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Concept of Sustainability and Impact in Applying the Principles of Green Architecture for Saving Energy in Buildings

Fatemeh Saravi[1*]

1- Department of Architectural Engineering, Islamic Azad University, Central Tehran Branch, Iran
*Corresponding Author: atena.sv2906@gmail.com

ABSTRACT

Since the United Nations Conference, which was held under the title of "Earth Summit" in 1992, striving for achieving sustainable development must also include a complete realization for fulfilment buildings and towns which is characterized by sustainability principle, after the conference lots of serious global trends began to appear and tried to accomplish with the environment and these trends called contemporary trends of environmental design, one of the most important trends is "green architecture" which focuses on the relationship between buildings and natural, this trend appeared as a reaction for facing the environmental problems and health risks which occurred because of the buildings which have no environmental dimension in their designs or the importance of keeping the energy and the natural resources.The Concept of Green Architecture, also known as "sustainable architecture" or "green building," is the theory, science and style of buildings designed and constructed in accordance with environmentally friendly principles. Green architecture strives to minimize the number of resources consumed in the building's construction, use and operation, as well as curtailing the harm done to the environment through the emission, pollution and waste of its components.to design, construct, operate and maintain buildings energy, water and new materials are utilized as well as amounts of waste causing negative effects to health and environment is generated. In order to limit these effects and design environmentally sound and resource efficient buildings; "green building systems" must be introduced, clarified, understood and practiced. This paper aims at highlighting these difficult and complex issues of sustainability which encompass the scope of almost every aspect of human life.
Keywords: Green Building Systems; Sustainable Buildings; Renewable Resources; Green architecture; Environmental Architecture

1. INTRODUCTION

Sustainability is comprehensive therefore a complex subject. It is of vital importance to all because it deals with the survival of human species and almost every living creature on the planet. Sustainable and eco-friendly architecture is one of the main aims that humans for creating a better life have made as the ultimate model for all their activities. For this reason, moving towards a greener architecture is well-thought-out the main goal of the present architecture of our time (Mahdavinejad, 2014).

At the rate the development needs of this world is using the scarce and limited resources found on the earth, it is becoming obvious that unless there are major changes to Man's thinking and behavior, the future of civilization as known today is dubious. This complex subject has no straight forward solution, especially considering that sustainability is a goal for all to reach as they continually strive to reach towards it.Green architecture produces environmental, social and economic benefits. Environmentally, green architecture helps reduce pollution, conserve natural resources and prevent environmental degradation. Economically, it reduces the amount of money that the building's operators have to spend on water and energy and improves the productivity of those using the facility (Thomas, 2009) And, Socially, green buildings are meant to be beautiful and cause only minimal strain on the local infrastructure. The buildings in which we live, work, and play protect us from nature's extremes, yet they also affect our health and environment in countless ways. As the environmental impact of buildings becomes more apparent, a new field called "green building" is gaining momentum.Green, or sustainable, building is the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition (Roy,2008).

1.1. Green Architecture

Green architecture, or green design, is an approach to building that minimizes harmful effects on human health and the environment. The "green" architect or designer attempts to safeguard air, water, and earth by choosing eco-friendly building materials and construction practices (Roy,2008).

1.2. Green Architecture and Green Design

Green architecture defines an understanding of environment-friendly architecture under all classifications, and contains some universal consent (Burcu, 2015), It may have many of these characteristics:

- Ventilation systems designed for efficient heating and cooling
- Energy-efficient lighting and appliances
- Water-saving plumbing fixtures
- Landscapes planned to maximize passive solar energy
- Minimal harm to the natural habitat
- Alternate power sources such as solar power or wind power
- Non-synthetic, non-toxic materials
- Locally-obtained woods and stone
- Responsibly-harvested woods
- Adaptive reuse of older buildings

- Use of recycled architectural salvage
- Efficient use of space

While most green buildings do not have all of these features, the highest goal of green architecture is to be fully sustainable.

Also Known As: Sustainable development, eco-design, eco-friendly architecture, earth-friendly architecture, environmental architecture, natural architecture (USGBC, 2002).

2. METHODOLOGY

In order to achieve the stipulated aim, the study presented in this paper, traces the following steps:
1. General overview on applying "Green Architecture "as a concept of sustainability.
2. Defining Considerations for Green Building.
3. Defining the benefits of applying criteria for Green Building strategies that could maximize energy efficiency, and indoor air quality.
4. Describing case Study potentials in terms of Green Building aspects.

3. CONSIDERATION FOR GREEN BUILDING

Green building involves consideration in four main areas: site development, material selection and minimization, energy efficiency, and indoor air quality

- Consider site development to reduce the impact of development on the natural environment. For example, orient the buildings to take advantage of solar access, shading and wind patterns that will lessen heating and cooling loads.
- Carefully select materials that are durable, contain recycled content, and are locally manufactured to reduce negative environmental impacts. A growing market exists of quality recycled products at affordable prices.
- Incorporate energy-efficient design into buildings to create an efficient and comfortable environment. Take advantage of the natural elements and technologies to conserve resources and increase occupant comfort/productivity while lowering long-term operational costs and pollutants (CBFEE, 1999).

4. THE PRINCIPLES OF GREEN BUILDING DESIGN

The green building design process begins with an intimate understanding of the site in all its beauties and complexities. An ecological approach to design aims to integrate the systems being introduced with the existing on-site ecological functions performed by Mother Nature. These ecological functions provide habitat, respond to the movements of the sun, purify the air as well as catch, filter and store water. Designers can create features in their buildings that mimic the functions of particular eco-systems. Species that thrive in natural ecosystems may also utilize habitats created in man-made structures. Creating new habitat on structures in urbanized areas is especially important to support bio-diversity and a healthy ecosystem (Thomas, 2009).

The following points summarize key principles, strategies and technologies which are associated with the five major elements of green building design which are: Sustainable Site Design; Water Conservation and Quality; Energy and Environment; Indoor Environmental Quality; and Conservation of Materials and Resources. This information supports of the use of the USGBC LEED Green Building Rating System, but focuses on principles and strategies rather than specific solutions or technologies, which are often site specific and will vary from project to project (USGBC).

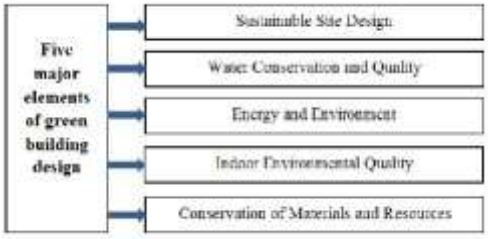

Fig.1: Elements of green building design by author (USGBC).

4.1. *Water Systems*

Water - often called the source of life - can be captured, stored, filtered, and reused. It provides a valuable resource to be celebrated in the process of green building design.

According to Art Ludwig in Create an Oasis out of Greywater, only about 6% of the water we use is for drinking. There is no need to use potable water for irrigation or sewage. The Green Building Design course introduces methods of rainwater harvesting, grey water systems, and living pools (BCKL, 2009).

The protection and conservation of water throughout the life of a building may be accomplished by designing for dual plumbing that recycles water in toilet flushing or by using water for washing of the cars. Waste-water may be minimized by utilizing water conserving fixtures such as ultra-low flush toilets and low-flow shower heads. Bidets help eliminate the use of toilet paper, reducing sewer traffic and increasing possibilities of re-using water on-site. Point of use water treatment (fig5) and heating improves both water quality and energy efficiency while reducing the amount of water in circulation. The use of non-sewage and greywater for on-site use such as site-irrigation will minimize demands on the local aquifer (Stephen & Harrell, 2008).

4.2. Natural Building

A natural building involves a range of building systems and materials that place major emphasis on sustainability. Ways of achieving sustainability through natural building focus on durability and the use of minimally processed, plentiful or renewable resources, as well as those that, while recycled or salvaged, produce healthy living environments and maintain indoor air quality. Natural building tends to rely on human labor, more than technology. As Michael G. Smith observes, it depends on "local ecology, geology and climate; on the character of the

particular building site, and on the needs and personalities of the builders and users (Smith, 2002).

The basis of natural building is the need to lessen the environmental impact of buildings and other supporting systems, without sacrificing comfort or health. To be more sustainable, natural building uses primarily abundantly available, renewable, reused or recycled materials. The use of rapidly renewable materials is increasingly a focus.

In addition to relying on natural building materials, the emphasis on the architectural design is heightened. The orientation of a building, the utilization of local climate and site conditions, the emphasis on natural ventilation through design, fundamentally lessen operational costs and positively impact the environmental. Building compactly and minimizing the ecological footprint is common, as are on-site handling of energy acquisition, on-site water capture, alternate sewage treatment and water reuse (Smith, 2002).

4.3. Passive Solar Design

Passive solar design refers to the use of the sun's energy for the heating and cooling of living spaces. The building itself or some element of it takes advantage of natural energy characteristics in its materials to absorb and radiate the heat created by exposure to the sun. Passive systems are simple, have few moving parts and no mechanical systems, require minimal maintenance and can decrease, or even eliminate, heating and cooling costs (BCKL, 2009).

Passive solar design uses that to capture the sun's energy:

- Solar passive features
- Shape and form of buildings.
- Orientation of the facades.
- Design of Building plan and section.
- Thermal insulation and thermal storage of roof.
- Thermal Insulation and thermal storage of the exterior walls.

Homes in any climate can take advantage of solar energy by incorporating passive solar design features and decreasing carbon dioxide emissions. Even in cold winters, passive solar design can help cut heating costs and increase comfort (BCKL, 2009).

Solar buildings are designed to keep environment comfortable in all seasons without much expenditure on electricity 30 to 40% savings with additional 5 to 10% cost towards passive features.

Major Components: Orientation, double glazed windows, window overhangs, thermal storage walls roof, roof painting, Ventilation, evaporation, day lighting, construction material etc.

Designs depend on direction & intensity of Sun & wind, ambient temp., humidity etc. Different designs for different climatic zones.

4.4. Green Building Materials

Green building materials are generally composed of renewable rather than non-renewable resources and are environmentally responsible because their impacts are considered over the life of the product. In addition, green building materials generally result in reduced maintenance and replacement costs over the life of the building, conserve energy, and improve occupant health and productivity. Green building materials can be selected by evaluating characteristics such as reused and recycled content, zero or low off-gassing of harmful air emissions, zero or low toxicity, sustainably and rapidly renewable harvested materials, high recyclability, durability, longevity, and local production (Cullen, 2010).

The materials common to many types of natural building are clay and sand. When mixed with water and, usually, straw or another fiber, the mixture may form cob or adobe (clay blocks). Other materials commonly used in natural building are: earth (as rammed earth or earth bag), wood (cordwood or timber frame/post-and-beam), straw, rice-hulls, bamboo and stone. A wide variety of reused or recycled non-toxic materials are common in natural building, including urbanite (salvaged chunks of used concrete), vehicle windscreens and other recycled glass (Woolley , 2006).

One-half of the world's population lives or works in buildings constructed of earth. Straw bale construction is now gaining in popularity and Many jurisdictions in California have adopted the Straw bale Building Code. Green Building Design favors natural building for its local availability, ease of use, lack of toxic ingredients, increased energy efficiency, and aesthetic appeal (NAOHB, 1998).

Several other materials are increasingly avoided by many practitioners of this building approach, due to their major negative environmental or health impacts. These include unsustainably harvested wood, toxic wood-preservatives, Portland cement-based mixes, paints and other coatings that off-gas volatile organic compounds (VOCs), and some plastics, particularly polyvinyl chloride (PVC or "vinyl") and those containing harmful plasticizers or hormone-mimicking formulations (Woolley , 2006).

4.5. Living Architecture

The environment like our bodies can metabolize nutrients and waste. Living Architecture focuses on these processes, integrating ecological functions into the buildings to catch, store, and filter water, purify air, and process other nutrients. Living Architecture also addresses biophilia, the documented health benefits associated with being in touch with living systems in the built environment (Susan, 2008).

Throughout history greening of outside walls and roofs of buildings has taken place. Reasons for doing so were the increase of insulation (keep cool in summer and keep cold out in winter), improved aesthetics, improved indoor and outdoor climate, reduce the greenhouse gases such as Carbon Dioxide (CO2), Carbon Monoxide (CO) and Nitrogen Dioxide (NO2) as well as increasing ecological values by creating habitats for birds and insects (Sheweka & Magdy, 2011).

4.5.1. Green roofs

serve several purposes for a building, such as absorbing rainwater, providing insulation, creating a habitat for wildlife, increasing benevolence
and decreasing stress of the people around the roof by providing a more aesthetically pleasing landscape, and helping to lower urban air
temperatures and mitigate the heat island effect (Vandermeulen, 2011)
There are two types of green roof:

1. Intensive roofs, which are thicker, with a minimum depth of 12.8 cm, and can support a wider variety of plants but are heavier and require more maintenance.
2. Extensive roofs, which are shallow, ranging in depth from 2 cm to 12.7 cm, lighter than intensive green roofs, and require minimal maintenance (Volder, 2014).

The term green roof may also be used to indicate roofs that use some form of green technology, such as a cool roof, a roof with solar thermal collectors or photovoltaic panels. Green roofs are also referred to as eco-roofs, vegetated roofs, living roofs, green roofs and VCPH (Wilmers, 1990). (Horizontal Vegetated Complex Partitions).

4.5.2. Green Walls

Also known as vertical greenery is actually introducing plants onto the building façade. Comparing to green roof, green walls can cover more exposed hard surfaces in the built environment where skyscrapers are the predominant building style (Jonathan, 2003).

According to Ken (Ken,2008), if a skyscraper has a plant ratio of one to seven, and then the façade area is equivalent to almost three times the area. So, if the building is covered two thirds of the façade, this have contributed to doubling the extend of vegetation on site. So a skyscraper can become green, thus increasing the organic mass on the site (Wilmers, 1990).

There are three types of Green Walls:
The green walls can be divided into three fundamental types according to the species of the plants; types of growing media and construction method.

1. Wall-climbing Green wall is the very common and traditional green walls method. Although it is a time consuming process, climbing plants can cover the walls of building naturally. Sometimes they are grown upwards with the help of a trellis or other supporting systems (Wilmers, 1990).

2. Hanging-down Green Wall is also another popular approach for green walls. It can easily form a complete vertical green belt on a multi-story building through planting at every story compare to the wall-climbing type (Wilmers, 1990).

3. Module Green Wall is the latest concept compared to the previous two types. It requires more complicated design and planning considerations before a vertical system can come to place. It is also probably the most expensive green walls method (Jonathan, 2003)

5. GREEN BUILDING BENEFITS

Green building is not a simple development trend; it is an approach to building suited to the demands of its time, whose relevance and importance will only continue to increase (USGBC)

- Comfort. Because a well-designed passive solar home or building is highly energy efficient, it is free of drafts. Extra sunlight from the south windows makes it more cheerful and pleasant in the winter than a conventional house (Kats, 2006)

- Economy. If addressed at the design stage, passive solar construction doesn't have to cost more than conventional construction, and it can save money on fuel bills (Kats, 2003)

- Aesthetics. Passive solar buildings can have a conventional appearance on the outside, and the passive solar features make them bright and pleasant inside.

- Environmentally responsible. Passive solar homes can significantly cut use of heating fuel and electricity used for lighting. If passive cooling strategies are used in the design, summer air conditioning costs can be reduced as well (Woolley , 2006).

6. MAIN OF AXES OF THE RESEARCH

This research includes three chef axes as the following:

6.1 First axis: the means of rationalization of energy consumption in the building

6.2 The second axis: models of global and Arabian experiments, which apply the principles of the green architecture in some of the buildings

6.3 The third axis: The basics, targets, and the means of the green architecture in order to provide the buildings with energy

6.1 The ways of rationalization of energy consumption in the buildings

Due to the rising cost of energy resources and its techniques, the process of production and process of transmission and distribution, so great awareness started to appear to rationalization of energy consumption and improving its efficiency, some governments realized the consumed quantity in cooling and warming, so those governments organized that by impose taxes and laws in order to prevent the increase of energy consuming. Then a stormy wave of books and researchers started which forced the Economists and architectures towards rationalization of energy consumption, and trying to reduce of consuming it, and because of that, they refused the Economic valuation by using money, and decided to take the units of energy as a Standard instead of money [(3)]. In general, there is great wasted quantity of energy its percentage different according to each element in the building and it can be detected in the explained points in figure (1) as the following: 15% of buildings heat is being wasted because of the Leakage resulting from the outer shell. 10% is wasted through the windows and doors

6.1.1 Concept of Rationalization of Energy Consumption

The meaning of rationalization of energy consumption is "The optimal use of available energy by investing with more possible means to gain the maximum economical profits"[(2)]. That requires integrated planning and rationalization of energy resources consumption and Make an effort to increase the using efficacy in all the sectors that use energy like: The upstream sector, production, transmission and distribution or in the final use sectors of energy

6.1.2 The Importance of Rationalization of Energy Consumption in Buildings

The importance of rationalization of energy consumption assimilate in (2):

1) Preserving the energy and this element is so necessary because it may result in Capital increase, the environmental value and national security, personal security and Comfortable for humans.
2) Resulting in reduce the energy demand for every user and that's also would reduce the need of building electricity stations.
3) Reduce polluting emissions, which causes climate changes.
4) Reduces the depletion and continuous consuming for the unrenewable energy sources.

Therefore, the choice of improving the energy efficiency and rationalization of energy consumption is the most important choice for the long term because it considered alternate for new production to rationalization of energy consumption in most cases economically, it Costs less than establishing new building for producing this energy.

6.1.3 The Ways and Axes of Rationalization of Energy Consumption in Buildings

Improving the efficiency of energy and rationalization of energy consumption in buildings depends on the Procedures and the actions taken by the building users and the energy administration in those buildings that can be classified according to three axes as following [(3)]:

- First axis: Rationalization of energy consumption with respect to the same building.
- Second axis: Rationalization of energy consumption with respect to instruments, tools, and systems used in the building.
- Third axis: Rationalization of energy consumption with respect to the users of the building.

6.2 Prototypes for the Global and Arabian Experiments Applied to the Green Architecture Principles in Some Buildings

As following, we present a show for some models of global and Arabian buildings that has been used the green architecture standard in their design, to conclude what are the best basics and means that have been used in those buildings to get the full advantage and applying it to save the energy in the building. Some of those building got the LEED certification as an evaluation standard for the green architecture and that reinforce the using of this means and how to get the full benefits so then we can have an Environment Friendly building:

6.2.1 Great River Energy Headquarters Building Introducing the building

- This building located in state of Minnesota in the United States of America.
- The building got the platinum LEED certification (14) by USGBC
- The number of floors: 6

- An area of 1666.000 square-feet
- The date of project ends: mars, 2008
- Climate: Tropical

Environmental Architecture Processors of the Building

1) The Architectural Design of the Building

- The perfect direction for the building to get benefits of sun light for the natural lighting in the morning and Granulocytes wind for good ventilation.
- Choose the horizontal extension instead of the vertical Extension to guarantee the ventilation and good lighting, figure (3) and to find wide areas to put the solar energy production units.
- Building beside water body to improve the quality of air surrounded by the building, figure (4).

2) The Environmental Processors to Supply the Building by the Natural Lighting

- Recruit the Atriums to provide the building with natural lighting,

- Fig.2:

Fig.3:

- The interfaces have been designed using doubled glazing to improve the internal lighting.
- 3/4 of the building is being exposed to natural lighting intensity by 25 lumens / Square feet from the natural lighting during daytime.

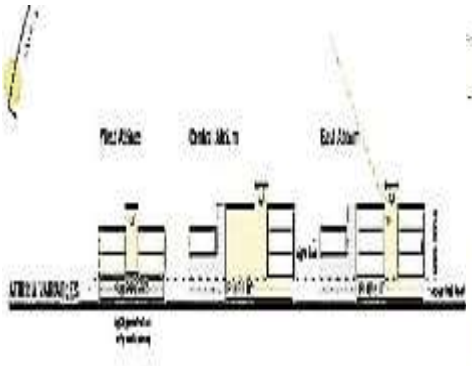

Fig.4

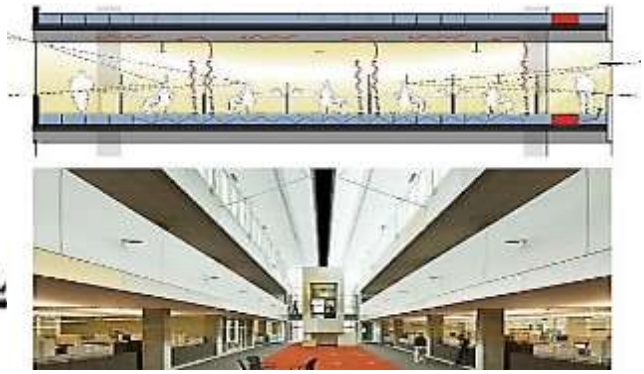

Fig.5

3) The Environmental Processors to Provide the Natural Ventilation

- Using ventilation displacively to provide the natural Ventilation with 20%, where the replacement occurs for the hot air found in emptiness with the cold air through the roof or walls, figure (6).

- Air entry and exit from Atriums holes, which helps to improve the quality of internal air.

4) The Environmental Processors for Rationalization and Re-use

- Implementation of the systems for re-use the water of rain.
- The using of can be reduced by 89% through using the gain of rainwater on the roof, and the modern installations in the building.
- The treatment of wastewater and re-use it in watering the plant elements, figure (7).

Fig.6

Fig.7

5) The Means of Producing Clean Energy (New and Renewable Energy)

- Investment the photovoltaic cells to produce solar energy
- Using wind turbines for electricity production
- The building gets about 14% of its needs of energy from renewable energy (10%from wind turbines and 3- 5% from photo voltaic cells).

6) The Green Architecture Processors Environmental –Friendly

- Using environmental –friendly materials like wood.
- Implementation of the plant elements with low consuming of water.
- All paints and building materials leak-proof.

7. FINDING

- The principles of the green architecture have been implemented to have environmental and architectural processors helps to rationalization of energy in buildings according to (formatting of the building, direction of the building, designing of the interfaces, thermal controlling elements, natural lighting, natural ventilation, the good employment of rationalization of energy, and finally recycling and future expansion).
- Respecting for the principles of the green architecture by preserving the environment, climate adaptation, rationalization of consumption for the new sources and respect the site, the environment, and on the other side respecting the users of the building, which considers the most important entries to preserving the environment and the building.
- Implementation of the plant elements the aqua elements and their ability to provide the thermal comfort for the building.
- Necessary of resorting to the environmental design (the negative design for the building) by using the

architectural elements such as sistrum and internal yards water bodies, internal gardens, roof gardens, Because of their ability of achieving the goals of the green architecture and rationalize consumption the energy in the building.

- Get benefits of the new and renewable energies in providing the commercial buildings with energy like solar energy and wind energy.
- We must not forget the modern architectural elements and the smart productive techniques, which have the

advantages of rationalization of energy and keep up with progress by using the modern technology also it is environmental –friendly.

- The research found that the presence of applications at the local level is still limited compared to the

applications at a global level.

8. CONCLUSION

The implementation of the principles and basics of green architecture and resorting to environmental design trends consider from the most successful followed ways to get rid of the increasing energy problems and also the problem of energy depletion those principles also preserves on achieving comfort for the users of the buildings by ensuring the thermal comfortable, natural ventilation and natural lighting not only this but also it can save and provide the building with its needs from energy by taking full advantage from the natural energies like: (solar energy, wind energy and water energy), which helps to reduce energy consuming also it helps to get benefit from rain water, gray water and wastes of buildings instead of leaving it pollute the environment, the principles of green architecture demanding of recycling for all this elements and using it to, maintain a clean environment and get benefits from the new and renewable energies studying the global and local buildings, which apply the green architecture and gained certificates for of rationalization of energy consumption like LEED, the desired targets have been extracted by application of the green natural methods and modern techniques which is unamortized of energy in order to reach to a commercial building and environment – friendly.

- Principles of Green Architecture are: Water features and their management; natural building design; passive solar design; green building materials; living Architecture. These principles are applied in a sustainable fashion to achieve an eco- friendly building.
- Any architect has the ability to change an entire building process by specifying materials with low carbon dioxide emissions.

- Green building standards are available for almost every type of building on a global basis and these standards are well developed and are regularly being updated; they cover all phases of a building’s life cycle from design through demolition.

- Buildings that have been designed according to sustainability standards need to be operated and maintained according to these same standards.

- Buildings that were built prior to enacting these sustainability standards can also be upgraded to meet the standards that have subsequently been put in place.

- Green buildings must have a number of common components: these include a focus on energy efficiency and, in some cases, renewable energy; the efficient use of water; the use of environmentally desirable building materials and specifications; a minimization of the waste

and toxic chemicals generated in the building's construction and operations; good indoor air quality; and an eye on so-called "smart" growth and sustainable development.

- Green architecture produces environmental, social and economic benefits. Environmentally, green architecture helps reduce pollution, conserve natural resources and prevent environmental degradation. Economically, it reduces the amount of money that the building's operators have to spend on water and energy and improves the productivity of those using the facility. And, socially, green buildings are meant to be beautiful and cause only minimal strain on the local infrastructure.

- Traditional building materials are to be adapted to meet code-required standards for health and safety in contemporary buildings. Not only are they cost effective and environmentally friendly, but, when used correctly, these natural alternatives match the strength and durability of many mainstream construction materials.

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