

Green Building Construction: Strategies and Practices for Sustainable Project Management

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ABSTRACT

This thesis investigates sustainable construction practices and project management strategies aimed at fulfilling environmental objectives. It examines the definition of eco-friendly structures and analyzes the fundamental elements required for promoting sustainability in construction. Across the nation, several evaluation frameworks are in place, both within private enterprises and public institutions, with the LEED rating system developed by the United States Green Building Council standing out as the most prominent. Within the LEED system, multiple rating categories tackle distinct aspects of sustainability.

The research emphasizes the importance of green building practices over conventional construction methods and scrutinizes green building techniques, with a specific emphasis on construction phases. Traditional buildings exacerbate environmental harm by emitting greenhouse gases, producing construction and demolition waste, depleting natural resources, and consuming excessive amounts of energy and water.

Through the adoption of straightforward and sustainable practices on a case-by-case basis, it becomes feasible to develop eco-conscious structures that reduce resource usage while remaining economically viable. The study investigates green building construction methodologies and pioneering technologies geared towards sustainability. It encompasses design principles, procedural approaches, material specifications, and offers recommendations for developing a construction checklist to guide builders through each project phase.

Keywords: Sustainable construction, Project management, Eco-friendly structures, LEED rating system, Green building practices, Construction phases, Environmental harm, Greenhouse gases, Construction waste, Natural resources, Energy efficiency

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INTRODUCTION

The Ecological Impact of Construction Project Management

The coordination and oversight of construction projects, known as construction project management, has been a cornerstone of engineering practice. However, traditional approaches in construction management have raised environmental concerns. Beyond construction techniques and material choices, several factors contribute to environmental harm, with functional design being a significant factor.

Recently, there has been significant growth in the construction industry, prompting concerns about its environmental impact. According to information from the UK Green Building Council, the sector consumes over 400 million tons of materials annually, some of which pose environmental risks. Research highlights the adverse effects of material extraction on the environment, exacerbating these concerns.

Moreover, insights from the Environmental Protection Agency (EPA) highlight the risks associated with common

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tools and materials used in the US construction sector, posing threats to both public health and the environment. These include workplace chemicals and the widespread use of diesel fuel in construction machinery and vehicles.

Moreover, the EPA underscores the substantial waste generated by the construction industry in the United States, totaling 160 million tons each year, comprising a significant portion of the country's non-industrial waste. Numerous construction techniques, particularly in residential

construction, contribute to environmental harm in both immediate and long-lasting ways. Here are some illustrations of such practices:

Resource depletion

The construction industry heavily depends on natural resources such as timber, minerals, and water. Nonetheless, unsustainable mining practices can result in ecosystem depletion, habitat degradation, and soil erosion.

Energy consumption

Obtaining, transporting, and using building materials require substantial energy, often sourced from non-renewable sources. This heightened energy demand leads to increased greenhouse gas emissions, worsening concerns about climate change.

Greenhouse gas emissions

Manufacturing building materials, especially energy-intensive ones like steel and cement, emits substantial amounts of carbon dioxide, a significant greenhouse gas. Additionally, emissions rise during the transportation of materials and equipment to construction sites.

Waste generation

Construction operations generate a substantial volume of waste, encompassing surplus materials, packaging, and debris from demolition. Effective waste management is vital to mitigate habitat destruction, soil and water contamination, and overflow in landfills.

Water pollution

Construction activities can have adverse effects on water bodies through inadequate waste disposal, runoff containing sediment, and chemical leaks. Sediment runoff poses threats to water quality, aquatic habitats, and ecosystems, impacting both the environment and human health.

Air pollution

Construction sites produce air pollutants like dust, particulate matter, and emissions from vehicles, material processing, and machinery. Substandard air quality resulting from these activities can cause respiratory problems and other health issues. Furthermore, it can jeopardize the health of nearby residents and workers.

Promoting Environmental Protection in Construction

LEED, an environmental organization, stresses that incorporating environmentally sustainable building materials can lead to a substantial reduction in annual CO₂ emissions. Projections suggest that by 2018, approximately 60% of construction projects would integrate green practices, with 70% of respondents highlighting reduced operational costs as the primary advantage. These figures indicate a trend where the prevalence of green buildings is doubling every

three years, as indicated in a survey conducted by Dodge Data & Analytics.

The increasing demand for sustainable and energy-efficient structures is putting unprecedented pressure on construction companies. In response, numerous studies have been conducted, driven by the EPA's prioritization of green construction initiatives. Through collaboration with the National Institute of Building Sciences, these efforts have led to the creation of a comprehensive guide for green building construction. This guide offers strategies for aligning construction practices with federal regulations while integrating green building principles into operations.

In addition, several initiatives have been introduced to alleviate the environmental footprint of buildings, including:

- Industrial Recycling Program
- The Energy Star Program

Sustainable Building Practices

Data from the US EPA reveals that buildings consume a considerable share of the nation's resources, accounting for 68% of power, 12% of water, 39% of energy, and 38% of carbon dioxide emissions. This underscores the significant influence of buildings on environmental sustainability and public health. Moreover, given that the average American spends up to 90% of their time indoors, it underscores the importance of fostering healthy and productive indoor environments.

High-performance buildings demonstrate efficient resource usage throughout their lifecycle, from design and construction to renovation and operation. The primary goal of the "green building" approach is to minimize negative effects on public health and the environment.

As a result, high-performance buildings, often referred to as sustainable or green buildings, strive to achieve the following objectives:

- Optimize the utilization of water, electricity, and other resources
- Minimize pollution, waste, and environmental damage
- Enhance productivity while placing a premium on occupant well-being

The current study evaluates conventional building practices in comparison to environmentally friendly approaches throughout the planning, construction, and commissioning phases. In addition to underscoring the advantages of sustainable construction, the study incorporates an extensive review of existing literature. Ultimately, practical recommendations will be provided for enhancing project management systems for green buildings.

Investigative Procedure

Site assessment

In evaluating potential construction sites, the following factors warrant consideration:



On-Site Evaluation

Preservation of indigenous soil

To uphold natural ecosystems, promote sustainable land management, and safeguard ecosystem health, preserving indigenous soil during the construction of green buildings is paramount. Here are several strategies to ensure the conservation of native soil:

- Comprehensive Site Evaluation and Planning
- Implementation of Erosion and Sediment Control Measures
- Reduction of Soil Compaction to a Minimum
- Preservation of Vegetation
- Adoption of Soil Management Practices
- Integration of Water Conservation Strategies
- Conducting Soil Testing and Analysis
- Compliance with Environmental Monitoring Standards
- Provision of Education and Training Initiatives
- Collaboration with Relevant Stakeholders

Groundwater assessment

Examining groundwater is a crucial measure in constructing eco-friendly structures to guarantee that the endeavour doesn't negatively impact neighbouring water reservoirs and complies with environmental laws.

Geotechnical analysis

A geotechnical assessment intended for the construction of eco-friendly buildings should offer detailed information on the soil and geological features of the location. This information assists in designing, building, and ensuring the sustainable performance of the project over time.

Key components of the report include:

- Provide an overview of the site's topography, geological structure, and water flow patterns, emphasizing key geological features, groundwater presence, soil composition, and seismic hazards.
- Identify any environmental constraints or sensitivities that could impact site development or construction activities.
- Describe the methods used to collect geotechnical data during on-site investigations, including soil sampling, test pit excavation, borehole drilling, and in-situ testing techniques, specifying locations, depths, and methodologies.
- Offer recommendations for foundation design, soil classification, load-bearing capacity, slope stability, and settlement analysis based on the findings and interpretation of the geotechnical assessment.
- Assess the site's suitability for construction, highlighting any geotechnical risks or limitations that may require attention.

Foundation and Wall Construction

When constructing walls and foundations for eco-friendly buildings, it is essential to integrate environmentally

conscious construction methods, energy-efficient design principles, and sustainable building materials. Here are some guidelines to adhere to:

Energy efficiency

Incorporate advanced techniques in designing foundations and walls to minimize the energy required for heating and cooling. Implement strategies such as constructing double walls with an air gap in between, utilizing structural insulated panels (SIPs), or employing insulated concrete forms (ICFs) to diminish heat loss and enhance energy efficiency.

Material selection

Select environmentally friendly building materials that are sustainable, such as fly ash, reclaimed wood, recycled concrete, and locally sourced stone. Consider utilizing alternative materials for walls, such as rammed earth, bamboo, or straw bales, to reduce the building's carbon emissions.

Structural planning

Selecting the appropriate structural materials is paramount for developing environmentally friendly buildings that prioritize sustainability, energy efficiency, and environmental consciousness. Below are examples of structural material types commonly utilized in constructing green buildings:

Engineered wood products (EWPs)

Substitute conventional building materials with sustainable alternatives like cross-laminated timber (CLT). CLT consists of multiple layers of timber planks adhered together at right angles. It offers strength, dimensional stability, and fire resistance while also sequestering carbon dioxide.

Glulam, or glued laminated timber, serves as a robust structural component formed by bonding individual lumber planks. It offers design flexibility for various applications, and its components are both sturdy and lightweight.

Recycled steel

Utilizing structural steel derived from recycled materials presents a sustainable option for constructing green buildings. Recycled steel maintains its strength and durability while reducing the consumption of new materials and mitigating environmental impact. Moreover, at the end of its lifespan, recycled steel can undergo recycling processes for reuse, further extending its sustainability.

Exterior finishes

Selecting the optimal material for the outer layer of a green building relies on various factors such as sustainability, durability, appearance, and local climate. Different materials are frequently employed for green building exteriors, considering energy efficiency, longevity, and aesthetic appeal. Here are some common materials utilized:

Wooden applications

Reclaimed or certified timber is a notable sustainable option for exteriors. Its sourcing follows sustainable practices, resulting in a smaller carbon footprint compared to some alternatives, and it's both renewable and biodegradable. However, routine maintenance may be necessary to prevent decay or damage.

Fiber cement

Fiber cement siding, constructed from cellulose fibers, sand, and cement, stands out as a durable and low-maintenance material. It offers a prolonged lifespan and is available in numerous styles, with certain options closely resembling the aesthetic of wood.

Brick

Bricks are well-known for their durability, requiring minimal maintenance and being very sturdy. They have excellent thermal mass properties, which help regulate indoor temperatures, potentially lowering heating and cooling costs.

Stone

Natural stone siding provides timeless beauty and exceptional durability. Needing little upkeep, it effectively withstands harsh weather conditions. Moreover, using locally sourced stone can cut emissions linked to transportation.

Metal

Metal siding, whether crafted from aluminum or steel, demands minimal upkeep, boasts longevity, and is recyclable. Its resistance to pests and fire renders it a durable choice for green buildings. Furthermore, metal siding can be coated or pre-painted to reflect heat, potentially reducing cooling costs.

Plumbing

When choosing plumbing materials for green buildings, focus on water efficiency, durability, and environmental sustainability. Commonly used plumbing supplies include:

High-efficiency fixtures

Incorporating water-efficient fixtures such as low-flow showerheads, faucets, and toilets can significantly reduce water consumption. Look for fixtures certified by WaterSense or similar regional standards to ensure their efficiency.

PEX (Cross-linked Polyethylene)

PEX piping is gaining popularity in green building projects due to its flexibility, strength, and resistance to freezing and corrosion. Additionally, PEX is recyclable and demands less energy to manufacture compared to metal piping.

CPVC (Chlorinated polyvinyl chloride)

Thermoplastic CPVC pipes are renowned for their cost-effectiveness, resistance to rust, and long-term durability. They are frequently employed in both residential and

commercial buildings for the distribution of both hot and cold water.

Rainwater harvesting systems

Rainwater harvesting systems offer a solution for gathering and storing rainwater for various non-potable uses such as irrigation, toilet flushing, or cooling systems. These systems can be integrated into plumbing designs for eco-friendly building projects, typically incorporating pumps, filters, and storage tanks.

Ventilation and Natural Heating and Cooling

In green building design, incorporating efficient ventilation and natural heating and cooling systems is crucial for maximizing energy efficiency, indoor air quality, and occupant comfort. Here are some commonly employed strategies in green buildings:

Natural ventilation

Design the building layout to capitalize on natural airflow patterns for ventilation and cooling. This might entail strategically placing windows, incorporating operable skylights, and aligning the building to harness prevailing winds.

Passive solar design

Position the building to maximize solar exposure and integrate features such as large windows, thermal mass, and shading devices. This optimizes solar heat gain during winter while minimizing it in summer.

Lighting

Lighting plays a pivotal role in green building design as it enhances energy efficiency, occupant comfort, and overall sustainability. Here's how lighting should be planned and implemented for a green building:

Natural daylighting

Maximize natural daylight by integrating large windows, skylights, and light wells into the building design.

Arrange building spaces to optimize daylight penetration while mitigating glare and solar heat gain.

Employ daylight sensors and automated shading systems to regulate daylight levels and decrease dependence on artificial lighting.

Energy-efficient lighting fixtures

Opt for energy-efficient lighting fixtures like LED (light-emitting diode) and CFL (compact fluorescent lamp) luminaires to minimize energy consumption and operating costs.

Select fixtures with high efficacy ratings and long lifespans to decrease maintenance requirements and lifecycle costs.

Incorporate lighting controls such as occupancy sensors, dimmers, and timers to regulate light levels based on occupancy, daylight availability, and time of day.



Fire Systems

Fire protection within a structure is a comprehensive system that relies on all its components functioning together effectively. I've designed fire systems in compliance with USA fire standards.

Sprinkler System

Ensuring sufficient pressure and flow rate to a water distribution piping system, which fire sprinklers are connected to, constitutes the foundation of an active fire prevention system, often referred to as a fire sprinkler system.

Green Element

This section explores the components that contribute to a building's sustainability, using categories outlined by LEED for Homes for consistency. LEED for Homes is selected for its comprehensive coverage of green building aspects. The thesis utilizes these categories to analyze green building components without showing preference for LEED for Homes over other rating systems.

Innovation & Design process

LEED for Homes strives for distinctive design techniques, regional credits, unaddressed measurements, and exceptional performance levels. It provides three approaches for earning points for innovation and design. Encouraging an integrated, system-oriented approach to design and implementation is one such method. Project teams are encouraged to maximize green project development. Here are some suggested tasks for the project team:

- Conceptual or schematic design.
- LEED planning.
- Preliminary design.
- Energy and envelope systems analysis or design.
- Design development.
- Final design, working drawings, or specifications.
- Construction.

Location & Linkages

The primary goal of LEED for Homes is to integrate homes with the broader community in a socially and environmentally responsible manner. Points in this LEED category can be earned in the following six areas:

- Neighborhood Development: Following the LEED for Neighborhood Development program.
- Avoiding environmentally sensitive areas: For example, refraining from construction in flood plains, near waterways, on properties with endangered species, or on land with significant soil qualities.
- Developing residential areas within existing communities.
- Building homes in areas with existing infrastructure.
- Supporting walking, biking, or public transportation to minimize automobile use and environmental impacts.
- Selecting a site near a publicly accessible or community-based space.

Sustainable sites

The fundamental objective of LEED for Homes is to utilize the entire property to mitigate the project's impact on the site. There are six areas where points can be earned within this category:

Site stewardship

Minimizing environmental damage to the building lot during construction by planning to minimize disturbances, erosion, and preserving existing plantings.

Landscaping design

Avoiding invasive species, reducing water demand, and minimizing the need for synthetic chemicals.

Heat island effect

Designing landscaping to reduce local heat island effects by providing shading and using light-colored materials on sidewalks, patios, and driveways (Parasaram, 2022).

Water efficiency

The primary objective of LEED for Homes is to implement water-efficient practices both indoors and outdoors. There are three elements within this category where points can be earned:

Utilize municipal recycled water or capture and reuse rainwater and/or greywater to offset central water supply. Rainwater storage systems should accommodate all water from a one-inch rainfall event, and greywater systems should collect water from clothes washers, showers, and some faucets.

Energy & Atmosphere

LEED for Homes strives to attain energy efficiency, particularly in the building envelope and heating and cooling design. There are eleven items for possible credit:

- Meeting or exceeding ENERGY STAR performance.
- Installing insulation to minimize heat transfer.
- Controlling air leakage into and out of air-conditioned spaces.
- Maximizing the energy performance of windows and doors.
- Minimizing energy consumption due to thermal bridges and leaks in the heating and cooling distribution system.

Material & Resources

LEED for Homes emphasizes efficient material use, environmentally preferable materials, and waste minimization during construction. There are three areas for earning points:

- Optimizing framing material use to limit waste.
- Utilizing regionally extracted, processed, and manufactured products.
- Employing low-emission products or locally produced materials extracted, processed, and manufactured within 500 miles of the home.

Indoor environmental quality

LEED for Homes aims to enhance indoor air quality by reducing pollutant creation and exposure. There are ten areas for earning points:

- Installing an ENERGY STAR-approved bundle of air quality measures as defined by the U.S. Environmental Protection Agency.
- Minimizing leakage of combustible gases into the occupied space of the home by adhering to minimum measures such as avoiding unvented combustion appliances and installing a carbon monoxide detector on each floor.
- Controlling indoor moisture levels to enhance comfort, reduce mold risks, and increase home durability. Install dehumidification equipment to maintain humidity at or below 60%.
- Reducing occupant exposure to indoor pollutants by venting with outside air. Install whole-building ventilation systems meeting ASHRAE requirements.
- Decreasing moisture and indoor pollutant exposure in kitchens and bathrooms by meeting specific design requirements, such as installing exhaust systems with automatic sensors.
- Ensuring proper distribution of space heating and cooling to improve thermal comfort and energy performance.
- Reducing particulate matter from the air supply system by installing air filters.

Awareness & Education

The goal of awareness and education is to furnish homeowners, tenants, or building occupants with instruction on home operations and maintenance to uphold performance. Under LEED for New Construction, there are no specific requirements concerning awareness and education.

Investigative Result

By integrating these measures and recommendations, a comprehensive checklist can be developed for builders or organizations to ensure thorough implementation at each stage of construction. This checklist facilitates the identification of essential steps to be regularly executed as the construction progresses and the application of suggestions as the work advances.

Nonprofit entities such as LEED and Build Green in the United States have devised similar checklists for certifying environmentally friendly buildings. Each aspect is allocated points, and upon reaching a minimum point threshold, the building becomes eligible for certification.

Site Preparation

- Preserve topsoil and minimize disturbance to existing vegetation.
- Reuse topsoil post-construction.
- Define and restrict construction footprint to maximize protection.

- Utilize recycled construction materials.
- Recycle and diversify construction waste.
- Mitigate the site's heat island effect.
- Implement a Construction Environment Quality Management Plan, including duct sealing and covering air distribution component openings during construction.

Foundation

- Substitute slag or reclaimed fly ash for Portland cement in concrete production.
- In cold climates, employ frost-protected shallow foundations.
- Establish foundation drainage systems.
- Control moisture in crawlspaces.
- Employ Structural Pest Management practices.

Landscape

- Design resource-efficient landscapes.
- Plant shade-providing trees.
- Install high-efficiency irrigation systems.
- Minimize turf area (Parasaram, 2022).
- Apply compost to soil.
- Implement rainwater harvesting and recycled wastewater usage.
- Use environmentally preferred materials for fencing and non-plant landscape features.

Structural framework

- Optimize construction material efficiencies.
- Utilize engineered lumber.
- Implement solid wall systems.

Exterior

- Use environmentally preferable decking.
- Employ verified flashing installation methods.
- Install rain screen wall systems.
- Utilize durable, non-combustible siding materials.
- Use fire-resistant roofing materials.

Insulation

- Install insulation with recycled content.

Plumbing

- Enhance domestic hot water distribution efficiency.
- Install water-efficient fixtures.

Heating, Ventilation, and Air Conditioning (HVAC)

- Properly design HVAC systems and conduct diagnostic testing.
- Install sealed combustion units.
- Utilize high-performing zoned hydronic radiant heating.
- Install high-efficiency air conditioners.
- Design and install efficient ductwork.
- Employ mechanical ventilation systems and integrated control systems.



Finishes

- Design entryways to minimize contaminants.
- Use paint containing recycled materials.
- Utilize environmentally preferable interior finishes.

Flooring

- Choose environmentally preferable flooring for a portion of the floor area.
- Incorporate thermal mass flooring for a significant portion of the floors.

CONCLUSION AND RECOMMENDATIONS

The global trend towards zero-energy construction has underscored the importance of sustainability for building professionals, lawmakers, and the industry as a whole. As buildings aim to achieve net-zero energy consumption, the significance of embodied energy and greenhouse gas emissions cannot be overstated. Different materials and construction methods play a role in zero-energy home construction, each contributing to its own carbon footprint. Notably, wood products often have minimal or even zero carbon footprints, positioning wood as a vital renewable resource for reducing environmental impact.

By embracing the proactive measures and recommendations outlined earlier, individuals and organizations can develop structures that integrate practical strategies for sustainable building practices, thus earning them the designation of “green buildings.” This initiative endeavors to furnish users with comprehensive knowledge to design new green buildings or upgrade existing ones, ensuring the effective application of sustainable principles.

The implementation of these measures yields buildings that consume less energy, boast reduced life cycle costs, enhance the quality of life for occupants, conserve water and natural resources, and emit fewer pollutants. To encourage broader adoption of green building practices, it's imperative for contractors, builders, and consultants to comprehend the concept of green building and advocate for its advantages.

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