Study on using biocompatible architecture in expanding green buildings and its effects on citizens' psychological behavior

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Abstract: Today, concept of sustainability has been considered due to sustainable development implementation, growing population and rapid growth of construction. The sustainability concept is very broad in architecture. Biocompatible architecture subject (green architecture) is one of the most important and challenging issues in sustainability field of todays and future world. Biocompatible (green) architecture is a branch of architecture in which all or parts of a building are covered with green vegetation (plant growth medium) based on environmental and sustainable principles. This architecture style is one of the most innovative approaches in architecture and urbanism, all of which derive from sustainability concept. Although attention to nature and biocompatibility has long been visible in many civilizations and cultures, but this issue is becoming more and more important today due to increased population and construction, high energy consumption in buildings and cities, reduced natural green per capita, air pollution, climate changes and eventually disrupted ecosystem. Beauty of green spaces in urban sector and consequent positive psychological impacts on citizens, which is less discussed, is another important issue of this architecture style. Given the speed and expansion of construction in cities and decline of green spaces, beauty of green spaces will be one of the major challenges for architects and urban planners in future. In this paper, we study and analyze biocompatible architecture (green architecture) in order to expand green buildings and positive psychological effects on citizens.

Keywords: Biocompatible Architecture; Green Buildings; Optimize energy consumption in buildings; Environmental Psychology

1. Introduction

Sustainability is a comprehensive and complex issue. Sustainability is of paramount importance to everyone because it is related to survival of human species and almost every living thing on planet. Sustainable and environmental friendly architecture is one of the main goals and ultimate model of all human being activities in creating a better life. For this reason, move to greener architecture is recognized as the main goal of current architecture [1].

In the case of world developmental needs including ground scarce resources use, it is clear that civilization future is uncertain unless situations where there are major changes in human thinking and behavior. There is no easy solution for this complex issue, especially since sustainability is a goal for all human beings because they are constantly striving to achieve it. Green architecture provides environmental, social and economic benefits. Environmentally, green architecture helps pollution reduction, natural resources conservation, and environmental degradation prevention. Economically, green architecture reduces the building operators cost for energy, water and efficiency of equipment improvement [2].

The buildings where we live, work and play protect us against severe natural disasters; also, they affect our health and environment in countless ways. A new field called Green Architecture is developing based on apparent environmental impact of buildings. Green or sustainable building is a way of creating and utilizing healthier models and more efficient resources of construction, renovation, commissioning, maintenance and demolition [3].

In the present age, the shortage of fossil fuels and resulted pollution have led people to resort to other clean and renewable energy sources in meeting their future needs. Therefore, using sustainable and environmental friendly energy sources is very important in order to reduce and optimize energy consumption, especially in building sector. According to released statistics by Tavanir Organization, buildings account for about 40 percent of total energy consumption in country, with residential sector accounts for the most demand of 33% [4].

2. The main aim of sustainable development

One simple definition can be justified in defining sustainable development. "Sustainable development is one that improves in long run human health and ecological systems". Sustainable development is one that considers current needs of human being in terms of future abilities.

"Environmental sustainability" in keeping with sustainable development aims has high importance. Environmental issues that have risks for human futures have worried architectures. Architectures like other scientists try to find good living for human being. It is clear that living, working and recreation are all kinds of activities that occur in spaces provided by architects. Since strengths and weaknesses of a building have direct impact on world ecosystem, architects will have sensitive responsibility. Sustainability concepts application in architecture has opened a new field called "sustainable architecture" or "ecological or green architecture" or "environmental architecture" all of which have the same meaning and signify an environmental friendly architecture. The main aim of sustainable development is to meet basic needs, improve living standards, preserve and manage ecosystems and provide a safer, happier future. Human has reached a critical stage in his history due to changes in natural environment; as a result, healthy life on earth requires revision of assumptions on which common models of planning and development are based. The material and spiritual aspect of life and attention to collective spirit rather than individualism and many other features can be considered as Iranian version of sustainable development [5].

2.1 The principles of designing sustainable building

The process of designing sustainable buildings began through carefully examining of their construction site with all complexities and difficulties. An ecological approach of design seeks to integrate systems that are in line with ecological activities of place that are performed by Mother Nature. These ecological activities provide habitat, respond to sun's movements, purify air as well as extract, filter and store water. Species that work in natural ecosystems may use habitats that are built on artificial structures. The construction of new habitats in urban area structures is of particular importance in order to contribute in healthy biodiversity and ecosystems. The followings are the key principles, strategies and technologies that relate to five key elements of green building design, including sustainable design place, conservation and quality of water, energy and environment, indoor quality and preservation of materials and resources. The information confirms using of USGBC LEED Assessment System but their focus is on specific solutions or technologies and principles which are location specific and change project to project [6].

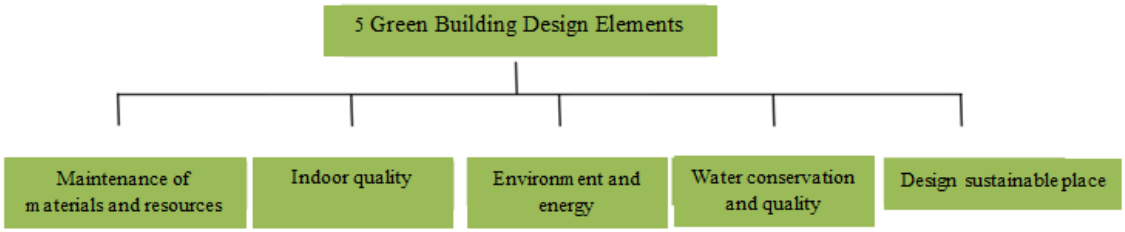

Fig1. Green Building Design Elements provided by the author (USGBC)

3. Green architecture

Today, preserving and protecting natural resources of world has become one of the most important concerns of present era due to negative consequences of industrial world. That's why Vertical Green Architecture tries to align with nature through increased efficiency and optimization in materials, energy consumption and space expansion while minimizing the negative impacts of buildings on environment. Thus, green architecture harnesses nature energies and uses them in building instead of being hostile to nature [7].

Green architecture encompasses a type of design in which every building provides residents with satisfaction in all areas of physiology and psychology as well as it must do the least harm to environment through using sustainable development strategies and sustainable, non-harmful natural materials for human life [8].

3.1 Green building concept

The green building term in today's world is an interesting topic that is considered by urban landscape engineers, architects and developers. What is green building? US Department of Environment defines green building as: a process of enhancing the quality of buildings in which buildings and their locations use water, energy, and materials and reduce the negative effects of building on human health and environment through better locating, designing, constructing, implementing and maintaining the complete life cycle of building; thus, green building does not damage the environment and contributes positively in ecosystem and may even cures the damaging landscape effects [9].

3.2 Principles of green architecture design

There have been more and more declarations and discussions on principles of green architecture throughout world in recent years. However, these announcements have lightly addressed the issues on energy, space features, workers and surrounding communities. British architects Brenda and Robert Weil have outlined one of the simplest and most explicit frameworks for green architecture in their book entitled "Green Architecture: Design for an Energy-conscious Future". They have illustrated these principles using different examples of building design for people in Europe, England and United States. They focused on local architecture that have special climate. Generally, there are various principles involved in constructing any type of structure that have many common points for discussion. However, the presented topics have a set of different principles that lead to balance and creation of green architecture [2].

Table1: Various principles in each type of structure

First principle: preservation of energy [11]	Each building must be designed and constructed in a way that minimizes the need for fossil fuels. The necessity of accepting this principle in past is undoubtedly undeniable, given the way in which it is constructed.
Second principle: work with climate [11]	Buildings must be designed in such a way that they can utilize local energy sources and climate.
Third principle: reduced use of new resources [11]	Each building must be designed to minimize the use of new resources and provide a source for other structures creation at the end of its useful life.
Fourth principle: respect to users [11]	Green Architecture respects everyone who uses the building.
Fifth principle: respect to site [11]	Every building must touch ground in a light and calm way. Australian architect Glenn Morkat presents a strange saying: The building must touch the ground in a light and calm way.
Sixth principle: holistic [11]	All green principles need to participate in a holistic process in order to build an artificial environment. Find buildings with all principles of green architecture in 2005 is not easy task. (12)

Source: authors

3.3 Considerations related to green building

There are four main areas that must be considered in green buildings: Development of construction site, selection and minimization of materials, energy efficiency and indoor air quality.

1. Consider the site of construction development in order to reduce the impact of development on natural environment. For example, build a structure in a direction that uses sunlight pass, shadows and wind patterns in heating and cooling loads reduction.

2. Careful selection of durable and recyclable internal materials in order to reduce adverse environmental impacts. There is a growing market for low-cost recycled products.

3. Provide a plan with high energy efficiency for buildings in order to construct efficient and calm place. Use natural elements and technologies in order to maintain resources and increase productivity power of residents as well as reduce long-term operating costs and pollutants.

4. Design excellent indoor air quality in order to improve health and productivity power of residents, minimize waste in manufacturing and demolition processes through recycling and reusing materials [13].

4. Concepts of sustainability in architecture and green architecture

- Use energy in everyday consumption

- Use waste products and effluents in water supply required for green space irrigation
- Use appropriate practices in order to reduce or control wasted energy and optimize energy consumption
- Use non-chemical recyclable materials and materials that do not conflict with human health
- Design and construct with natural- based materials
- Prevent the negative effects of building and its products on environment
- Use natural herbs as inspiration for living design in business
- Avoid damaging the land in order to generate more profit
- Achieve the highest quality of life based on environment
- How to use the land
- Pay attention to ecological character of area
- Consider the climatic properties of area
- Special attention to light and air effect on whole complex design and layout of public and private spaces
- Pay attention to mobility and living in open environment [14]

4.1 Green buildings materials

Green building materials generally are made from renewable sources instead of non-renewable resources and are environmentally credible materials, because their effects are taken into account throughout the product life. In addition, green building materials generally lead to lower maintenance and replacement costs over building lifetime, energy conservation, and improved health and productivity of residents. These materials can be chosen through evaluating characteristics such as reuse and recyclable contents, non-emission of air or harmful substances or low emission, without toxic or low toxicity, stable and fast renewability, high recyclability, durability, longevity and native production [15].

Clay and sand are common materials used in many types of natural buildings. When clay and sand are mixed with water or fibers, the resulting mixture can form a stratum or clay (clay blocks). Other materials used in natural buildings include: soil (cracked or sac soil), wood (light wood / timber / pole), rice hulls, bamboo and stone. Various non-toxic reusable or recycling materials are common in natural buildings such as urbanites (large waste chunks of waste concrete), large screens for cars, and other recyclable glass [16].

Many professionals of building process are increasingly avoiding other materials because of their major adverse effects on environment or human health. These materials include biodegradable (unstable) harvested wood, toxic wood coatings, Portland cement based mixtures, paints and other covers that emit Volatile Organic Compounds (VOCs) and some plastics, especially polyvinyl chloride (PVC or vinyl) and materials which contain harmful lubricants or harmful hormone formulations [17].

4.2 Green roof

Green roofs have many uses in buildings such as absorbing rain water, insulating, creating a habitat for wildlife, increasing the kind of worship and reducing mental stress of people on roof through providing pleasant scenery and reducing urban air temperature and effects of heat island [17].

There are two types of green roofs:

1. Concentrated roofs that are thinner and have a minimum depth of 12.8 cm and help a great deal in life of various types of plants but are weightier and require more maintenance.

2. Large roofs that are shallow and have 2 to 12.7 cm depth but are lighter than green roofs and require minimal maintenance [18].

The green roof term is also used in referring to roofs that use some form of green technology, such as a cool roof, roofs with solar thermal collector or photovoltaic panels. Green roofs are also called ecological roofs, vegetation roofs, living roofs and VCPHs (complex horizontal blades with vegetation covers) [19].

4.3 Green wall

The green walls, also known as vertical greenhouses, bring the plants into building facade. Compared to green roofs, green walls can cover more rigid surfaces of environment whose predominant style is skyscraper [20].

According to Ken's article (Ken 2003), if a skyscraper has vegetation ratio 1: 1, its façade surface will be 3 times of this surface. If building is covered with two- thirds of facade, vegetation cover of building will be two times. Then, each skyscraper will be green and organic mass will be increased [21].

There are three types of green walls. Green walls can be divided into three basic types based on plants types, growth environment and construction method:

1. Upright green wall is a common and traditional type of green wall. The walls construction is time consuming process, but upright plants growth on these walls can cover the building in natural way. Sometimes these walls rise with the help of scaffolding and other auxiliary systems [19].

2. The hanging green wall is another popular type of green wall. The wall can easily form a vertical green belt on a multi- floor building through the vegetation on each floor [19].

3. Modular Green Wall is the newest idea compared to other two types of green wall. The wall needs more sophisticated design and considerations before a vertical system can fit in place. Also, it is arguably the most expensive type of green wall [20].

5. Benefits of green buildings

Green building is not a simple process; it is a structural approach that is compatible with demands of its time as well as its relevance and importance is increasing [21].

- Convenience: Since a well-designed passive solar home or building has high energy efficiency, it has no sloping. The extra sunlight of south windows in winter makes it brighter and more pleasant than ordinary homes. [22]

- Cost-effective: Considering the solar passive design stage, the designing cost of this type of construction is no higher than conventional one and can save fuel costs [22].

- Beauty: Passive solar buildings can have a normal outside look and solar passive capabilities make them brighter and more enjoyable.

- Eco-friendly: Passive solar homes can greatly reduce the consumption of heating fuel and electricity used for lighting. If passive cooling strategies are used in design, summer air conditioning costs will be reduced [16].

6. Urban green space

In general, the existence of green spaces and their effects on cities is unavoidable. It is not possible for cities to remain sustainable without these spaces [23].

Green spaces include trees and other plants that are used as cities' lungs. Urban interactions provide natural processes, create recreational spaces and serve as perfect link of city dwellers to natural world [24].

High quality green spaces provide people a healthy lifestyle and enjoyment and it’s designing and building is key element of urban planning that is in search for healthy communities and sustainable cities [25].

If urban green spaces are quality enhancers, incorporating them into one system will be of added value for city. Thus, creating urban green structures is important and balances the urban green system at both functional and

structural levels. It is proved not only by added intrinsic value of separating spaces, but also by relationship between these spaces and connections between them and around city [26].

According Antwerpen on urban green spaces: "there is a great demand for landscapes in future that will perform multiple functions at a time: ecological function (space for living), economic function (space for production), social and cultural function, historical function (a space for identity and belonging) and aesthetic function. The combination of landscape constituent elements is essential in achieving equilibrium and sustainable evolution [26].

7. The beauty and psychological function of green spaces

Eskarder (1991) showed that natural environment with plant life and water induces relaxation and creates less distress in viewers compared to urban landscape without plant life. Ability of natural elements "natural buildings" is a benefit for urban areas. Natural landscape of city can have social benefits, in addition to health, psychological and beauty benefits.

Mental and psychological effects of urban green spaces: Humans are inherently biased towards nature. Human needs for plants and nature have been vital since the creation outset. According to Mori, need is an assumed structure that justifies objective and intellectual realities [27].

Green is dominant color in green space. This color enhances the mood, confidence and power of dominance on events, so it is useful in relaxing the nerves and relieving fatigue; also, it enhances strength and endurance and makes the city's atmosphere more psychologically viable for residents [28].

8. Types of landscapes and their health effects on individuals from psychological perspective

The study aimed to identify the landscape characteristics and their health effects on individuals. Research has been done in this area. In this regard, Ward et al. refer to more than 30 studies conducted between 1979 and 2006 that examined landscapes and health and the relationship between different elements and patterns of visual perspective. The following table is divided into two categories based on researches [29].

Table2: recognition of the characteristics of the landscape and their health effects on people

Landscape type	Landscape features	Reported health effects	Authors
Natural landscape - green landscape	Natural environment; dense and open forests, roads, without people	Reduced fatigue and increased people's attention	Staats et al (1997)
	Natural spaces; forest with lakes and creeks, park with lakes and creeks, park with a variety of plants and artificial rivers	Reduced stress and regenerative effects and increased heart rate due to natural landscapes	Laumann et al (2001, 2003)
	Landscapes with open views of natural elements	Effect on direct attention, satisfaction, more patience increase	Kaplan (1993), Tennessen and Cimprichi (1995)
	Old garden with fruit trees and a variety of flowers	Increased power of focus	Otosson and Grahn (2005)
	Natural landscape; River Valley, with the sound of water	Significantly reduced pain for those who have such a landscape	Diette et al (2003)

	Natural environment: plants and water	Reduced fear and anger, rapid illness relieve and reduced stress	Ulrich (1991)
	Trees / forest landscapes with dirt paths / park-like forest landscapes	Pleasure from the perspective, reduced anger and tension, increased focus	Van den Berg et al (2003)
	Coastal water areas with pastures	Restorative and regenerative effects: Reduced heart rate	Laumann et al (2003)
	Natural environment: display of trees and natural resources	Reduced stress and increased boredom, reduced stress and blood pressure, reduced anger and increased positive effects	Harting et al (2003)
	Hedge	Relaxation	Nakamuraad Fuji (1993)
	The view of window to natural elements	Better perception performance, stronger effects on satisfaction, and increased regeneration, less frustration and more patience, more satisfaction with life and overall health	Wells (2000)

On the other hand, urban landscapes with no natural elements have negative effects on human health. Researches in this area show that complexities and driving forces of urban landscapes and need for direct environmental perception lead to stress and fatigue. The worn-out urban fabric landscape, major industrial and commercial landscapes, and landscapes without natural elements have the most negative effects on residents' mental and emotional states [29].

Table3: The relationship between landscape and man-made landscape

Landscape type	Landscape features	Reported health effects	Authors
Urban landscape - man-made landscape	The city's central fabric, worn-out fabric, commercial streets, residential areas traffic	Intellectual fatigue and reduced attention, less healing power, depression, anger	Staats et al (1997)
	Urban spaces: great streets	Much less restorative and regenerative effects and increased heart rate due to natural landscapes	Laumann et al (2001, 2003)

	Public spaces lacking plants	Increased aggression and anger, increased hopelessness and more mental fatigue	Kuo (2001)
	Landscapes of commercial and industrial sectors	Increased nostalgia, decreased concentration, increased distraction	Ulrich (1979, 1981)
	Urban landscape lacking natural elements	Increased chronic diseases and decreased job satisfaction, less satisfaction and less ability to recover	Kaplan (1993)
	Visibility of built areas (buildings, brick walls, concrete fences)	Less relaxation and nervousness, sensory tensions	Nakamuraad Fuji (1992)
	Expand medium density urban environments and retail sellers in urban spaces	Increased blood pressure, increased anger and aggression, decreased concentration	Hartig et al (2003)

9. Conclusion

In this study, we express the importance of biocompatible architecture for green building expansion and necessity of its implementation. Generally, a biocompatible building will provide saving in energy, utilities, improving air quality, health, resident welfare, beauty of urban landscape, mental relaxation of residents and protection of finances and dramatic reduction of costs. The aim is to expand sustainable and green buildings, improve the quality of life and prevent the negative effects of construction on environment and thereby reduce the negative psychological burden on citizens. Nowadays, many problems of environment and detrimental effects on human mental and physical health as well as natural ecosystem disruption are due to industrialization of countries as well as illegal construction through eliminating natural green spaces without considering their harmful effects; this issue is one of the most important challenges of mankind in Earth future. Architecture can effect positively on environment through identifying materials that emit less carbon dioxide. To this end, biocompatibility buildings or green buildings must have efficient components of: focus on energy efficiency, efficient water consumption, utilize environmentally sound building materials, minimize waste and toxic chemicals involved in construction process, good outdoor air quality and consider citizens' mental and physical health. Green architecture has environmental and economic benefits and affects positively the beauty of urban landscape. Today, urban landscape beauty subject is one of the challenges and issues of urban designers; it is one of the best options in improving the problems related to visibility and beauty of urban landscape and enhances the performance of such green buildings.

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