Creating Passive Defense System By Using Smart Materials in Sustainable Buildings

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Abstract. Todays, due to the increase of urban population and lack of resources and too much focus on cities, energy supply, due to increased energy consumption, is very difficult and expensive. This is despite the fact that over % 40 of the energy is consumed in buildings and people's lives depend on it and this issue reaches to its peak when people’s lives are in danger during the crisis of power outage. Passive defense measures are done to reduce vulnerability in times of crisis without the use of military actions and exclusively by the use of technical and management practices to reduce losses and casualties. To avoid or lessen such tangible disasters that may happen during floods, earthquakes, wars and so on strategies such as the use of smart materials can be used. In fact, sustainable buildings with passive defense system can be designed so that the agent or other person is not needed to provide energy and the building itself could easily provide the required energy. Sustainable architectural principles used in these buildings should also meet the needs of its users as well. In other words, it should provide the maximum comfort for the residents and the lowest cost and to act in times of crisis so that the residents’ energy requirements gets resolved without the presence of the agent. Therefore, in this study in which the library method was used to collect data, smart materials which help to achieve passive defense in construction of sustainable buildings, were introduced.

Keywords: Sustainability, Passive Defense, Smart, Building

INTRODUCTION

Today, passive defense as one of the most effective and sustainable ways to defend against threats, has always been considered by many countries of the world and even countries like the US with high military capabilities has particularly paid attention to this issue. For example a country like Switzerland which is neutral in the most political and military equation has paid especial attention to this issue (Kianejad & Firuzpoor, 2012). The rapid growth of urban population in the world has brought about complexities and new problems to the issue of settlement and human society. Complexities that had crossed the border of economic problems and turned into social, environmental and defense dimension. Wars taken place in this time were too much different from the past in which the number of civilian victims was much more than the militarian victims and in fact, wars were stretched into the depth of the human habitat, the towns and homes and buildings of the cities. Urban professionals suggested many principles and rules in international conferences to achieve the guidelines to organize the human life in the cities which uninterruptedly turned to use natural resources and pollute the environment. Also the countries that experienced destruction and casualties of the war seek ways to prevent these tragedies. Passive Defense was something regarded all countries as a preventive method for invading countries and defensive approach to reduce the loss of lives and properties for the countries involved in the war. By applying effective and practical and possibly inexpensive and

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multipurpose measures before the crisis reduced a large number of severity, extent of damage, and the risks losses (military and non-military, nature). Applying passive defense principles as a solution to reduce the dangers against various risks and increase efficiency when dealing with risk is one of the most important measures which should be taken into consideration at different levels of planning and different regional, urban and architectural aspects. One of these principles is the principle of relative self-sufficiency which with assuming the worst crisis it should be able to meet the most critical needs of victims in situations just before and immediately after the occurrence of the risk. In fact, sustainable buildings with passive defense can be designed so that the agent or person is not needed for energy and the building itself can easily provide its own power with respect to this principle. With the psychological approach to the architecture and urbanism, safety and security should be considered at all levels of planning and design, the major issues of urbanism from to architecture and technical details (Zargar & Hoshyar, 2011). Architecture and urbanism as an intermediary raise defenses. Passive defense measures in architecture and urbanism can help to reduce the loss of human threats such as wars as well as to reduce the risk of a variety of natural hazards (Farzamshad, 2009). For example, the internal architecture of the buildings and furniture in passive defense should be such that the vibration caused by the blast wave and shake of the earth does not damage humans and sensitive equipments. The materials which create Shrapnels should not be used in internal walls. The most detailed engineering field such as making building doors and windows and smart materials of building should be reviewed in a comprehensive and balanced way to ensure that the design is sustainable.

Review of literature

With a look at the history of urbanization, in most countries, while striving for the development of cities, specific measures were made to maintain the safety of their homes against marauding tribes. With the knowledge of the city gates collapse, the enemy attacks the residents’ neighborhoods and homes, passages in the streets and alleys were designed and manufactured in the dimensions through which cavalry groups could not pass, or the exterior of the buildings were designed so as not to attract the attention of plunderers (Rahnamaie, 2008). In this era the passive defense measures against invasion involved castles, strongholds, towns, walls, strong defensive ramparts and bastions, creating strong shelters and etc. For example, people in Ray built their homes under the ground and made the passage into the homes dark and difficult (Kariman, 1987). But after the invention of gunpowder and its use in the manufacture of arms and weapons with the ability to throw with curve, the passive defense was gradually relying on their principles changed. During the regional invasion and after World War I, damages caused by the invasion and destruction of cities, factories, the subject of passive defense was bulked larger. During World War II. when using aircrafts bombing cities and industrial centers and investment and then the the use of missiles by Nazi, damages resulting from the invasion and particularly damage to public and civil sectors increased in compare to World War I. and this led various countries to pay more attention to the passive defense. But since 1980, with rapid urbanization in developing countries the situation in urban areas was changed. In several cases such as in Saygn the bloodiest military conflict was taken place. US operations in Beirut (1983), Grenada (1983), Panama (1989) and Mogadishu (1993) are confirmation to the movement of a growing need for the provision of military operations in urban areas (Vautravers, 2010). Operations done in southern Lebanon (1982 and 2006), Israel (2009 and 2012), the Balkans (1999) and Iraq (1999-2000 and 1994-1996) and Chechnya (1994 and 2003), indicated this change. Also, with the occurrence of September 11 attacks and the wars between countries in the last decade, regarding passive defense in urban areas entered to a new phase of programs and studies. So that the United States is making scenarios such as building strong and flexible shelters as the operation of passive defense against air and missile attacks, especially from Russia (Stillion, 2002).
Sustainability

The term sustainability was first proposed in 1986 by the Committee of the global environment as “facing the present needs without compromising the needs of future generations to deal with their needs” and this concept has been completed and is being expanded. Increases in greenhouse gases and ozone layer thinning, reduction of nonrenewable resources and endangered species, all are the factors together try to make the concept of sustainability clearer than before. Development with the concept of construction was introduced as a threatening factor for the environment and pursuant groups were formed in the mid 1960s with the increasing environmental pollution (Nasreh, 2010). In other definitions, sustainability means the ability of the system to establish justice to share fair development opportunities between the current and future generations and pandemic among humans from all human, political, economic, and social aspects. In action, sustainability is a balance between environmental and development needs which can be met through reducing the pressure and increasing the capacity of existing potentials (Nasiri, 2000).

Sustainable design

Sustainable design is the philosophy of designing physical objects or environments or services based on the sustainable economic, social and environmental principles. The main objective of sustainable design is completely to eliminate negative environmental impacts through design (Mclennan, 2004). Fiksel in 1996, defined sustainable design as the process of product development which is responsible for cost, performance, quality and environmental characteristics of a product by integrating environmental aspects into product design process (Fiksel, 1996). Also Karna (1998) did not say that sustainable design is a process that reduces the environmental product in the total of life cycle with regard to the environmental aspects of the product in the entire development process (Kama, 1998). Keolin and Menry have stated in 1982 sustainable design is a systematic approach to design products which is essential to be economically and environmentally sustainable. This definition emphasizes the connection of the life physical cycle of the product and the final design with development cycle (Keoleian & Menerey, 1993).

Sustainable architecture

It must be considered that sustainability in architecture can not be a style or a specific orientation or even belongs to the present time because what is involved in sustainable architecture can be as old as human’s architecture history. It is noteworthy that in the second half of the twentieth century, the flow of events and the threat of adverse environmental phenomena led to new challenges in the international community towards environmental issues. The origin of sustainable architecture can be studied in two main areas (Asadi, 2007). The buildings with the purpose of efficient use of environmental energy resources, required the lowest level of fossil fuels to provide favorable living conditions (heating, cooling, ventilation, lighting and humidity) (Haves, 1992). However, public opinion in favor of main and common capital of human, the earth and the environment and the efforts of government and international organizations, researchers and scholars to promote practical solutions, create developments in different field and it also got popular in architecture (Madahi & Yazdanparast, 2010). It should be noted that an absolute and pure expression of sustainability may never become structural reality because an architectural work is always full of compromises and conciliations (Willamson, 2003). Using the concepts of sustainability in architecture proposes new subject called sustainable architecture or ecological architecture, or environmental architecture, or green architecture which all have the same meaning and express eco architecture. Sustainability means tolerable. As Tadao Ando says I build the buildings tolerable in nature. In other words, sustainable architecture is responsible to build buildings tolerable in nature as well as keeping identity and matching objectivity with subjective images within the layers of history, present and future (Panahi, 2007).
Passive Defense objectives and definitions

Passive defense is a set of measures done to lessen potential damage to its minimum in the event of war or major natural disasters. In other words, passive defense is the non-armed action that reduces the vulnerability of people, buildings, facilities, equipment, documents and major arteries in the face of natural disasters or enemy’s destructive and hostility acts.

Passive defense measures in modern asymmetric wars is a fundamental issue whose breadth and scope involve the entire infrastructures and critical military, political, civilian communications, and transportation facilities such as ports, airports, bridges, infrastructure, key products such as refineries, power plants, large industrial complexes, malls and guidance Command post and the country’s population; so that national security and economic invincibility in battle is greatly related to planning and organizing all aspects of critical issue, passive defense. The purpose of passive defense is to reduce the vulnerability of manpower, critical facilities and equipment of the country despite enemy’s hostile and destructive attacks and continuity of operations and infrastructure services and providing vital needs and the continuity of the country’s governing during crisis caused by war. In section 21 of the National Regulations of the Building, any unarmed actions that reduces the vulnerability of people, buildings, facilities, equipment, documents and arteries in the face of human-made threats are called passive defense. In online resources there is a term called civil defense which is kind of dimensional concept. In the first group, civil defense is introduced as protecting civilians in situations of armed conflict and hence consists of part of the national defense following measures in order to adequately prepare against any possible attacks or blackmail from a country. According to this definition, civil defense should guarantee the safety and survival of the civilian population in wartime. Therefore, The civil defense has been systematically pursuing the following objectives.

Passive defense and its history

The term “Passive defense” was first found in the book “temporary protection shelter” regarded in the activities at the headquarters of America’s Army in 1954 to meet new phenomenon of intense surprise nuclear attack. Since then, the concept was developed and has found a special place over all factors related to human habitat, especially in the field of architecture and urbanism so that, today it is considered at all levels including the design of streets, applications, and even how to make doors and windows and glass and their locations in the buildings and its final goal is to achieve sustainability in modern architecture and urbanism. Hence, any new technologies lead us towards sustainability in architecture and urban planning and their objectives can also be effective in passive defense. Although power is an integral part of today’s cities urban facilities and intelligent systems in the production and distribution of power in the topic of "smart grids" is a movement towards sustainable urbanization.

Principles of passive defense

In most of the world’s scientific and military resources, principles of passive defense issues are 6 to 7 actions which should be carefully considered in planning and implementation measures (Zargar & Hoshyar, 2011):

1. Camouflage;
2. Concealment;
3. Cover;
4. Concealment;
5. Dispersion & Separation;
6. Hardening;
7. Early Warning.
Passive defense in urbanism and Architecture

Doctor Asgharian named the requirements of architecture and urbanism in the passive defense in the table below (Asgharian Jedi, 2004). Given the invasion of the enemy including the reconnaissance, presence, recognition, aiming, damage and escape, using each of these factors in the design of passive defense disrupts the enemy at every stage of invasion and makes the enemy fail to achieve its goal. The requirements in the table are classified into certain groups as follows:

1. Planning includes placing and formation, obstacles, distribution and management of construction and operation;
2. Confusion in the enemy’s observation including anti observation;
3. Enemy’s observation including camouflage, concealment and deception factors;
4. Interior design including multi-functional spaces, normal entrances and exits and emergency and repairment;
5. Construction including network infrastructure, installations and fortifications (Asgharian Jedi, 2004).

Table 1. The requirements of architecture and urbanism in the passive defense.

<table>
<thead>
<tr>
<th>Escape</th>
<th>Firewall</th>
<th>The structure of enemy invasion</th>
<th>Invasion classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>F Escape</td>
<td>E damage</td>
<td>D Aiming</td>
<td>C recognition</td>
</tr>
<tr>
<td>E1</td>
<td>D1</td>
<td>C1</td>
<td>B1</td>
</tr>
<tr>
<td>E3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E4</td>
<td>D4</td>
<td>C4</td>
<td>A4</td>
</tr>
<tr>
<td>E5</td>
<td>D5</td>
<td>C5</td>
<td>A5</td>
</tr>
<tr>
<td>E6</td>
<td>D6</td>
<td>C6</td>
<td>A6</td>
</tr>
<tr>
<td>E7</td>
<td>D7</td>
<td>C7</td>
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<tr>
<td>E8</td>
<td>D8</td>
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<tr>
<td>E9</td>
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<td>E10</td>
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<td>E11</td>
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<td>E12</td>
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</tr>
<tr>
<td>E13</td>
<td>D13</td>
<td>C13</td>
<td>A13</td>
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<tr>
<td>E14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E15</td>
<td>C15</td>
<td>A15</td>
<td>Network Infrastructure</td>
</tr>
<tr>
<td>E16</td>
<td>C16</td>
<td>A16</td>
<td>Installation</td>
</tr>
<tr>
<td>E17</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the draft of the principles of building based on passive defense regulations, buildings in urban areas are divided into five groups based on the type of use, the number of residents or employees in the building, the capital value of the building, area and the number of floors (Table 2).
Table 2. Buildings’ ranking based on importance.

<table>
<thead>
<tr>
<th>No.</th>
<th>Importance</th>
<th>Sample position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>One (critical)</td>
<td>Place of performing key missions and national security</td>
</tr>
<tr>
<td>2</td>
<td>Two (very high)</td>
<td>Multi-storey buildings with more than 15,000 square meters and more than 450 inhabitants</td>
</tr>
<tr>
<td>3</td>
<td>Three (High)</td>
<td>Multi-storey buildings with 8,000 to 15,000 square meters and 151 to 450 inhabitants</td>
</tr>
<tr>
<td>4</td>
<td>Four (average)</td>
<td>Multi-storey buildings with 400 to 8000 square meters and 21 to 150 inhabitants</td>
</tr>
<tr>
<td>5</td>
<td>Five (less)</td>
<td>Buildings with 400 square meters and 200 inhabitants</td>
</tr>
</tbody>
</table>

Source: National Building Regulations Section 21

Definition of smart materials

Smart materials are a new term for materials and products which has the ability to perceive and process environmental events and show proper responses (Gorji, 2009). Smart materials can also provide their own energy needs and the environment or react according to the surrounding circumstances. For example, make it warm while cooling or reacts vice versa.

Classification of smart materials

Generally, building materials in the fields of traditional, natural and artificial are classified based on their characteristics, such as appearance, texture, chemical composition, mechanical and physical properties, environmental impact and etc. (Gorji, 2009). But in the classification of smart materials in addition to the above features, other properties in particular to distinguish intelligent materials of traditional materials are also included. In fact, the classification of smart materials is presented based on the following three properties.

The use of smart materials

The importance of smart materials becomes clear when their role in the development of adaptive systems is regarded (Mahtab, 2011). Materials or devices that change energy from one state to another state by the external controller to get the the desired end state. One of the most interesting classes of smart materials that are being considered is the material with the ability to change the color (Chromic) (Masaumi, 2011). These materials are described in Table 3.

Table 3. Types of smart materials and their reaction conditions.

<table>
<thead>
<tr>
<th>Type of smart materials</th>
<th>Input Power</th>
<th>Output Power</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termochromic</td>
<td>Change in temperature</td>
<td>Change in Color</td>
<td>1</td>
</tr>
<tr>
<td>Fotochromic</td>
<td>Change in light</td>
<td>Change in Color</td>
<td>2</td>
</tr>
<tr>
<td>Electrochromic</td>
<td>Change in voltage</td>
<td>Change in Color</td>
<td>3</td>
</tr>
<tr>
<td>Liquid crystal</td>
<td>Differences in electricity current</td>
<td>Change in Color</td>
<td>4</td>
</tr>
</tbody>
</table>
Examples of smart materials

Termochromic smart materials

This type of smart materials that are a subset of smart materials of color change have an inherent feature which enable them to reversibly react against the temperature of the surrounding environment (Ivan, et al., 2012). Termochromic smart materials change color due to reversibly absorbing the heat and with the loss of the factor causes temperature change return to the initial state (Sedighziabari, 2010).

Smart materials change color

As it can be seen from the name of these materials, they can reversibly change color or visual characteristics in response to one or more external stimulants (Bazrafkan, 2009). These materials can be used in the warning cases which should be considered given to the use of stimulants. Change in color for a fire alarm or low oxygen environment can be considered a good material in passive defense. It can also be used in the design of the building to take advantage of the its beauty.

Photochromic glasses

Now Photochromics abbreviated as PC are available in the form of photochromics pigments, photochromics glasses, photochromics plastic or polymer (Gorji, 2009). Photochromics glasses by exposure to radiation, the amount of transmission of visible light drops sharply, and if the radiation stops, the amount of transmission of visible light returns to the initial state (Bazrafkan, 2009).

Electrochromic glasses

Electrochromic materials are used in designing electro-optical glass (Pahlavan, 2011). In this system the glass unit with a transparent film thickness of 200 or 300 nm in the visible spectrum with different color intensity varies from clear to dark blue (Sedighziabari, 2010). Glass unit is connected to the electrical current to change the transparency of glass regarding different amount of optimal heat transfer. After the cutout, the optical mode is kept and a steady flow of electricity is not needed. When the color of glass change to dark, heat radiation reduces and more light is filtered through the infrared spectrum. Energy consumption for the complete cycle is less than 5.0 kWh m (Gorji, 2009). Sometimes smart windows are also called smart glass shade that can prevent absorbing heat from the radiation of sun’s harmful rays (Modaberi, 2012).

Termochromatic glasses

Glasses and glass materials are the examples of products that are widely used in various fields (Sedighziabari, 2010). Using the cover of termochromic materials, kind of smart glass can be made that prevents heat without blocking visible light passing(Sedighziabari, 2010). This type of cover made from a derivative of vanadium dioxide, can pass visible wavelengths of light at any temperature and only at temperatures higher than 29 ° C reflects infrared light. Covering ability to change the condition between the absorption and reflection of light, means utilizing the benefits of solar heating in winter conditions and reflection in higher temperatures and thus preventing fusion of spaces (Ivan, et al., 2012).

The impact of applying smart materials in passive defense

Considering the importance and necessity of the use of passive defense in the cities and towns to protect residential areas, the importance and different strategies of using passive defense, the need to use and caring the best practices including the use of materials appropriate to the danger ahead are felt. The use of smart materials is based on the principle which can show different responses in different situations such as materials responding to smoke, fire, shock, etc., which
can be helpful against natural disasters such as fires, earthquakes, hurricanes, and etc or manmade and help to preserve and save more lives. Applying the materials temporarily increase the construction cost of buildings but after the completion of the construction in a short timeframe cause the cost to be returned and also prevent the creation of financial costs of natural and abnormal disasters. Under normal conditions, this material also provides greater convenience for residents. Utilizing the materials is a long step in achieving sustainable buildings.

**Conclusion**

In this study, a brief definition of sustainable architecture and passive defense and a brief introduction of smart materials are first expressed. Given that some types similarities found in natural hazards and threats to human, to reduce the risk, optimized passive defense measures can be considered by evaluating the potential hazards in each location. The structure and the constituent elements of cities can comfort people in times of crisis or by creating confusion leads to intensifying the stress resulted in emergencies. In architectural design of the cities, the design is successful and sustainable which can find proper solutions by functional and aesthetic considerations with regard to total defense and civilian components. Although at first glance the use of passive defense in urban design principles is unnecessary or limits other factors affecting the landscape of the town, but by understanding the principles it is possible to apply them as a factor in sustainable urban design and higher performance in times of crisis. The design based on passive defense and considering the critical condition in the buildings known as urban signs, can save many people’s lives in a crisis and war. Interactions between passive defense measures and threats to human on the one hand and with the other natural hazards such as earthquakes on the other hand, can lead to sustainable architecture. Thus, using the principles of passive defense in the Comprehensive Disaster Management Programme, it is possible to greatly reduce the severity and extent of risks arising from losses by using practical and cost-effective measures with the design and versatile in the preparation phase before the crisis. In fact, sustainable buildings with passive defense using smart materials can be designed so that the individuals do not need the agent or man for power and the building itself could easily provides its required power by using the materials. Sustainable architectural principles used in these buildings should also meet the needs of its users so that it provides the maximum comfort for the residents and the lowest cost and to automatically act in times of crisis so that the residents’ energy requirements gets resolved without the presence of the agent.

**References**

[26] www.hamshahrionline.com