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NEW EMERGING MATERIALS BETWEEN ARCHITECTURE AND ENVIRONMENTAL PROTECTION

Abstract: *Twenty first century brought many new technologies and research possibilities. We are witnesses of research boom that gave us as a product many different emerging materials. Through smart evolution and correspondence between different research fields inducted through new scales (micro and nano) of material observation and interaction life was given to these states of art materials. Without any direct or indirect use, emerging materials are basically useless. In this paper properties and performances of emerging materials will be examined and analyzed in correspondence with architecture and environmental protection. This way new approaches for protection of environment (air, water, soil and biota) will be made possible.*

Key words: *emerging materials, architecture, environmental protection*

1. INTRODUCTION

Since humans first learned to use wood and stones to create tools, human race have manipulated the materials around them, and invented new materials to make lighter, stronger, more efficient, and higher performing products. Modern day life would be hard to imagine in any aspect which has not been improved through advances in materials science and technology.
The construction industry consumes more natural resources than any other industry. The increase in public awareness and rise of the needs and demands of sustainable development and environmental conservation has passed large burden on to building industry. The industry has been given task to evolve their practices to satisfy the needs of our current generation, without restraining the resources of future generations to meet theirs. For example, concrete is by far the most important building material, with billions of tons produced each year worldwide, and without which the nation's infrastructure is unthinkable. Considerable progress and breakthroughs have been made in recent years in concrete technology, which have largely gone unnoticed by the public at large.

It is said that more progress has been made in the last 25 years than in the previous almost 200 years since Portland cement was invented. Modern cement composites can now be modified to have strengths similar to those of steel, very low energy squandering and durability properties that can make it last principally indefinitely, while giving it decorative and aesthetically pleasing futures as natural stone, but with superior mechanical properties. Composites reinforced with fibers in the aerospace and automotive industries decades ago and are now finding their way into civil engineering structures. Smart materials, defined as those materials that can change their properties in response to external conditions, are also starting to be used in civil infrastructure systems, and so are new developments in metals, with new high-strength steel alloys and non-corrosive steels that are changing engineering practice.

All of these advanced materials are essential for an efficient renewal and maintenance of our infrastructure. The variety of possibilities offers exciting prospects for vibrant research areas. But one of the main goals all of these research efforts should be guided by the overarching goal of reducing footprint on planet from the construction industry.

Realizing the needs and the requirements of modern age, care about environment is becoming extremely important topic, which is present in all fields. Working towards lowering and positively influencing environment, architecture must achieve sustainability. Sustainable architecture includes green technologies and materials needed to design and construct energy-efficient, environmentally friendly, and sustainable buildings. Smart – sustainable Architecture adopts new developments, innovative techniques, and advanced technologies that helps it restore the balance between the user and the natural environment.

Advanced materials role is all present and evolving in the fields of architecture and environmental protection as one of the most carriers of the interrelations and progress.

2. DEFFINING ADVANCED MATERIALS

Understanding the fact that buildings forma part of the environment and that in that process cause a large part of environmental pollution, we can conclude that environment and architecture are inseparable. And there for the following equation stands:

$$\int (he) = Ka * Ke * Km * Ko \qquad (1)$$

This equation represents dependence of healthy environment on architectural coefficient (Ka) in correlation with environmental coefficient (Ke), material coefficient (Km) and other less important influences (Ko). Having set basic relations we can see how huge role advanced materials have in maintaining relations of architecture and environment.

Great attention should be given to the use of innovative smart materials which enhance environmental sustainability, cost-effectiveness and security. New technologies and high-performance materials are being developed to meet those needs, offering innovative and creative solutions for long standing problems, especially for negative impact on environment. Providing benefits, whether to structural stability, the environment or to the maintenance and repair process, they affect positively architectural design thinking. One of the major goals of these materials is to find new class of advanced materials, considered as multipurpose materials, that is required for creative architecture and constructions through sustainability.

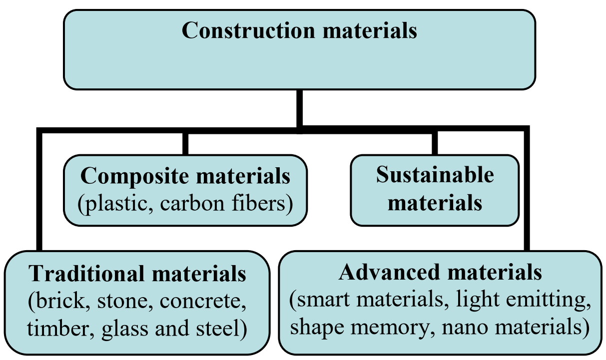

Fig. 1. Construction materials layout

Architectural materials are generally deployed in very large quantities and building systems needs to tend to be highly integrated into the building to maintain homogeneous interior conditions. Materials and systems must also withstand very large range of temporary exterior conditions. The combination of these two general requirements tends to result in buildings of high thermal and mechanical inertia, and highly interconnected with environment.

Advanced materials can be considered as engineered materials which are able to provide a unique beneficial response when a particular change occurs in its surrounding environment. They can also be considered as materials that remember configurations and can reform to them when given a specific stimulus. In environmental terms we can consider as advanced materials those materials that sense environmental events, a process that sensory information, and then act on the environment. In architectural terms, advanced materials are high technological materials that when placed in a building they respond intelligently to the climatic changes. These materials responsively react to changes in interior and exterior environments through material properties or material synthesis. They are considered to be a logical extension of the trajectory in materials development toward more selective and specialized performances, and they are in a way similar to living beings- having the ability to sense and are capable of adapting to changes in the environment. Exploiting these materials, a complicated part in a system consisting of individual structural, sensing and actuating components can now exist in a single component, in that way reducing in general size and complexity of the system, but they can never replace system fully.

3. ARCHITECTURAL MATERIALS INFLUENCING ENVIRONMENT

Whether a molecule, a material, a composite, an assembly, or a system, advanced materials and technologies implementing them needs to demonstrate the following characteristics:

-Immediacy – to respond in real-time
-Transiency – to respond to more than one environmental state
-Self-actuation – intelligent to activate it self
-Selectivity – to be able to respond on selected stimulus
-Directness – to respond directly to activating source
-Environmental friendly- to positively influence on surrounding environment

3.1 Advanced material types

Taking into account all stated above we can separate materials in following groups, based on their abilities:

-Thermochromic – an input of thermal energy (heat) to the material alters its molecular structure. The new molecular structure has a different spectral reflectivity than does the original structure. As a result, the material changes color – its reflected radiation in the visible range of the electromagnetic spectrum.
-Magnetorheological – the application of a magnetic field causes a advanced material change in micro-structural orientation, resulting in attribute change.
-Thermotropic – an input of thermal energy (or radiation for a phototropic, electricity for electrotropic and so on) to the material alters its micro-structure through a phase change. In a different phase, most materials demonstrate different properties, including conductivity, transmissivity, volumetric expansion, and solubility.
-Shape memory – an input of thermal energy (which can also be produced through resistance to an electrical current) alters the microstructure through a crystalline phase change. This change enables multiple shapes in relationship to the environmental stimulus.
-Photovoltaic – an input of radiation energy from the visible spectrum (or the infrared spectrum for a thermo-photovoltaic) produces an electrical current (the term voltaic refers more to the material which must be able to provide the voltage potential to sustain the current).

-Thermoelectric – an input of electrical current creates a temperature differential on opposite sides of the material. This temperature differential produces a heat engine, essentially a heat pump, allowing thermal energy to be transferred from one junction to the other.
-Piezoelectric – an input of elastic energy (strain) produces an electrical current. Most piezoelectrics are bi-directional in that the inputs can be switched and an applied electrical current will produce a deformation (strain).
-Photoluminescent – an input of radiation energy from the ultraviolet spectrum (or electrical energy for an electroluminescent, chemical reaction for a chemoluminescent) is converted to an output of radiation energy in the visible spectrum.
-Electrostrictive – the application of a current (or a magnetic field for a magnetostrictive) alters the inter-atomic distance through polarization. A change in this distance changes the energy of the molecule, which in this case produces elastic energy – strain. This strain deforms or changes the shape of the material.

3.2 Cutting edge advanced materials

The following building materials represent cutting edge technologies that will help to restore unity between architecture and environment.

3.2.1 Colored solar thermal cladding

One main barrier to the acceptability of façade use of solar thermal collectors is their black appearance and the visibility of piping or absorber irregularities through the glazing. Developments focused on producing colored thermal collectors suitable for smooth façade integration**.** To facilitate façade integration, material is developed with selective filters reflecting only a small part of the solar spectrum in the visible range while letting the rest of the radiation heat the absorber.

These filters were successfully produced and combined with a diffusing glass treatment. They have achieved the desired masking effect with only a minor impact on the collector efficiency (less than 10%). Glasses of various colors combined with several diffusing finishing (acid etching, structured glass etc…) can be produced that are able to hide the absorber. Such glazing will allow the use of the same product both on façade areas equipped with solar absorbers (as collector external glass) and in front of the non exposed areas (as façade cladding)**,** opening the way to a broad variety of active façade designs.

3.2.2 Self-Healing Concrete

Also known as bio-concrete, it is usually used to fill up cracks in the existing concrete. This kind of concrete uses a simple process to close the formed crack. The main mechanism is achieved by making a concrete mixture that contains a precursor like calcium lactate ($Ca(C_3H_5O_2)_2$) and bacteria planted in micro capsules or just added to the mixture that will later germinate, once the water reaches the crack. As soon as the bacteria germinate, they produce limestone ($CaCo_3$) caused by the multiplying bacteria. Incorporating bacteria in concrete adds a double layer shield in order to prevent corrosion in steel, it also employs oxygen present which would then benefit the process of steel corrosion. The bacteria which are applied in this kind of concrete are spore-forming and alkali-resistant bacteria. Using bacteria as a healing mechanism is one of the best mechanisms to produce this kind of concrete because of its sustainable organic properties.

3.2.3 Photocatalytic TiO_2 self-cleaning coatings

The coating is made of a superfine titanium dioxide (TiO_2), a pollution-fighting technology that is activated by ambient daylight. This is the nano photocatalytic version of conventional TiO_2 commonly used as pigment and already known for its self-cleaning and germicidal qualities. It requires only small amounts of naturally occurring UV light and humidity to effectively reduce air pollutants into harmless amounts of carbon dioxide and water. When positioned near pollution sources, the coated surfaces breaks down and neutralize NOx (nitrogen oxides) and VOCs (volatile organic compounds) directly where they are generated. The most adequate way of using this coating is to design facades or modules that will be coated, so that they will have more surfaces to maximize the effect of TiO_2, capturing omni-directional light where light is dense or scarce.

4. CONCLUSION

The application of advanced technologies and smart materials has the ability to significantly improve the sustainability of buildings and the environment. Many of the advantages offered by these materials and technologies can be appropriated by a greater diversity of designs for new and retrofitting existing buildings. Material properties are determined by either molecular structure or microstructure. So, architects have to understand all material behavior in relation to the phenomena and environments they create. Architects must consider advanced materials as a functional element in design, especially as their abilities can help improve environment.

The twenty-first century has steered in a period of pressing threats to the environment, rising energy costs and a firming resolve that sustainable architectural design can gain in long-term resource preservation and overall quality of life. Using sustainable ideas we can crate clean technology products and processes that not only protects environment, but do so profitably.

We must achieve high level of understanding of advanced materials, their correlation, compound, interactive and complex connection between architecture and environment. Understanding these relations is primary step in adoptions of advanced materials and their quality use. Considering all of this, advanced materials are to be regarded as a key driver of

architectural innovative design, new smart materials which start to appear in the architecture field, emphasizes this design approach, and it gives us new possibilities and potentials which affect the way we think.

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