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SYSTEMIC DESIGN APPROACH APPLIED TO BUILDINGS - DEFINITION OF A CO-OPERATIVE PROCESS

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ABSTRACT: *The aim of the research is the application of ecodesign principles to buildings. The study starts from the analysis of relevant international case studies that offer a benchmark of "good-practice" solutions. These examples are useful for the definition of guidelines for a building, characterized by the optimization of resources consumption and costs reduction. Key role for the study is the creation of a co-operative behaviour among the involved actors, which sets up research groups, formed by different professionalisms into the construction companies. According to that, the designer becomes the stakeholders' connector and drives the entire construction process towards a multidisciplinary and systemic approach.*
KEYWORDS: *Systemic Design, case studies, buildings, designer, cooperative behaviour*

BACKGROUND

The overall objective of this research is the comprehension of how a systemic thinking can lead advantages for the understanding of buildings, taking into account the environmental sustainability and respecting the value of the Nature's resources.

According to the projections of the United Nations-Population Division, the current world population [1] is close to 7 billion and, following the high variation in fertility, will be approximately around 10.6 billion in 2050 and 15.8 billion in 2100; at this time the Urban Population [2] is close to 3 billion and is growing very fast and will be close to 6.5 billion in 2050.

These figures mean that we will have to build a huge number of houses for the next 35 years; because of that we need to underline samples of good-practice in term of environmental sustainability as source of inspiration and example for future buildings.

The basic idea of this research is the relevance of a methodological approach based on the systemic thinking, which takes into account exchanges among the building and its surroundings and moreover among the components of the building.

Thanks to this concept, every building should be put in relation with its own context and furthermore it becomes clear the relevance of the nature as resource base and sink.

For these reasons this study is based on the analysis of several international relevant buildings, in order to show some examples of best practice, which can inspire a more sustainable approach for next constructions.

Per each case study good-solutions in term of technical plants, shape of the building and interaction among involved actors are pointed out. The final result is a benchmark of sustainable practices that will be compared among each other in order to obtain guidelines for the design of the building, based on the systemic approach.

METHODOLOGIES

This research is fully inspired by holistic and systemic approaches; in particular the Systemic Design methodology, namely with the acronym SD in the paper, and the Urban Metabolism theory, namely afterwards with the acronym UM, are used for the case study analysis.

Methodologies' principles of both approaches assume the central role of the human being and the relevance of considering a system - a building in this case - not as a static entity but as an organic element, which should be designed according to its connections with surroundings and others components of the bigger system.

In these approaches the nature's rules are taken as source of inspiration. A natural system is always designed around its own flows, no natural element evolves in a static way: everything interacts with the surrounding [3].

In particular according to the UM theory, flows through an area, not matter its size, can be described as "metabolism" [4].

Furthermore following the metabolism concept and focusing the attention on the involved actors too, the building should also be studied through the metaphor of the "pump".

Buildings are part of the built environment's metabolism as huge, complex pumps: they are guided by habits and needs of users and depending on the local management. Like the digestive system of people and animals, they depend on the context for supplies and taking care of their waste [4, 5]. (Figure 1)

As Herbert Girardet argued, cities are more than static structures of stone and concrete: with their complex metabolism they are like huge organisms without precedent in nature [5, 6].

All cities, and as a consequence all buildings, have a massive throughputs of resources. By starting from this concept, Girardet distinguished the inefficient linear metabolism of cities, which don't take care of their waste, from the circular metabolism of modern cities [6].

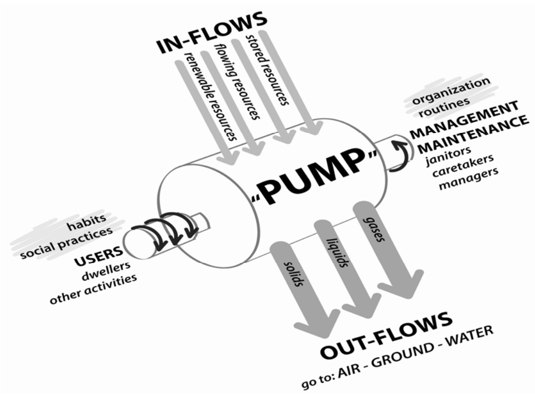

Figure 1 – The metaphor of the pump (Björkholm, Svane 1998)

Lately Newman extended this concept with the "Extended Metabolism Model of the City" stating that "it is possible to define the goal of sustainability in a city as the reduction of the city's use of natural resources and production of wastes while simultaneously improving its livability, so that it can better fit with the capacities of the local, regional and global ecosystems" [7].

Indeed the model of a natural ecosystem is in some sense the model for developing sustainable built environments [8].

Natural ecosystems are generally energy self-sufficient and consider waste as resources and raw material for the development and the survival of something else.

The concept of the "metabolism" is strictly related with exchanges and relationships between the elements of a system, which actually is also one of the main key-concepts of the Systemic Design methodology [9].

The Systemic approach is based on five principles, which show how the design process should learn from the natural realm.

1) *Output > Input: the output (waste) of a system becomes the input (resource) for another one, creating an increase in cash flow and moreover new job opportunities;*
2) *Relationships: relationships generate the system: each one contributes to the system; they can be within the system or outside of it;*
3) *Auto-generation: self-producing systems sustain themselves by reproducing automatically, thus allow them to define their own paths of action and jointly co-evolve;*
4) *Act locally: the local context is fundamental because it values local resources (humans, cultures and materials) and it helps resolve local problems by creating new opportunities;*
5) *Man at the centre of the project: Man is connected to own environmental, social, cultural and ethic context.*

For these several reasons the study is focused into the understanding of the essential functioning of the building.

Every case study is based on the flows' analysis: it starts from the essential need of material (i.e. water and air) and energy (i.e. for ventilation, cooling and heating) resources and ends with the production of waste, which should be seen as raw elements for the same or another system.

RESEARCH METHOD

The study is based on the analysis of international relevant buildings, in order to show some examples of best practice, which can inspire a sustainable approach for future constructions.

The purpose of this research is the desires of showing good examples, understandable by companies of this sector as well as ordinary people, in order to demonstrate that it is possible take actively part to the environmental solutions [10, 11, 12, 13, 14].

All the cases have been studied through the principles of the Systemic Design methodology, starting from the relationships among the technical plants and the shape of the building.

In particularly four different classes of buildings are pointed out:

- *high level of technology applied to technical plants*
- *strong connection with the infrastructure (e.g. eco-districts that strictly depend on the city's services)*
- *predominance of solutions based on nature's rules*
- *mix of high technology with solutions inspired by the natural ecosystem*

Per each case study, good-solutions in term of technical plants and shape of the building are pointed out.

The final result is a benchmark of good-practices, which will be compared among each other in order to obtain guidelines for buildings' design.

Because of the guidelines will be based on the systemic approach, the key elements will be:

- *interactions among components of the system*
- *reduction and optimization of resources consumption*
- *reduction of costs*
- *reduction of environmental impact*

At this phase of the research, the author wish will be able to define a proposal of a co-operative behavior based on interaction of the involved actors. This suggestion will consequently lead, when applied to the construction companies, the emergence of co-operative research groups formed by different professionalisms (e.g. physicist, technicians, sociologists, specialists, engineers, architects).

In this multidisciplinary scenario becomes desirable defining the role of the designer as connector of different expertise, which participates in the project. The designers' capacity in showing the possible hidden connections among the elements of a system, can allow the dialogue among the actors, which probably will be able to discover common area of interactions.

The Figure 2 presents the conceptual map of the author's doctoral thesis and is the synthesis of what has been previously.

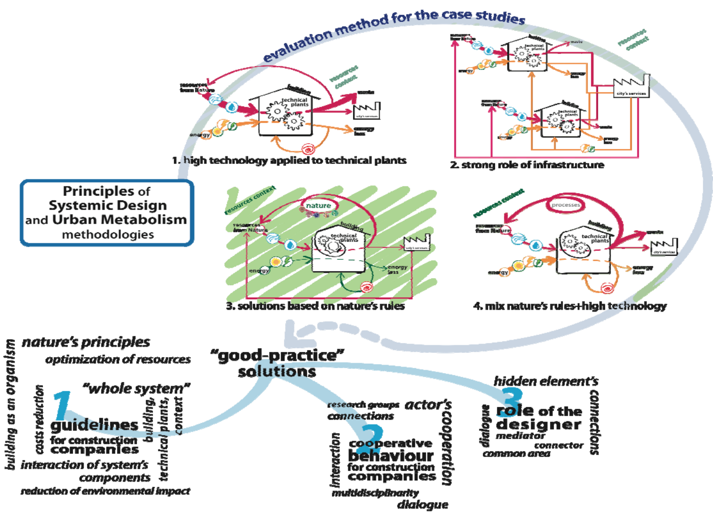

Figure 2 – Conceptual map of the author's doctoral thesis

Not rarely the analysis of these cases have showed that a non well-functioning building in term of resources consumption, is not matter of a lack in the solutions available on the market, but is due to solutions that are not applied in the correct way and also because there is a scarce tendency in seeing the building as an interrelated system of elements.

According to the literature, ecodesign is not the facile assembly in a single structure of ecological and technological plants and gadgets, namely solar collectors, wind generators, photovoltaic panels and so on. Such technology may be part of the ecological designer's tool kit, but the ultimate objective is the environmental integration by design. The key word in ecodesign is "to integrate" [15].

With the nature as source of inspiration, it is possible to learn that in an ecosystem every part is optimized according to variations of a component. The changing of a part modifies all the system and causes the co-evolution of the others elements. This is the explanation of why, in the architectural sector, is not possible to design a single component without taking into account all the building structure and moreover without considering surroundings, the neighborhood, the clime and the local culture of the context. This process creates positive synergies into the system [16].

The same interactions and connections should be applied in handling the participants' relationships. As Paul Hawken points out in his book "Natural Capitalism", every component of a product is designed in relation with the other elements of the system. So that, the cost of a product which utilizes innovative technologies and uses less resources and energy, is not higher than a standard one, because every component is not considered as isolated but is put in relation with the others.

By following these methodological paths, it becomes important start to think "Out of the Box", which means start to apply consolidate solutions in different application fields and also starting a co-operation among several area of expertise [10, 17].

Hence, the success for a sustainable building doesn't require more knowledge but only a shifting of what we know, toward new models [16].

For a successful project everyone should contribute with knowledge and experience throughout the entire process. By following a cooperative method, no valuable information are lost along the way and furthermore it is possible to "protect" the basic concept from old, customary working methods as well as the new advanced technological solutions [12, 13].

Clearly, the co-operation among the actors assumes a key role for the success of the project.

CASE STUDIES ANALYSIS AND RESULTS

In order to show some of the good-practice solutions available on the market, this research is structured around the analysis of relevant case studies, which are thoroughly studied through the application of principles from SD and UM.

According to these approaches, central role in the study are input and output flows of material (i.e. air, water and sewage) and energy (i.e. for cooling and heating, ventilation and domestic hot water) through buildings.

The flows analysis allows a deep comprehension of the buildings' functioning, pointing out interactions and influences among the elements of the system.

Per each case study graphical schemes have been made, in order to underline the good-solutions examples and furthermore noticing possible common fields among participants' expertise.

In this paper the "GreenZone" case study is presented [14, 18, 19]. GreenZone, namely GZ further in the paper, is an interesting example of how the co-operation among actors can head the project manager toward sustainable and systemic buildings.

GZ is developed with an holistic view based on how it is possible, in the best positive manner, conserve natural resources within the building sectors without compromising function or comfort.

This comprehensive approach has characterized the project from the outset, from the design and the building phases, as well had strongly influenced the various activities in the area.

The project is located in Ersbroda, Umeå, Sweden; it is an innovative, sustainable platform for providing service to motorists. The area offers service for car and driver (ownership of Ford Motor Company), an energy station with food store (ownership of Statoil) plus a road-site restaurant (ownership of Mc Donald's).

The aim of GZ is to stimulate innovative thinking and increase knowledge in the field of environmentally sound building.

The project of the motoring area started in the 1997, it took one year for the definition of the plot, one year for writing the program and the building specifications and it was completed in June of 2000.

The purpose of this project was to minimize the environmental impact of a building during its different life stages, gradually improving the environmental adjustment, thereby increasing the knowledge of everyone involved in construction and management building processes.

In GZ the best available technology has been combined with an overall perspective in order to form new systems solutions with substantial synergetic effects.

According to the opinion of the project manager, the working method and the actors' involvement had played a decisive role in reaching the final goals.

An expert group (i.e. formed by one architect; an electrical consultant; an engineer expert in geological studies; an heat, water and sewage system designer; a building planner and an expert in land, water and sewage) was assembled during the first phase in order to have at disposal the best available technology and the opinion of different experts.

Moreover, in order to increase knowledge about ecological sustainable issues, everyone who worked at the project has completed an environmental training course, sponsored by the owner.

In order to involve all the actors in the process, the architect has illustrated the functioning of the building through simple diagrams that point out input and output flows involved into the building system (Figure 3).

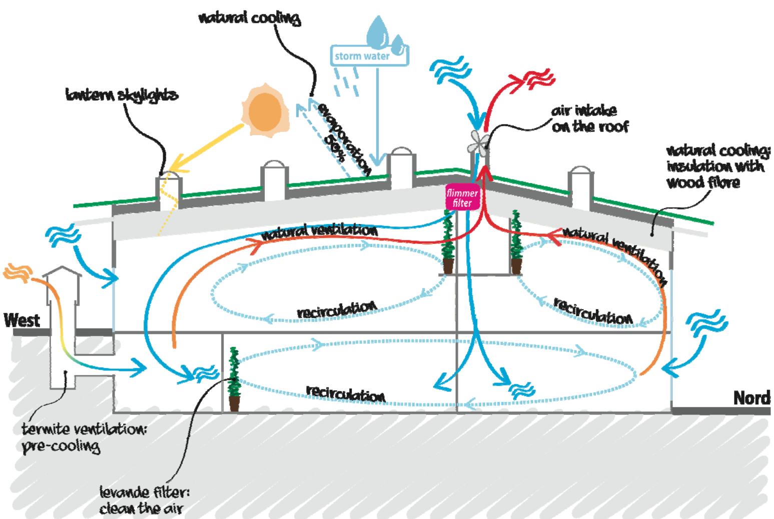

Figure 3 – Ventilation and cooling in GreenZone (review of Anders Nyquist's schema)

By following a holistic approach, GZ is the result of the crossing of different technical areas and expertise. All participants in the process have been trained in environmental technologies and the architect has explained why it is important build in a sustainable way, how build and what it is possible to learn from other projects. According to the project manager, the education and the client's involvement were prerequisites for the success of this project.

CONCLUSIONS

The final purpose of this work is underline the relevance of a multidisciplinary approach in the analysis of building sector. By starting from paradigmatic examples in which the co-operation among *actors is the key for the process' success, it becomes clear the relevance of creating connections among the project's participants, starting from the initial phases of building's construction.*

The key consequences of this approach are basically two: the former is the creation of a co-operative behaviour which should drive research groups in construction companies, the latter is the definition of the role of the designer, as connector and mediator among different involved expertise.

By following the Systemic Design principles, the designer has the ability to find hidden connections among elements of the system and furthermore to define area of interest in common with different actors.

In this process it is important create a collaboration of architects, engineers, building occupants, owner and specialists that utilize a systemic approach in order to holistically consider the building structure and its related surroundings, examining how they best work together to save energy and reduce environmental impact.

In the integrated design process, multiple disciplines and seemingly unrelated aspects of design are interrelated in a manner that permits synergistic benefits to be realized. The goal is to achieve high performance and multiple benefits at a lower cost, than the total for all the components combined [20].

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