

# From Traditional to Smart Building Materials in Architecture

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**Abstract.** Building materials from traditional to contemporary and from traditional to high-performance materials in architecture and their implementation in energy-efficient constructions can be compared with smart ones? Can we bring these materials to superior performance? Building materials in general, either smart, energy efficient or with new performance, are based on the same traditional materials. A material is considered to have special properties only when it contributes to the improvement of construction criteria. With all these advances in construction techniques and architecture, along with end-user demand for 2021 buildings, as architects we will need to introduce something new and smart to meet their requirements and needs. We can build intelligently and at the same time use traditional materials or current construction, needs guide us to a new era of building materials, high-performance materials, smart, etc. This abstract is a comparison between the high performance direction that is foreseen in the future in building with intelligent materials and returning to nature by using traditional building materials to build just as efficiently. This transformation is possible and to what extent the new requirements can bring traditional materials to these standards. The paper is an overview of the types of materials that can be used in construction and architecture, thus offering a new perspective on innovative techniques that will be available or are already available that improve this field. The comparison between classical concrete and concrete that changes the image of architecture through the created image or between traditional and performance materials for building envelopes are only a small part of the options available for use in construction and architecture.

## 1. Introduction

Throughout history, in the field of construction materials, innovation and development of materials has been achieved through a test of the physical and mechanical limits of them. What is new or old in this field is relative. They have been used since the very beginning of humanity, for primary or later developed needs.

High-performance materials, materials with superior properties are today materials that are more resistant, more sustainable, more durable than the basic one from which they started. The materials that have been used in construction for thousands of years are still present today to an overwhelming extent. Wood, stone, concrete are existing materials used in a large percentage in construction, however the development needs, have led to the creation of better materials on certain levels than the initial counterparts. These new materials are important because they shape our physical environment, leading to a deeper understanding of current needs.



Often, apart from the usual tendencies to improve the physical performance and chemistry of materials, there are also the tendencies to dematerialize and achieve counterparts that are the same but that we perceive differently being lighter or more transparent, without changing the initial structure.

## 2. Construction material throughout history.

Starting with the industrialization period, when there was a significant progress in the evolution of construction materials, from the evolution of steel structures, glass industries, then the development of materials in the aeronautical industry, with the development of capacitive materials with much higher qualities, until the present years when it is discussed the return to nature, sustainability but also zero energy consumption, building materials have experienced an expansive development.

Can the classic materials still fulfill the basic functions to satisfy the current needs? The decision in choosing the construction materials in the period before the 19th century was taken more based on the criteria of function and form and less on performance. "Materials were chosen either pragmatically – for their utility and availability – or they were chosen formally – for their appearance and ornamental qualities" [1,p.2]. Over time the more special properties of the materials have been achieved through continuous observation and through the experience given to their use. Matter is an objective reality, of which the whole surrounding world is composed. Man becomes aware about its presence through his senses (sight, hearing, smell, taste, touch), so palpable matter is in a continuous motion in space and time. "Beginning in the 19th century with the widespread introduction of steel, leading to the emergence of long-span and high-rise building forms, materials transitioned from their pre-modern role of being subordinate to architectural needs into a means to expand functional performance and open up new formal responses" [1,p.3].

Materials are, in fact, pure substances or mixtures of substances. Among the first building materials used by man were: wood, natural stone and clay. In areas where there is no stone, dry clay bricks were used. The emergence and development of capitalism determined the evolution of the construction materials industry because now there is a need to carry out civil, industrial and military constructions of great importance. For this purpose, new materials, techniques and construction technologies appear, such as: steel, monolithic reinforced concrete and prefabricated buildings, industrialization, etc.

Advances in all fields (biology, neurology, chemical) have led to discoveries in the intelligent materials field. In addition to increasing human requirements, there is a need for a framework for their application in architecture. Materials have become more than physical elements, they have become methods of designing architecture on more developed levels, of dematerialization or materialization, of constraint or not, with capacities to incorporate certain functions. An example of dematerialization can be translucent concrete. Concrete is a material that has always been perceived as a heavy, opaque or thick material, can now be a transparent, lighter material. So we can change the perception of architecture being able to see through the walls. Sometimes walls were changed from simple elements to close the rooms in to free-standing modular wall system. "Each brick, or "blob unit," is a trilobed hollow shape that is mass produced through rotational"[2,p.91]

The concern to create adaptive structures dates back no more than two decades. The study of materials with shape memory began sixty years ago and, gradually, with the discovery of new technologies, they became more and more efficient and used in technology.

There is a trend to gradually replace traditional construction technologies with new ones, which bring a number of advantages:

- ✓ improving the quality
- ✓ increasing durability over time

- ✓ obtaining a special design
- ✓ reducing the execution time

In order to understand certain materials we must define them. Such a definition is given by "technology theorist Clayton Christensen describes a new product or material that displaces an old one unexpectedly" [3,p.9]. He describes destructive technologies and applications, as superior to previous ones and they are an unexpected replacement of the old ones with newer ones. "While disruptive technology generally refers to a product or material, a disruptive application considers a more complex system or physical assembly—such as a building—as well as its larger cultural and environmental context. An application is not only considered disruptive in the result it produces but also in the methods used to achieve the result—such as in the robotic fabrication of brick panels instead of traditional hand-laying" [3,p.9]. This concept can be applied to many building materials.

An example can be ceramic materials, some of the oldest materials used in construction. They have undergone significant changes due to their contemporary use, with high strength or optical transparency properties, with higher mechanical performance, so they have been used not only in construction but also in the aerospace industry. Carbon fiber-reinforced ceramic composite materials have superior strength properties and are more recently used in construction. Terra Cotta, a classic material, is now used in architectural rain-screen application.[3,p.22]

### 3. Sustainable development concept

Today it is established a different approach rather than a classic one regarding the buildings. These are "organisms" in a permanent evolution, which, in time, must obey and submit to new requirements set by users during a certain time period. "A sustainable project is designed, built,renovated, operated or reused in an ecological and resource efficient manner"[4,p.127]

Smart and sustainable designing means carrying out architecture designs with protective features towards the environment, with solutions regarding minimum energy consumption and, at the same time, with provision of permanent and efficient sources of supplementary energy forms. The ecological building can be one of the solutions for developing a stable environment, taking into account that resources are not infinite and that they must satisfy the requirements of the activity sectors.

Based on the main type of information received from the environment, generally, comfort regards thermal, visual and acoustic comfort. The comfort level has a certain degree of subjectivism, mostly regarding its real perception, but on the other hand, it is the result of real, objective elements. These can be classified as architectural, constructive or operating. The achievement of a good acoustics of a building is related to a good sound insulation of the walls or windows. Some classic materials can be reused in architecture, such as straw bales or sound-absorbing tiles for ceilings. These reuses of materials have a great advantage in terms of ecological construction by recycling them and using natural materials.[5]

If acoustic comfort is not directly related to energy, thermal comfort and visual comfort surely are. And during the entire period of an year, we need a certain amount of energy consumption for heating, climate and lighting. The heat loss through the windows is 25% bigger that the total loss of a construction. Most of the times, when studies on lighting were done, scientists considered that the natural light has the same importance as the artificial one. This led to a partial interpretation of measures and variables on which they rely and also underestimated the advantages of natural light. Another very important aspect of integrating the natural and the electric light, is improving the building energy efficiency by reducing the necessary electric lighting. By implementing techniques and systems using advanced natural lighting, we can obtain an important reduction of the electric

power consumption and an increased growth of the internal light quality. Hence, a detailed analysis of the building and their location together with the connection to the outside environment can result in a classification criterion for choosing a certain configuration. This leads to a matrix used to describe and analyse some real or proposed buildings, putting these parameters on different hierarchical levels such as: Level I –urban context + Level II–building configuration + Level III–room.

This work aims at drawing the attention towards some architectural principals – the relationship between the construction materials – the natural light and the artificial one in order to obtain energy efficiency, ambient control and ecologic compatibility in designing new buildings and at the same time, modifying some existing buildings together with having a normal answering reaction to the present earthquake requirements.

The building materials – either traditional or modern, eco-friendly/natural or artificial– due to their diversity, role and function, evolve by transforming, being closely connected to the human society (educational level) but also to nature (pollution and/or protection).

The current tendency towards the use of building materials should be surveyed- the traditional vs. the modern attempts for substituting and/ or gradually improving their technologies and materials- and thus the world dominated by these building materials will understand/ discover the advantages or disadvantages of their use.

Some of the general requirements are:

- To respect the present standard rules regarding the quality of the materials and of the services;
- To encourage curiosities for investigating new phenomena or in the fabric procedures for the traditional building materials as well as for the current, everyday advanced or smart ones;
- To stimulate the enrichment of the technical vocabulary already acquired correspondently ( by knowing the main classes of traditional and modern building materials);
- To know the categories of the building materials currently used on every work site and the present products used in architecture, constructions and Architectural Finishing Systems (ecological, composite, durable, advanced, smart)
- To improve the scientific knowledge in the domain of new materials which (chemical, electric, optical, magnetic mechanics) have far more superior properties than the classic materials.

#### 4. Conclusions

Although the changes and evolution were made at the level of elements, it must study the construction materials in accordance not only with the direct needs, but at the overall level. That is why it is important to take a step and see the needs of humanity from macro to micro. This is the question of: interaction between the building and the outside space and the interaction between the building and the interior space. Before choosing whether to use traditional materials or design an “energy-conscious” construction, we need to review all the factors that can influence the choice of certain solutions. Basic parameters must include and integrate natural energy, and in particular solar energy, into the energy balance of buildings. Engineering is the “art or science of making practical application of the knowledge of pure sciences”. We need to learn from nature the method of adaptation through systems, that change depending on the environment, to look at how these systems through muscles, nerves are designed to produce adaptive life functions.[6]

To achieve a sustainable architecture we must consider: energy efficiency, design passive solar, design the solar asset, high level of insulation, effective air and water heating, ensuring correct ventilation, correct lighting systems, proper waste management. We have to use: renewable materials, non-toxic materials, recyclable / recycled materials, materials from local sources. New trends in the

new construction materials sector take into account: efficient building materials and resources, smart materials, biotechnologies and environmental protection, nanomaterials and nanotechnologies.

We can study and develop construction materials on three levels. This leads to a matrix used to describe and analyse buildings, putting these parameters on different hierarchical levels such as: Level I–urban context + Level II–building configuration + Level III–room.

#### Level I–urban context

Urban areas are major consumers of materials and energy. Researchers and urban planners recognize the challenge posed by environmental problems, urban infrastructure and natural resources. The execution of the numerous works of systematization of the urban localities must ensure superior hygiene, living and rest conditions as well as demanding visual working conditions, simultaneously with a rational energy consumption and optimal investment and exploitation costs. The natural factors increased in the urban environment due to the urbanization lead to changes in the energy performance of the buildings and of the external thermal comfort. The increase in these factors leads to more in-depth studies on the use of certain systems. The choice of materials is an important factor in the general analysis of urban development factors. "Urban policy makers and researchers consistently recognize the challenge of more effectively reshaping the linkages between cities, urban infrastructure, ecosystem services, and natural resources"[7]

#### Level II–building configuration

Buildings must be in line with development trends in the field of construction materials and technologies, in close connection with the growing expectations of the occupants regarding the quality of the interior environment. Research activity on the passive house and the nearly zero led to a different understanding of the choice of building materials and also led to a step forward in the development of alternative systems like proposing new energy-efficient solutions using materials with low embodied energy (wool, soil, cellulose), classic materials that find a new opening through their contemporary application. Various studies have been done and a significant decrease in the embodied energy of buildings has been demonstrated if higher quality, more efficient materials are used.[8] Innovations in the field of architecture and construction regarding sustainable materials are constantly emerging. Sheep wool has been used not only in construction but as an absorbent material for various substances in agriculture. In construction it is used more recently as a material for thermal insulation.[9]

#### Level III–room.

If on level III of the room our perception is as volume, as perimeter. We conceive these spaces as a space with air and light and we define it as a surface that delimits interior with exterior. This leads to the creation of multifunctional systems that respond to several factors. The wall has been and will always be a need for protection against external factors but our needs have increased so the walls are not only to protect in the minimal sense but to protect at a higher level. Its important to be made of multifunctional material, to meet all external factors, protecting from sun and wind, but also to isolate or integrate photovoltaic systems, sensors or smart materials that lead the evolution of the concept of smart facades.

An ecological architecture harmonizes the interests of man and the environment, recognizes and activates the network of forces and relationships that exist between architecture, man and the environment.[10] This type of design minimizes pollution and negative effects on the environment. The "solar", "bio-climatic", "ecological", "green", "intelligent" construction offers new possibilities

for the dialogue between the architect and the construction material. An open dialogue, which, due to variable climate conditions, must be permissive. So the evolution and the changes in the field of construction materials, the choice of a traditional or smart construction material must be made considering the macro view on the construction systems starting from the urban level to the interior level.

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