Energy and Materials in Architecture

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Architecture & Energy. Seminar of Architecture and Environment.

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ABSTRACT: Nowadays it is well know that urban systems require a huge material and energy input for its function. Previous studies have noticed that most of this energy demand is produced by construction. This ambit absorbs the energy consumed by electricity and gas, but also the energy embodied in the construction materials, which it is defined by the origin of the resources utilized, its posterior industrial manipulation and transport. The role of architecture inside energy balance and masses fluxes inside the urban system has an important relevance. In order to this, architects require new design and construction strategies that allow a better use of materials and efficiency on the energy use of our buildings. This article has the objective of expose the energetic weight of design decisions, looking for an adequate habitability of spaces and also at the technology applications and selection of construction materials. Our principal intention is to approximate life cycle of materials as an architectonic design regulator.

Conference Topic: Low energy architecture
Keywords: energy, materials' life cycle, sustainability, sustainable architecture

INTRODUCTION

The need of settlements' efficiency it is an inherent question to long term planning strategies. This efficiency is conditioned principally by the way resources are used and the energy consumption; both ambits represent a complex field of influence that involves interests and activities of diverse collectives.

Nowadays, the application of construction environmental criteria is overcoming an extending threat. The compromise established by Kyoto, reducing emissions in industrialized countries, obligates the incorporation of new strategies that make effective this diminution in a global level.

It is well known that the most important ambits of energy consumption and CO_2 emissions are generated by industry and housing. In countries such as China where their principal economic activity is manufacturing industries, almost the 64% of the total energy consumption is spent on industry and a 16% in housing [1]; meanwhile on industrialized countries the total housing consume can arrive to the 35% of the total consume (United States).

Most of housing energy consume is generated by buildings heating and cooling conditioned systems. This is the reason why the incorporation of an optimized criteria application on buildings thermal behavior and use is so important.

In other words, the embodied energy on construction materials represents an important input on the total energy and emissions urban balance as well. It has been calculated that a university building with 2,16 ton of materials/m^2 represents 5.576 MJ of energy invested on materials per m^2, that means 521kg of CO_2 emitted to the atmosphere in order to produced those materials/m^2 [2].

The role of architects in this field is of an incredible importance in reference to the design process, materials election (implicating systems that produce them) and systems utilized to transform matterial and energy wasted during and by the action of building.

A different conception of architectonic projection and design is necessary. This has to be consistent to the present needs and to the possible future ones within a sustainable framework.

According to this vision, this paper has the objective to establish the factors that define the architectonic program and wich are directly related to matterial and energy in buildings.

This way, there are some particular strategies that are suggested, such as materials life cycle analysis as a tool for new architectural design conception.

2. OBJECTIVES AND METHODOLOGY

The main objective is to provide a different interpretation of architectural design, which allows the introduction of maximum resources profile at the design stage.

2.1 Architectural Program

One of the most important part of the design stage is to define spatial requirements of users' needs in order to carry out several activities in interior spaces such as resting, cooking, getting washed, working and communicate with others.

Each one of these activities supposes a determinate space with specific lighting, thermal and acoustic conditions. At the same time, it requires several kind of objects, accessories and appropriate furniture to develop certain activities in a comfortable manner. Basic spatial requirements could be different according to cultural habits and traditions.

2.2 Projectual Guidelines

First of all, some principal design guidelines have to been defined in order to elaborate a project requirement program. These have to be Projectual Guidelines based on the integral composition of several aspects resumed in the next three factors:

- *Formal*
- *Metabolic*
- *Communication*

2.2.1 Formal factors make reference to aspects that define geometry and interior spatial distribution of buildings, including exterior spaces. For example, spaces can be characterized as compact and compartment or as clear and open.

Human comfort depends of the characteristics of interior spaces and further more in cooling and heating demand.

2.2.2 Metabolic Factors, make reference to building behavior, in order to the matterial and energy inputs and outputs. These factors are defined in one hand by electric, gas, climatic, and water systems and also by the materials cycle of building. Metabolic factors depend also of the next variables:

- Use and building maintenance.
- Climatic Conditions
- External Resources Management.

2.2.3 Communication Factors, are defined by the information contained at the proper building and its external relation.

In these sense, we can see two kind of information related to architecture, the first one links the building with exterior as a cultural reference with a formal context integration. The second one links the building to the exterior by the kind of activity that is developed inside it and the exchanges that produces with the immediate spaces.

Each one of these factors affects in different aspects to design decisions, and the most important, to the posterior behavior in time.

Usually, designers use to consider, even in an exhaustive way, the formal factors that affect architecture, however metabolic and communication factors are usually solved without an integrated vision.

We consider that conceptual and design guidelines should base formal solutions according to the metabolic building needs and the way it has to interact with the exterior.

The maximum profile of matterial and energetic resources provided by the settlement is the most efficient strategy from a sustainable architecture point of view in a long term.

3. THE RESEARCH CASE

A recent research [3] analyses the architecture of an isolated community located in Chiapas, at the southeast of Mexico, in a jungle ecosystem.

This research shows the close relation existing between metabolic, formal and communication factors; standing out the determinate role of the metabolic factors.

The isolated conditions in which the community settlement is, makes evident the importance of matterials life cycle in order to reach a sustainable development of the local architecture and the proper community in a long term.

The supply of matterials for construction, tools, objects and also, energetic demands implies a huge effort of extraction and transportation of resources. This is why it obligates the maximum profile of them.

For example, a new house is made up with several kind of vegetal species which are produced in the surroundings of the community settlement. The remaining material generated during the construction stage is used for posterior energetic demands such as cooking and heating. Some others are reused for the creation of domestic tools for their own use, or to commercialize them as arts and crafts, which means an economic income to families.

The quantification of the results shows that the highest percent of reuse materials are for firewood and tools. In some cases, the remaining or recycled materials coming from construction stage is 92% for domestic tools, 77.6 % for work tools and 74% for firewood.

All of these organic material resources are transformed into ashes at the end of their useful life, as a waste, is reuse as fertilizers on domestic cultivation and also as a degradation substance for faeces which are strategically place at the exterior of the house.

This way, the organic materials' cycle related to construction represented, are closed, returning the wastes to the Biosphere and recovering the quality of resources.

It is quite different in the case of inorganic materials such as those imported from proper commercial centers and produced by industrialized systems. This materials doesn't reach the enclosure material cycle and remain in the local environment as contaminants, their degradation is more difficult to absorb, and over limits a sustainable model.

The closed cycle of organic materials not only satisfies the use and maintenance of local architecture, it determinates the principal material and energetic resource management through productive systems that get the maxim profile of the local environmental resources.

Fig 1 & 2. Organic Materials Life Cycle Analysis, which ends as ashes and returning to the Biosphere. Pictures by Jordi Piqué.

This means that the community is obligated in order to satisfy its own basic needs of housing and feeding, to conserve its traditional productive practices carried out for generations from a long time ago that assures them the resources they need.

At the same time, they conserve the ecosystem, in this case the jungle, the water elements and the vegetal species surrounding the houses.

On the other hand, the climatic conditions with high temperatures and humidity in air make necessary a construction typology that provides shadow and the most possible natural ventilation.

The architectonic solutions responds with walls made of planks and wood sticks slightly separated between them, similar to a porous envelope façade that allows the pass of the air. The interior distribution is configured by several individual rooms grouped inside a vegetated radio which helps to generate a comfortable microclimate.

These rooms are destined to several functions and are classify by internal activities (cooking area, resting zone, workshop and warehousing). Each one of the rooms are spatially adapted according to the function.

For example kitchens present a different separation of wood sticks and opens on top of the walls that allow not only a better ventilation but also a fast smoke extraction from the firewood.

Meanwhile, resting rooms require a minimum separation that doesn't allow the pass of insects and rodent animals.

Fig 3. Sleeping room on the left and kitchen on the right. Pictures by Jordi Piqué.

Communication factors are represented in the configuration of the rooms inside the vegetative radio and the relation with the rest of the houses that respond to their particular cultural characteristics of relationship between the people of the community.

In the case of study, the metabolic factors have determinate formal and communication factors of the design solution.

The consolidation of these factors in the community development in time makes a strong correspondence that actually there is no boundary between one factor and another

Fig 4 & 5. Different ways of using the woods. Pictures by Jordi Piqué.

4. CONCLUSIONS

The materials' cycle from industrialized products in urban systems as well as materials' cycle of local resources in a rural systems, means an important effort for both context reason that confirms the importance of maximum approach of materials.

As in urban contexts, the most important material consumption fields in the case of study were construction and firewood as an energetic font, and also transportation and extraction of resources represents one of the principal activities of the community.

The main difference from urban models is the way the wastes turn back and the velocity of resources extraction and consumption. We can conclude that even if there is an urban o rural context, the energetic weight of construction materials is an important issue on the total energy balance of the system, the environmental impact depends in the way that these materials are used and its posterior return to the environment.

The materials life cycle analysis is confirmed for any kind of system were architecture is present, as a design tool strategy that permits evaluate the effects of metabolic factors the material election and design or planning decisions.

In order to this, the architectonic conception proposed in this paper, allows solutions with a close correspondence between metabolic, formal and communication factors generating a solid design structure in coherence with the environmental guidelines needed to reach sustainability.

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