Effectiveness of smart materials in buildings to reduce energy consumption

Shahram Mohammdyani, Hadis Mohammadyani, M. Amin Mohammadi, Farshad Marzbanpour

1Member of Architecture Faculty, Islamic Azad University, Kermanshah
2Lecturer of Architecture, Islamic Azad University, Kermanshah
3Architectural Lecturer at Sama School, Unit of Islamabad Gharb
4Architectural Lecturer at Sama School, Unit of Islamabad Gharb

In contrast to the world around us with arrival of a lot of cars and industrial production, the resulting in reduced energy stores, looking for a new system in order to further advance the technology to the preservation of nature and the revival of the welfare. Sustainable architecture as well as an important branch of contemporary architecture, in dealing with the effects of technological progress and industrial communities, has offer ways to reduce the environmental damage, the construction industry and offer the new buildings in harmony with the nature. Necessary to achieve such a building is heading back to work in production technology, by using smart materials and new materials that conduct ecological building intelligent management of energy in order to move forward, and that it means using materials that adapt itself to environmental changes in best way. Due to reduced energy stores to take advantage of smart materials that can reduce energy use in buildings, including the necessary steps in the construction field. This paper first introduces the concepts of sustainable architecture and smart materials and then by introduce a new smart materials, strategies to achieve the goals of sustainable architecture, by using of these materials is provided.

INTRODUCTION

As we know, the industrial revolution and technological advances in the field of architecture, vernacular architecture around the world that would shape in accordance of its nature and environment and Consistent with the climate forgotten and day to day the usage of groundwater is increased. In the 70 decade, societies of environmental awareness, had reactions that the development and sustainable design are the basic cases. Humanism, with respect to the environment, by using recyclable materials and the use of renewable energy from design the principles, and are sustainable. Building materials as well as one of the constituents of building should follow goals sustainable design in the best way. Nowadays, with the development of techniques in the field of materials and construction techniques, buildings with higher performance, economically more cost-effective and better built environment, and advances in technology led to offering new material as “smart materials” to the architectural and engineering community. It is composed of materials that have a certain understand the environment and react to it and the specifications for such a significant external factors influenced by temperature, light, humidity, magnetic influences and altered. High potential in developing smart material forms and more adapted to the environmental conditions cause a revolution in the field of architecture is currently, in such a way that even according to the German architect Axel Ritter: “The color, size and shape of buildings in the future will be able to modify by the exchange of environment.” Architects will be able to design the geometry of the buildings they are changed according to the weight of the people inside the building.

The best way to design buildings can interact with the environment and also save more energy provide, is identify and understand the characteristics of smart materials and their application is inevitable.

2 - Concepts of sustainability

In my dictionary Dehkhoda, the meaning of sustainability is durable and lasting stability. Meaning for the word sustainability is considered in this matter is: “what can be sustained in the future.” Environmental sustainability is also on this basis is the idea of sharing the land in the best form for the next generation, with
this definition the human activity only the time is in terms of sustainable environment, which natural resources without diminishing or degrade the natural environment can run. Environmental sustainability with the aim of preserving the environment in the field of working architects emphasize on items such as the use of renewable materials, energy supply and conservation and its full recovery without creating pollution and………etc. [1].

2-1 - Sustainable Design:

Raised in the definitions for sustainable design, more on the idea of environmental sustainability is sometimes associated with the architecture will be emphasized, including the construction of sustainable buildings: that has the lowest natural environment influences on the conflict over the life of the building and has the establishment of regional and global efforts.

Principles of sustainable design are based on the fact that building should be a small part of the surrounding nature and function of ecosystems and the life cycle. Speaking of sustainability in architecture can be interpreted to conceive and design the future construction of buildings and not just physical stability, but stability and preserve the planet's energy resources. Thus, this appears to be consistent pattern of thought that is based on materials and sources available, more over waste or neglect, is to be applied more efficiently. In other words, the sustainable design should concentrate on building capacity to integrate environment and climate change them into the space and comfort and form qualities. Due to popular principles of sustainable architecture attention to the quality of indoor spaces is important. Without a doubt good quality regardless of the nature; appropriate skylight does not provide adequate space and ventilation. Additionally, the stability and durability of the building itself as a phenomenon is considered, therefore, with the ability to build high quality and using durable materials must also be considered. Using design principles to achieve such conditions, efficient management and use of the latest technologies in the field of building materials is possible [3].

2-2 - Principles of Sustainable Design:

Place identifying: Sustainable design is brought to identifying the place because if we have sensitivity about the issues of delicate place we can dwell without destroying. Place identifying like lighting in a building designed to help protect the environment and even is easier to access.

Contact with nature: the design of the site, what dose within the city or in the natural environment is harmonious with nature, drawing back to life and influences in their environment is designed to help us to have the natural space.

Identifying the natural process: is not in waste nature. Produce make food organism for other, and providing a sense of natural systems that have a closed cycle. Working with living processes, we respect to need of species and with design that be in their own the cycles of nature, we give back design to life.

Identifying environmental influences: sustainable design is an attempt to have an identifying of and environmental impacts with assessment of the site. The negative effects of environmental with performance of renewable energy, technology of constructions and choice of sustainable materials can reduce.

Identifying people: sustainable design have the vast expanse of cultures, generations, religions and habits of the people who make it work and are residing in or of interest to, and this requires a sensitivity to the needs of people and society. [2].

This question can be raised after knowing the location, nature and people and reviews of all its needs and how relationships can be used to create a favorable environment that is both physical and spiritual needs of human provisioning and could also be an optimal relationship with the natural environment and organisms?

According to The reviews and studies in this field, one of the most important ways to achieve sustainable design principles, is use of new technologies in the construction industry, such smart materials of construction that can be named in went on to introduce this material and its features, and how to correctly apply this material to reduce the energy consumption in the building stages.

3 - Smart Materials:

3-1 - Definition of smart materials:

Smart materials are a new term materials and preparations that have the ability to understand and process environment events and react appropriately is represented. In other words, these materials are variable and are able to change shape, form, color and energy of their inner fashion in reversible manner in response to the physical or chemical environment effects. If material is classified into three groups: not smart, half smart, smart, we first group of materials, not smart, has not high specific features, half smart only able to respond to environmental influences of shape soon changed or once but in smart materials that changes are repeatable and reversible. Smart material are well known as "flexible" and “adaptive” due to their special characteristics and circumstances of arrangement with environment.

1) UV rays: ultraviolet and visible part of the electromagnetic radiation.

2) Temperature: The temperature changes of a physical system created like the human body.

3) Pressure: The pressure difference created in a region.
4) Electric field: electric field created around once.
5) The magnetic field: Field is created around a magnet or moving charge.
6) The chemical environment: the presence of a particular chemical element or compound, such as water [6]

3-2 - Types of smart materials:
Generally available ranging from traditional building materials, natural and artificial, due to its characteristics, including its appearance, texture, composition: chemical, mechanical and physical properties, environmental impact, etc. are classified. But considering the classification of smart materials in addition to the above features, in particular to distinguish the different properties of smart materials of traditional materials is also included. The proposed classification of smart materials presented are based on the following three properties:

3-2-1 - the intrinsic properties:
Smart materials that change shape
Smart materials that change color
Smart materials that change binder
3-2-2 - The ability to exchange energy:
Smart materials that emitting light
Smart materials that producing electricity
Smart material that saves energy

3-2-3 - change and exchange internal material:
The inner conductor material [5].

4 - Reduce energy use with appropriate application of smart materials:
4-1 - Temperature responsive smart materials:
These types of materials have inherent characteristics that enable them to react the sense of environment temperature changes reversibly. Effect of temperature changes may have disabled so that the internal temperature of continuous materials with your natural state, having set up through the outer shell and if it is actively influences, some kind of active heating to apply an electric field can be created through contact. A sample of the reaction temperature materials (TEM) with the abbreviated name (Thermal Expansion Material) is expandable material which has a coefficient of expansion thermal. But the most important applications of them is in the heating thermostat architecture for building services as well as special incentives in greenhouses and in view of the buildings to control and manage energy. Their other use is in the ventilation system of building rooms. Workings of the system is such that the specified temperature system is open or closed to provide space ventilated conditions. They can also raise or lower parts of the roof lining, automatic, as components of the ventilation system shall be designed in view of the buildings. Applying this kind of smart materials in accordance with appropriate ventilation systems require complex and highly denies spending and energy consumption slows down considerably as much. [6]

4-2 - smart materials that change color:
These materials are capable change color or visual characteristics in response to external stimuli in the form of one or more reversely. These materials include various types according to their driving motivation, but some of them are in great architectural applications, including photochromic, thermo chromic and electro chromic. (Addington, D. Michelle; Schodek, Daniel L. 7004002).

We have highly regarded architects PC abbreviated (Photochromic Material) are photochromic materials. Although initially applied to these materials because of their beauty (because of the color spectrum of the light) however, researchers did a lot of research on the study of materials in order to reduce the energy consumption of this product for other functions such as temperature changes of the coatings used. Electro chromic materials are used in the architectural glass electrooptical. The materials exposed to the sun's rays, the visual characteristics of its transparency change [6].

Fig. 1: windows made of photochromic glass. [4]
4-3 - smart materials for energy storage:

Transparency and the ability to heat conduction can be used at any time that the temperature of the indoor space is higher than the temperature of the bi-directional flow to be established outside of the radiant energy is transmitted into space while the thermal energy to the driven out. Change in net absorption of glass ultimately affect the conductivity flow and will cause a change in the equilibrium state. Many materials such as photochromics, thermochromics, thermo tropics, electro chromic, liquid crystal suspended particle system usability are making smart windows. In many cases, smart materials can be used in windows, and can be used interchangeably, for example, electro chromic, liquid crystal materials with suspended particles, all of them are used in guidance and control of light and heat, the maximum difference in the activation of these materials is by electric current (M., Kienzl, N. and Schodek, 7004:770).

The materials and energy products can either shown or hidden in their stores, such as light, heat, hydrogen or electricity. It is noteworthy that this vulnerability is also back feature materials. So this building will be able to save energy are different. It is noteworthy that these materials have the ability reversible. Therefore; these materials are able to store energy in different ways.

But among them smart materials saving heat has much interest in, these materials have an inherent characteristic which enables energy to heat or cold (inverse temperature) are stored in the form of potential energy [4].

The materials used in architecture and are regarded highly. They are widely used as switching material is known to those materials and preparations abbreviated PCM (Phase Changing Material) refers to the server that can act as intermediaries temperature regulation. For example, cold and heat storage as intermediary element or attribute that the heat have their status from solid to liquid state to withhold PCM device settings the temperature inside the room. Crystal materials change and a certain amount of thermal energy that is already stored in a higher temperature of the reverse mode free itself by changing from solid to liquid state at the time of entry of the amount of heat or heat energy keep the temperature constant. It should be noted that materials with high thermal storage capacity or a lower thermal dissipation are not in this class of smart materials.

PCM as an example of these materials that can be named windows in which the hydrated salt is used as the transparent hollow plastic blocks. The system is working it out in the summer sun's rays by a prism panels will be returned to outside. The heat of hydrate salt (hydrated salt heat stores in at temperatures from 26 to 28 degrees Celsius) turn into solid to liquid state and heat as latent heat is stored in the system. When room temperature is lower than 26 ° C, for example at night or on cloudy days, and release hydrated salts crystallize and heat energy stored in room [6].

Fig. 2: change the molecular structure of radiation photochromic materials (the same)

Fig. 3: Degree of windows or insulated salt hydrates, summer and winter [6]
Another advantage of this system is that the charge state whether or not the storage system, is visible from the visual appearance. In this way, if the view seems so hydrate thermal storage is salt charging but if transparent mode or semi opaque façade has been salt hydrate deposit in the view and its thermal reserve is full.

Fig. 4: Details of the facade windows in charge state [6]

Fig. 5: Details of facade windows in charge state [6].

Conclusion:
Research on new materials, puts new horizons on architectural design. Intelligent and specifically the use of smart materials that respond to the environmental issues may facilitate maintenance of buildings; increase the useful life of buildings, to prevent excessive consumption of energy, and creating creative architectural designs. In addition, through the design, based on the characteristics of these types of materials, can be the greatest amount of savings in energy consumption in the building that the same thing led to realization of the objectives can be sustainable architecture. In the arena of global competition in line of the correct and optimum use and produce more energy, countries and Nations that have been successful in the competition, said that perhaps in another look, this name of the activity is survival struggle and continue to fight for the win, The studies fail success to find new technologies and then apply the methods and ways to stop wasting energy. Today, in many parts of the world, there are many modern homes with photovoltaic Systems with minimum public electricity or even without public electricity; the energy required is produced independently. In view of the fact that our country has a favorable climate can be fertile ground for the spread of this technology in the field of architecture, clear horizons of research in this direction could be facing practitioners in the field and provided good conditions for energy efficiency.

REFERENCES


