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GREEN BUILDING PRACTICES: A FRAMEWORK FOR SUSTAINABLE CONSTRUCTION

Dr. Pankaj Chhabra*, | Ar Silia Grover**

**Associate Professor & Head, Department of Architecture, Guru Nanak Dev University, Amritsar, Punjab, India.*

***Assistant Professor, Department of Architecture, Guru Nanak Dev University, Amritsar, Punjab, India.*

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ABSTRACT

The construction industry is a major contributor to global resource consumption, environmental degradation and carbon emissions. As the demand for infrastructure and urban development continues to grow, the need for sustainable practices in the sector has become increasingly urgent. This article examines the concept of sustainability in construction through a life-cycle perspective emphasizing the importance of integrating sustainable solutions across all project phases.

A construction project encompasses multiple stages from material extraction and production to construction, operation, maintenance and eventual demolition or renovation. Each phase presents environmental, social and economic challenges that require a strategic approach to sustainability. By adopting a life-cycle perspective stakeholders can gain a comprehensive understanding of the interrelated impacts of construction activities and implement effective strategies to minimize negative consequences. The article also explores key barriers to sustainability adoption in the construction sector including fragmented supply chains, limited data availability and resistance to change in conventional practices. Overcoming these challenges demands collaborative efforts to enhance transparency, streamline processes and foster innovation-driven solutions. Building on these insights, the article introduces a structured framework for integrating sustainability principles into the construction industry, focusing on three key dimensions: environmental, social, and economic. By systematically addressing environmental challenges and identifying opportunities for improvement, stakeholders can prioritize interventions that enhance sustainability. Additionally, considering social and economic factors ensures that construction projects generate positive community and economic benefits while mitigating adverse social impacts. The framework highlights the interconnected nature of these dimensions, advocating for holistic solutions rather than isolated approaches.

By embracing a life-cycle approach, the construction industry can enhance resilience, optimize resource efficiency and contribute to long-term societal well-being. This article underscores the critical role of sustainability in the sector and presents a comprehensive strategy for embedding sustainable practices across all stages of the construction process. Through innovation, collaboration and commitment to sustainability, the construction industry can drive progress toward a more sustainable and resilient built environment.

Keywords: *Sustainable Development, Energy Efficiency, Green Building, Construction Industry, Life-Cycle Approach.*

ABOUT AUTHORS

Dr. Pankaj Chhabra is an architect & Urban Planner as well as an academician, author and a researcher. He has professional as well as academic experience of more than 26 years. Currently, he is working as Associate Professor & Head in the Department of architecture at Guru Nanak Dev University, Amritsar. He handles associated responsibilities of Member of Board of Control, Board of Studies, Doctoral Research Board, Academic Council and Press & Publication of the university.

He is author of the book “20th CENTURY INDIAN ARCHITECTURE: Genesis and Metamorphosis of Modernism”. He is actively involved in architectural research at doctoral level and had guided one and currently guiding three more research scholars. He has written extensively for National and International Journals with more than 70

papers and book chapters. He has numerous presentations to his credit in both National and International conferences. He has also been invited as resource person/ critic at various National and International forums. He is member of Doctoral Research Board and Board of Studies of various Public and Private sector Universities and is panel reviewer for many refereed journals of repute and in National and International Conferences, both in India and Internationally.

Ar. Silia Grover is an Architect & Urban Planner as well as an academician, author and a researcher. She has professional as well as academic experience of 6 years. Currently, she is working as Assistant Professor in the Department of Architecture at Guru Nanak Dev University in Amritsar.

As a dedicated educator, she is committed to fostering critical thinking and research skills among her students. She teaches courses where she integrates her research expertise to provide students with hands-on learning experiences and equips them with the necessary tools to excel in different subjects. Her scholarly contributions extend beyond the classroom. She has written extensively for various publications in various magazines, journals, conference proceedings, professional websites etc. on Sustainable Architecture, Housing, Urban Planning and Governance, Energy Efficiency, Urban Design, Transport Systems, Sanitation and related fields. Committed to advancing knowledge and promoting diversity in academia, she actively engages in conference presentations at National level i.e. Planning and Architecture for Hill Regions in NIT Hamirpur and International level on Emerging Trends in Engineering, Science and Management at Global Group of Institutes in Amritsar.

INTRODUCTION

The Earth's capacity to mitigate the impacts of human activities is increasingly being recognized. However, the current rate of consumption in developed countries is unsustainable and continues to deplete the planet's natural resources irreversibly. The construction industry alone accounts for 40% of global energy consumption, making it a major contributor to environmental degradation. Consequently, building professionals worldwide are striving to enhance construction practices to reduce their ecological footprint.

Sustainable development relies heavily on the building and construction sector, which, while offering economic and social benefits, also poses significant environmental challenges. Key concerns include waste production, energy consumption, greenhouse gas (GHG) emissions, and the use, reuse, and recycling of construction materials—factors that contribute significantly to global warming. In India, energy consumption in buildings varies depending on climatic conditions and building type, ranging from 400 kWh/m²a to 280 kWh/m²a. With a growing population and expanding economy, construction activities are on the rise. According to the Ministry of Statistics & Programme Implementation, India's economy is projected to grow by 7.3% during the 2023-24 five-year plan, following a provisional growth rate of 7.2% in the previous financial year. The construction sector, in particular, is estimated to experience a significant increase, with a projected growth rate of 10.7%. Ensuring the long-term availability of affordable, accessible, and environmentally sustainable energy resources is essential for India's economic growth. Without effective policy interventions, these existing consumption trends are unlikely to change.

The objective of this paper is to establish a framework for integrating sustainability strategies into the construction industry through a life-cycle approach. By applying sustainable principles, strategies, and methodologies, this framework aims to provide valuable tools for key industry stakeholders—including planners, contractors, architects, and suppliers—to enhance environmentally responsible construction practices.

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1. The building industry's contribution to sustainable development

Two essential components are present in sustainable development, according to the 1987 World Commission on Environment and Development Report (WCED, 1990). First, that in order for the world's poor people to lead reasonably comfortable lives, their basic needs must be met; and second, that the environment's capacity to provide for both present-day needs and those of the future must be maintained. Every facet of infrastructure development is impacted by and opens up possibilities for interaction with the broad concept of sustainability. The construction industry has significant economic implications as well as negative social and environmental effects. It is crucial to quality of life in terms of housing, workspace, utilities, and transportation infrastructure. The extraction, transportation, building, operation, maintenance, demolition, and other energy-intensive processes all contribute to the emission of greenhouse gases, which is directly and indirectly the responsibility of the construction industry.

The construction industry is unique among other industries in that it is a long-lasting one. In developed nations, the typical lifespan of a structure is between 80 and 100 years. This implies that a structure's environmental performance will be affected over time. It is essential to apply sustainability principles from the outset of a project in order to achieve a high-performance, low-impact structure. Sustainable design and construction add the concerns of resource minimization, environmental degradation, and the creation of a healthy built environment in addition to guaranteeing human health. Construction activities focus on cost, performance and quality issues, sustainable design and construction adds the issues of minimization of resource consumption, environmental degradation and the creation of a healthy built environment as well as ensuring human health and confront. Instead of considering the built environment as an object separate from the natural environment, it should be viewed as part of the flow and exchange of matter and energy that occurs naturally within the biosphere.

2. Principles, Techniques, and Strategies of Sustainable Design

Based on the three pillars of sustainable development—environment, social, and economic—sustainable building principles may be distinguished. By emphasizing environmental issues and opportunities and outlining the connections between construction operations and social, economic, and environmental challenges. This framework illustrates the potential of the construction industry in achieving the objective of sustainable development.

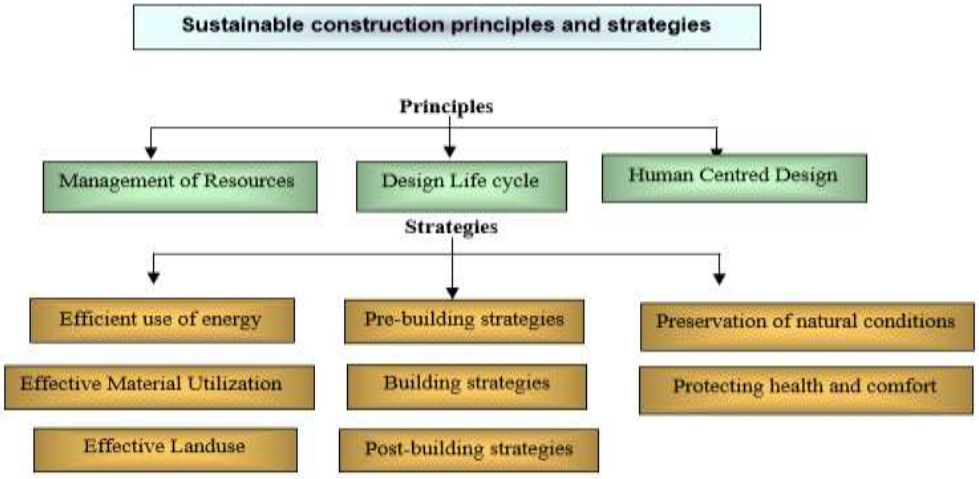

Fig. 1: Framework of evaluating the sustainability of the construction industry

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2.1 Management of Resources

The energy used for the shipping, assembly, and installation of materials on site, as well as the energy needed to maintain indoor ambient conditions, are all inputs into the built environment, in addition to building materials. The effects of resource usage affect both the local environment and the global environment. Reducing, reusing, and recycling resources that go into a structure is what resource management offers.

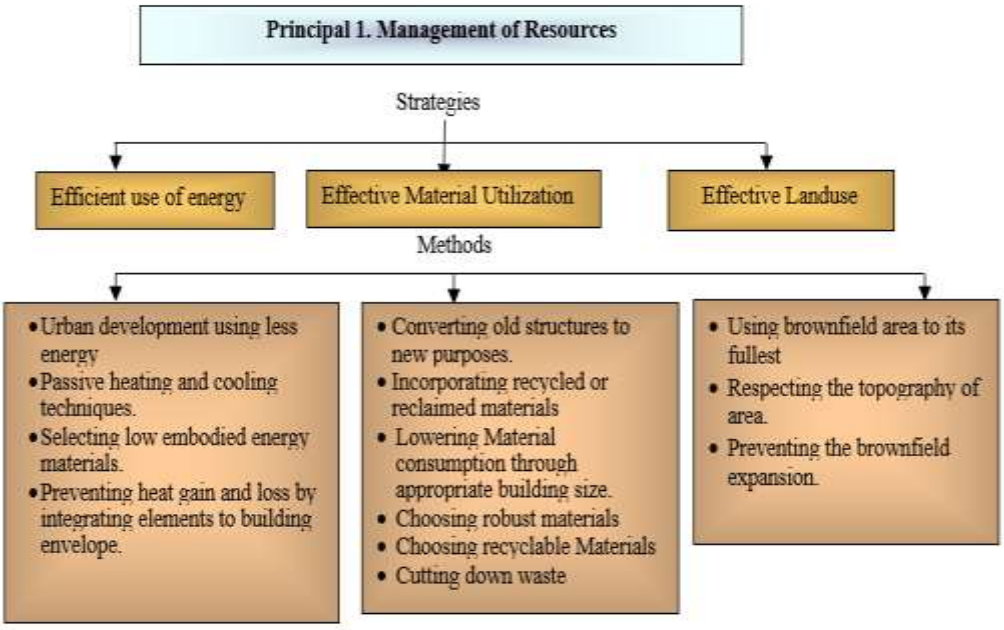

Fig. 2: Resource Management Techniques for Building Industry

2.2.1 Efficient Use of Energy

Most structures use significantly more energy for operations than they do for embodied energy. For instance, the ratio of embodied to operational energy for a 60-year design life of an air-conditioned office building is around 1:10 (Burgan and Sansom, 2006). Reducing fossil fuel usage and boosting the use of renewable energy sources are the fundamental objectives of energy conservation. The following strategies can be used to accomplish this goal:

Urban development using less energy-In low-energy communities, mixed-use zoning policies are encouraged to foster an energy-conscious culture that relies more on public transit and pedestrian pathways than on automobile mobility. Planning for land use in conjunction with transportation encourages sustainable development and helps to avoid environmental issues. The microclimate is influenced by the way a city is settled, which establishes the direction and arrangement of buildings.

Passive heating and Cooling Techniques-It makes the most use of the site's renewable resources, such as wind and solar energy. When designing a building, the architect must consider the project's overall environmental effect in relation to the site and seek for ways to orient the structure such that passive solar gain and day illumination are provided by the sun's path. Another useful method for passive heating and cooling is vegetation. For instance, planting deciduous trees on a building's south face will shield it from summer heat while evergreen trees on its north face would shield it from winter winds.

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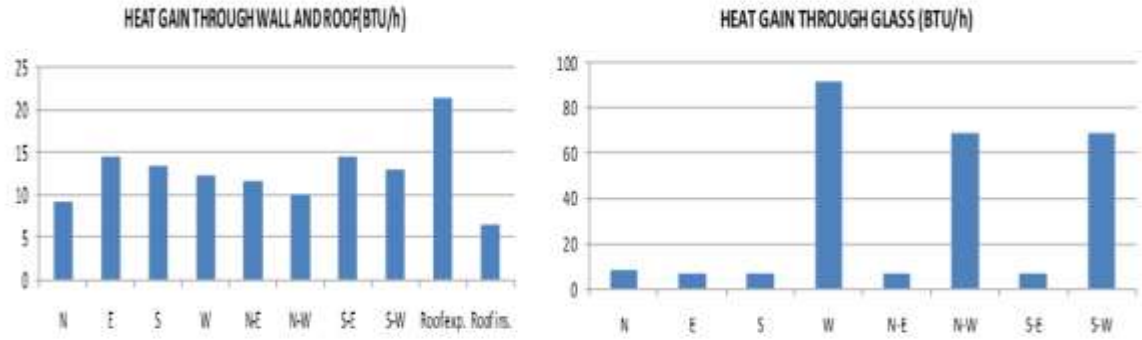

Fig. 3: Heat Gain through various Building envelope components

Selecting low-embodied energy materials -Energy used for resource extraction, processing, manufacturing, and transportation of building materials can be lessened. A material's embodied energy is an attempt to quantify the energy expended during the material's lifespan. For example, the high embodied energy of aluminium stems from the significant amount of power needed to extract the raw material. So, by selecting low -embodied energy materials, we can save upon the energy consumption at construction stage.

Preventing heat gain and loss by integrating elements to building envelope -It lowers the loads required for heating and cooling, which raises the building's energy consumption. High-performance windows, the use of phase-changing materials (PCM), and wall insulation, for instance, minimize heat gain and loss. As a result, the building requires HVAC equipment with a reduced capacity, which lowers the emission of greenhouse gases.

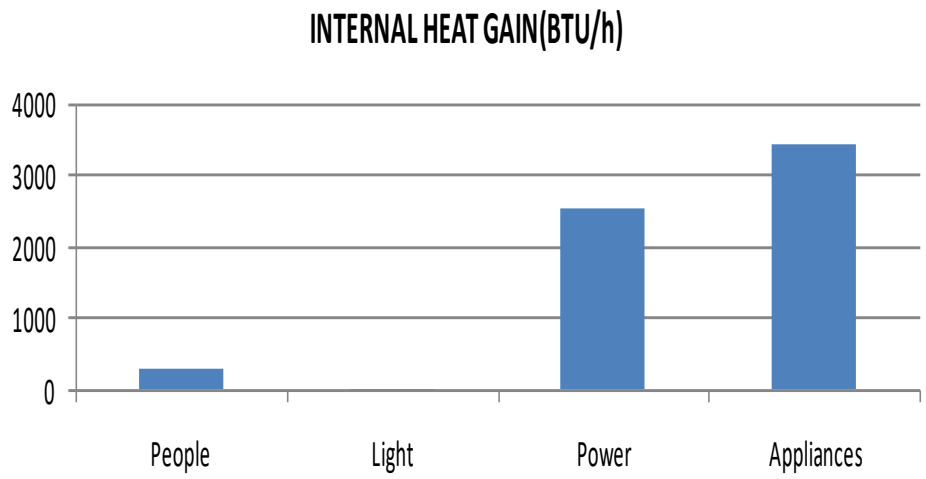

Fig. 4: Internal heat gain contributors in buildings

2.1.2 Effective Material Utilization

According to Kim and Rigdon (1998), the building sector accounts for around 40% of all worldwide material flows, and the amount of trash generated by this industry is estimated to be around 2 billion tons annually. Consequently, it is imperative to reduce the quantity of resources needed in building construction. Material efficiency can be achieved by

Converting old structures to new purposes-It is a useful technique for cutting down on material usage while protecting the building's embodied energy. One may argue that renovating abandoned buildings is the pinnacle of recycling. Compared to demolition, it produces a lot less trash from building.

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Incorporating recycled or reclaimed materials -By transforming garbage into new, usable items, their usage in building projects lowers the amount of waste that is disposed of. Additionally, recycling often requires less energy than the creation of new materials.

Lowering material consumption through appropriate building size - A structure that has facilities that are too large for it or is too big for its intended use will use too many resources. Although newer buildings often have more energy-efficient features, they nonetheless consume more energy than older ones. According to a research, China's per capita living space has more than quadrupled since 1960.

Large-scale retail mall and other public building construction has exploded in the last ten years, reaching a size never seen before. Constructed under temporal and financial constraints, these enormous edifices featuring enormous atriums have received the least attention with regard to their energy potential. We perhaps need to handle our mindset and redefine the vocabulary of space grandeur.

Palladium Mall in Mumbai

Elante mall in Chandigarh

Fig. 5: Massive atriums of Malls

Choosing robust materials-It is a practical method of lowering material use and prolonging the life of existing buildings. As a result, less energy and natural resources are used in the production process. Additionally, durable materials require less upkeep, which lowers the building's running costs (Kim and Rigdon 1998).

Choosing recyclable materials -It's a useful technique for material efficiency as well. By looking for methods to employ recyclable materials, we can protect the natural resources and energy used in their production.

Cutting down on waste-Material conservation is made possible through modular coordination and use of prefabrication. It helps in converting building construction process to mere assembly on site thereby reducing waste significantly.

2.1.3 Effective Land Use

Reusing an existing building in an adaptive manner can also reduce the demand for new construction, which will stop the built environment from growing and from taking over agricultural and environmentally sensitive regions.

2.2 Design Life Cycle

Architecture, construction, operation and maintenance, and demolition make up the traditional building life cycle model (Kim and Rigdon, 1998). The sustainability concerns pertaining to the sourcing, production, and recycling of architectural resources, as well as their reuse, are not covered by this approach. Sustainable design, on the other hand, acknowledges the environmental effects of a building's whole life cycle, from the procurement of all materials, energy sources, and natural resources to the point at which the building reaches the end of its useful life and is demolished.

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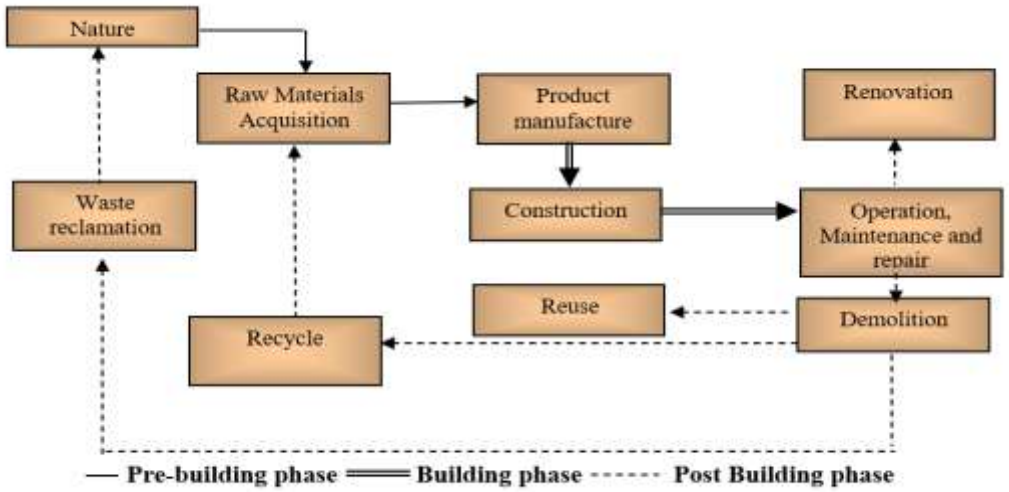

Fig. 6: Sustainable building life cycle

The life-cycle approach aims to strike a balance between conventional issues and environmental considerations, which always influence decisions and choices during the design process. Three phases can be used to manage a building's life cycle. Pre-construction, construction, and post-construction. Every step includes a set of techniques that will raise the structure's sustainability.

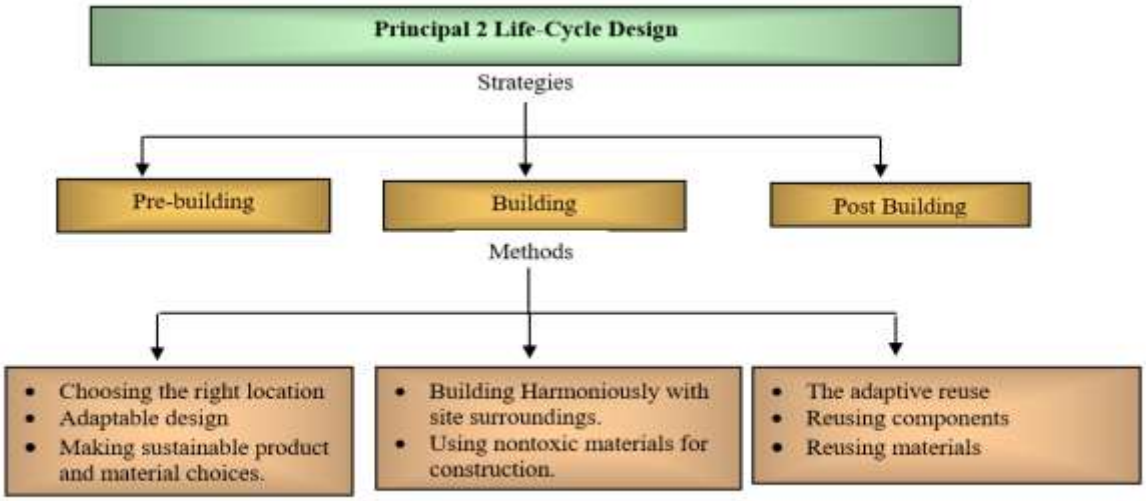

Fig. 7: Methods to achieve the sustainability by 'Life Cycle Design' Approach

2.2.1 Pre-Building Techniques

Choosing the right location -The cost of site development can be decreased and the environmental effect can be minimized by choosing locations that are well-served by utilities and public transit.

Adaptable design-It is attainable through standardized and modular design approaches, which also enable future modifications in an economical and resource-efficient manner.

Making sustainable product and material choices -It significantly enhances performance in the surroundings. Before choosing the materials, questions and assessments on the origins of the raw materials, manufacture process, transportation to the site, installation and usage, and disposal or reuse are necessary. By using local resources, the embodied energy of the material is decreased since less energy is required throughout the production, installation, maintenance, and distribution processes.

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2.2.2 Building strategies

Building Harmoniously with site surroundings -This may be accomplished by carefully organizing and supervising the building process and by guarding against the intrusion of large machinery, which can harm the site's environment and actual formation. The way groundwater moves through the site shouldn't be changed by excavations. Completed constructions must to take into account the drainage system and topography of the land. Removing trees and other plants should only be done when it is absolutely required to get access.

Utilizing non-toxic tools and materials for construction- It is crucial for their health and safety of construction workers since construction workers sometimes spend more than three quarters of their time indoors (Kim and Rigdon 1998). Nontoxic materials and products exhibit limited or no hazardous emission tendencies, have minimal or no toxic properties, do not shed dust and fiber, and do not absorb pollutants that are later released. So, thereby reduce the chances of occupational hazards.

2.2.3 Post-Building Strategies

When a building reaches the end of its useful life, the post-building process starts. At this point, construction wastes and/or materials are recycled back into the natural world or used as resources for new construction. The period of a building's life cycle that the designer gives the least thought to is when the building has reached the end of its usable life. The building's destruction and the subsequent rubbish disposal have a big effect on the environment. While inert materials eat up increasingly limited landfill space, degradable materials may create harmful waste. In this phase, the following techniques will be used to minimize or completely eradicate trash.

The adaptive reuse

It conserves the energy used in the production of building materials, its construction stage and drastically lowers waste. By maintaining and operating a historically significant structure, this strategy may also help to protect cultural heritage.

Reusing components-It reduces the amount of waste that is produced. Individual architectural elements, such windows, doors, and interior fittings, may be renovated and reused if an older structure cannot be fully restored.

Reusing materials-Recycling improves the building industry's sustainability after demolition. Waste is a source of new resources for building projects. Generally speaking, producing goods from demolition trash has a smaller environmental effect than producing new goods.

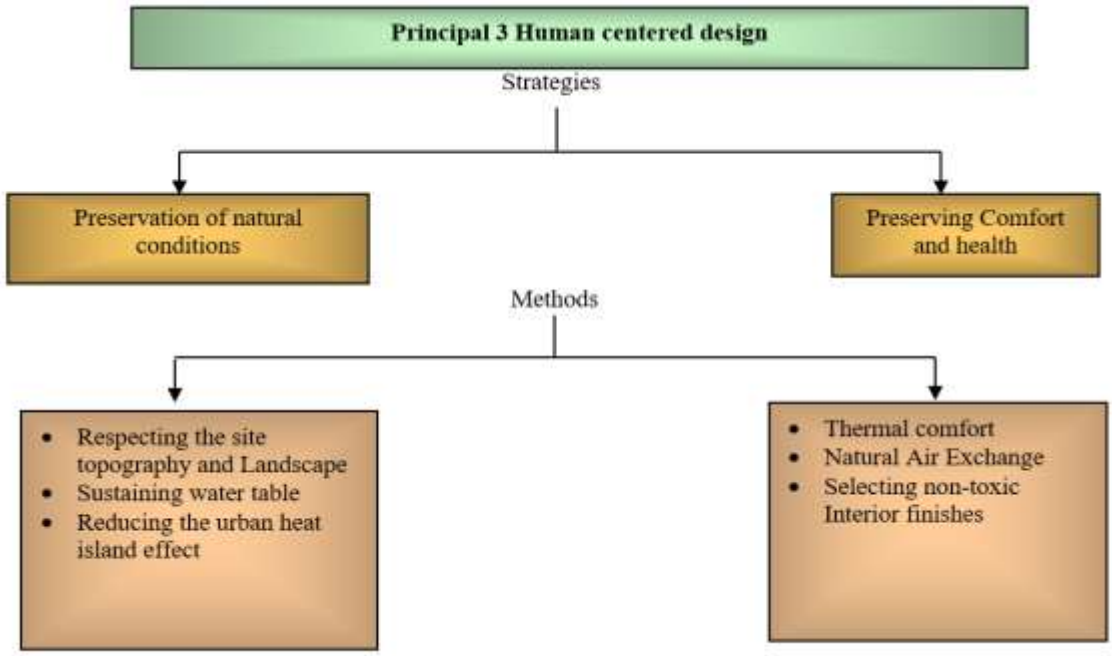

Fig. 8: Methods to achieve "Human Centered Design"

2.3 Human-centred design

Over 70% of a person's time is spent inside in modern culture. Ensuring the safety, health, physiological comfort and productivity of its inhabitants is a fundamental responsibility of architecture.

2.3.1 Preservation of Natural Condition

Respecting the site topography and Landscape-It is crucial because it lessens the adverse effects of the construction on the environment.

Sustaining the Water Table -Buildings that don't require excavation below the local water table are suitable for this operation. When the water table is exposed as a result of building operations, it becomes prone to contamination from polluted surface runoff.

2.3.2 Preserving Comfort and Health

In addition to conserving resources and preserving the environment, sustainable buildings must offer a cozy and healthy inside atmosphere. There are other ways to accomplish it.

Thermal Comfort-It enhances the well-being, comfort, and productivity of the inhabitants. Among the options available to designers to maximize thermal comfort and increase energy efficiency are reflective roofs, low-E windows, window tinting, and sun shading.

Natural Air Exchange-It is the process of ventilating enclosed areas without the need of mechanical ventilation by using fresh air that has enough volume and air change. Given that a space's ventilation directly affects people's comfort, health, and productivity. Unhealthy indoor air has resulted from enclosed interiors with minimal ventilation and air exchange, and the use of synthetic building materials. The health and comfort of tenants can also be enhanced by choosing non-toxic, non-outgassing flooring, wall treatments, furniture, and cleaning products. If not, emissions from these materials might result in a host of grave health issues, such as cancer, genetic damage, respiratory issues and skin allergies.

2.4 Green Rating Systems

Numerous evaluation instruments have been created to measure the buildings' effects on the environment and to provide guidance for improved building performance with the least amount of environmental risk. (Evaluation of Green Design) India has accepted these assessment matrices, Out of many,one is created by Tata Energy Research Institute (TERI). The 32 criteria that make up the standard matrix are further broken into 100 points.

LEED (Leadership in Energy and Environmental Design)

The design and environmental assessment evaluation matrix has six sub-headings with 69 points on the project checklist. Nevertheless, one discovers that these rating matrices are empirical in nature and that several characteristics must be assessed in the absence of a baseline or other standards. Comparing the evaluation against traditional methods and processes is essentially the main focus.

Summary

Sustainability appears to be the only way to solve environmental issues if humankind is to live, and it needs to be implemented in all spheres of human endeavour, including agriculture, transportation. Building Construction is the industry that uses the most energy, Thus by reducing it, a big contribution can be made to Sustainable development. The construction industry confronts possibilities and challenges in bringing a fresh perspective and language to architectural expression on the sidelines of the objective to achieve sustainability in the built environment. Since the building sector accounts for around 40 percent of worldwide energy usage, it may help bring about a low carbon society through inventive design vocabulary, proper building codes, use of energy saving technologies, and behavioural changes.

Intelligent decision-making is necessary to achieve sustainable development for the construction industry and society at large. This involves fully considering and understanding the effects of each alternative on the natural and cultural resources of the local, regional, and global environments.

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