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Application of green technologies in architecture

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Abstract

The modern day construction activities use forms of energy and the natural resources on a large scale with the production of huge quantities of by-products. The production of tones of by- products is introducing unwanted materials into the environment as a result, further polluting it. The present day world is experiencing a number of problems like the different kinds of pollution (air, water, land and noise pollution), shortage of the natural resources etc. All this highlights the very need of protecting the environment and preserving it for the future generations, points towards the high need of adopting a sustainable way of construction and architecture.The purpose of this research is to highlight the raising need of adoption of green technologies especially in the field of architecture and construction for ensuring sustainable development in the present era. This paper specifies the definition of green architecture and covers the need, aspects, methods and its advantages, along with the use of various green technologies. It brings to fore the importance of green architecture for development in a sustainable way. It highlights the various green technologies by which sustainability in architecture can be achieved and adopted with its benefits to the environment as well as the society.

Keywords: Green technologies, green architecture, sustainability

GREEN ARCHITECTURE

Green architecture is architecture that seeks to minimize the negative environmental impact of buildings by efficiency and moderation in the use of materials, energy, and development space.

Concept of Green Architecture

The concepts about green architecture can generally be organized into several areas of application. These areas include sustainability, materials, energy efficiency, land use, and waste reduction.

The concept of green building stems from effective utilization of energy resources including sunlight, electricity and water. It is more about sustainability, aimed at creating healthier and more resource efficient models of construction, renovation, operation, maintenance, and demolition.

Typical principles include climate-responsive design, use of local and sustainable materials, water harvesting, etc.

Why Green Architecture?

Environmental Benefits

- Enhance and protect biodiversity and ecosystems
- Improve air and water quality
- Reduce waste streams
- Conserve and restore natural resources

Economic Benefits

- Reduce operating costs
- Improve occupant productivity
- Enhance asset value and profits
- Optimize life-cycle economic performance

Social Benefits

- Enhance occupant health and comfort
- Improve indoor air quality
- Minimize strain on local utility infrastructure
- Improve overall quality of life

Fundamental Principles of Green Building and Sustainable Site Design Sustainable Site Design

Sustainable Site Design

Key Principles

Minimize urban sprawl and needless destruction of valuable land, habitat and green space, which results from inefficient low-density development. Encourage higher density urban development, urban re-development and urban renewal, and brownfield development as a means to preserve valuable green space.

Preserve key environmental assets through careful examination of each site. Engage in a design and construction process that minimizes site disturbance and which values, preserves and actually restores or regenerates valuable habitat, green space and associated eco-systems that are vital to sustaining life.

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Key Strategies and Technologies

- Make more efficient use of space in existing occupied buildings, renovate and re-use existing vacant buildings, sites, and associated infrastructure and consider re-development of brownfield sites. Design buildings and renovations to maximize future flexibility and reuse thereby expanding useful life.
- When new development is unavoidable, steer clear of sites that play a key role in the local or regional ecosystem. Identify and protect valuable greenfield and wetland sites from development.
- Recognize that allowing higher density development in urban areas helps to preserve green space and reduce urban sprawl. Invest time and energy in seeking variances and regulatory reform where needed.
- Evaluate each site in terms of the location and orientation of buildings and improvements in order to optimize the use of passive solar energy, natural daylighting, and natural breezes and ventilation.
- Make best use of existing mass transit systems and make buildings and sites pedestrian and bike friendly, including provisions for safe storage of bicycles. Develop programs and incentives that promote car-pooling including preferred parking for commuters who carpool. Consider making provisions for re-fueling or recharging alternative fuel vehicles.
- Help reduce the urban heat island effect by reducing the building and site development footprint, maximizing the use of pervious surfaces, and using light colored roofs, paving, and walkways. Provide natural shading of buildings and paved areas with trees and other landscape features.
- Reduce impervious areas by carefully evaluating parking and roadway design. Pursue variances or waivers where local ordinances may unintentionally result in the over-design of roadways or parking.
- Optimize the use of on-site storm water treatment and ground water recharge. Minimize the boundaries of the construction area, avoid needless compaction of existing topsoil, and provide effective sedimentation and silt control during all phases of site development and construction.
- Use landscape design to preserve and restore the region's natural habitat and heritage while emphasizing the use of indigenous, hardy, drought resistant trees, shrubs, plants and turf.
- Help reduce night-time light pollution by avoiding over-illumination of the site and use low cut-off exterior lighting fixtures which direct light downward, not upward and outward.

Energy and Environment
Key Principles

Minimize adverse impacts on the environment (air, water, land, natural resources) through optimized building siting, optimized building design, material selection, and aggressive use of energy conservation measures.

Resulting building performance should exceed minimum International Energy Code (IEC) compliance level by 30 to 40% or more. Maximize the use of renewable energy and other low impact energy sources.

Key Strategies and Technologies

- Optimize passive solar orientation, building massing and use of external shading devices such that the design of the building minimizes undesirable solar gains during the summer months while maximizing desirable solar gains during winter months.
- Optimize building orientation, massing, shape, design, and interior colors and finishes in order to maximize the use of controlled natural day lighting which significantly reduces artificial lighting energy use thereby reducing the buildings internal cooling load and energy use. Consider the use of light shelf technology.
- Use high performance low-e glazing, which can result in significant year round energy savings. Consider insulated double glazing, triple glazing or double pane glazing with a suspended low-e film. Selective coatings offer optimal light transmittance while providing minimal solar gain and minimal heat transmission. Window frames, sashes and curtain wall systems should also be designed for optimum energy performance including the use of multiple thermal breaks to help reduce energy use.
- Optimize the value of exterior insulation and the overall thermal performance of the exterior envelope assembly. Consider advanced/high performance envelope building systems such as structural insulated panel systems (SIPS) and insulated concrete form systems (ICF's) that can be applied to light commercial and institutional buildings. SIPS and ICF's and other thermally "decoupled" envelope systems will offer the highest energy performance.
- Use energy efficient T-8 and T-5 bulbs, high efficiency electronic ballasts, and lighting controls. Consider using indirect ambient lighting with workstation based direct task lighting to improve light quality, reduce glare and improve overall energy performance in general office areas. Incorporate sensors and controls and design circuits so that lighting along perimeter zones and offices can be switched off independently from other interior lights when day lighting is sufficient in perimeter areas.
- Use state-of-the art, high efficiency, heating, ventilation and air conditioning (HVAC) and plumbing equipment, chillers, boilers, and water heaters, etc. Use variable speed drives on fan and pump motors. Use heat recovery ventilators and geothermal heat pump technology for up to 40% energy savings.
- Avoid the use of HCFC and Halon based refrigeration, cooling and fire suppression systems. Optimize the use of natural ventilation and where practical use evaporative cooling, waste heat and/or solar regenerated desiccant dehumidification or absorption cooling. Identify and use sources of waste energy.
- Use Energy Star certified energy efficient appliances, office equipment, lighting and HVAC systems.

- Consider on-site small-scale wind, solar, and/or fuel cell based energy generation and co-generation. Purchase environmentally preferable "green" power from certified renewable and sustainable sources.

Materials and Resources
Key Principles

Minimize the use of non-renewable construction materials and other resources such as energy and water through efficient engineering, design, planning and construction and effective recycling of construction debris. Maximize the use of recycled content materials, modern resource efficient engineered materials, and resource efficient composite type structural systems wherever possible. Maximize the use of re-usable, renewable, sustainably managed, bio-based materials. Remember that human creativity and our abundant labor force is perhaps our most valuable renewable resource. The best solution is not necessarily the one that requires the least amount of physical work.

Key Strategies and Technologies

- Optimize the use of engineered materials which make use of proven engineering principles such as engineered trusses, composite materials and structural systems (concrete/steel, other…), structural insulated panels (stress skin panels), insulated concrete forms, and frost protected shallow foundations which have been proven to provide high strength and durability with the least amount of material.
- Identify ways to reduce the amount of materials used and reduce the amount of waste generated through the implementation of a construction waste reduction plan. Adopt a policy of "waste equals food" whereby 75% or more of all construction waste is separated for recycling and used as feedstock for some future product rather than being landfilled. Implement an aggressive construction waste recycling program and provide separate, clearly labeled dumpsters for each recycled material. Train all crews and subcontractors on the policy and enforce compliance.
- Identify ways to use high-recycled content materials in the building structure and finishes. Consider everything from blended concrete using fly ash, slag, recycled concrete aggregate, or other admixtures to recycled content materials such as structural steel, ceiling and floor tiles, carpeting, carpet padding, sheathing, and gypsum wallboard. Consider remanufactured office furniture and office partition systems, chairs and furniture with recycled content or parts.
- Explore the use of bio-based materials and finishes such as various types of agriboard (sheathing and or insulation board made from agricultural waste and byproducts, including straw, wheat, barley, soy, sunflower shells, peanut shells, and other materials). Some structural insulated panels are now made from bio-based materials. Use lumber and wood products from certified forests where the forest is managed and lumber is harvested using sustainable practices. Use resource efficient engineered wood products in lieu of full dimension lumber which comes from older growth forests.
- Evaluate all products and systems used for their ability to be recycled when they reach the end of their useful life. Preference should be given to products and systems that facilitate easy, non-energy intensive separation and recycling with minimal contamination by foreign debris.
- Recognize that transportation becomes part of a product or building materials embodied energy. Where practical, specify and use locally harvested, mined and manufactured materials and products to support the regional economy and to reduce transportation, energy use and emissions.

Green Technologies
Green Roofs

A green roof or living roof is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems. Container gardens on roofs, where plants are maintained in pots, are not generally considered to be true green roofs, although this is debated. Rooftop ponds are another form of green roofs which are used to treat grey water.

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, oikosteges, vegetated roofs, living roofs, green roofs and VCWH (Horizontal Vegetated Complex Walls).

Benefits

- Reduced heating due to fewer fluctuations in roof temperature and insulating properties of vegetation
- Reduced cooling costs due to fewer fluctuations in roof temperature and heat loss due to evaporation in the summer
- Increased property value
- Extension of the life of the roof membrane because of protection from intense ultraviolet radiation and continued expansion and contraction due to fluctuating temperatures
- Noise insulation

Rammed Earth Brick

Rammed earth is an ancient construction technique similar to adobe that uses the raw materials of the Earth to form sturdy buildings through a simple process. Rammed earth has been around for thousands of years -- portions of the Great Wall of China were constructed using the rammed-earth technique. Today, the process of forming a rammed-earth structure isn't so different than it was centuries ago. A moist mixture of earth and hard substances such as clay or gravel are combined with a stabilizing element like concrete and compressed to form dense, hard walls. After forming, rammed earth must cure for months -- or as long as two years -- in a humid climate to fully cure and completely harden [source: USC].

The density of rammed earth makes it an ideal material for regulating the temperature of a building. It will stay cool in the summer and warm in the winter, and constructing rammed earth produces fewer emissions than the typical building process [source:

USC]. Modern rammed-earth equipment makes the compacting process a bit easier than it was thousands of years ago, but there are still tools out there specially designed to compress the walls by hand.

Rammed-earth construction isn't exactly the norm for the 21st century, but it still exists, and there are contractors out there who specialize in designing homes with the Earth's minerals. Rammed-earth construction does have to take special care to properly regulate water to prevent damage, which is much like our next green technology, a system designed to harness water runoff.

Passive solar systems

The term passive solar refers to systems that absorb, store and distribute the sun's energy without relying on mechanical devices like pumps and fans, which require additional energy. Passive solar design reduces the energy requirements of the building by meeting either part or all of its daily cooling, heating and lighting needs through the use of solar energy.

Passive heating

Heating the building through the use of solar energy involves the absorption and storage of incoming solar radiation, which is then used to meet the heating requirements of the space. Incoming solar radiation is typically stored in thermal mass such as concrete, brick, rock, water or a material that changes phase according to temperature. Incoming sunlight is regulated by the use of overhangs, awnings and shades while insulating materials can help to reduce heat loss during the night or in the cold season. Vents and dampers are typically used to distribute warm or cool air from the system to the areas where it is needed. The three most common solar passive systems are direct gain, indirect gain and isolated gain. A direct gain system allows sunlight to windows into on occupied space where it is absorbed by the floor and walls. In the indirect gain system, a medium of heat storage such as wall, in one part of the building absorbs and stores heat, which is then transferred to the rest of the building by conduction, convection or radiation. In an isolated gain system, solar energy is absorbed in a separate area such as greenhouse or solarium, and distributed to the living space by ducts. The incorporation of insulation in passive systems can be effective in conserving additional energy.

Passive cooling

Passive solar technology can also be used for cooling purposes. These systems function by either shielding buildings from direct heat gain or by transferring excess heat outside. Carefully designed elements such as overhangs, awnings and eaves shade from high angle summer sun while allowing winter sun to enter the building. Excess heat transfer can be achieved through ventilation or conduction, where heat is lost to the floor and walls. A radiant heat barrier, such as aluminum foil, installed under a roof is able to block upto 95% of radiant heat transfer through the roof.

Water evaporation is also an effective method of cooling buildings, since water absorbs a large quantity of heat as it evaporates. Fountains, sprays and ponds provide substantial cooling to the surrounding areas. The use of sprinkler systems to continually wet the roof during the hot season can reduce the cooling requirements by 25%. Trees can induce cooling by transpiration, reducing the surrounding temperature by 4 to 14 degrees F.

Active cooling systems of solar cooling such as evaporative cooling through roof spray and roof pond and desiccant cooling systems have been developed along with experimental strategies like earth-cooling tubes and earth-sheltered buildings. Desiccant cooling systems are designed to dehumidify and cool air. These are particularly suited to hot humid climates where air-conditioning accounts for a major portion of the energy costs. Desiccant materials such as silica gels and certain salt compounds naturally absorb moisture from humid air and release the moisture when heated, a feature that makes them re-useable. In a solar desiccant system, the sun provides the energy to recharge the desiccants. Once the air has been dehumidified, it can be chilled by evaporative cooling or other methods to provide relatively cool, dry air. This can greatly reduce cooling requirements

Roof spray

The exterior surface of the roof is kept wet using sprayers. The sensible heat of the roof surface is converted into latent heat of vaporization as the water evaporates. This cools the roof surface and a temperature gradient is created between the inside and outside surfaces causing cooling of the building. A reduction in cooling load of about 25% has been observed. A threshold condition for the system is that the temperature of the roof should be greater than that of air.

There are, however, a number of problems associated with this system, not least of which is the adequate availability of water. Also it might not be cost effective, as a result of high maintenance costs and also problems due to inadequate water proofing of the roof.

Roof pond

The roof pond consists of a shaded water pond over a non-insulated concrete roof. Evaporation of water to the dry atmosphere occurs during day and nighttime. The temperature within the space falls as the ceiling acts as a radiant cooling panel for the space, without increasing indoor humidity levels. The limitation of this technique is that it is confined only to single storey structure with flat, concrete roof and also the capital cost is quite high.

Earth cooling tubes

These are long pipes buried underground with one end connected to the house and the other end to the outside. Hot exterior air is drawn through these pipes where tit gives up some of its heat to the soil, which is at a much lower temperature at a depth of 3m to 4m below the surface. This cool air is then introduced into the house.

Special problems associated with these systems are possible condensation of water within the pipes or evaporation of accumulated water and control of the system. The lack of detailed data about the performance of such systems hinders the large-scale use of such systems.

Earth-sheltered buildings

During the summer, soil temperatures at certain depths are considerably lower than ambient air temperature, thus providing an important source for dissipation of a building's excess heat. Conduction or convection can achieve heat dissipation to the ground.

Earth sheltering achieves cooling by conduction where part of the building envelope is in direct contact with the soil. Totally underground buildings offer many additional advantages including protection from noise, dust, radiation and storms, limited air infiltration and potentially safety from fires. They provide benefits under both cooling and heating conditions, however the potential for large scale application of the technology are limited; high cost and poor day-lighting conditions being frequent problems.

On the other hand, building in partial contact with earth offer interesting cooling possibilities. Sod roofs can considerably reduce heat gain from the roof. Earth berming can considerably reduce solar heat gain and also increase heat loss to the surrounding soil, resulting in increase in comfort.

Active solar architecture

It involves the use of solar collectors and other renewable energy systems like biomass to support the solar passive features as they allow a greater degree of control over the internal climate and make the whole system more precise. Active solar systems use solar panels for heat collection and electrically driven pumps or fans to transport the heat or cold to the required spaces. Electronic devices are used to regulate the collection, storage and distribution of heat within the system. Hybrid systems using a balanced combination of active and passive features provide the best performance.

Active solar systems
Active heating

In active systems, solar collectors are used to convert sun's energy into useful heat for hot water, space heating or industrial processes. Flat-plate collectors are typically used for this purpose. These most often use light-absorbing plates made of dark colored material such as metal, rubber or plastic that are covered with glass. The plates transfer the heat to a fluid, usually air or water flowing below them and the fluid is used for immediate heating or stored for later use. There are two basic types of liquid based active systems-open loop and closed loop. An open loop system circulates potable water itself, through the collector. In closed loop systems, the circulating fluid is kept separate from the system used for potable water supply. This system is mainly used to prevent the freezing of water within the collector system. However, there is no need to go in for such a system in India, as freezing of water is not a possibility. Also closed loop systems are less efficient as the heat exchanger used in the system causes a loss of upto 10 degrees in the temperature of water, at the same time, one has to reckon with the extra cost of the heat exchanger as well as the circulating pumps.

Active cooling

Absorption cooling systems transfer a heated liquid from the solar collector to run a generator or a boiler activating the refrigeration loop which cools a storage reservoir from which cool air is drawn into the space. Rankin steam turbine can also be powered by solar energy to run a compressed air-conditioner or water cooler.

Solar refrigeration is independent of electric supply and without any moving parts, for example, Zeolite refrigerator Solar Designs.

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