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Engineering

TRENDS OF SUSTAINABILITY SUSTAINABLE ARCHITECTURE IN CONSTRUCTION INDUSTRY

KEY WORDS: Sustainability, Conservation, Design

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ABSTRACT

Sustainability recognizes that human civilization is an integral part of the natural world and that nature must be preserved and perpetuated if the human community itself is to survive. Sustainable design articulates this idea through developments that exemplify the principles of conservation and encourage the application of those principles as sustainable Architecture. The paper aims at discussing sustainable architectural aspects and exploring sustainable architectural features of some of the tall buildings, private residential houses, school buildings etc. The structures use climate and environment to their advantage and adopt three principles of sustainability in architecture namely, Sustainable Design, Economy of Resources & Life Cycle Design — in design, construction, operation & maintenance, and recycling & reuse of architectural resources.

INTRODUCTION: As per World Commission on Environment and Development "Sustainability" is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs. The need for finding long-terms solutions that warrant continuing human existence and well-being is of paramount importance.

Economic development demands more factories, office buildings, and residential buildings. Also, the increased incomes leads to a desire for a larger house with more expensive building materials, furnishings & home appliances, more comfortable interior spaces and larger garden or yard. Both putting more stress on the ecosystem. Site development together with influx of construction equipments & personnel and construction activities itself disrupt the local ecology. The procurement and manufacturing of construction materials impact the global environment. Once constructed, building operation inflicts long-lasting impact on the environment by production of toxic gases and sewage by its inhabitants. Consumption of energy and water along with the extraction, refining, and transportation of all the resources used in building operation and maintenance also have numerous effects on the environment.

Architectural professionals have to accept the fact that as a society's economic status improves its demand for architectural resources-land, buildings or building products, energy, and other resources-will increase. This in turn increases the combined impact of architecture on the global ecosystem, which is made up of inorganic elements, living organisms, and humans. The goal of sustainable design is to find architectural solutions that guarantee the well-being and coexistence of these three constituent groups.

PRINCIPLES OF SUSTAINABILITY: Jong-Jin Kim, Assistant Professor of Architecture, of College of Architecture and Urban Planning, The University of Michigan proposes three principles of sustainability in architecture. **Economy of Resources** , concerned with the reduction, reuse, and recycling of the natural resources that are input to a building. **Life Cycle Design** provides a methodology for analyzing the building process and its impact on the environment. **Humane Design** focuses on the interactions between humans and the natural world.

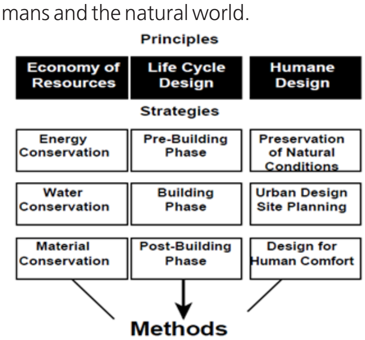

Figure 1. Three Principles of Sustainability in Architecture (Jong-Jin Kim)

Economy of Resources: Natural and manmade materials are required as a resources right from the beginning with the construction of building to useful lifespan of the building. Once building's useful life is over, it should be turned into components for other buildings. The three strategies for the economy of resources principle are energy conservation, water conservation, and material conservation. Each focuses on a particular resource necessary for building construction and operation.

Material Conservation: Range of materials are to be dealt with for an architectural structure may it be building materials, waste generated during construction & installation process, materials for maintenance, replacement & renovation activities and Consumer goods to support human activities of the occupants. All of these materials are eventually to be managed efficiently preferable to be recycled and used as constituent of the construction material.

Construction and demolition debris generated during building, renovation and demolition could be in tones, as per Laquatra and Pierce 2004 , it amounts to 2 to 4 tonne for a single family home in United States. The widespread practice of simply burying construction and demolition materials instead of using those materials to reduce the amounts of raw materials extracted from the environment is a strategy that cannot be sustained indefinitely, the linear process currently used for material acquisition and use must end. Ways to imitate natural systems, where there is no such thing as waste material, must be found so that materials are constantly recycled and serve as inputs to the human economy or ecosystem.

Water Conservation: A building requires a large quantity of water for the purposes of drinking, cooking, washing and cleaning, flushing toilets, irrigating plants, etc. All of this water requires treatments and delivery, which consume energy. Efforts to put on efficient use of the water along with recycling, reuse and safe disposal of treated sewage. Rain water collection & use , Wastewater disposal and Water-efficient plumbing are considered to be key water conservation elements

Tam et al. 2010; Thurman 1995; Yaziz et al. 1989 emphasis rain water collection & use as key element with collection of all water from the roofage and also all sealed area, plus its storage for later use. Large capacity tanks to be installed for storage of water to be used for toilet flushing, showers and cleaning.

Hophmayer-Tokich 2010 emphasis safe disposal of Wastewater, which includes collection of the wastewater from toilet flushing, Showers & kitchen water and its removal. The collected waste water to be treated before being released into the environment. The disposal of un cleaned wastewater into the environment can cause huge damage on the ground, fauna, flora, and the ground wastewater quality in the area of seepage.

Water-efficient plumbing fixtures and appliances are considered to be critical by Sydney 2003. Water-efficient plumbing fixtures

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such as shower head, toilet flush, water tap in wash basins and bath tubs could be an water saving installations. Water-efficient shower heads use more pressure to have the same cleaning effect whilst saving water. Appliances that are water-efficient could be the washing machine or the dishwasher. Usually these appliances are already judged after their energy and also water efficiency, and are therefore easy to identify.

100% rainwater is harvested, 100% of grey water is recycled via an on-site sewage treatment plant into flushing, air-cooling and landscaping systems at One Earth. Water fixtures including low flow fixtures that reduce in-building water consumption by 65% and touchless urinals with hytronic sensors all help reduce water consumption and make One Earth water efficient.

Energy Conservation : Building requires a constant flow of energy input during its operation. The environmental impacts of energy consumption by buildings occur primarily away from the building site, through mining or harvesting energy sources and generating power. The energy consumed by a building in the process of heating, cooling, lighting, and equipment operation cannot be recovered. The type, location, and magnitude of environmental impacts of energy consumptions in buildings differ depending on the type of energy delivered. Coal-fired electric power plants emit polluting gases such as SO2 , CO2 , CO, and NOx into the atmosphere. Nuclear power plants produce radioactive wastes, for which there is currently no permanent management solution. Hydropower plants each require a dam and a reservoir which can hold a large body of water; construction of dams results in discontinuance of river ecosystems and the loss of habitats for animals and plants.

Basic features of a highly energy-efficient house or a high performance house include high levels of insulation in the building enclosure, an uninterrupted air barrier, a drainage plane, and high-efficiency space conditioning and other mechanical systems. A net-zero-energy house, on the other hand, is one that produces the energy it uses and has zero annual carbon emissions (McNabb 2013)[1].

Buildings account for 8% of the total country's utilization in terms of power and grow steadily at 11 to 12% an annum. This rate of growth of energy demand among buildings is much higher than the 6% growth that the electricity sector sees overall. Most commercial buildings in India have an Energy Performance Index (EPI) of 200 to 400 kWH/sq. m/year. In contrast, buildings in Europe and America have an EPI of less than 150 KWH/sq. m/year. For uninterrupted functioning, business cannot compromise on their energy needs. However, with India developing as a leading IT and services power house, there have been progress towards exploring and implementing sustainable alternatives for energy generation. Indian Green Buildings Council (IGBC) promoting energy conservation through Green Building certifications.

The solar air conditioning at Turbo Energy systems at Chennai uses solar power to condition or control the air in the building by passive solar, solar thermal energy conversion and photovoltaic conversion in which sunlight is converted to electricity. The plant has installed the 90-TR hot water fired VAM system up to 26,000 sq.ft which has reduced the Heating Ventilation and Air-Conditioning (HVAC) electrical load by 117kW. In addition to this Turbo Energy India also has a working turbine of 5Kw capacity in position.

Earth tunnel Air conditioning system also known as passive air conditioning is deployed at Aqualmall water solutions in Dehradun, which sucks air from the outside and with the help of geothermal cooling the air is then sent to interiors. Whereas, at IGP office in Gulbarga Passive downdraught evaporative cooling (PDEC) system is installed, wherein air passes through a layer of water in the wind tower. This cools down the water and that water is sent to the interiors of the building.

TCS Technopark and Grundfos Pumps in Chennai adopted thermal energy systems which collect energy and store it for later use, even months later. This also works inter-seasonally where during winters it uses the solar heat collected in the solar collectors and during summer it uses the cold air conditioning obtained from the winter air.

Figure 2. Thermal Storage at Grundfos Pumps, Chennai

A hybrid wind (80%) – solar (20%; through photovoltaic panels) energy system located on-site and off-site generates 155 kW of power, making One Earth India's first 100% renewable energy campus. Smart solutions like motion/occupancy sensors, Low-E glass for the buildings, low energy LED lighting, aluminum louvres that shade the interiors while providing ample natural illumination, HVAC systems that filter and cool air before resupplying them to ACs to reduce the load on ACs etc., optimize energy consumption.

Life Cycle Design : The conventional model of the building life cycle is a linear process consisting of four major phases: design; construction; operation and maintenance; and demolition. The problem with this model is that it is too narrowly defined: it does not address environmental issues (related to the procurement and manufacturing of building materials) or waste management (reuse and recycling of architectural resources).

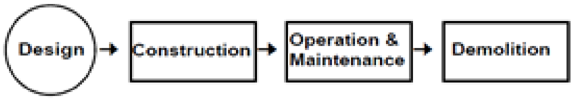

Figure 3. Conventional Model of the Building life Cycle

The second principle of sustainable architecture is life cycle design (LCD). This approach recognizes environmental consequences of the entire life cycle of architectural resources, from procurement to return to nature. LCD is based on the notion that a material transmigrates from one form of useful life to another, with no end to its usefulness. The life cycle of a building can be categorized into three phases: pre-building, building, and post-building, as shown in Figure 4. These phases are connected, and the boundaries between them are not obvious. The phases can be developed into LCD strategies that focus on minimizing the environmental impact of a building. Analyzing the building processes in each of these three phases provides a better understanding of how a building's design, construction, operation, and disposal affect the larger ecosystem.

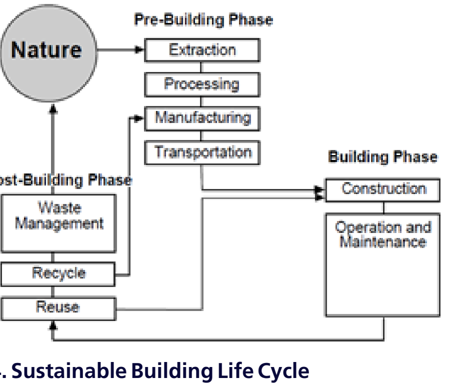

Figure 4. Sustainable Building Life Cycle

Ali M. Memari, Patrick H. Huelman, Lisa D. Iulo, Joseph Laquatra, Carlos Martin, Andrew McCoy, Isabelina Nahmens and Tom Williamson emphasis identifying and elimination of Seven Types of Waste to reduce the cost of homebuilding under the lean-construction approach[1]. Focus on the construction process and the flow of materials and information is of paramount importance to identify root causes of waste. Waste is any nonproductive activity, from the perspective of the homebuyer and hence must be eliminated.

1. Defect: Activities involving repairs or rework, e.g., wrong installation, defects in fabrication, and errors in punch lists;
2. Excess inventory: Any inventory that is not directly required to fulfill current customer orders, e.g., uncut material, work in process, and finished assemblies that pile up in the construction site;
3. Excessive transportation: Any activity related to material movement that does not directly support productive activities, e.g., double handling drywall stacks around the jobsite;
4. Excessive motion: Any movement of a crew that does not contribute added value to the house, e.g., when material is stored far away from the point of use or when workers tools;
5. Overproduction: Any activity involved in producing too much at a particular point in time, e.g., stockpiles of WF for windows at the jobsite too early in the construction process;
6. Overprocessing: Any extra operation or activity in the construction process, e.g., requiring additional signatures on a requisition and multiple handling of timesheets; and
7. Waiting: When an operator is ready for the next operation but must remain idle until the previous step is completed, e.g., when a crew waits for instructions or materials at the jobsite.

Eliminating waste from the homebuilding process through lean strategies have proven effective in improving productivity levels and the company's bottom-line profit (Womack and Jones 1996; Dentz and Blanford 2007).

Pre-Building Phase : This phase includes site selection, building design, and building material processes, up to but not including installation. Under the sustainable-design strategy, we examine the environmental consequences of the structure's design, orientation, impact on the landscape, and materials used. The procurement of building materials impacts the environment: harvesting trees could result in deforestation; mining mineral resources (iron for steel; bauxite for aluminum; sand, gravel, and limestone for concrete) disturbs the natural environment; even the transport of these materials can be a highly polluting activity, depending on their weight and distance from the site. The manufacturing of building products also requires energy and creates environmental pollution: for example, a high level of energy is required to manufacture steel or aluminum products.

Building Phase : This phase refers to the stage of a building's life cycle when a building is physically being constructed and operated. In the sustainable-design strategy, we have to examine the construction and operation processes for ways to reduce the environmental impact of resource consumption; we also have to consider long-term health effects of the building environment on its occupants.

Post-Building Phase : This phase begins when the useful life of a building has ended. In this stage, building materials become resources for other buildings or waste to be returned to nature. The sustainable design strategy focuses on reducing construction waste (which currently comprises 60% of the solid waste in landfills1) by recycling and reusing buildings and building materials.

Humane Design: Humane design is the third, and perhaps the most important, principle of sustainable design and is concerned with the livability of all constituents of the global ecosystem, including plants and wildlife. This principle arises from the humanitarian and altruistic goal of respecting the life and dignity of fellow living organisms.

With more than 70% of a person's lifespan is spent indoors, essentiality is to provide built environments that sustain occupants' safety, health, physiological comfort, psychological well-being, and productivity. The following three strategies for humane design focus on enhancing the coexistence between buildings and the greater environment, and between buildings and their occupants,

Preservation of Natural Conditions: Minimizing impact of a building on its local ecosystem (e.g., existing topography, plants, wildlife). In a world with an expanding global economy and increasing demand for material resources, the linear process currently used for material acquisition and use must end. Ways to imitate natural systems, where there is no such thing as waste material, must be found so that materials are constantly recycled and serve as inputs to the human economy or nourishment to the ecosystem.

Urban Design and Site Planning: Neighborhoods, cities, and entire geographic regions to get benefited from cooperative planning to reduce energy and water demands. The result can be a more pleasant urban environment, free of pollution and welcoming to nature. Global warming has given a new dimension to urban design efforts that seek to integrate the infrastructure systems of a city into a sustainable and more natural built environment.

Human Comfort: Design to enhance the work and home environments so as to improve productivity, reduce stress, and positively affect health and well-being of the occupants. The the performance goals and attributes that today's owners or occupants desire are more demanding. For instance, comfort expectations are very different today than they were a century ago. Likewise, comfort expectations might be quite different for a new home than an existing home, especially one that is 30 or 40 years old. As an example, it was not that many years ago that a home in the United States did not even have a thermostat for automated heating and cooling control. Today, the standard practice is to design a system to ensure all conditioned spaces are within 1.1_C (2_F) in heating mode or 1.7_C (3_F) in cooling mode of the thermostat set point. But there is a whole host of building performance expectations beyond thermal comfort, including durability, maintenance, convenience, indoor air quality, energy efficiency, and environmental impacts. Fortunately, understanding of the physical forces that act on and within a structure is far more advanced today. This makes it possible to predict and successfully meet these expectations for much higher levels of building performance.

The main issue that should be solved in this studied office is the HVAC system. A new system is recommended to be installed with certain specifications with the aim of improving the IAQ. The system should allow some proportion of outdoor air, without causing much energy loss, instead of using 100% recirculated air. This is necessary for the purpose of renewing the used air recirculated within the building. Studies (Weschler and Shields 2003; Fadeyi et al. 2009) have shown that an increase in the outdoor fresh air rate can help dilute pollutants in indoor sources

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