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Assembling sustainable ideas: The construction process of the proposal SMLsystem at the Solar Decathlon Europe 2012

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ABSTRACT

The innovation of the construction process in SMLsystem lies in an evolution of the way of thinking the sustainable architecture. The key is that SMLsystem proposal is not constructed but is assembled. This way, it is designed with prefabricated and industrialized elements which allow themselves to connect as in a plug and play process in order to reduce the risks and save time and costs consequently. About that, the study and design of the junction has been another interesting issue to solve the assembly of the modules, focusing on factors like the isolation and the rainwater always present. In addition this proposal shows a new way in the use of wood as a structural material, as a building enclosure and as a dynamic system of solar protection, all of them as a result of the combination of various premises inherent to the concept of the project like the respect for the environment, recycling or sustainability and, of course, with an absolute integration with the architectural design. This way, the complete development of SMLsystem has had the capacity of defining a global project which reflects the primal ideas: design, sustainability, modularity, flexibility and prefabrication.

1. Introduction

Society demand of sustainable architecture in terms of energy, that came from the oil crisis of 1973, was a true reflection of a need for change of awareness in how to address energy savings issues and concerning, of course, to architecture.

The development of theories about sustainability and bioclimatic architecture that appeared since then and which are so fashionable today, are one of the main references in the architect Olgyay. A pioneer in the study of treatment of bioclimatic architecture from concepts, he determined in [1] how to address the issue of sustainability of the building differentiating from the pre-existing relationship with the place in which it is located and, on the other hand, the sustainability of the architectural element itself. That means the building conceived as an expression of the results obtained from previous studies of both climate and technological solutions adopted. This allows to establish the possibilities of relationship with the environment, the materialization of this relationship, and the control and regulation of energy exchange between people and the building itself, i.e., the relationship between form and volume, skin and enclosure and between interior and environmental quality, respectively.

Technological development and current needs make possible to apply, test and develop Victor Olgyay studies (later picked up and advanced by Givoni in [2]) in research projects currently being realized in the field of self-sufficient architecture.

Any architecture to be identified as bioclimatic (also called "energy efficient buildings", or "green building") must have, as a condition of departure, a design in consonance with the climate in which it operates and with the people who will inhabit in order to be healthy with them and consume as less as possible resources. That design also must combine passive and active resources in order to get an optimal building design and an efficient control of the indoor climate [3]. Therefore, natural resources should be optimized constructively to obtain the best indoor environment, minimizing or, if possible, eliminating the use of mechanical technology. In fact, according to Professor Javier and González in [4]:"The most effective measures, the ones which may represent the higher contribution, cost nothing, since they are the logical result of the use of design and construction elements".

Both the evolution of the technique and technology make easier a previous approach to comfort conditions. Through simulations

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from architectural design and the certified properties of materials or building methods used and their organization, can be undertaken potential design and constructive mistakes in order to make proper corrections to improve the efficiency of the building without having to construct it. Thus the building realized will respond to optimized comfort conditions.

Despite not providing accurate results, the use of current computer tools does allow to know globally the building behavior and its impact on indoor environmental quality, based on the order of arrangement of the materials and their technical characteristics. Consequently, as in many other occasions throughout the history of architecture, specialization leads to the emergence of new fields in research and experimentation (in this case applied to sustainable development). A clear example of this can be found in the homes for the Stuttgart international exhibition (*Weissenhofsiedlung*) promoted by the *Deutsche Werkbund* in the summer of 1927. Disassociating the relationship between loading system and formal aesthetics of the building, Corbusier began a personal research in the field of the enclosure as a fully autonomous and independent element of the structure, which meant a break with classical composition relating building, structure and shape, and twisted on the concept of the construction process. According to Corbusier in [5], *modern materials* made possible to reduce the thickness of heavy structural walls and re-compose them in walls with thinner specialized layers, more efficient and independent from the structure.

Despite this research of Corbusier, years before were already introduced concepts as assembled architecture, prefabrication or serial production at the Universal Exhibitions, which showed both the evolution of the industry and the research advances in building construction. One of the most famous examples is the Crystal Palace by Paxton [6] in 1851, who managed a comprehensive solution through standardization of elements, its dimensional coordination, its prefabrication and its assembly process optimization. It allowed to build 72,000 m^2 just in four months [7]. Shortly after in 1854, were developed examples applied at the housing field like the famous working class neighborhood "*le Dolfus*" nearby Mulhouse [8].

In the same line of research and expertise but using technology and current building systems, the proposals of the international competition Solar Decathlon Europe are an opportunity for the future development of sustainable and self-sufficient architecture. The proposal SMLsystem of the CEU Valencia Team for Solar Decathlon Europe 2012 takes on the challenge of combining the concepts of industrialization, prefabrication and flexibility through researching a sustainable building, drawing on the experience acquired in the 2010 edition with the proposal SMLhouse [9].

2. The SMLsystem proposal

SMLsystem (Fig. 1) is a clear reflection of that development that attempts to" satisfy the needs of the present without compromising the ability of future generations to satisfy their own needs" [10].

The design of the proposal arises from the concept of housing as a personalized solution to user needs. Furthermore, the housing configuration is proposed as a system, generating multiple dwelling solutions through the choice by catalog of prefabricated components which are later assembled (Fig. 2).

The idea to generate a catalog reprises the final objective of standardization of the elements to provide an overall forecast that improves the result of the work. This concept was already developed in the beginnings by the manufacturers of industrial and agricultural machinery of the nineteenth century. In fact, in this period appeared the first leaflets with elements for dwellings like the ones by Charles Young and Company in 1885 [11]. Years later appeared various attempts of prefabricated dwelling like the famous Dymaxion House by Richard Buckminster Fuller in 1929 or other local examples like the *Modul-Arch system* by GO-DB architects [12].

Learning from these examples, the catalog developed in our proposal requires simplifying the number of elements to maximize their possible combinations in the most flexible way. Thus, the main components that make up the SMLsystem are a base module and prefabricated indoor boxes that form the wet cores.

To achieve the objectives of the system, the construction design of SMLsystem focuses on the ease of manufacturing of its components, as well as optimization of times and assembly processes.

3. The structural base module

Unlike in a conventional process, the beginning of the design phase starts with the understanding of all the constraints arisen by the implementation of housing, both projective and construction of facilities, and by the optimization in every moment of the execution. Therefore the first strategy proposed for the self-sufficient SMLsystem house is to optimize the number of necessary modules for the construction of the maximum area allowed at the competition. This way, SMLsystem decreases the number of the elements used in the 2010 prototype, and increases their size.

The overall dimensions chosen, take as a basis the module of 0.30 m, since the most of the construction materials such as panels or boards are made on the base of this measure, thereby obtaining for the compliance of the program a base module of 7.20 m long, 3.60 m wide and 3.00 m high (Fig. 3). That generates as a main inconvenience the need to use special transport for transfer by its width, but on the opposite of this problem, otherwise easily affordable, are the benefits of time and optimizing the assembly.

Among those, the greatest virtue is the drastic reduction in the number of singular points in this type of construction, among which the most important is the joint between modules. In the SMLhouse of the 2010 edition, there were six modules, with their respective five joints, that during the successive assembly and disassembly became one of the weaknesses of previous prototype.

Therefore, for the 2012 proposal, this point was to be solved in detail, starting from the reduction of the number of joints, thereby decreasing the number of modules to three. In addition, the reduction of the number of modules directly decreases the number of trucks needed to transport and also the use of aids such as cranes and hoists, improving the sustainability of the proposal since it generates less CO_2 on the overall calculation of the construction process.

Another fundamental premise to the entire proposal is the complete execution made by prefabricated or postformed materials and the subsequent dry assembly, being timber the predominant material. This concept results in a cost and time reduction. On the other side the intention of this construction design was to avoid the appearance of fissures, as during the lifting and handling for the module assembly we foresaw the appearance of possible deformations.

Regarding the first of the basic components, the structural module is fully materialized in spruce (*Picea abies* L.) cross laminated timber (CLT) of visible quality. The horizontal structure consists of cover panels made of cross laminated timber CLT 60 L3s, supported on L-shaped pillars and floor panels made of cross laminated timber (CLT) 120 L3s. As it is shown, panels are used as a component of an integral prefabrication [13]. The vertical structure consists of four L cross laminated wood pillars (CLT) C3s (210 mm wing and 100 mm wide) transversely braced with beams, cross laminated wood also (CLT) C3s with required buttonholes for dry assembly with screws (Fig. 4).