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Architecture Building Sustainability Regarding Smart Materials

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ABSTRACT: In contrast with the arrival of machine and abundant industrial production that leads to reduction of energy resources supply, the world around us is looking for modern systems to be able to not only improve technologies for welfare of human, but to conserve nature and restore resource. As an important branch of modern architecture dealing with adverse effects of technological progress and industrialization, sustainable architecture offers strategies to reduce demanding building industry on natural environment and conveyed modern buildings compatible with nature. What is important to have these buildings, is to reuse technology in smart studding and new material that can improve ecologic behavior of building in smart management; that is, using materials that can adapt itself with environmental changes in the best way. By reducing energy resources it is necessary to use the materials that lead to reduction of energy consumption in buildings. In this paper, first consistent architecture conceptions and materials in Iran are discussed and then with introduction of smart materials, there will be some solutions in order to achieve the goals of constant architecture by using these materials.

Keywords: Sustainable Architecture, Building Features, Smart materials.

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INTRODUCTION

Over the last century, technology has had a noticeable development in making crumble of bigger pieces. But modern technology in the present century is somehow different. It combines super-crumble materials in order to gain bigger and better ones, the same way the nature applies in production. The final goal of researching smart material is finding the new class of materials with the method, considered as a multipurpose material; what required for the survival of the phenomenon in the recent days. With respect to increase of greenhouse gas emission, global heating, jeopardizing environment, and the importance of energy sustainability, presence of architecture in this area will be very important. Sustainable architecture is one of the issues of the world architecture that Nano technology plays an important role in its realization in construction materials. This phenomenon goes toward simple, stronger, lighter and cheaper materials than current materials through the help of intellectual technologies.

With growing warming of the earth, and the loss of its natural resources, we need to look for solutions to protect the environment. This problem not only relates to our life but also can be dangerous for the future generations. Regarding the fact that buildings form a part of environment, therefore, cause a larger part of environmental pollutions. With an accurate thinking, designing and planning, building could be constructed with less negative effect on environment. Sustainable architecture is one of ideas for planning and designing such buildings. Thus, considering their effect on environment and energy, smart materials can play an important and determinant role in help and maintaining environmental health.

Research objective

The objective of any scientific research is to recognize realities, limitations and restrictions, observing opportunities and making them more tangible, by providing practical methods that can be considered as a proposal or theory. This study aims to review the terms of sustainable material in Iran to investigate the role and function of smart material as flexible approach in architectural materials in order to reduce energy consumption and to reduce environmental emissions in the construction.

Literature Review

The form of modern buildings that is related to needs of human today, it is not only because of different design, but implementation and the type of materials used in constructing are also influential in modern building difference. Today, human has entered a new era and acts more sensitive than previous. New look of human to maintain environment and save energy consumption is result of this new approach. Without material there will be no production. Moreover, at any design, materials represent rational principals as well as emotions, and in most technical expertise provide a meaning for emotional inspiration.

At that time, "Paolo Soleri" made the word "Archeology" with combination of words architecture and ecology and started to make societies without automobiles (Shahrokhi, 2010). Subsequently, the first universal wave of environment formed and the word "sustainability" became fashionable. Transformations of urban societies in Iran, before globalization caused by industrial revolution, were very unnoticeable so the environment of the cities did not change considerably. From Qajar era and

especially from Pahlavi era urban structures a long with economic, social and cultural transformations have changed basically (Kabiri Dehkordi, 2014).

In last two decade technical and aesthetical observations were considered in constructions. Among these new progresses, material engineering lead to the increase of modernization technologies, and like aesthetics aspects of materials it can be suggested as a design opportunity. Well-known materials in today's constructions include brick, stone, plaster, iron, steel, glass and concrete, while, in last decade the great effect of natural material has been considered. For example, demands relating to wood structures, croton steel, oxidized copper, Zn, multicolor furnace brick and new types of concrete indicate this issue. But it should be accepted that these progresses are disappearing soon (The structure engineers of Arvin, 2010) .But one of the shortages that threaten this generation wontedly or unwontedly is Lack of attention to the potential caused by the use of indigenous materials and architectural lack of adaptability to climate (Mehr Ali, 2012). Modern and smart materials have great effect in decrease of energy consumption. One of the effective ways to decrease energy consumption in buildings section is using modern materials and technologies of construction (Ghale nuri, 2011). Survival of human sustainability and its environment depends on maintaining balance and durability of life that requires accepting the role and moral responsibility of human supervision on ecological resources and informed and smart performance in adjusting its relations with natural environment (Sedigh, 2011). New look at construction method, also requires application of new material. Although construction technology or implementation method of applying these new materials may be unfamiliar, but recognizing new material and exploring their properties have influential assist on creating the need for them in the society (The structure engineers of Arvin, 2010).

Research Questions and Hypotheses

– Application of proper and smart material in architecture can influence operation and maintenance of environment.

– Applying smart material in architecture and achieving new forms, new method can be achieved in future architecture, because refers to important issues such as smart material and regarding lack of using environmental pollutants.

Does using smart material leads to better quality of sustainable architecture?

Does using smart material puts the building in front of nature or along with it?

Research Methodology

Descriptive study can only be used for more reorganization of present conditions or to help decision-making process, and to answer the research questions such as what relationship exist among events? (Sarmad et al., 2009)

Based on the objective of this study to determine application of smart materials in construction industry and architecture, in addition to referring reference and library resources, using analytical-descriptive methods, investigates various aspects of materials in construction and architecture and studies their effect on sustainable environment and reduction of pollution.

Theoretical principles

Concept of sustainability and sustainable development: Human life always has been dependent on available resources at all periods of his life. This dependence reached to the summit after industrial revolution and caused indiscriminate use of natural resources, irreversible energies and fossil fuels from human. Danger of run out of irreversible resources and environmental problems such as global warming, ozone layer perforation, air pollution, etc. causes the formation of the movement toward environmental sustainability. Environmental instability, social and economic instability in the last decades of the twentieth century led to the formation of a global and comprehensive "sustainable development" movements, which seeks to develop in the cultural, social, economic, and natural areas.

Sustainable development is a concept that considers constant supply of needs and satisfaction of people with increased quality of life. The concept of sustainable development can be seen as a continuation of development concept approach that while trying to improve the economic, social and cultural level in the context of financial, natural and human resources, make sustainable human development also possible. Improvement in cultural, economic and social level along with the rights of future generation and social justice for them, is considered as the objective of sustainable development (Poormokhtar, 2011).

The concept of sustainable development in different extents of life is very important, however, these different discussions have been classified at three comprehensive extents: social development, economic development and environmental development. Hence, in the case of realization of every three extent, sustainable development achieves its comprehensive meaning. In fact, it can be said that sustainable development is cooperation district of triple development extents (social – economic – environmental).

Sustainable Architecture: It refers to giving solutions in physical, environment, social, and cultural fields that can prevent problems such as destruction of natural resources, degradation of ecosystems, environmental pollution, increase of population, the prevalence of injustice and low quality of life and reduce the balance between humans (Soflaei, 2004). As Tadoo Ando says: “I build houses that are endurable in nature". In another word, sustainable architecture is responsible for building houses that can be endurable, and not only be a keeper of identity but also accord with mental pictures during history, present and future (Panahi, 2007).

Principles of Sustainable Architecture

In order to achieve sustainable development, there should be some principles to be observed.

a. Implementation and sustaining the use of renewable solar and wind resources

b. Optimizing the use of resources and minimizing natural resource consumption that proportionately is less than their natural growth.

c. Minimum production of wastes and pollution that can be absorbable in local to global environment scale.

c. Providing basic needs of human and society and creating a healthy environment for future generations (Singari, 2007).

Smart Materials

Definition of smart materials: Smart material is a new terminology for material and productions that have capability of perceiving and processing environmental events and show proper reaction to them. In other word, these materials has capability to change and are able to reversible change their form, color, and internal energy in response to physical or chemical effects of surrounding. If materials are classified in three groups of non- smart, semi-smart and smart. First group, non-smart materials don't have above-mentioned special characteristic. Semi-smart materials are just able to change their form in response to environment effect, for once or short time; while in smart materials these changes will be repeatable and reversible. Smart materials are also known as "flexible" and "adaptive", and this is due to their particular feature in adjusting with environmental conditions. The effect of chemical and physical variables is stimulants that smart materials react against them.

☑UV light: UV and visible parts of electromagnetic radiation

☑Temperature: temperate changes that a physic system creates, like human body.

☑Pressure: pressure difference created in an area.

☑Electrical field: the field made around an electrical load.

☑Magnetic field: the field made around magnet or moving electrical load.

☑Chemical environment: presence of an element with special chemical composition, like water (Ritter, 2007).

Types of smart materials

In general, housing material, whether traditional, artificial and natural, is classified according to their properties such as appearance, texture, chemical composition, mechanic and physical properties, environment effect etc. In classification of smart materials not only these features, but other characteristics that relates to distinguishing smart material from traditional material are considered. In fact, classification of smart material suggestions is presented based on three following features:

Capability to change intrinsic properties:
a. Modifying smart material
b. Color changing smart material
c. Bounding changing smart material.

Capability of energy exchange:
a. Light emitting smart material.
b. Electricity producing smart material.
c. Energy saving smart material.

Capability to change internal material exchange

a. Conductive smart material (Atkins et al., 2004).

Programs to reduce energy consumption

In his paper "Architecture and urbanism criteria and fuel consumption optimization", Naghizadeh cites energy consumption reducing plans, especially fossil energy, that can either in short time and long-time reduce pollutants discharged into the environment, and be effective in maintaining national and human capital, in four main classifications:

Tendency to nature: tendency to nature can decrease energy consumption from two types of programs, one is tendency to use renewable natural energies and the other is applying natural elements and natural conditioning and skylight for building.

- Executive and engineering operations: executive and engineering operations include extensive range of operations and programs from energy efficiency strategies to the identification of new materials as well as executive details. By executing instructions in Section XIX of National Building Regulations, there would be about 36% saving in fuel consumption for heating that leads to about 15% reduction of pollution, correspondingly, in power consumption, hence will save fossil energy consumption to cool the building.

Cultural issues: for example electricity saving using the simplest activities such as: making use of proper curtains, keep glasses clean, using appropriate light, appropriate furniture, use of focused light for precision work, making use of proper colors, increasing natural light efficiency and use of smart controllers (Naghizadeh, 2002).

Material impact on architecture

What changes an architectural plan or other development programs from subjectivity to objectivity, and materialized the corpus of the design are materials. Certainly, using more capable, effective and resisting material, buildings can be designed and constructed that have less limitations and meet the environmental and mental needs of people.

Since materials form central stone of building construction, and great part of human resources are involved, it is expected to benefit from modern technologies. Study of building material production process show that in most of material production processes, they gather raw and primary material and in a predetermine process, form the collection of materials in a known format and use them in construction (Golabchi et al., 2011).

Smart Material

In third millennium, we confront new modernization in more efficient multi-functional material. More efficiency means increase of resistant, formability, durability and more ability than traditional material (Golabchi et al., 2011) .The materials (smart material) feel environmental events and process information and appropriately react to environment and its circumstance (Sadeghi, 2011).

In other word, they have natural ability in rapid response to the environment. These materials not only increase useful life of houses, but have significant role in reducing maintenance costs of buildings.

Temperature responsive smart materials: This type of materials has intrinsic property that enables them to reversibly react to surrounding temperature. Temperature changing may have an inactive effect; so that materials constantly balance their inner temperature with natural surrounding by their outer skin and if the effects are active a kind of active heating is created with applying and electricity field by contact.

An example of thermal expansion material (TEM) is expansion materials with thermal expansion coefficient. But their most important application at architecture is in heating thermostats for building services and also as especial stimulant at greenhouses and building facades for energy control and management. Another application of them is in air conditioning system of rooms. The system works in a way that in special temperatures the system opens or closes to provide appropriate conditioning. They also can be designed as elements of air conditioning system in facades of buildings by automatically raising or lowering parts of roofs covers. Implementation of these smart materials in the building, rejects the need for complex systems and high expenses by appropriate air conditioning, and considerably lowers energy consumption (Ritter, 2007).

Color changing smart materials: These materials are able to reversely change their color or visual features in response to one or several external stimulant. With respect to its stimulations these materials contain different types but the most applicable types in architecture include: photo chromic, thermo chromic and electro chromic material (Addington et al., 2005). Currently, the material that are highly regarded by architects are called photochromic material (PC). Although these materials were primarily implemented because of their aesthetic (its color spectrum against the light), but researchers have done many studies to use them in other applications such as decreasing energy consumption or thermal changes of these covers. Electro chromic materials are also used in electro optical glass architectural. These materials change their visual feature (i.e. their transparency) exposed to solar radiation (Ritter, 2007).

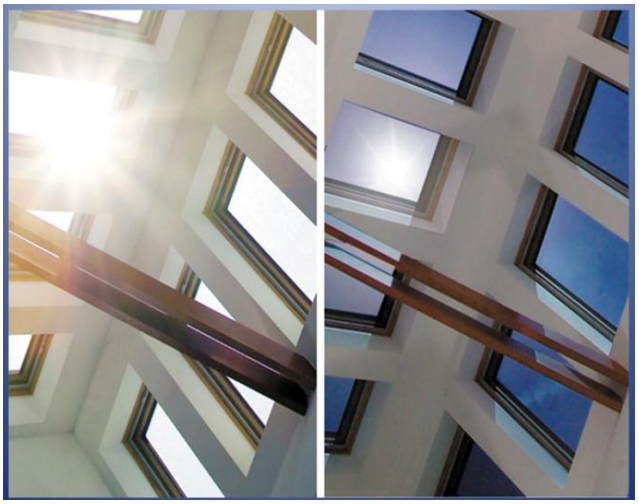

Figure 1. photochromic windows (Addington, et al. 2005)

Energy Saving Smart materials: Transparency and heat conductibility can be used simultaneously. Whenever the internal temperature of the building is more than external temperature, a bidirectional flow will be established; radiance energy transfer into inner space while inner heat energy lead to outer. Changing the amount of absorption of glasses finally effect their pure conductivity and change equilibrium of these flows. Many different materials can be used in construction of smart windows such as photo chromic, thermo tropics, electro chromic materials, fluid crystals and suspended particles system. In many cases smart materials used for windows can be used interchangeably. For example, electro chromic, fluid crystals and material with suspended particles are all applicable in controlling heat and light conduction. The most difference of these materials are their activation by electricity (Kienzl, and Schodek, 2005).

These materials and products are able to save energy visibly or hidden; for example, in the form of light, heat, hydrogen or electricity. It is worth to note that these materials are also reversible. Thus, these materials are able to save energy in different forms. But heat saving smart materials is more considered. These materials have a kind of intrinsic specification that enables them to latently save energy as heat or cold (Addington, et al., 2005).

These materials are more applicable at architecture. The most applicable materials is known as mode changing material, referred to phase changing material (PCM) that can act as thermal adjusting intermediates. For example, as cold or heat saving element, they have features to change their status from liquid to solid by final PCM of room thermal adjusting. It is necessary to say that material with high heat saving and low heat wasting capacity are not placed in this class of smart materials.

For instance, we can mention windows in which salt hydrate are used in hollow and transparent plastics blocks. In this system, summer, the solar radiation is reversed outside by prismatic panels in the summer and in winter, the sunray that has less angle crossing from system and in addition to heating inner space, heat the panels. This heat change salt hydrate from solid into liquid and obtained heat is saved in saving system as inner heat. When the heat of room is lower than 26Ċ, for example during the night or in the cloudy days, then salt hydrate are crystallized and release saved heat energy in the room. (Ritter, 2007).

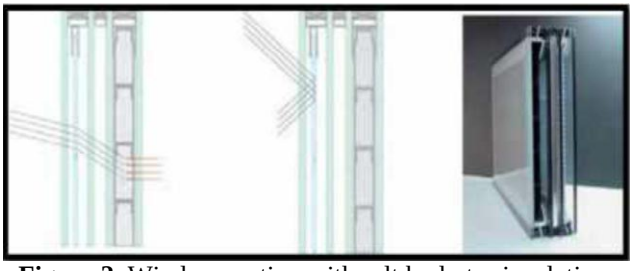

Figure 2. Window section with salt hydrates insulation, summer and winter (Ritter, 2007)

Another advantage of this system is charging or non-charging status of heat storing system is visible from its appearance. So that, if appearance is opaque, the salt hydrate is not charged, means it does not have heat storage but if the appearance is transparent or semi-transparent, salt hydrate is charged and its storage and heat storage is full (Ritter, 2007).

Table1. Distinguishing characteristics of smart materials (source: the authors)

The ability of changing property	The sustainable design is considered with recognition of place because if we are sensitive to subtle place issues, we can reside there without destruction. Place recognition, such as the direction of light in the building helps to plan and lead to protection of the environment even facilitates the accesses (Williams, 2007).
The ability of energy exchange	In site design, that is natural within the city or in environment, design in harmony with nature leads to return in environment, and environmental effects of nature help us to have a natural space (Williams, 2007).
Discrete size position	There is no waste in the nature, production provides a food organism for another, in another word, natural system has closed circle. Working with live process we respect the needs of species, and return design to life with design that can place itself in nature cycle (Williams, 2007).
Reverse ability	Sustainable design is an effort to have knowledge about environmental effects with evaluation of site. Negative environmental effects can be reduced by efficiency of renewable energy, infrastructure technology and sustainable materials selection (Williams, 2007).

Recent Developments in strong construction materials

In early 1980s, design and building construction range was confronting new innovations in the more effective and more efficient materials. More efficiency means increasing strength and ductility, durability and ability than traditional material. Undoubted, using these materials will increase the useful life of buildings and consequently, construction maintenance costs reduce significantly. Implementation of new strong materials can also decrease construction costs. They would be valuable for construction. They can improve the building design and construction methods. For example, in sustainable buildings design approach (new approach in building design that should satisfy high level of environmental standards with emphasis on the costs of useful life cycle), they often use these efficient materials because these materials have more suitable adaptation with environment and also they have ability of recycle that we have seen it less in traditional materials. Using strong materials can increase useful life of building from 50 to 100 years. That result in saving maintenance costs that is higher than constructions cost. Also, this decision can lead to conservation of natural resource and reduce negative impacts on the environment.

Smart Environments

The Smart covers are systems that during operation are able to present information about thickness and defects. Active covers are smart covers able to give the optimal response to external stimulus like temperature, stress, and strain or environment corrosive factor and in some cases if there were a defect can repair in the part of its own cover (Ram, 2010).

In the future the atmosphere of house will communicate with its inhabitants, what is hard to imagine now. Small Nano-sensors place in the construction material, soon can trace movements and recognize changing temperature, moisture, toxins, weapons and even money. The sensors collect the request of user and answer them with adjusting light or temperature change. Soon, a network of information and smart things from the photo chromic windows and sensitive to light to equipment will be used in design and constructions. The building will not be motionless but they will change because the components of buildings regularly are related to users. One of the reasons of using the Nano-technology in the architect is its high energy efficiency (Khakzadi, 2010)

CONCLUSIONS

What ways lead to a substantial and ecological city in future? This is the question we will face so many times in future. So experiences, science and inspirations of before and after examples can be the basis for city planning guidelines and strategies. Cities and their inside structures are very dynamic and change rapidly. After consuming low-priced, abundant natural resources, cities now face some crises which are prepared to deal with or they continue their ineffective life. It is obvious that the second solution will be defeated so some strategies should be taken. The first and most important strategy is cleverly dealing with problems like energy production, regaining residues, protection of environment etc.; to be able to have an exact program of negative and positive points of the city. The second strategy is creating the city for humans not for machines and remove mechanization of the city. The third strategy is localizing production, consumption and reproduction to save energy and expense. The fourth strategy is observing justice and fairness, something that has not been observed in any part of the world since cities emerged. The new research on the innovation material will face new horizons in architectural design. Making smart and use smart material that reacts to environmental problems and lead to facilitate the maintenance and repair buildings and rising buildings useful life and avoid consumption excessive energy and move innovation architectural design. In addition to that through design based on property, this kind of material can have more storing in the consuming of energy in the building lead to achieve aims of sustainable architecture. Today, we must pay attention to utilization of the method of modern science and technology and new material is considered as one of basic materials for rising quality of industry building in the country. The past experiences show that the ways like building industry products for some of

societies is a successful solution. In other society, it needs to search and pay attention to technical states and perform once and economic. Industry production and material that are used in Iran are real and essential need in the construction industry. During the past decade quality and quantity needs show that the best way of achieving the aims of different people of society is using modern ways in the construction systems and producing the new material and smart material is one of the new ways in the design and construction of sustainable and less economic costs. It is saving energy consumption and also it doesn't have destructive effects on the environment and nature. It is architecture and construction conforms to the environment and nature states.

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