GREEN SUSTAINABLE ARCHITECTURE

Preeti Shrestha and Prabin K.C
Civil Engineering Department, Lamar University, Texas
Email: shresthapreeti@hotmail.com
prabinkc76@hotmail.com

Enno 'Ed' Koehn
Civil Engineering Department, Lamar University, Texas
Email: ed.koehn@lamar.edu

Abstract

In this paper, the concept of the green and sustainable architecture is presented. Green architecture has seen a revival in today's society. It provides many functions of which both the society and the individual can take part. In particular, Green Architecture may be considered a building and structural design philosophy that aims at minimal use of non-renewable and polluting materials and resources in construction and use of a facility. These require little or even zero maintenance and provide very valuable functions. In fact, Green Buildings affect our environment and our economy in a positive manner providing a healthy environment.

In this research work, the impact of green architecture on society has been examined. The result is a compilation of contemporary research together with a discussion about the use of green buildings. The concept of Green Buildings, as such, envisions a new approach to save water, energy and material resources in the construction and maintenance of facilities and can reduce or eliminate the adverse impact of buildings on the environment and occupants. The Green building technology can trim energy cost and gas emission by approximately 40%. Therefore for achieving future sustainability, energy-efficient buildings in the form of green architecture are proposed in the study.

The research demonstrates, through example, how green architecture is gaining acceptance in the recent years and how different tools and techniques are being used in green design.

1 Introduction

Green Architecture also known as Eco-Friendly Architecture provides a soothing, natural and healthy non-toxic green building in any environment. Green building is an outcome of a design that transcends mere technical, ecological and economical issues[1]. Green architecture is more a set of strategies and values than an architectural style. The architecture mainly focuses on increasing the efficiency of resource use – energy, water, and materials while reducing the building's impact on human health and environment during the building's lifecycle, through better sitting, design, construction, operation, maintenance, and removal.

Green architecture is for everyone. Not only does green architecture benefit our generation by sometimes saving money or potentially giving better health options, but Green Architecture will also help the generations in the future[2].

Green Architecture involves architects, clients, consultants, construction managers, and material suppliers who strongly believe that our planet is a precious commodity, something that should be greatly cared for through sustainable development. "Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs"[3]. Sustainable developments attempts to minimize green house gases reduce global warming, preserves environmental resources and provide communities that allow people to reach their fullest potentials.

The focus of green architecture is for the project to work in harmony with the natural features and resources surrounding the site, to use materials that are recycled or easily grown, and to maximize the efficiency of the building. Good green architecture reduces waste, of both energy and materials. During the construction phase, the goal is to reduce the amount of material going to landfills. Well designed buildings also help reduce the amount of waste generated by the occupants as well, by providing onsite solutions.

2 Background

Green architecture originated in Europe and Japan. In the United States, green architecture really started in the mid-1970s, following the OPEC oil crisis in 1973[4]. According to a U.S. Green Building Council (USGBC) report, the industry uses 40% of the world's energy for construction and building operations. Construction and operation of buildings in the United States accounted for more than one-third of this country's total energy use and the consumption of more than two-thirds of its electricity, 30 percent of its raw materials, a quarter of its harvested wood, and 12 percent of its fresh water[5]. In addition a correlation between poor indoor air quality and respiratory health problems tends to reduce productivity.

Construction and operation of buildings not only uses energy but also causes many forms of environmental degradation that places an increasing burden on the earth's resources and jeopardizes the future of the building industry and societal health and welfare. The way the buildings are built today is leading to depletion of natural resources as well as reduction of the ozone layer and global change or warming. Natural disasters are occurring all over the world and lives are drastically changing. These events are causing people to go green, changing architectural styles and using green architecture. This will protect upcoming natural challenges and give the future generation something to live for.

3 Objectives

Green architecture is going to be more important in the near future. The preservation of the planet depends on how we continue to build and develop. At the rate we are going, the earth will be destroyed. Now, it is beyond imagination, how much damage has been inflicted on the earth by the construction of various types of buildings using sand and water from rivers, stones, mountains, and cement manufactured from the ingredients dug from the land. In addition, carbon emissions from the buildings and manufacture of construction materials

warm up the air and space. Therefore, change may have to come in the field of development. And, it seems Green Architecture can provide an arena to talk about and actually use to reduce resources in the near future.

The main objective of this research is to explore the emerging concept of Green Architecture as a form of sustainable architecture in this changed national and international context. Being aware of the dangers of toxic materials and wasting resources, it may be possible to change the way to construct future infrastructure facilities. This study will help to educate ourselves about the green tools and technique, so that we can identify the special type of materials utilized in sustainable building and also we can design with green materials in the future.

4 Characteristics and Significance of Green Architecture

Green Architecture is a broad approach to green building that seeks to create or renovate buildings so that they will have very minimum harmful effects on the environment and the human health. There are different approaches to green architecture but mostly idea revolves around Optimization of Resources, Optimization of Physical Resources and Utilization of Energy.

Optimization of the resources includes use of local building materials, use of natural and biodegradable building materials and use of non-synthetic, non-toxic materials. Whereas optimization of physical resources means landscape planning, efficient use of space, ventilation systems, water supply and sanitary systems, adaptive use of older buildings and use of recycled architectural facilities. And tricks and tools used for the utilization of Energy are maximum use of renewable resources, use of solar and wind power, efficient lighting and appliances and using daylight system.

Green building brings together a vast array of practices and techniques to reduce environmental impact and improve health of residents increasing the productivity of employees. It utilizes the tools and techniques that protect natural resources and provides one of the mitigation measures of climate change which is the challenging and alarming issue of 21st century. Green Building promote resource conservation, including energy efficiency, renewable energy, and water conservation features; reduce operation costs by increasing productivity, improve public and occupant health due to improved indoor air quality and address issues such as historical preservation, access to public transportation and other community infrastructure systems finally reflects the healthy and wealthy environment.

5 Green Building Rating System

World Green Building Councils (WGBC) supports the adoption and ongoing development of market-based green building transformation systems that meet local needs for each country. The World GBC does not promote any particular system or methodology as a global standard. Rating tools should facilitate the sharing of information on environmental building performance that is relevant to the regions climatic and commercial context[6].

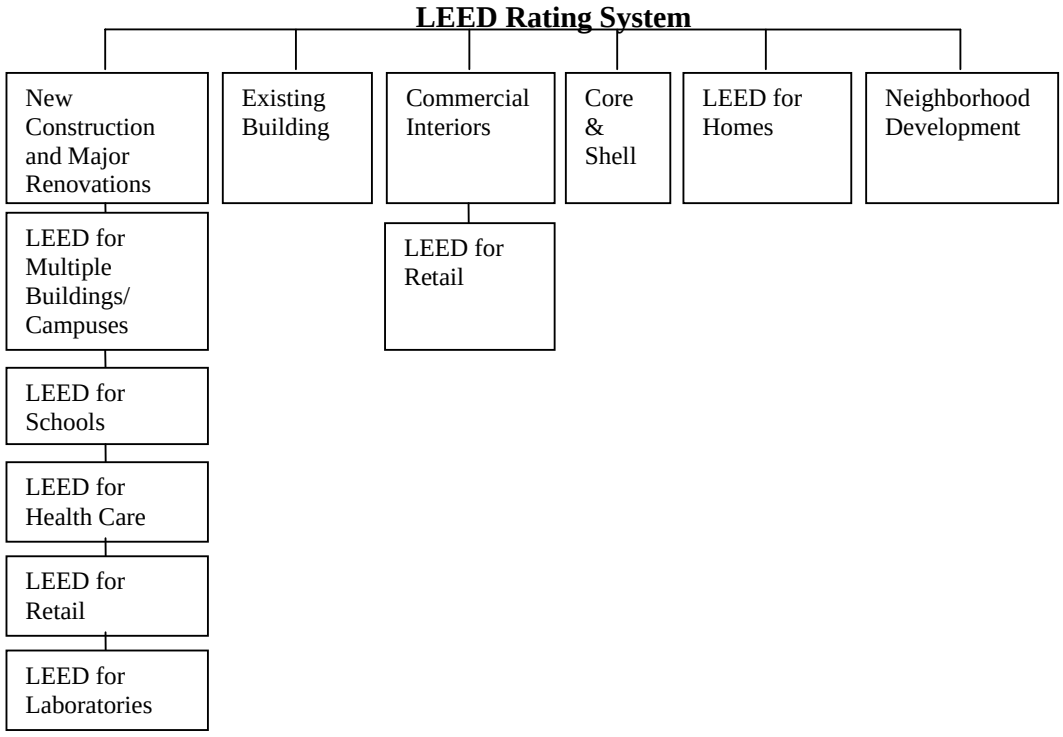
The following Green Building Councils have developed rating systems:

- Australia - Green Star
- Canada - LEED Canada

- Germany - German Sustainable Building Certification
- Japan - Comprehensive Assessment System for Building Environmental Efficiency (CASBEE)
- New Zealand - Green Star NZ
- South Africa - Green Star SA
- United Kingdom - BREEAM
- United States - LEED Green Building Rating System

5.1 LEED Green Building Rating System:

The Leadership in Energy and Environmental Design LEED, developed by the U.S. Green Building Council (USGBC) has become the standard by which all sustainable buildings are designed and rated[6]. It is the nationally accepted benchmark for the design, construction and operation of high performance green buildings. LEED Certification (as shown in table: 1) provides independent, third party verification that a building project is environmentally responsible, profitable and a healthy place to live/work. LEED for homes is a rating system that promotes the design and construction of high-performance green homes. Benefits of a LEED home include lower energy and water bills; reduce greenhouse gas emissions, and less exposure to mold, mildew and other indoor toxins[7].



Award	Certified	Silver	Gold	Platinum
Green Building Rating System for New Construction & Major Renovations(LEED NC) Version 2.1	26-32	33-38	39-51	52-69
For Building Operation & Maintenance	34-42	43-50	51-67	68-92
For Commercial Interiors	40-49	50-59	60-79	80 pts & above
LEED for Schools for New Construction and Major Renovations	29-36	37-43	44-57	58-79
LEED for Homes	45-59	60-74	75-89	90-136

Table 1: LEED Certification

6 Practices

Green Architecture practices aim to reduce the environmental impact of buildings.

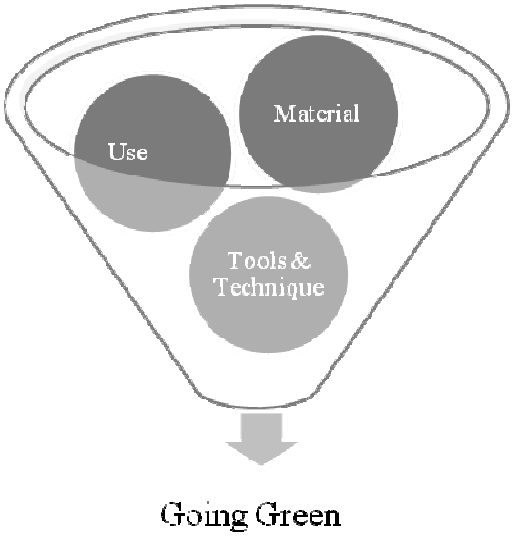


Fig. 1: Going Green Concept

Sustainable architecture seeks to minimize the negative environmental impact of buildings by enhancing efficiency and moderation in the use of materials, energy, and development space (as shown is fig: 1). Tools and techniques can help to optimize the use of the materials. Most of the resource professionals are trying to use the abandoned material as per the specific purpose. The reuse of an abandoned material such as a shipment container, bottle, plastics, can be the one of the options for the facility.

Buildings are one of the main causes of pollution i.e. 40% greater than automobiles. Buildings account for a large amount of land use, energy and water consumption, and air and atmosphere alteration[5].

Considering these statistics, green building technology is essential for future sustainability as they reduce the amount of natural resources consumed and the amount of pollution given off(as shown is fig: 2). Green building technology can trim energy cost and gas emission by a minimum of 40%. By preferring Green building over a conventional facility we help this planet earth and the people to retain nature to a maximum extent possible[9].

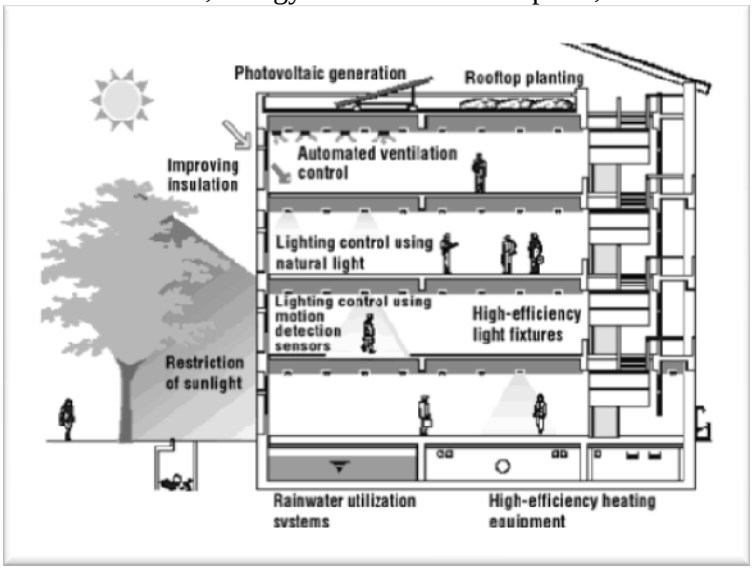


Fig. 2: Green Building Technology[9]

Green building brings together a vast array of practices and techniques to reduce and ultimately eliminate the impact of buildings on the environment and human health. Effective green buildings are more than just a random collection of environmental friendly technologies such as,

6.1 Buildings Built of Bamboo and Straw

Bamboo is one of the most amazingly versatile and sustainable building materials available. Structurally it is ductile in nature. It grows remarkably fast and in a wide range of climates. It is exceedingly strong for its weight and can be used both structurally and as a finish material[10].

Fig. 3: Straw and Bamboo house, Nepal

Straw is a byproduct of the crops use as a renewable resource that acts as excellent insulation and is fairly easy to build with. The straw walls offer insulation from the summer heat, while the earthen plasters and floor give thermal mass to maintain an even interior temperature.(as an example see fig:3&4) Care must be taken to assure that the straw is kept dry, or it will eventually rot. For this reason it is generally best to allow a straw bale wall to remain breathable[10].

Fig. 4: Straw Bale House[12]

6.2 Buildings Built of Local Materials

Adobe is one of the oldest building materials utilized. Clay or mud is the prime material used in construction of the Adobe homes. The moistened dirt or the straw can be used to strengthen the structural properties of the adobe. Commonly adobe is shaped into uniform blocks that can be stacked like bricks to form walls or simply piled up to built the structure. Historically these houses were used because there was no other choice available while these days adobe material mixed with the straw are used as environment friendly houses[10].

Similarly, earth ramming is done so that the material is compressed or tamped into place, usually with forms that create very flat vertical surfaces. Modern rammed earth typically utilizes heavy mechanized equipment to move and compress the material. The walls can be made sufficiently thick to give enough bulk to be stable and provide the thermal mass for comfort[10].

6.3 Earthship Houses

An earthship is really just a self-sufficient greenhouse with a huge, inbuilt storage heater. The basic earthship design incorporates substantially beamed, passive solar architecture. The primary retaining walls may be constructed with used tires, filled with earth and stacked up like bricks (as shown in fig5&6). The interior surface of the tires is then plastered with adobe or cement so the tires don't normally show. The walls are load bearing and provide thermal mass. This helps keep the house cool in the summer and warm in the winter.

Fig. 5: An Earthship House

An Earthship has minimum utility bills because it solves the issue of internal temperature by means of a highly efficient insulation system. Its power comes from solar and wind energy[10].

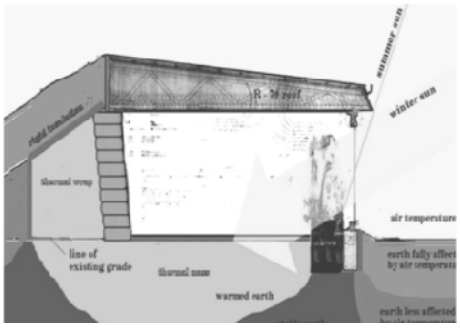


Fig. 6: Section showing the Construction

6.4 Village Houses, Nepal

The materials used are similar as that of earthship, the only difference is the facilities that have to be provided for the daily farm world is lacking. The use of such material is most common in the country unknowingly supporting the concept of green architecture named as eco friendly houses.

Fig. 7: Stone, Mud and Straw House[11]

Fig. 8: Mixing of Mud[12]

Fig. 9: Mixing a Mud[12]

Fig. 10: Handling[12]

Fig. 11: Mud and Bamboo House[12]

6.5 Building with Use of Recycle Materials

Green architects know that building materials created with recycled content reduce the amount of raw materials taken from land, the amount of waste that reaches landfills, and the amount of energy to manufacture the building materials. Therefore they recommend houses of materials made with recycled content such as plastic lumber, cellulose insulation, aluminum, tires, bottles, and particle board (refer to fig:12,13&14). Benefits of recycled content materials include reduced solid waste, reduced energy and water use, reduced pollution, reduced greenhouse gas emissions, and a healthier economy.

Fig. 12: Recycled Bottled Used for Construction[10]

Bottles

A Master Piece Built with 1.5 million recycled bottles)

Fig. 13: Recycled Tires Used for Construction[10]

Fig. 14: Wat Pa Maha Chedio Kaew Temple, Thailand[13]

6.6 Shipping Containers

The construction industry has used extensively large amount of natural resources. It is time to think about facilities built of recycled materials (as illustrated in figure:15). Shipping containers are a new concept in affordable housing. There are as many as 300,000 containers located in ports around the country causing a storage problem. The production of homes using reclaimed shipping containers is intended to reduce waste and save material used in typical conventional house construction. The structural rigidity of the metal frame and corrugation of the shipping container equals more than the standard strength of timber and steel construction.

`The solar energy can be used as a conservation of energy. To reduce the consumption of artificial light, a natural daylight concept may be used. Rain water harvesting can be accomplished to meet the requirements of water use in a kitchen garden, lawn, and dual flush toilets[14].

Fig. 15: Use of Shipping Container

Fig. 16: House made of Shipping Container, Houston Texas

6.7 Buildings with Use of Nature (Plants and Trees)

Trees and shrubs have been used for many years to reduce traffic noise from busy roads. Research now shows that plants can also reduce summer air-conditioning costs while providing numerous other benefits. By taking advantage of the variety of heights and forms of plants, it is possible to create light or heavy shade at any time of day and during all seasons. Small plants near windows can obviate the need for blinds and still provide the benefits of a view. In atriums and other highly glazed spaces, large plants and trees can be used to replace manufactured products and provide other indoor climatic benefits. A green roof shown in fig: 17&18, also helps to mitigate heat and reduces energy use. Green roofs provide many benefits to a building, including (but not limited to): (a) providing cooling to the building and its neighborhood. (b) Collecting and utilizing storm water. (c) Providing aesthetically pleasing color and breaking the monotony in building appearance[15].

Fig. 17: School of Art, Design & Media, Singapore[13]

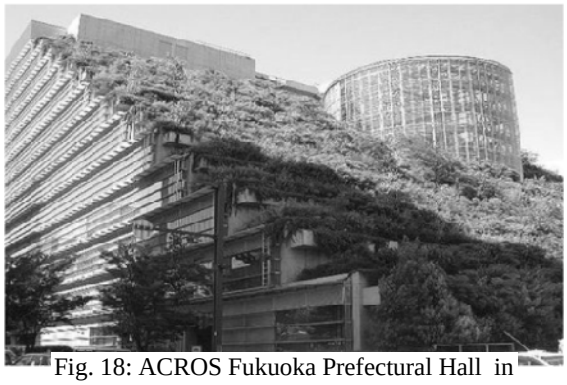


Fig. 18: ACROS Fukuoka Prefectural Hall in Fukuoka, Japan

6.8 Buildings with Use of Renewable Energy

As buildings consume large amounts of energy, some alternative methods like solar power and wind power are applicable these days to reduce energy costs and preserve the non-renewable resources in the environment. These clean and cost efficient sources of power are changing the way in which the world looks at energy. A solar power system is an effective way of bringing power to your home or business using sun energy[16]. A residential solar power kit can substantially reduce utility bills and is very environmentally friendly because there are no emissions from the burning of fossil fuel (refer fig: 19). Solar power systems use daylight to power ordinary electrical equipment like household appliances, computers and lighting.

Fig. 19: Use of Solar Energy in Yellowstone National Park[17]

Photovoltaic means electricity from light. A photovoltaic system never needs refueling, emits no pollution and can be expected to operate for twenty to twenty-five years with minimal maintenance. A typical PV system on a house roof could prevent over 34 tones of greenhouse gas emissions during its lifetime[16]. (See fig: 20)

Fig. 20: Use of photovoltaic on the roof in Eco-village, New York[18]

6.9 Wind Energy

Wind Energy systems are one of the most cost-effective home-based renewable energy systems. Wind turbines convert the kinetic energy of wind into mechanical power that runs a generator to produce clean electricity.

6.9.1 Bahrain World Trade Center

The world trade center of Bahrain is a sophisticated commercial development that incorporates wind turbines directly into its structural design. The wind turbines are expected to provide 11% to 15% of the total power consumption, or approximately 1.1 to 1.3 GWh a year. This is equivalent to providing the lighting for about 300 homes annually[13].

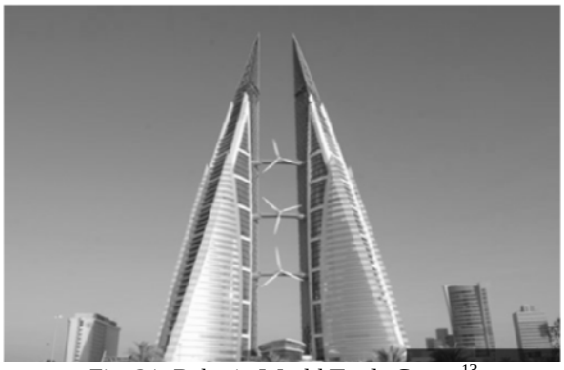


Fig. 21: Bahrain World Trade Center[13]

6.9.2 Rotating Wind Towers, Dubai

Proposed by Dr. David Fisher, it is the world's first self powered green building in motion with the ability to generate electricity for itself through the use of horizontal wind turbines and solar panels. The building is to be entirely built from pre-fabricated parts custom-made in a factory that will vastly reduce construction time, offer substantial cost savings, provide an environmentally friendly construction

Fig. 22: Rotating Wind Towers, Dubai[13]

site and increase safety for workers. The structure twirls around and uses wind and solar energy to produce power that is sufficient to power another 5 skyscrapers along with power to support its own residents' energy needs[13].

7 CONCLUSIONS

Society is changing and the population is growing day by day, people are utilizing limited resources rapidly and world is facing new environmental challenges. Sustainability of resources will be one of the main issues in the near future and society should initiate, in advance, actions to conserve the resources in a sustainable way. Going Green is a recent development in the design and construction industry. Its acceptance and support continues to broaden among public agencies, private developers, building operators and users, architectural and engineering firms, contractors, and materials producers. With each passing year, green sustainable building techniques are becoming less a design specialty and more a part of mainstream practice.

Green architecture may be a fad but it does help the earth. It only can help people and the earth but cannot hurt anything. Green architecture is about recycling and using what is available or can easily replaced. Green architecture is good because it has advantages such as energy savings but also intangible things like: a better workplace, increased productivity and lower vacancy rates. Green architecture is something good and definitely needs to be encouraged and popularized[2].

8 References

1. URL: http:// www.wikipedia.org/greenbuilding.
2. URL:https://wikiland.wikispaces.com/Popularity+Report+Green+Architecture+,+Erin+Rouchi.
3. URL: http://www.energyresources.it/public/file/COMPANY%20PROFILE%20ENG.pdf.
4. URL:http://nhs.needham.k12.ma.us/cur/environment/Envir00_01/p4/kmcpd4/k-history-page.htm
5. URL: http://www.architectureweek.com/2009/0408/environment_1-1.html.
6. URL:http://pubs.asce.org/NR/rdonlyres/.
7. URL: http://www.greenhomechicago.us/Site/Zero_Net_Energy,_LEED,_Green_Building.html.
8. URL: on July 2http://www.design-e2.com/.
9. URL: http://truthdive.com/2009/06/05/.
10. URL: http://www.greenhomebuilding.com.
11. URL: http:// www.answers.com/topic/vernacular-architecture.
12. URL: http:// www.overthehorizon.net/images/nep16.jpg .
13. URL: http://www.alternativeconsumer.com/2009/01/19/5-faves-green-architectural-design-projects/.
14. URL: http://www.greenhomebuilding.com/articles/containers.htm.
15. URL:http://www.bordbia.ie/aboutgardening/GardeningArticles/Documents/Plants%20in%20Green%20Buildings.pdf.
16. URL:http://www.self.org/shs_envir.asp .
17. URL: http://www.montanagreenpower.com/solar/projects/yellowstonepark.php.
18. URL: http://www.ecovillage.ithaca.ny.us/.
19. PHILIP JODIDIO, 2008, Green Architecture.
20. CHARLES J. KIBERT, 2007- 2nd Ed, Sustainable Construction.