Sustainable Building Design

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Abstract

Sustainable development is the integration of economic, environmental, and social goals on which reasonable people may agree in principle, but passionately disagree in practice. Yet, sustainable development is fundamentally a matter of practice, minimizing the conflicts among these three goals and making choices when conflicts are unavoidable.

The concept of sustainable design has come to the forefront in the last 20 years. It is a concept that recognizes that human civilization is an integral part of the natural world and that nature must be preserved and perpetuated if the human community is to survive. Sustainability design articulates this idea through developments that exemplify the principles of conservation and encourages the application of these concepts in our daily lives.

This paper introduces the philosophy, objectives, importance, and advantages of sustainable building design and examines its effects on economic, environmental, and social sustainability.

Introduction

Sustainable development is about ensuring a better quality of life for everyone, now and for future generations. The proper conditions for society to meet in order to achieve sustainability are: use of renewable resources that do not exceed their rates of regeneration, use of non-renewable resources that do not exceed the rate at which sustainable substitutes are developed, and rates of pollution emissions that do not exceed the assimilative capacity of the environment.

Sustainability should not be an academic pursuit or even a professional activity: it is a way of life affecting everything an individual does. The primary aspect is to maintain good relationship with the global and local environment and then, mention how this relationship is to be achieved. To move from theory into practice it is necessary to understand the impacts associated with other work and life-related activities.

There are two main aims for sustainable architectural design. First, the design of sustainable buildings such that they are fairly light on the earth by minimizing the environmental impact associated with their construction, their life in use, and at the end of their usefulness. Second, buildings should make a positive and appropriate contribution to the social environment they inhabit, by addressing people's practical needs while enhancing their surrounding environment and their psychological and physical well-being. [1]

Objectives of Sustainable Building Design

The long-term objectives of sustainable design are to minimize and optimize the consumption of resources, prevent environmental degradation caused by facilities and their infrastructure throughout their life cycle. The primary objectives for the design of sustainable buildings are as follows:

- Selection of the proper site is the initial part of sustainable building design. The local ecosystem, transportation, and energy usage are affected by the location, orientation, and landscaping of a building.
- A sustainable building should meet applicable energy performance standards. Usage of fossil fuels for operations is expensive. In order to minimize energy consumption it is better to rely on efficient and passive design measures.
- Scarcity of fresh water is the basic problem in many parts of the world. A sustainable building seeks to reduce, control site runoff, use water efficiently, and recycle water for on-site use when feasible.
- Environmentally preferred products are used to minimize life-cycle environmental impacts such as global warming, resource depletion, and human toxicity. In a material context, life cycle raw materials acquisition, product manufacturing, packaging, transportation, installation, use, and reuse/recycling/disposal is important.
- A sustainable building should maximize day lighting, provide appropriate ventilation and moisture control, and avoid the use of materials that are high in VOC emissions to enhance indoor environmental quality.
- The design of a facility will greatly contribute to an improved work environment, higher productivity, and reduced energy costs when proper operating and maintenance considerations are considered. Designers are encouraged to specify materials and systems that simplify and reduce maintenance requirements.[2]

Main Environmental Issues

The principles of sustainability aim to address the problems of environmental degradation and lack of human equality and quality of life, by supporting development that is sustainable in economic and social terms and is capable of retaining the benefits of a healthy stable environment in the long term.

The main environmental issues which are threatened by human activities are:

Water: A third of the world population is still without access to safe water and as the global population grows, the need for water will grow, as will waste and pollution which will increasingly threaten the quality of groundwater and rivers.

Pollution: Pollution of air, water, and land, resulting from burning of fossil fuels, industrial processes, agriculture, and other human activities, is endangering human health, biodiversity and the built environment.

Global Warming: Global warming describes the process by which greenhouse gases accumulate in the atmosphere in abnormally high amounts, trapping the earth's radiation and causing its temperature to rise. This is linked to environmental problems such as changes in rainfall patterns, rising sea levels and expansion of deserts.

Soil Degradation: Urbanization, construction, mining, war, agriculture, and deforestation can cause soil degradation. Soil erosion, increased salination, altered soil structure, drainage capacity, and fertilization can diminish crop yields, and increase the risk of flooding and destroy natural habitats.

Waste: Increasing amounts of waste add pressure for more landfill sites, which may pollute air, soil, and groundwater. Furthermore, incineration pollutes the air and produces generally toxic residue.

Ozone Depletion: Ozone shields the earth from ultraviolet (UV) radiation and its depletion is caused by emissions of chlorofluorocarbons (CFCs) and the other ozone-depleting substances into the atmosphere. Increases in UV radiation are thought to be linked to a rise in skin cancers, damage to the human immune system, and altered crop yields.

Population: Global population growth is associated with increase in the human-induced environmental impacts mentioned above.

Resources: Some non-renewable resources, including natural gas and petroleum resources will eventually be depleted. The economically viable extraction of some abundant mineral ores may also be limited. Renewable resources such as timber are also at risk of over-exploitation.

Deforestation: Deforestation through commercial logging, conversion of forest land to agriculture use, and other activities causes the destruction of natural habitats and extinction of plant and animal species and exacerbates the effects of global warming and pollution.

Extinction of flora and fauna: The current mass extinction rates of plant and animal species are the culmination of the environmental damage to our planet. [1]

Factors to be considered

Detailed analysis of the specific site is required to properly balance human needs with environmental opportunities and liabilities. The following information is very general and considered as basic checklist once a specific site data is obtained.

Natural Factors

Climate: Analyze whether the climate is comfortable, too cool, or too hot for the anticipated activities, and then which of the primary climatic components of temperature, sun, wind, and moisture make the comfort level better (asset) or worse (liability). Avoid overdependence on mechanical systems to alter the climate (such dependency signifies inappropriate design, disassociation from the environment, and no sustainable use of resources).

Temperature: Temperature is a liability in climates where it is consistently too hot or too cold.
When climate is predominantly too hot: Minimize solid enclosure and thermal mass, maximize roof ventilation, use elongated floor plans to minimize internal heat gain and maximize exposure for ventilation, separate rooms and functions with covered breezeways and roof over hangs to maximize wall shading and induce ventilation.

When climate is predominantly too cool: consolidate functions into most compact configuration, insulate thoroughly to minimize heat loss, minimize air infiltration with barrier sheeting, weather stripping, sealants, and airlock entries

Sun: Sun can be a significant liability in hot climates, but is rarely a liability in cold climates. It can be an asset in cool and cold climates to provide passive heating. Designs must reflect seasonal variations in solar intensity, incidence angle, cloud cover, and storm influences.

When solar gain causes conditions too hot for comfort: Use overhangs to shade walls and openings, site features and vegetation to provide shading to walls with eastern and western exposure, use hading devices such as louvers, covered porches, and trellises with natural vines to block sun without blocking out breezes and natural light, orient broad building surfaces away from the hot late-day western sun (only southern exposures are easily shaded).

Wind: Wind is a liability in cold climates because it strips heat away quicker than normal; wind can also be a liability to comfort in hot dry climates when it causes the human body to dehydrate and then overheat. Wind can also be an asset in hot, humid climates to provide natural ventilation, use natural ventilation wherever feasible; limit air-conditioning, if possible, to areas requiring special humidity or temperature control such as artifact storage and computer rooms, maximize/minimize exposure to wind through plan orientation and configuration, number and position of wall and roof openings, and relationship to grade and vegetation

Vegetation: Locate and size facilities to avoid cutting mature vegetation and to minimize disruption to, or disassociation with, other natural features. Use natural vegetation and adjustments in building plan to diminish the visual impact of facilities and to minimize imposition on environmental context.

Topography: Consider building/land interface to minimize disturbance to site character, skyline, vegetation, hydrology, and soils. Consolidate functions or segment facilities to reduce footprint of individual structures to allow sensitive placement within existing landforms. Use landforms and the sensitive arrangement of buildings to: Help diminish the visual impact of facilities, enhance visual quality by creating a rhythm of open spaces and framed views, orient visitors to building entrances.

Hydrology: Locate and design facilities to minimize erosion and impacts on natural hydrological systems and Safeguard hydrological system from contamination by development/activities

Seismic: Determine soil substrate and potential seismic risk, use shear walls and appropriate building anchorages and bracing details.

Human Factors

Cultural Resources

Archeological resources: Use preservation and interpretation of archeological features to provide insight to previous cultural responses to the environment, their successes as well as failures.

Vernacular architecture: Analyze local historic building styles, systems, and materials usually for time-tested approaches in harmony with natural systems, use local building material, craftsmen, and techniques to the greatest extent practical in the development of new facilities.

Historic resources: Reuse historic buildings whenever possible to assist in their preservation, **contribute** to the special quality of the place, and extend the payback of their embodied energy and materials.

Sensory Experience

Visual: Provide visitors with ready access to educational materials to enhance their understanding and appreciation of the local environment and threats to it. In addition, incorporate views of natural and cultural resources into even routine activities to provide opportunities for contemplation, relaxation, and appreciation, use design principles of scale, rhythm, proportion, balance, and composition to enhance the complementary integration of facilities into environmental context.

Sounds: Locate service and maintenance functions away from public areas. If possible, place lodging units so that natural, not human, sounds dominate. Use vegetation to create a sound baffle between public and private activities and orient openings toward natural sounds such the lapping of waves, babbling of streams, and rustling of leaves by the wind.

Touch: Allow residents and visitors to touch and be in touch with the natural and cultural resources of the site. Vary walking surfaces to identify or give different quality to different spaces and use contrasting textures to direct attention to interpretive opportunities.

Smell: Allow natural fragrances of vegetation to be enjoyed and especially direct air exhausted from utility areas away from public areas.

Taste: Provide opportunities to sample local produce and cuisine.[3]

Water and Energy for Sustainable Building

Water is essential for life on earth. Water is needed for plant growth and for the survival of animals, including human beings. Of the total amount of water on earth, 97.25 percent is contained in salty seas, 2.05 percent is contained in glacial icecaps, and most of the remaining 0.7 percent is contained in aquifers (Paola sassi).

In the future, water scarcity and stress are expected to be the cause of political friction and even armed conflicts. But just as essential as the quantity of freshwater is its quality. Water pollution is threatening the quality of fresh drinking water and at the same time having detrimental impacts on the natural environment.

There are three main approaches relevant to building design and water-related environmental problems that contribute to reducing water use and pollution. First, the need for fresh water should be reduced and efficient means of using this water should be introduced in buildings. Second, sources other than fresh water, such as rainwater and gray water should be used where appropriate. Third, the disposal of gray and rain water has to be considered.

Sustainable water usage and wastewater disposal is mentioned below:

Minimizing the need for water: Encourage the use of composting toilets and showers instead of baths. Also select plants with low watering requirements.

Use water efficiently: Install water-saving spray or automatic taps on basins and showers in addition to low or dual flush WCs. Retrofit existing appliances, e.g. upgrade existing WCs with an efficient flush mechanism or a 'hippo' (heavy duty plastic container that displaces water) in the cistern, and upgrade taps. Install irrigation system, growing plants by their water requirements and utilize water meters. Most importantly educate users and adopt a water-conscious approach.

Recycle used water: Install gray water collection systems from basins, showers, and baths to flush WCs or water gardens.

Recycle rainwater: Install a system to collect and recycle rainwater for gardening.

Reduce the use of mains drains: Install on-site waste water treatment systems in addition to utilizing a sustainable urban drainage system.

The aim of sustainable building in respect to energy is to enable the occupants of a building to maintain, and, if possible, improve their quality of life, while producing the least possible amount of CO2 emissions. The most direct solution is to change the source of energy from a fossil fuel-based system to renewable sources with low CO2 emissions. However, considering the economic and technical barriers, this approach on its own is unlikely to be a realistic solution.

To minimize the environmental impact of energy use, a three-stage approach should be adopted. First, how energy is used in buildings should be analyzed and building fabric design alternatives selected to provide the same performance with reduced energy requirements. Second, if a zero energy design solution is not possible, active systems should be selected that use energy in an efficient way. Third, the resulting reduced energy requirements should be provided by alternative, low CO2- emitting energy sources specifically, to minimize CO2 emissions and pollution, consider the following:

Reduce energy requirements: Design with the natural environment, orient building to maximize or protect from solar grains depending on requirements. In addition, orient buildings to make use of planting and landscape to protect it from or take advantage of prevailing winds. Also, consider using planting to provide shade and to moderate the internal environment and orient the spaces in a building that can benefit from solar heat gains on the south side and spaces that can remain cool on the north side.

Design the building envelope to moderate internal temperature: minimize heat loss through appropriate insulation and unwanted heat gains with solar shading, insulation, and reflective finishes. Consider using thermal mass to moderate daily temperature variations and as a seasonal heat source to make use of summer heat in the winter and provide natural ventilation and cooling, if possible.

Design the building envelope to minimize electrical lighting needs: provide ample natural light and encourage a resource-saving lifestyle.

Use energy efficiently: provide heating and cooling through energy-efficient mechanical appliances. Use energy-efficient lights and appliances and provide communal heating and electricity where possible. Set energy design targets and monitor building performance in addition to educate users and implement energy-saving policies.

Use ‘green’ energy sources: use ‘free’ energy sources (e.g. wind, sun, and ground heat) and renewable energy sources (e.g. timber from managed forests). [1]

Sustainable Material Selection

Protecting humans and the environment from toxic chemicals has long been central to the EPA's mission. It is at the heart of many EPA programs that seek to promote the use of cleaner materials and to reduce material waste and chemical contamination. The material (for construction) selection criteria of a particular action can be given as:

Minimizing the need for materials: build only when really necessary and build small. Also, design for effective use of materials, for durability, and for reduced maintenance.

Use existing materials: reuse existing buildings and existing building components in addition to recycled materials.

Design to enable future buildings and material reuse and recycling: design for flexibility and desirability to maximize the building life as well as for durability and desirability to maximize building component life. Consider utilizing recycling or the biodegradation of materials.

Select new materials with care: specify renewable materials with short regeneration cycles such as timber from managed and accredited sources. Avoid scarce resources and specify materials mined, harvested or extracted with minimal impact on the local and global environment. Utilize materials associated with low manufacturing pollution. Specify materials associated with low level of CO_2 emissions over the life of the building considering their impact on saving running energy.

Material disposal and waste minimization: segregate timber, inert, metal and soil waste during construction and demolition and ensure their recycling. Arrange for excess material and reduce, when possible waste material to be to be taken back by material suppliers. Include recycling provision in buildings. [1]

Leadership in Energy and Environmental Design

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. LEED gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings’ performance. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

The LEED Rating System was created to transform the built environment to a system where sustainability is taken under consideration. It provides the building industry with consistent, credible standards for what constitutes a green building. LEED can be used by architects, real estate professionals, facility managers, engineers, interior designers, landscape architects, construction managers, lenders, and government officials. [4]

Conclusion

It appears that the concept of sustainability has recently received sufficient attention in the construction industry. In fact, numerous consultants believe that it is important in their area of work and have the intention to implement sustainability in their designs. This presents a great potential and an opportunity to expand the number of sustainable facilities built by the construction industry.

Examples

COR- Green Building in Miami:

A new high rise being built in Miami may be classified as a lean, green, eco machine. It integrates green technologies including wind turbines, photovoltaic panels, and solar hot water generation. The building's exoskeleton is a hyper- efficient structure that provides thermal mass for insulation, shade for residents and architectural elements such as terraces and armatures that support turbines.[5]

Centre George Pompidou:

The Centre George Pompidou, a museum for the modern art is located in Paris. Its architecture is bold and controversial: in the midst of classical Parisian buildings, proclaiming its presence with big exposed service elements outside the main columns-red elevators, escalators in clear plastic tunnels, and various color coded tubes: green for water, yellow for electricity, and blue for air. The "inside-out" approach lets it stand out from its neighborhood, and gives it an uncluttered inner space for artwork and displays, though it has also drawn fierce critics labeling it an oil refinery.[6]

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