

Ecological Design Process, the Way toward Improve Modern Sustainable Architectural Design

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ABSTRACT: Nowadays the main question of designers is about the consequences of their activities on the natural environment that how should be designed the built environment which not to destroy nature. Due to energy and environmental crisis conditions of present age, it is essential that instead of imitating the techniques of sustainable architecture, to be dealt with a more radical and looked for answer not in the design itself but in the point of view to that. The reason of existing architecture instability can be connected to the lack of designer's sufficient knowledge of the current situation, inability to categorize and organize their vast architectural information and field of design with the principles of sustainability. The problem could be related to deficiency of a specific design process and lack of holistic and sustainable design approach by the designers. The appropriate design in educational or in commercial architecture requires accurate and systematic process from beginning to the end. The main question of this research that is a logical argument with qualitative- interpretation approach using by library is how could specify the path of the design and promote the theoretical foundation step by step in order to develop suitable architecture. The main assumption in this research is how the design principles is more accurate and predetermined consequently the results is more desirable. Such principles could be found in ecological design. The objective of this work is the present a procedure of modern sustainable architectural design with the title of ecological design which has been introduced by Malaysian architect Ken-Yeang. Based on the mentioned method, the process of design was presented in form of a table to make the designer to be capable to the accurate and classified design.

Keywords: Ecology, Built Environment, Sustainable Architecture, Ecological Design.

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INTRODUCTION

Literature and utilizes of ecological design is not to be considered as expected. Also there is no fundamental design criterion for such approach. The ecological design is a general understanding of modern human communication and built environment in order to integration of natural environment and current life. Ecological design should be used in all fields of built environment such as land use planning, building design, oriented production, energy systems, transportation, conservation, agriculture, forestry and urban design is applied. Ecological design in relation to architecture is to being have a new point view than what earlier was that is referred to type of architecture. Built environment and its application should be distinguished completely and its measure depends on benefits to human. The object of this work is expression of executive instructions for ecological design: response to performance and formation of architectural configuration by using specific process. Another purpose of this research is to provide guide lines and principles for professional to better understanding the ecological consequence of their work on the environment. And how transform their companies in to sustainable form. There is no comprehensive book in ecological design filed till yet except an elementary book which was written by Malaysian ecologist and

architect, Ken-Yeang. Nevertheless this book tries to present instruction and principles to design, doesn't cover the all design requirements. Overall, based on green design criteria the data gathering, analysis and complaints rates can not to be a final design solution. Of course by application and execution of this process diverse aspect of ecological design can be responded. This should be specified in all areas of design process the designers need a creative activity to complete design. Just similar to combination of the bunch of letters or aphorisms which together make up a whole. Design is like to this. Finally, in combine with aesthetic elements become a complete whole. It should be wary that ecological design and its principles are not something permanent, regular and consistence in order to use and application but it can be wary depend on location and type of use which is dependent on designer's discretion. Ecological design should be begun from experimental thinking (Yeang and Llewelyn, 2008). Therefore the most of the workload is related to basic and abstract knowledge. The main challenge ecological design is converting of this abstract knowledge to application. Another major effort of ecological design is make integrity and harmony nature. In theoretical point of view of this approach can be like bees in looking for foods in nature without any impact to environment, however, in practice it is not possible. Because humans

implies the most impacts to environments in different forms of contamination. Therefore to reach safe environment the essential step needs a good cognition of environment. As a consequence the details of design should be considered rather than general purposes (Azizi, 2011). In following the information and basic definitions are explained to produce brief fundamentals of a practical method to sustainable design in architecture.

What is the ecological design process

Ecology is study of the distribution of microorganism of group's organism in an environment and often is misunderstood with natural environment or oriented environment (Dadson et al., 1998). But in practice and design, ecological design means unification of built environmental systems with natural systems. In other words, ecological design is utilizes of principles of ecological design for built environmental design and life style. So that they to be integrated safe and appropriate to the nature including of biosphere. There are more differences in the field of ecological design that the design is only a part of problem that can be solved by technology. Many of researchers believe that if a building utilized by ecological instruments such as solar collector, wind turbines, photovoltaic and etc., the building would be ecological building; this is just coming from engineering approach which of course is not true. This is consequences from a misunderstanding of architectural design. Definitely, in order to achieve to ecological design there is no necessity to use such instruments and facilities. So it seems that green design means no design for low energy consumption. Final goal of ecological design complete integrity with nature by designing. There is big difference among engineering and ecological viewpoints. In engineering view point, designer begins his work from the end. It means he has a distinct image from predicted consequences to raise efficiency. But in ecological approach design begin with cognition and perception of environment. Ecological design is peaceful design with nature. Some of designers consider green design with ecological design as the same that with minimum impacts on the environment. In ecological design the procedure can be compared with a tree that produce oxygen, use solar energy and water treatment. In despite of all this consequences, this design in integrity with nature has problems. One of the solutions to survey the magnitude of design integration with environment is to prevent wasting of solids, liquids and gas materials. Integration with environment in ecological design was applied in three levels (Yeang and Llewelyn, 2008).

- 1- Physical integration:
- 2- Systematic integration
- 3- Temporal integration

Relation with green architecture and sustainable building

Sustainable architecture is inclusive and not to be limited Architectural branches such as technical architecture, green architecture, smart architecture, environmental design, behavioral design and economic oriented architecture in low usage of energy or material. In fact it is in contrast to the former architecture which

follows functions or creating pure form (Ahmadi, 2003). Also based on another definition, sustainable architecture is kind of architecture that respect to the life and its existence. Sustainability can be assumed that available materials and resources are employed more efficient (Jowdat, 2002). According to figure 1 colorful means more stable build colorless side of figure means ordinary building. Stability is threshold condition in which use of building material and waste are in balance. The sustainable buildings should reach in three fields of social, economical and environmental sustainability.

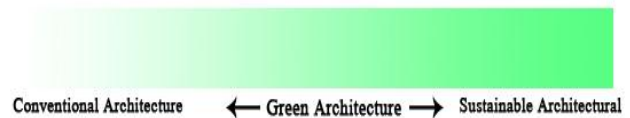


Figure 1. Bound of sustainable and conventional architecture

Green buildings are path between conventional buildings and sustainable buildings in order to achieve sustainable building. Usually, there is a misunderstanding between ecological, green and sustainable architecture, so that these terms are used as the same. While, these concepts are easily separable from each other according to their relevant aspects. Ecology is the first term which is used in this classification and includes the design of eco-village and eco-city that is refer to protection of environment (El Feky, 2006). The green architecture is divided to 15 classes which one of them has special professional fields. Table 1 presents all these classes and the more important factors is highlighted.

Table 1. Main classification of green architecture (El Feky, 2006)

Classification	Explanation
Design of sustainable site	Including: proper site selection, landscape design, technical methods with the least impacts on the environment
High energy efficiency	-
Rain water	-
Waste water utilization	-
High energy yield	-
contaminant	-
Material conservation	-
Resource conservation	-
Energy conservation	To reduce use of recycle energy, using energies which has minimum impacts on the environment, protection of Ozone layer
Inner air quality improvement	
Satisfactory of inhabitant	Thermal, visual, and sound comfort
innovation	-
Waste and exotic	-
transportation	-
Eco-friendly	-

Activists in ecological design

Inventors such as, Buckminster Fuller, Paul McCartney, and architects like Paolo Soler Peter Kltrvp, Pliny Fisk, James Wayne, the landscape architect William McDonough and Ian Mc Harg and Ndrvpvgvn

could be mentioned. In fact these researchers are the first founders of theory bases of sustainable architectures that had been employed fundamentals of sustainable design in own works. Each designer brings us to explore their design process that opens their minds and the techniques which used in procedure and also their vision to the future. Their special view to this subject includes details of microorganism to mega structures. Each had specific slogan for own design. Some of more important slogans were such as "design is way of life", "design along with nature", "regenerative design", "forms of value creation" and "Biosphere Technology". The works of these designers and their ideas is similar to painting present the beginning of ecological design as a new phenomenon that was became a theoretical foundation in 21st century. Among the structures that affect the development of green architecture in world are famous universities such as Harvard University, the University of Arizona and the University of Calgary. The three universities in North America are leaders and pioneers in green building design. They have certificates of green design to the university buildings (www.filmwest.com, 4-3-2013). One of the famous designers that could be noted as green designers of early years is Bob Berkebile and Ken Yeang.

Bob Berkebile: He is the chief of Bnim Company in USA. He has received Hayenz award from Haynz family in 2009. He awarded because of his role and attempts in developing green architecture and his commitment and action to restore social, economic and environmental vitality (sustainability in three fields) in American community through sustainable planning and architecture. His aim is improving the quality of life in terms of mental and emotional. He is the third person among five the most impressive persons whom introduced and promoted sustainable architecture and green design in America (www.Bnim.com, 30 -1-2014).

Ken Yeang: One of the most famous and active person in the field of green architecture is Malaysian architecture and ecologist Ken Yeang. He is one of the main founders of this method and one of the 50 people who could save the planet. His ecological design hand book as a main reference source is used by architects and designers all over the world. In this research this book was used as framework of study. Young's own words: "I am an ecologist first, an architect second" (www.Kenyeang.com, 6-7-2013).

MATERIALS AND METHODS

Ecological design basics (fundamental of ecologic design) and design concepts

Ecological design must be based on the concept of ecosystem. This concept was first published by Sir Arthur George Transley (1871-1955) and then extended by Eugene P Odum (1913-2002). Ecosystem is an independent unit in nature that is a community of living organisms (plants, animals and microbes) in conjunction with the nonliving components of their environment (things like air, water and mineral soil). The ecosystem concept is derived from the word ecology that was first used by German biologist Ernst Heinrich Haeckel in 1866. The most important feature of ecosystem is to exist on a variety of scale. Regarding to this definition

ecological design also can be in any scale. There is no closed system in any ecosystem means that all ecosystems are linked together by energy and material flows. Any system has a spectacular energy and material flow and it is necessary for the designer to study the ecosystem thoroughly because this enables him to understand ecological environment and ecologic processes to preserve it. In Figure 2, the components of the ecosystem and their connections are indicated so the designer will be able to understand all factors affecting the design process before starting project.

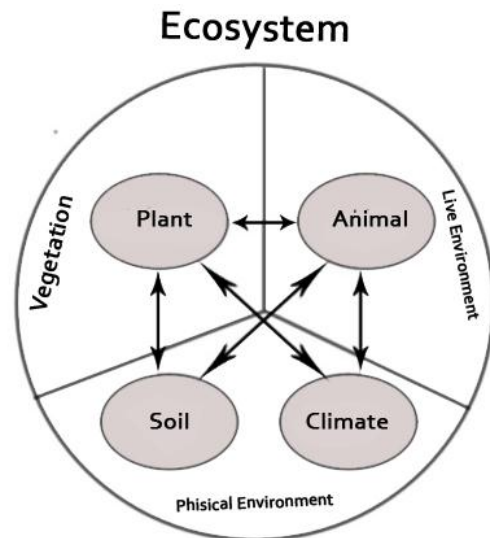


Figure 2. Ecosystem components

(Yeang and Llewelyn, 2008).

Principles of ecological design

The task of ecological design is to maximize use of passive (static) systems and other possible technological tools. Designing is on the basis of the ecosystem survey. In fact bio imitation is a kind of utilizing ecosystem as a model for the design. The important fact in ecosystem is energy and energy usage. Ecosystem is relating to solar energy. Free and renewal energy that stores in nature as fossil energy. So the solar energy is the basic source of energy. Ecological design must have the minimum impact on natural environment. And the other fact in ecological designing is to consider biodiversity (Yeang and Llewelyn, 2008).

RESULTS AND DISCUSSIONS

Design process or bio-design instructions

The important fact in bio designing is being process-oriented and to have a clear process in design to access the best results that is the main purpose of study. The process starts with simple and clear questions and continues with analyses to achieve result. After presentation this part will be used in practice.

First step: answering fundamental questions

Ecological approach must be started by this hypothesis: "Environmental impacts of any design system increase when the damages and destruction on the human life condition, increases". What should be built and if it is vital for biodiversity of human being; are

the first questions must be asked by designer. For example while describing the construction conditions at the first steps of design, housing development and comfort conditions as Confining layers required for the design must be discovered. The liveability of the project in an ecological design must be indicated while assessing design requirements. The next questions are:

1. What are the needs of users and what is the function of design system? Designers often give antonym answers to these questions that are not always true.

2. The other step is to indicating expectations of living environment of designed system. What are the expectations of design system? Is it long-term or short-term? If it is long-term means that less recycling must be done which is more flexible. Easy to use and possibility to reuse continually throughout the life of the building.

3. What are the effects of construction on the ecosystem? Determine the exact level of occupation, the infrastructure and built form, are principles and conditions of physical impact of design systems on the

ground. Therefore by using factors like plants, water and ground we can impact physical properties of the site.

4. How is the morphology of designed system? This question is related to designer need for construction rate for example it should be High density or extended? Or how is the mass-space of building and interaction between inside and outside of the building

5. What are the site conditions and ecological complexities of the environment that is related to human activities or what are the equipment and artificial structure and infrastructures required for the system (Yeang and Llewelyn, 2008).

Second step: estimating ecologic history for site designing

First of all designer should study the ecological history of site to indicate the range of analyses required. In selecting and designing site; variety of choices from different parts of site must be analysed. The ground surface can be divided into different parts according to qualities like vegetation. Ecological history Classification of sites is indicated in Table 2.

Table 2. Ecological history Classification of sites

Ecologically mature ecosystems	These ecosystem includes biodiversity and high diversity of living organism for example 400 kinds of trees
Ecologically immature ecosystems	An ecosystem that is still natural and is trying to renew itself from the damages
Ecologically simplified ecosystems	Are semi or completely wild ecosystems but can be controlled by grazing domestic animals or by burning or by preserving some kinds of animals in it
Mixed artificial ecosystems	Ecosystems that are controlled and preserved by human. For example parks and garden. And it is important to consider the natural ecosystem in site revival like vegetation and plants.
Monoculture ecosystems	These ecosystems are also artificial but are used to agriculture and planting trees for obtaining wood and lumber, meadow and grassland. These ecosystems are called protected area
Zero culture ecosystems	Sites with ecosystems with minimum ecology like cities and towns which there is no natural elements in there and the ground soil is completely destroyed. In these sites in some parts there are some signs of historic ground and geographical and cultural properties that must be revived, renewed and reconstructed. In these kinds of ecosystem we must try to revive the first conditions of ground. For this purpose we must study plant species in the region. For example we could use plants in street margins and near green areas. In fact the proper kinds of plants for area must be identified before construction.

Third step: design with plants

There are 3 guidelines for designing plants:

- Juxtaposing : green areas and plants will be located in one or more places inside the building (it means that green areas must be concentrated in limited places in building)

- Intermixing: in this system green area will surround the building.

- Integrating: green areas and plants of outside area will join to interior plants and animals can be able to walk in.

The main features of ecological design is utilizes both the outside and around it by using plants.

The most important effects of plants beyond its shades are the reduction and regulation of temperature and moisture inside and outside of building. Shade and protecting the building from sunlight, preventing the reduction of wind speed around the building, reduce in temperature even till 5°C and prevention in waste of heat in winter until 30% (If it used in outer membrane of structure). The leaf of plans can reduce the temperature 1°C more than beside areas. Plants ad arbors can reduce the temperature of the ground about 2°C.

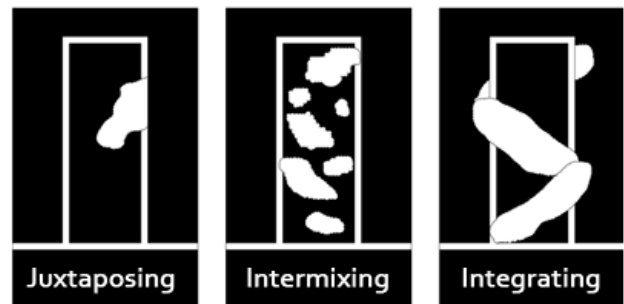


Figure3. Three different using forms of plants

Design with the purpose of inner thermal comfort of the building

According to ASHRAE standards the thermal comfort of each person is the mental condition which describes the satisfaction of the person from the temperature. The standards search the maximum thermal comfort for the different persons which locate in the same place. The standing of thermal comforts is important because it guides the designer to create the necessary colds and heat in the building by using mostly ways and lesser active methods. Determination of

comforts conducted by bio-climate diagrams of Olgey, Givoni and Mahooni (Heydari, 2001). It needs exact studying of continent by using of climate data and using the fundamentals methods of climatically design as well as determination of using efficiency of energy in cooling and heating of building.

Designing of building based on optimized and advanced systems

Ecological design is for human and to shape the form of building within internal environmental systems also it can provide some level of internal conditions that are acceptable to users. Additionally be taken simultaneously low energy (fossil fuels) uses among the crucial elements in the ecological design are Energy and how energy is consumed to achieve comfort conditions. Obviously comfort condition, lower than the accepted standard of comfort of users ,Under standard design conditions So that whatever standards are lower, the total energy consumption is also reduce. Comfort temperatures typically between 18 ° C to 24 ° C. It is temporary and depends on temperature and relative humidity that should be between 30 to 65 percent. In general it can be said that such high humidity need low temperature until men feeling comfortable (Lechner, 2007). Not only thermal comfort depend on temperature range radiant temperature, air flow and the vapor pressure but also related to population coverage, number of occupants, their activity level. Simultaneously designer solves the needs of select of space and form of the building materials and components for use in conjunction with the technologies and systems should be implemented to think so. The final option, In order to improve the external shell structure and the development of strategies to optimize static internal comfort conditions it Necessary to reduce energy consumption and demand for electricity and fossil fuels. Passive design uses simple ways to provide heating and cooling temperatures within buildings and uses of natural resources in the environment. First task specifying range of choices of passive systems that are based on local climates. This parameters are Radiation, air temperature, wind based on the surrounding topography and urban design and the built environment. The main approach not only architectural design, building and forms to comply with the regional climate, but also it is respond to the climate. Climate, does not specify the building form but impact on it. The first principle of design is Prioritize passive system on operating systems. The best way to achieve biological design is ideal. This design is based on the latitude and the position of sites. The main strategies of the system is forming a proper building by fallowing of the sun's path, the use of natural ventilation, vegetation, ghosting (Watson, 1992). Selection of building material impact on environmental effects on

them. The materials are processed before they used in the building and be a part of it. For example, in Great Britain it is estimated that the production of building materials, about one-tenth of the energy consumption and carbon dioxide emissions that contribute to a high rate. Several factors should be considered when selecting material, and it is unlikely that absolute rules can be found for all conditions. In this context, the first question is how environmental impacts should be evaluated. What is assessment factor of environment impact of material. This can be seen as a factor determined by the intrinsic properties of materials and to consider factors that affect the design.

Table 3. How to deal with the design of materials

Determinants of quality of materials
Energy requirements to production
Carbon dioxide emissions resulting from the production of materials
Environmental impacts of materials extraction (mining, timber, oil, etc)
Material toxicity
Transportation of materials from production to consumption
Level of contamination after the useful lifetime
Factors affecting the choice of materials and design decisions include:
Location and details of architectural elements
Maintenance and materials required for the repairs
Use of materials that reduce the environmental impact of the other elements
Flexibility of design to change in time and space
materials long life and its potential for recycling

Embodied energy is the energy which used to produce an object descriptions. This energy can be looked at in a brick and the total. Embodied energy because it is an important indicator of the amount of renewable energy is the main cause of environmental degradation (Roaf et al., 2001). Note that investigate of materials are an attempt to reduce energy consumption, It should be noted that in the early stages of design.

CONCLUSION

In practice and design filed ecological design means integrating artificial ecological systems with natural systems in other words, ecological design is employment of ecological design principles and guidelines in order to design built environment and life style. So that they would be integrate in safe and in harmony with nature. Whatever was said in this section is to present a process of ecological design to students and engineers. The main features of ecological design have been identified in table 5. And the holistic environmental designs are categorized totally in table 6.

Table 5. Main properties of an ecological design

Main features	Explanation
Design at any scale	In order to further integrate from macro and micro scale.
Using of ecosystem elements in design	In field of design process, including bionic design
Inspired by natural element and cycles	Water and energy cycles in site
Energy and use of solar energy	Design based on sun geometry

Having the least impacts and encroach on the site	Minimum encroach in environment
Reducing the demands and needs of the residents	Reducing energy usage

Table 6. Holistic steps of environmental designs (Author)

1- Assortment design beginning questions			
a. What are the needs of users and what is the function of design system			
b. Determining the expectation of life span			
c. What will be the effect of construction on environment?			
d. how will be the system configuration of designed system			
e. Site condition and ecological complexity that related to human behavior			
f. What is the comfort condition in built environment			
2- Site ecological design based on existence of site: physical assessment of climate, soil and plants and provide design solution			
2-1-Studing of site	Designing via plants	Green instruments	Arrangement Combination Integration
			Ecological Corridor Green Corridor Rows of bushes
		Design to reduce the heat island effect Design improvement to reduce microclimate effects	- Using of materials with less absorption and more reflection - Make greater use of trees on ground and roof
2-2- design with aim to improve inner comfort condition	Design building based on enhanced and optimized systems	Passive systems	Configuration and forms design Orientation Solar systems Natural Ventilation Landscape design

The purpose of this method is a way to offer a wide assortment of data in the early stages of design. The main advantages of such approach is that, since the goals initially, more accurate, more detailed and more specific, it is also easy to reach and will become clearer.

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