develop at three levels. The ground level with an urban passage character and vegetation forms a semi-open unified passage space with public functions, Fig. 1. The lowest level hosts the multipurpose room and the library of the building. External green areas support the natural ventilation and lighting of the spaces. The private research areas are placed at the highest level, Fig. 2. The introduction of vegetation within the unified open space is intensive allowing for an improvement of the microclimatic conditions of the interior as regards shadowing, temperature-, humidity regulation and air-quality, pleasant usage conditions and visual comfort.

The energy efficiency of the building is supplemented through the development of a technologically advanced envelope that ensures the functionality of the closed and open spaces of the program. It consists of interactive photochromic glasses that transform their surface properties according to the external climatic conditions and the internal functions, Fig. 2. The interactive envelope supplements the sustainability of the building solution and achieves a particular architectural expression.

Fig. 1. Interior perspective view of design example 1.

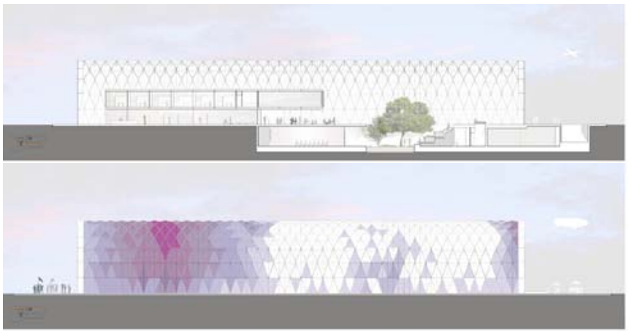

Fig. 2. Longitudinal section and elevation of design example 1.

The second design example is situated at the entrance of Nicosia, in parallel to the existing high-way. The functional spaces of the building are distributed at three levels; the public ones at the ground level, the private ones at the higher levels. All primary functions are concentrated in the centre enveloped through a peripheral ramp. In taking advantage of the high visibility of the high-way the design remains consciously geometrically neutral, Fig. 3.

Emphasis was laid on the development of a multilayered envelope, aiming at the achievement of optimal functional conditions in the interior and energy efficiency of the spaces, based exclusively on renewable energy sources. In principle, the building envelope consists of two elements, Fig. 4: The structural glass- and the external panel system. The panels filtrate the air-flow on the facade according to the climatic requirements and offer sound-protection for the internal functionality of the building spaces. Thus the envelope comprises a dynamic

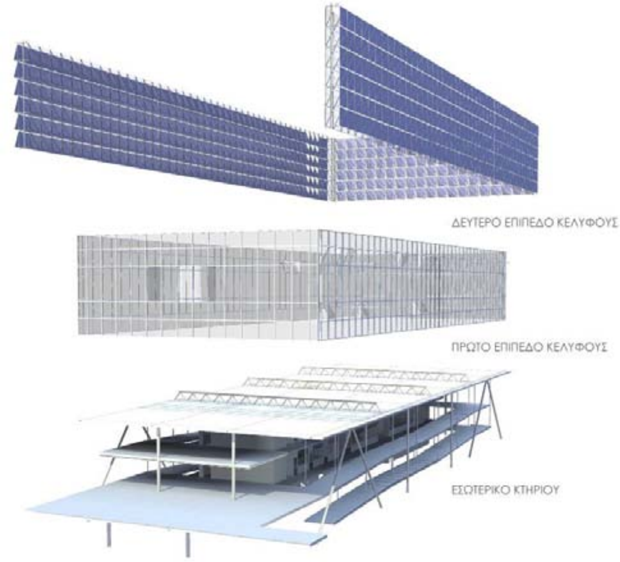

Fig. 3. Building elements of design example 2.

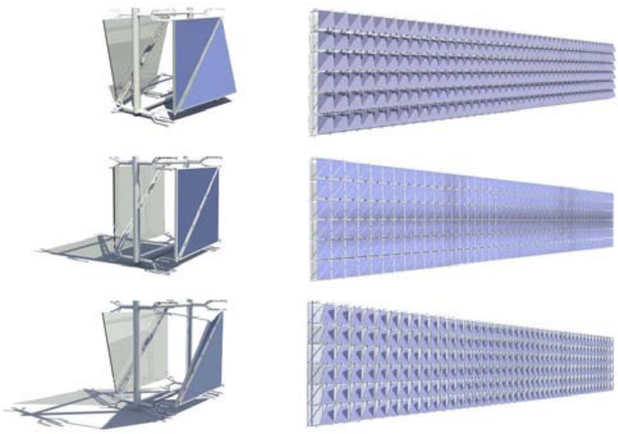

Fig. 4. Building envelope elements of design example 2.

filter aiming at the manipulation of the external climatic conditions and the preservation of the thermal comfort in the interior. In addition it contributes to the energy equilibrium of the building through integrated photovoltaic elements.

4. Research Based Design

The design examples at the diploma stage arise from a research process on analysis, evaluation and design proposals according to a respective initial aim set, in the case of the present examples, related to sustainability issues. The research process is developed based on a prototype development that is continuously revised following the integration of the scientific disciplines involved.

The first design example deals with the development of a design production model of green-energy from the sea, aiming at the coverage of operational needs of touristic areas in the city of Limassol, on the south of Cyprus, during the summer period, fig. 5. In this frame of major importance was the intense environmental problems in relation to the need for a highest possible replacement of fossil fuels by renewable energy sources. The primary fields of the state of the art analysis conducted, have been different types of renewable energy sources, green and floating structures, the energy characteristics of the island, the amounts of energy consumption, systems of wave energy and their operation and the coastal zone of Limassol.

The selection of sea wave energy to be applied in the design was based on the degree of possible efficiency and the particular morphology that develops through the autonomous system, Fig. 6. The energy production system applied influences highly the functional spaces configuration of the building. Every prototype unit consists of two turbines of in total 6 MW power supply, situated under sea level, and a multifunctional open space with a peripheral ramp and a central atrium, above sea level. In the respective application five such units have been developed to cover the electrical power required of in total 28.6 MW. The functional spaces within the units host research centres for energy and maritime life. Their interconnection is achieved through kinetic bridge elements. The units above sea level rest on mega-wheels with air-pressure, their anchorage on the ground takes place through tension elements. All architectural elements of the composition are temporary and partly autonomous, enabling the prototype concept to be independent of time and space.

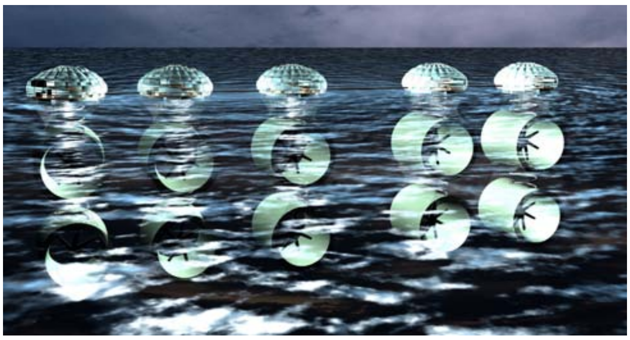

Fig. 5. Building units of design example 1.

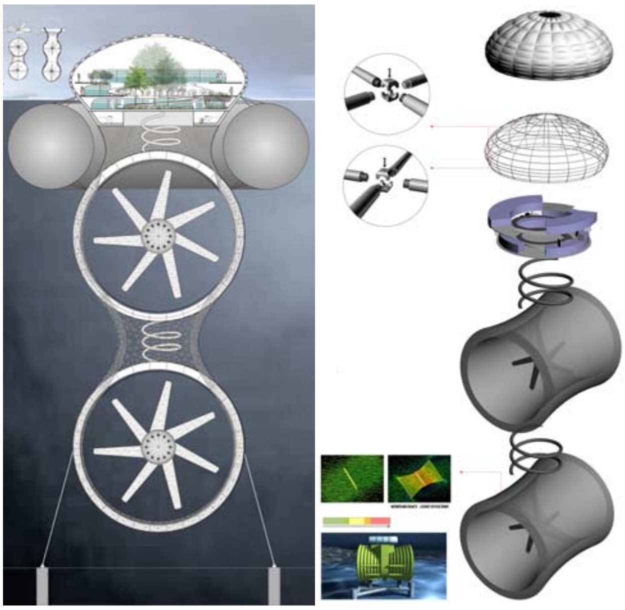

Fig. 6. Section and building elements of design example 1.

The second design example refers to new materials and technologies and the possibilities of renewable energy supplies in urban cities. In support of the design process, the state of the art analysis consisted of investigations in the areas of meteorology, mechanical-, electrical- and aerospace engineering, aerodynamics and informatics.

The design concept refers to the development of a number of standardized pendulous structural units, placed above the city core of Nicosia, Fig. 7. The concept aimed at a complete provision with electrical energy of the city centre. The dense built-up environment, the political situation and the necessity for regeneration of the city centre played a major role in the selection of the place of application.

Fig. 7. Building pendulous units of design example 2.

Fig. 8. Capsule Tower of design example 2.

Based on the energy requirements of the city core, 300 units with diameter of 20 m each and integrated photovoltaic on the upper membranes surface and a capsule underneath have been suggested, i.e. covering 5 % of the total urban area under consideration, with diameter of 1.4 km, Fig. 7. The photovoltaic satellite technology applied is capable of producing 150 W/kg, covering for the city core the maximum requirements for electricity supply of 24.000.000 W by the Cyprus Electricity Authority. The units may land within the city through a kinetic transformable structure, Fig. 8. The capsules towers host public and private functions, in the areas of applied research and entertainment through digital technology, for governmental departments and citizens respectively. The concept initiates new interrelations of energy production and supply, environmental data collection and digital realities through new technological applications.

5. Conclusion

The application of new technologies and materials in architecture takes place within an integrated design context, whereas morphological and aesthetic issues, functional constraints, the structure and construction of the building elements and environmental issues play in an integrated context a significant role. Undoubtedly, such a design approach is most effective, when practiced in an interdisciplinary environment. The analysis of the two main directions of interdisciplinary design, the holistic integrative design and the research based design, applied at different program levels at the Department of Architecture at the University of Cyprus, reveals design specific similarities and different technological potentialities in respect to environmental aspects of the designs achieved herewith.

The first two designs, presented herewith, are developed on the line of an initial vision set that binds the development throughout the transition in scale. The quality of the designs is measured in architectural, morphological terms, based on the specific technological syntax of sustainability, followed on the line of the interdisciplinary design approach. On the other side, the latter two design examples are based on the development of prototypes that are directed from an initial stage by environmental considerations. In both cases the application of technological systems for the reduction of the conventional energy forms consumption, the improvement of the energy behaviour of the buildings and the reduction of disadvantageous environmental consequences is actively pursued. The innovation degree of the designs is mostly reflected in the materials, systems and construction detail scale following discrete technological developments. In all cases technology serves as a design tool towards innovation and sustainability of the designs.

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