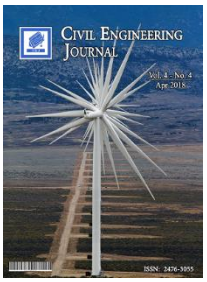
Available online at www.CivileJournal.org

Civil Engineering Journal

Vol. 4, No. 4, April, 2018



Analysis of Design Indicators of Sustainable Buildings with an Emphasis on Efficiency of Energy Consumption (Energy Efficiency)

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Received 24 February 2018; Accepted 21 April 2018

Abstract

Nowadays paying attention to sustainable development issues has been a priority for different countries, due to technological advances and increasing number of problems caused by neglecting the environment. Sustainable development is a new field that considers all the aspects of human life. One of important issues in this area is, considering the energy and efficient energy consumption and reducing the environmental consequences of its consumption. Sustainable design of buildings is also an example of sustainable development. The purpose of this study that has been conducted based on documents and library studies and analysis of samples that are built with the sustainable approach is to study and compare the fundamentals of investigated samples with the criteria of sustainable development. The result is that fundamentals of these buildings as architectural responses can help architectures challenges in different environmental conditions.

Keywords: Sustainable Design; Efficiency; Sustainability; Sustainable Buildings.

1. Introduction

In 1960s widespread questions and criticism about development programs and its incompatible consequences on the environment, was proposed that finally caused the issue of sustainability to be mentioned and developed frameworks and limitations for development. After that the slogan "development without sustainability, no," "sustainability without development, no" was formalized [1]. Charles Janker in the last chapter of his book sustainable architecture, notes that with destroying the earth, we destroy the 27000 biological species in a year, which means 74 extinctions in a day or 3 destructions in an hour. New evidences according to Times magazine dated January 31th, year 2000 shows higher numbers for these destructions that is hundreds of extinctions in a day, global warming, ozone layer is getting thinner due to the use of various contaminants, increasing environmental pollution and extinction of biological species, all of these merge together to forecast the necessity of ecology and environmental issues for future in a way that surpassing an ash against green world, be the most notable issue in this century [2]. Therefore, modern architecture inevitably should move toward sustainable design so that it would be a way out of the emerged crisis. According to definitions, sustainable design balances the needs and demands of human and other pillars of the global biological system in future and present time [3]. As a result, a sustainable building is a building that has the least opposite effect on the natural environment and local and global establishment [4]. In addition to environmental, social and economic factors, the increase of energy cost in recent years has increased the desire for sustainability. In this way, the increase of energy price and conservation of its resources is inevitable these days [5]. The purpose of this paper is to study the factors and elements used in sustainable building that have been designed up to now and proposing these principals as efficient methods for designing the sustainable building nowadays. This research is conducted based on library studies and a

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http://dx.doi.org/10.28991/cej-0309142

priori analysis. Reviewing this subject's literature and based on the conducted studies, it seems that the sustainability is a product of architecture process [6]. Sustainable architecture requires being seen as a power that makes anything. That's because, in this condition, a basic question then arises; what should be sustainable? And here is where the solutions are diagnosed [1].

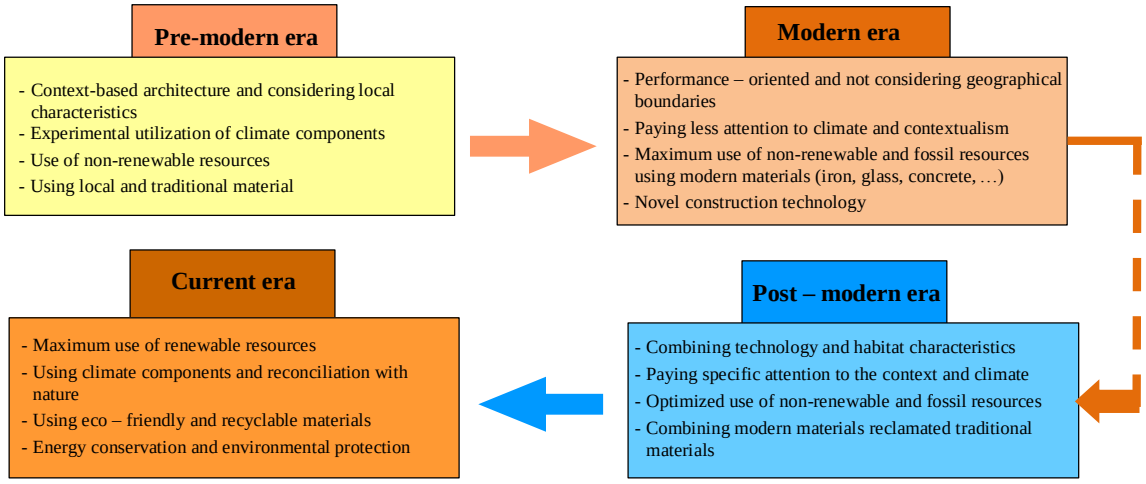


Figure 1. The historical trend of sustainable design

2. Research Background

Studying the past architecture and the way humans interact with the environment is evidence that architecture which is by the environment is not a new idea. In other words, the idea of sustainable architecture today has become a necessity, is not a novel and unprecedented approach. Since the earliest ancient human civilizations, human-made an effort to fit in with their environment. The discoveries in archaeological sites and the texts that are retained from the past are proof of this claim. But as a result of the industrialization of the world in this era, the relation between human and environment has changed, and in the era of technology and industry, people have irreparably damaged the environment due to their increasing demand for comfort and avarice. In the nineteenth century and with the start of modern thoughts, the society ignored the technology power of architecture in solving human problems [7]. In fact, modernists consider architecture a technological issue, and since technology has general features and it obeys the same rules and principles, they can build any architecture in any part of the world [7]. The architecture was performance-oriented modern, based on technology, scientific and outside the geographic boundaries and also provident and history conflicting [8]. But in sustainable attitude, technology is used for human interaction and their living environment with the around area. Sustainable architecture is a solution in which natural living areas can be constructed [8]. Based on the things that was mentioned, we can conclude that the so-called sustainable architecture is reflecting an illustration in design and constructing human spaces in the way to achieve " sensitive and responsive" architecture to the environment in the late 70s, that it considers having ecological sensitivities a necessity for making healthy spaces with pervasive environment [7].

Building envelope provides regulatory functions such as thermal control, moisture control, and indoor air quality control against the environmental impacts on the building system thereby protecting the indoor environment of building [9]. Besides, in the process of carrying out these functions against environmental impacts, building envelope interacts with three parts of building. The three parts of building include: exterior environment, interior environment and the envelope system itself [10, 11]. These three (3) parts interact with the physical system of building in the process of separating the interior environment from the exterior environment [12]

Also, according to Yeang (2006) [13] and Lucuk (2005)[14] building envelope reduces the level of supplementary mechanical energy needed in building being the barrier between the interior of building and the external environment and main determinant of indoor climate. Thus shows that there is a significant environmental impact on building envelope that can influence building sustainability. Also, building envelope provides indoor conditions suitable for human activities and protects building against undesirable external and internal impacts such as pollution, climate change, temperature, humidity, HVAC load, lighting load etc.

3. Sustainable Architecture

In a general framework, sustainable architecture can be explained as "creating human-made sustainable environments." An essential requirement to achieve environmental sustainability is establishing a dynamic equilibrium between different systems of the environment. This requirement from a scientific viewpoint is achieving ecological, social-cultural and economic systems simultaneously [2]. The principle of sustainable architecture is based on the fact

that a building is a small part of surrounding nature and it should act as a part of the ecosystem and be in the life cycle. The purpose of this architecture is to create a sustainable and organized balance between nature, organisms and the built environment [15]. And in this way all the process of architecture that is, thinking and studying, designing, building, using and demolition of the building is considered. Sustainable architecture is a kind of architecture that respects life and its existence in general and it considers life not only in anthropology, natural, local and immediate scale but also in all scales and everything that is related to the physical environment [15]. This kind of architecture that moves toward energy conservation can be relieved, sustainable, humane and aesthetically pleasing. And economically it is also much cheaper than conventional architecture [16].

3.1. Primary Principles of Sustainable Design

Sustainable design has full attention to the subject of design. This kind of design is thoughtful cooperation of architecture with mechanical, electrical and structural engineering. And in addition to elegance, coordination, texture, shadow, and light it considers long-term environmental, economic and humane factors. Therefore, its primary principles are as below:

- Understanding the environment: Sustainable design starts with understanding the environment. It helps to determine design process including its orientation relative to sun and arrangement of the building in the site, preserve the surrounding environment and system access to vehicle and pedestrian.
- Having relation with nature: whether the building is inside the urban environment or in a more natural environment, linking nature with the designed environment will enliven that environment.
- Realizing the existing mechanisms in nature; in the existing system in nature, there is not any garbage. Corpse body of an existent will be a food for another.
- Understanding environmental effects: Sustainable design makes an effort to realize environment effects through site evaluation and analysis, evaluation of energy consumption, the toxicity of materials and construction techniques. So that, negative environmental effects can be reduced through the use of sustainable building materials, non-toxic materials and recyclable building materials.
- Participatory design process: sustainable designers know the importance of an idea. Cooperation with consulting engineers and other expert is done in the early stages of design. Designers also pay attention to local residents and neighbors views.
- People's understanding: sustainable designers should consider culture, religion and ethnicity of the people, whom they are designed for [2].

3.2. Fundamentals of Sustainable Design

To achieve the goals of the sustainable design, this issue has been studied from different views. Some of the most important views are explained here.

Table 1. Fundamentals of sustainable design from various viewpoints

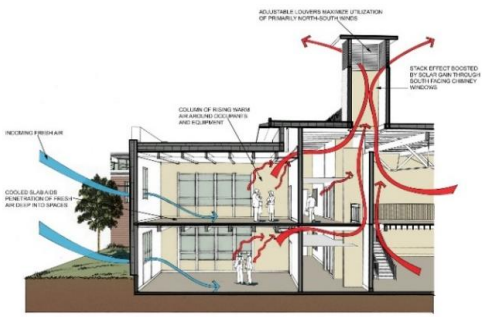
Title of view	Proposed principles
Principles of Thomas Fischer [2]	Healthy internal environment
	Energy efficiency
	Ecologically safe materials
	Environmental Form
	Good design
Hugh environmental principles [17]	Understanding environment and context
	Connecting with nature
	Understanding existing mechanisms in nature
	Natural mechanisms recognition
	Knowing environmental effects
	Understanding people
Principles of Jin Kim [18]	Economize the use resources
	Design based on life cycle
	Humane design based on the interaction between human and world
Hanover Principles [17]	Supply water and energy from the site itself
	Compatibility with site and climate and improve though conditions change
	Eliminate the concept of pollution and non-useful waste

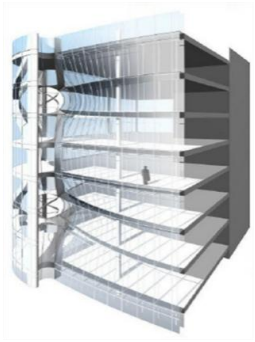
	Improve resident health like ecosystem
	Having comprehensive systems for maximum efficiency
	Improve the health and diversity of the local ecosystem
	Beauty and inspiration for residents imaginations
Brenda and Robert vale [19]	Energy conservation
	Having harmony with climate
	Reduce the use of new material resources
	Meet the needs of residents
	Having coordination with site
	Holism
Kelly and Rosana Hart Principles [19]	Small think Heat with the sun Keep your cool Use renewable energy Conserve water Use Local Materials Use Natural Materials Save forests Use recyclable Materials Build to last Produce your food Save your food

4. Contemporary Sustainable Building Design Indicators

Sustainable design's philosophy supports attitudes that consider negative effects on environments and consumers health in all stages of design, construction, operation, and use. This kind of design has specific principles such as energy resources management, design with the ability to return to the life cycle and design for humans that should be observed [19]. Sustainable building is designed and built with the aim of appropriate utilization of energy, prevent air pollution and comply with the surrounding environment [20]. Since the rational use of natural resources and appropriate building management helps to preserve limited natural resources and reducing energy consumption and improves environmental quality [21]. Therefore, parameters that are used in sustainable buildings are discussed below.

Table 2. Studying characteristics of sustainable buildings [22]

A visual introduction to building	Sustainability indicators	Building profile
 	-Innovative and efficient use of wood and composite and concrete panels -The electrical and Mechanical infrastructure required for integration in sports halls with building systems -Use of photovoltaic cells -Use of vacuum tubes and solar panels for building`s hot water supply -An accessible green roof planted with native flora and attracting local plant species -Use of Energy, light, and ventilation of the natural environment	Okanagan College Center of excellence Canada CEI Architecture Planning Interiors Educational and Office usage [23]
		

View details    Establishment wind turbines on the bulbous roof [23]	-Technology to have harmony with the natural environment, using wind turbine for utilizing wind speed, use of photovoltaic cells and south light to provide comfort and the energy that tower needs, respect users in designing plan and volume -Using double – shell transparent dome for the maximum use of natural light and produce negative pressure for better ventilation.	Clean Tech Tower Chicago - America Adrian Smith – Gordon Gill Architecture Hotel and Office usage [24] LEED Certificate
   Ref: Gültekin, Yavaşbatmaz, 2003 [22]	Underfloor Air Distribution, using recycled steel, creative use of energy saving system, use of glass facades as a parasol for building, automatic moveable shades, growing plants inside the building, applying proper systems for using natural light, sound insulation, considering humane design in plan and volume design.	New York Times Building Designed by Renzo Piano Building Workshop and FXFOWLE Architecture Usage: Office [24]
Front corner has a shape bird`s mouth [25]   	Equipped with a grain water supply system, resource recycles management, smart use of colors materials and colors, maximum use of natural lighting, Using motion sensors, lighting equipment, humane design and considering the climate of project`s construction location.	Hearst Tower New York - America Architect: Norman Foster Usage: office [23] LEED Certificate

  Ref: Gültekin, Yavaşbatmaz, 2003 [22]	Coordination with climate, using recyclable and eco-friendly materials, creative use of energy storage systems, building, applying proper systems for using natural light, use of glass facades as a parasol for building, using plans inside the building.	MVRD Office building in France Usage: Office [26]

5. Conclusion

Sustainability means perseverance, coherence, and continuity. It is active which means movement and motion. In other words, it is a storage future. It preserves something that has sustainability. So, architecture as a design activity should stabilize environment along with the ability to sustain anything that requires sustainability. According to mentioned points and obtained results from studying samples, what seems obvious is to protecting the environment is the basic rites of sustainable architecture that is achieved by application of modern advanced technologies, choosing the correct procedure for adaption and coordination with the environment and establishing a proper relation with the social and cultural context of consumers. So that, according to Alexander, knowledge ecology is the coexisting the objects, elements and environment. Whereas, current living conditions of the world has also led human society to compatibility with nature and the environment. To understand the relation of building with the environment, at first, we should consider the views of human about the environment and in general about nature. The basic of construction is the human encroachment into nature. The type of this encroachment has a very close relationship with thoughts of human about nature. As a result of modern vision about building, its relation with nature and people and revision of architectural design process, are essentials of sustainable architecture.

Table 3. Determination of common indicators in sustainable building (Gultekin and Yavasbatmaz 2013)

Certificate	Geothermal system	Thermal sensor	Considering climate	Using site's Potential	Smart ventilation system	Smart electrical system	Loss save and recycle management	Using natural light	Smart glass	Water saving	Green roof or plant coverage	Recycle rain water	Photovoltaic cells	Eco-friendly materials	Smart view	Sound and thermal insulation	Shade	Humane design	Wind Turbine	Double-shell design	Designer	Usage	Location	Title	Row
																					Calatrava	Residential	Chigaco-America	Chicago Spire	1
																					Jean Nouvel	Office	Barcelona-Spain	Torre Agbar	2
LEED																					Smith-Gill	Hotel-Office	Chigaco-America	Clean Technology Tower	3
																					Renzo Piano and FXFOWLE	Office	New York America	New York Times tower	4
																					Huygen Jaegers	Residential	Rotterdam Netherlands	Urban cactus tower	5
LEAF																					Atkins	Office-Commercial	Manama-Bahrain	World Trade Center	6
																					Skidmore-Owings-Merril-Gill	Office	Guangzhou-China	Pearl River Tower	7
CTBUH																					Cook Fox architects	Office	New York America	US Bank Tower	8
Holcim																					Atkins	Commercial recreational	Dubai Emarates	Sun Tower	9
																					Gordon Tait	Office	Manchester,-England	CIS Tower	10
																					Ken Yeang	Office	Kuala Lumpur-Malaysia	Menara Mesinlaga	11
																					Ingenhoven	Office	Essen-Germany	RWE Tower	12
																					Norman Foster	Office	Frankfurt Germany	Commerzbank Tower	13
																					Ken Yeang	Residential	Pinang Malaysia	Menara UMNO	14
LEED																					Lewenberg-Gang	Hotel-Apartment	Chigaco-America	Aqua tower	15
																					David Fisher	Multipurpose	Dubai-Emarates	Da Vinci Tower	16
																					Woha architects	Residential	Bangkok	Met tower	17
																					Eckhard Gerber	Office	Dubai Emarates	Energy Tower	18
																					Wag Tistelton	Residential- Office	London-England	Wag Tistelton Tower	19
																					Kisho Kurokawa	Cultural	Wakayama Japan	Museum of Modern Art	20
																					Ben van Berkel group	Office-Exhibitory	America	New Orlean building	21
																					Ben van Berkel group	Multipurpose	Groningen, Netherlands	Forum cultural center	22
																					AEG group	Office Commercial	Seoul South Korea	Sejong building	23
																					Atelier group	Exhibitory Commercial	Seoul South Korea	Doku Building	24
																					Carlo Moretti	Educational	Casanova-Italy	Scuola Materna school	25
																					DWP group	Residential	Hochiminh-Vietnam	Evi Project	26
																					Rene Datelonde	Educational	France	Campaign university	27
																					Gianni Arnado	Artistic	Saugnieu Italy	Mango music center	28
																					Francesco Gatti	Cultural	Nanjing-China	Automobile museum	29
																					Unsangdong architects	Residential	South Korea	Dancing apartment	30
																					Norman foster	Recreational	New Mexico	Hangar Airport	31
																					Richard Meier	Religious Cultural	Rome Italy	Jubilee Church	32
																					Paul Busse	Scientific	New York America	New York Botanical Garden	33
																					Jorge Hernandez	Residential	Mexico	Sun Tower	34
																					Jacob Klinkhamer and Adolf Gendt	Multipurpose	Amsterdam -Netherlands	Grain silo building	35
																					Craig	Residential	San Francisco	Residential house	36
																					Lane Arc group	Residential	Los Angeles	Net house	37
																					Joaquin Torres	Scientific	Murcia-Spain	Research center	38
																					Moho	Residential	Costa Rica	Cell Tower	39
																					Willy Müller	Multipurpose	Saint Petersburg	Resort center	40

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