Architects of the 21st century. Design decisions versus environmental impact

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Imagine we're architects of the 21st century aware than the social dimension of our work includes the preservation of the Planet. It's easy if you try.
Because of that, we design our buildings according to the right orientation. We do consider its landscape impact. And its mobility impact as well (accesses, public transport,..). We think of the influence on the local life of the new neighbours / users of the building (shopping, use of the public spaces,...) We minimize the energetic profits and losses. And we incorporate to our buildings systems of energy catchments.
Nevertheless... How do we choose the materials that shape not only the skin but the whole building?
It might be interesting to analyse some emblematic buildings because of its sustainability and evaluate the environmental impact due to its building materials. But how shall we analyse this? Does it make sense setting a "sustainable materials" ranking? According to the materials themselves or might the constructive system be involved as well? Or is it the amount of each material what makes de difference? There are many buildings properly orientated recovered by aluminium panels, despite of its high energetic cost. And others whose main concept is the natural enlightment getting in the whole building, but with constructive systems that need expensive maintenance.
As far as we teach Constructive Materials at the *Escuela Técnica Superior de Arquitectura de Barcelona (Universidad Politécnica de Cataluña),* we must absolutely think about how to teach the meaning of ecology in building construction, so our students might become, for real, architects of the 21st century.

Keywords: architecture design, environmental impact, building sustainability measurement, constructive materials, teaching.

1. Imagine we're arquitects of the 21st century aware than the social dimension of our work includes the preservation of the Planet. It's easy if you try.

Or maybe not, because being aware of that is not such an evidence, and of course not as extended as we would wish. Considering the environmental impact of the building construction is something, at least in Spain, reduced to a short list of "ecologists". And that's when we speak about architects. As far as look at the whole ensemble of those involved with building construction, de degree of worry is just irrelevant

But, on the other hand, there is no doubt that it is an unavoidable factor. Because of the will of the legislator, which is clear in the latest building laws promoted by the national government and also by the regional one, because of the trend of the society towards de environmental protection, sustainability in architecture is not only something en vogue.

By the mid 90's, some works generated some discussion in our school of architecture and in the order of architects as well, about how to insert the "new" architectural exigency inside an already complex table of exigencies, already filled with conditions of any kind. The point was how often the specific weight of the latest exigencies, precisely because its innovation, it's higher than it's objective value.

More than a decade later, it is clear than the new exigencies are to stay, but it is fair to say than the main point sustaining this reticence has consistency: the excessive relevancy granted to the new exigency may lead to results very rigorous in this field, but with a clear deficit on the solution of the whole ensemble of exigencies. To say it easy, they may become a scientific experiment rather than an architecture work.

But we are able now to grant to the new exigency its objective value inside the whole of exigencies. And it is clear to us that it is called to become a necessary condition in the architecture of today and of course tomorrow.

2. Because of that, we design our buildings according to the right orientation. We do consider its landscape impact. And its mobility impact as well (accesses, public transport,..). We think of the influence on the local life of the new neighbours / users of the building (shopping, use of the public spaces,...) We minimize the energetic profits and losses. And we incorporate to our buildings systems of energy catchment.

Which means that we adopt sustainability parameters, with two clear aims: closing the material cycles and produce the less damage to natural systems.

To be precise, there are four mains fields in which focus these environmental parameters:

Lot
Water consumption
Energy consumption
Materials consumption

2.1 Lot

The lot of the building means of course land consumption, for the building itself but also for the surrounding urbanization. Land which is, in many cases, an scanty good. It implies the loose of the existing natural systems, together with biodiversity with ecoystems. And it also has a great incidence on energy consumption (model of city, public transportation,...)

The aims are minimizing the consumption of new territories and recovering the ecological value than the lot had before the construction of the building, even improving it in case of damaged lots.

Some of this aims are out of the architect designer hands, but are under control of the architect urban planner. We all have to do our best.

2.2 Water consumption

Water consumption is straight linked to the natural systems preservation. It has a direct impact, which means that we cut the cycle of water, damaging the systems than should receive it, and in the best cases we return it back but definitely not in the same quality conditions. The indiscriminated and irrational water consumption is even worst as far as, in some countries, water, such a need for life, even human life, is a scanty good.

The aims are minimizing its consumption (95% of domestic water is used in developed countries for the evacuation of solid residues!) and reducing the impact of its use.

Strategies to achieve aims:

- Efficiency in consumption (efficient mechanisms, low consumption devices...)
- Proper choice of the plantation species and efficient irrigation systems
- Water captation (recycling water, rain water captation)
- Improve of the quality of the water before it returns back to the environment.

2.3 Energy consumption

The energy consumption, mainly if it its energy due to organic become to fossilized matter, is the paradigm of the unsustainability: it means extraction and consumption of a not renewable resource to obtain energy with a combustion which generates some residues that damage very hardly the natural systems. Not to forget that the other main energy resource, nuclear energy, is very damaging as well to the environment.

The aim is to reduce the consumption of energy due to fossil fuels and nuclear energy.

Strategies to achieve aims:

- Energetic efficiency of the building (thermal isolation, efficiency of devices and facilities, adequacy of the kind of fuel to every use).
- Utilization of the local conditions (thermal inertia, crossing ventilation, natural lighting, utilization of solar radiation,...), which means bioclimatic architecture improving the energetic relationship amongst the building itself and the surrounding environment.

3. Nevertheless... How do we choose the materials that shape not only the skin but the whole building?

The consumption of constructive materials produces a very high environmental impact because of the waste of resources (in Catalonia, it is estimated the use of about 3 tones /square meter built), waste of water and energy during the building process, residues production and the environment damage due to extraction and transformation process of constructive materials.

The consumption of constructive materials produces an impact on every one of the main fields which focus the environmental parameters: lot, water consumption, energy consumption. To make it clear, please note than the energy needed to produce the constructive materials of a dwelling is as much as 33% of the energy consumption of that dwelling within 50 years.

The aim to achieve is reducing the impacts linked to extraction, production and reintegration of the materials that shape the building, and reduce as well the energy and water consumption during the building process.

Strategies to achieve aims:

- efficiency in materials consumption (reducing the ratio quantity of material/service unity, increasing rehabilitation, use of recycled materials, waste management, increasing durability of constructive materials...)
- environmental improvement of the damage of the extraction process and the production of the constructive materials used during the building process (use of commercial products involved with decreasing environmental impact, avoiding use of constructive materials and systems with higher environmental impact...)

4. It might be interesting to analyse some emblematic buildings because of its sustainability and evaluate the environmental impact due to its building materials. But how shall we analyse this? Does it make sense setting a "sustainable materials" ranking? According to the materials themselves or might the

constructive system be involved as well? Or is it the amount of each material what makes de difference? There are many buildings properly orientated recovered by aluminium panels, despite of its high energetic cost. And others whose main concept is the natural lighting getting in the whole building, but with constructive systems that need expensive maintenance.

Several sustainability evaluating systems already exist nowadays, systems that consider the building as a whole. To all of them it is important to settle what is important to be measured in order to evaluate sustainability, and to settle as well the desirable values for every parameter.

Some of these sustainability measurement systems are the following:

LEED
BREEAM 98
EcoHomes
The Green Guide to Housing Specification
GBC 2000 (implanted in Spain as well).

To measure the sustainability of a building, the analysis focuses on the natural resources management and the natural systems preservation.

Natural resources management includes:

- complete the cycle of the constructive materials.
- waste management, returning waste into resources.
- use of renewable materials.
- recycle nor renewable materials.

Natural systems preservation includes:

- damages to the natural systems due to the implantation of the building.
- water management
- emission of noxious gases into atmosphere.
- environmental impact due to extraction and transformation of the constructive materials that shape the building.

Every one of this sustainability measurement systems includes punctuation and desirable values for every parameter. Its is interesting to see how the best score building is. If we have a look at LEED, for instance the "sustainbilitiest" building would be:

- built up on a lot which was already built before (even better if it is a rehabilitation which preserves as much pre-existing constructive sub-systems as possible).
- not fossil energy consumption.
- public transportation leading ti it not using fossil fuel.
- captation, use and purification of water (not interfering the cycle of water)
- use of constructive materials 100% recycled o renewable with local origin, that do no t produce any emission during its transformation or during the building process.
- granted efficiency

5. Analysis on the materials consumption

We are now getting to the point. What it is proposed here is to do a more precise analysis on the materials consumption, including those that shape the building and those that are used during the building process.

5.1 Sustainability at work

5.1.1 Water consumption at work.

As we have already seen, the aim in water consumption is to reduce it, and to purify water before returning it back to the environment.

In order to achieve that, it is needed to:

Reduce water consumption at work, which means avoiding indiscriminated and out of control waste of water.

Consider the quality of water according to the use. Which means that maybe non-drinking water, o rain water, could be useful to many of the water needs at work.

Purify water before returning it to the environment. Wich actually means captation of water after its use at work.

5.1.2 Energy consumption at work.

As we have already seen, the aim in energy consumption is to reduce it. Usual main energy sources at work are electricity and fossil fuel.

In order to achieve the aim, it is needed to:

Use of energetically efficient machinery, saving up to 33% of energy consumption.

Use of energetically efficient enlightment systems.

Use of renewable fuels, like bio-diesel.

Use of photovoltaic energy to generate electricity.

5.1.3 Materials consumption at work.

Along the building process, many materials are used that will not shape the building since it is finished, and become waste.

It is very important to reduce the environmental impact of waste materials, avoiding them, recycling them at work itself, or recycling them away. Of course, they cannot be just thrown away.

This means waste management. Laws are already dealing with this point, and its already considered in many of the building sustainability measurement systems.

5.2 Sustainability of constructive materials.

Materials consumption in dwelling buildings means up to 3T/m2. This means an amount of material per inhabitant/day (considering building life about 50 years) that doubles the urban waste generated by the very same person for the very same period.

Most of the materials have a local or regional origin (less than 400km away). So the main damage is on the local level. But the energy consumption to produce or transform them is fossil energy, estimated about 2.500kWh/m2 built up. That is the same amount of energy consumption of the dwelling for a period of 20 years. That produces, of course, a global damage.

(Production of ceramic and steel is about 50% of the total energy consumption needed to produce all the constructive materials that shape the building).

The main local damage is the extractive activities to achieve mineral materials (gravel, ceramic clays, calcaires for cement,...). Gravel is about 54% of the total weight of all the constructive materials that shape the building, and stone materials all together are about 85% of the whole.

New materials (PVC, aluminium,...) generate strong local damage, because extraction and production, but also global damage because of its distribution.

In order to reduce the environmental damage due to materials consumption it is needed to:

Recycle materials.

- use recycled materials
- waste management

Avoid most damaging materials

6. As far as we teach Constructive Materials at the *Escuela Técnica Superior de Arquitectura de Barcelona (Universidad Politécnica de Cataluña),* we must absolutely think about how to teach the meaning of ecology in building construction, so our students might become, for real, arquitects of the 21st century.

Architecture design still cannot be developed throw an algorithmic system. In fact, no one has dared to develop any software to solve "on a logical way" an architectural solution according to certain exigencies. The amount of inputs is that big and the form concept is that strong that make it impossible.

How to teach architecture? That's a long story. But how to add sustainability to the teaching of architecture is our story.

It should be about linking environmental exigencies together with the whole of exigencies of the building, trying to stay on global solutions and avoiding specific solutions only solving one exigency. It should be not about environment all alone, but about making sustainability possible in the very complex scene of the architecture design. And it should never be something only for specialized professionals.

7. Conclusion

It's all about the architects bearing in mind design decisions versus environmental impact.

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