

Building Design: An Integrated Framework

Giana Ibrahiem Khalifa¹, Shelly Engdau²

^{1,2} Department of Environmental Engineering

^{1,2} Maharishi Institute of Information Technology, India

Abstract: A green building is a clean, sustainable building, designed with natural materials, uses little energy and renewable ones at that, is easy to maintain and available at a reasonable cost. Reducing waste, pollution and harm to the environment. The term "green building" is used to describe buildings that are designed, constructed, and operated, to have a minimum impact on the environment, both indoor and outdoor. Green tech refers to the use of technology and science to minimize the environmental impact of human activity and protect the world's natural resources. This includes efforts in energy, agriculture, material science, atmospheric science, hydrology, and more. The discussions of indoor environment quality have not included many specific recommendations or criteria for building design, construction, or operation. Building projects described as green building demonstrations often make reference to indoor air quality, but these references are often general and qualitative. In addition, rating systems that have been developed to assess the "greenness" of a building are based largely on design features and are not particularly specific with respect to indoor air quality. This paper reviews the features of indoor air quality that are considered in green building discussions, demonstration projects, and rating systems. These green building features are discussed in terms of their completeness and specificity, and are compared to other guidance on building design, construction, and operation for good indoor air quality. A case study of indoor air quality performance in a green building is presented. This study includes a description of the indoor air quality features of the building and the results of a short-term indoor air quality evaluation of the building involving ventilation and contaminant concentration measurements. Green Building concept is the practice of creating structure using processes that are environmentally friendly and resources efficient during building life-cycle; selection of site, design, construction, operation, maintenance, renovation and destruction.

Keywords: sustainability, energy efficiency, water conservation, material selection, indoor environmental quality, and sustainable site development, Ranking System, air quality management, Resilient Infrastructure

1. Introduction

Green building (also known as green construction, sustainable building, or eco-friendly building) refers to both a structure and the application of processes that are environmentally responsible and resource efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition. They incorporate design, construction, and operation practices that reduce negative impacts on the environment and improve the health and well-being of occupants. Green building concept deals with the optimum use of natural resources for the development beneficial or non-harmful to the environment. There are many benefits of green buildings like: Green Buildings consume 40 - 50 % less energy and 20 - 30 % less water than normal buildings. If all the structures in the world are constructed giving due importance to the ecosystem and energy efficiency, the harmful effects on the environment and the earth's ecosystem such as greenhouse effect, ozone layer depletion, global warming etc. Green building concepts include environmentally conscious site selection, practices to facilitate and improve energy efficiency, water efficiency and indoor environmental quality, and efforts to limit carbon emissions. Successful green building projects often meet widely adopted green building standards, such as the Leadership in Energy and Environmental Design (LEED) framework.

2. Objectives

The main objectives of green building are to reduce environmental impact, conserve resources, improve indoor environment quality, and promote sustainable practices throughout the building lifecycle.

Objectives:

- To understand the fundamental principles and concepts behind green building rating systems.
- To reduce the ecological footprint of buildings by implementing green building practices.
- To promote the adoption of sustainable construction practices by emphasizing the environmental, economic, and social benefits associated with green building certification.
- To foster community engagement and social responsibility by involving local communities in the design and construction process

The primary goals of this project are:

- Environmental Sustainability
- Resource Conservation
- Renewable Energy
- Waste Reduction
- Material Selection
- Improved Air Quality
- Comfort and Well-being
- Natural Lighting and Ventilation

Concept of Green Building

Sustainable site planning • Building Design Optimization • Energy Performance Optimization • Renewal Energy Utilization • Water and Waste Management • Solid Waste Management • Sustainable Building materials and Construction Technology • Health, wellbeing and Environmental Quality

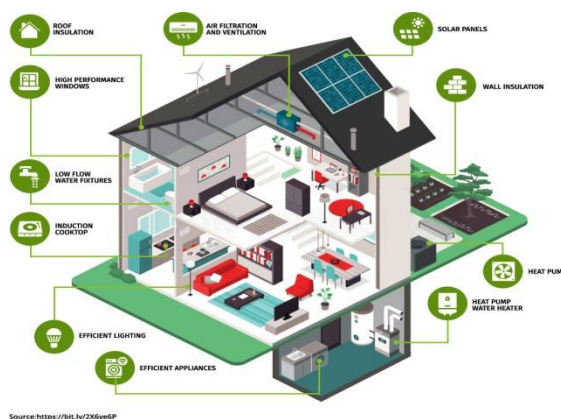


How to make a building Green

- Sustainable site planning with bioclimatic architectural planning
- Design energy efficient lighting and HVAC (Heating, Ventilation, and Air conditioning) system.
- Use low energy and renewable materials.
- Choose construction materials and interior finishes products with zero or low emissions to improve indoor air quality.
- Use dimensional planning and other material efficiency strategies.
- Design for gray water system that recovers rain water for site irrigation and dual plumbing system for use of recycled water for toilet flushing

Importance of Green Buildings

- Nowadays we should make a way to maximize our natural resources to help our mother earth to get relief from the pollutions like global warming that we are all experiencing. Non- renewable sources are expensive and unsafe.
- Green Building concept is the practice of creating structure using processes that are environmentally friendly and resources efficient during building life-cycle; selection of site, design, construction, operation, maintenance, renovation and destruction.
- The importance is to lessen the consumption of energy and pollution as well. More use of non-renewable energy leads to more pollution.
- The growth and development of our communities has a larger impact on our natural environment. The manufacturing, design, construction and operation of buildings are responsible for the consumption of our natural resources



Source: <https://bit.ly/2N6ye6P>

Benefits of Green Buildings

Buildings have large effect on environment, human health and environment.

The successful adoption of Green Building Development can maximize both economic and environmental performance of buildings.

Environmental Benefits:

- Protect Biodiversity and ecosystems
- Improve air and water quality
- Reduce waste streams
- Conserve natural resources

Economic Benefits:

- Reduce operating costs
- Create, Expand and Shape markets for green product and services
- Improve Occupant Productivity Ø Social Benefits:
- Enhance occupant comfort and health
- Minimize strain on local infrastructure
- Improve overall quality of life

Merits of Green Building

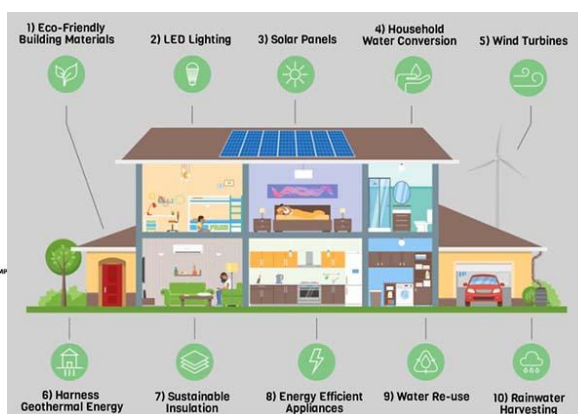
- Efficient Technologies
- Easier Maintenance
- Return of Investment
- Improved Indoor Air Quality
- Energy Efficiency
- Water Efficiency
- Waste Reduction
- Temperature Moderation
- Water Conservation
- Economical Construction for Poor
- Healthier Lifestyles and Recreation

Demerits of Green Building

- Initial Cost is High
- Availability of Materials is Less
- Need More time to Construct
- Need Skilled Workers

Fundamental principles of Green Buildings

- Structure design efficiency
- Energy efficiency
- Water efficiency
- Materials efficiency
- Waste and toxic reduction



Fundamental principles of Green BuildingsStructural design efficiency:

- It is the concept of sustainable building and has largest impact on cost and performance
- It aims to minimize the environment impact associated with all life cycle

Energy efficiency

- The layout of the construction can be strategized so that natural light pours for additional warmth
- Shading the roof with trees offers an eco-friendly alternative to air conditioning

Water efficiency:

- To minimize water consumption one should aim to use the water which has been collected, used, purified and reused

Material efficiency:

- Material should be use that can be recycled and generate surplus amount of energy
- An example of this are solar power panels, not only they provide lightening but they are also a useful energy source

Waste and toxic reduction:

- It is probable to reuse resources
- What may be waste to us may have another benefit to something else

Water efficiency:

To minimize water consumption one should aim to use the water which has been collected, used, purified and reused

Rainwater harvesting is a water conservation technique that involves collecting and storing rainwater for later use, typically from rooftops or other impervious surfaces, offering a sustainable and cost-effective water source.

Rainwater harvesting is a water conservation technique that involves collecting and storing rainwater for later use, rather than allowing it to run off, and can be implemented at various scales, from individual households to entire communities. Rainwater harvesting is collecting the run-off from a structure or other impervious surface in order to store it for later use. Traditionally, this involves harvesting the rain from a roof. The rain will collect in gutters that channel the water into downspouts and then into some sort of storage vessel.

The two major types of rainwater harvesting include roof based and land-based rainwater harvesting. Rain harvested water can be used for watering livestock, laundry, flushing toilets, etc.

Rain water harvesting is one of the most effective methods of water management and water conservation. It involves collection and storage of rain water at surface or in sub-surface aquifer, before it is lost as surface run off.

Rainwater harvesting helps manage storm water runoff to prevent erosion, flooding, and poor water quality in our lakes and streams. Rainwater systems counteract storm water runoff and thereby reduce flooding, erosion, and ground water contamination. Rainwater harvesting is a sustainable practice

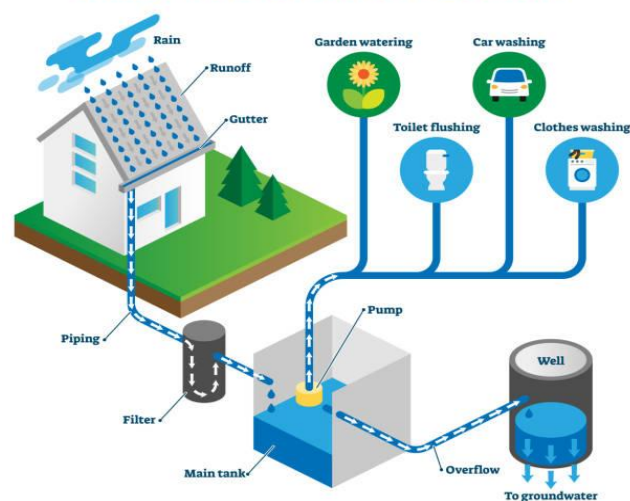
that involves collecting and storing rainwater for various uses, such as irrigation, drinking, and household purposes. This system captures rainwater from surfaces like rooftops, pavements, and other impermeable areas, directing it into storage tanks or reservoirs.

Key Components of a Rainwater Harvesting System:

- 1) **Catchment Area:** The surface from which rainwater is collected, typically rooftops or paved areas.
- 2) **Gutters and Downspouts:** Channels that direct the collected rainwater from the catchment area to the storage system.
- 3) **Storage Tanks:** Containers where the harvested rainwater is stored. These can be above-ground or underground tanks, made from various materials like plastic, concrete, or metal.
- 4) **Filtration System:** A mechanism to filter out debris and contaminants from the rainwater before it enters the storage tank, ensuring the water is clean and safe for use. The filter is used to remove suspended pollutants from rainwater collected from the roof. A filter unit is a chamber filled with filtering media such as fibre, coarse sand, and gravel layers to remove debris and dirt from the water before it enters the storage tank or recharge's structure.
- 5) **Distribution System:** Pipes and pumps that transport the stored rainwater to where it is needed, whether for irrigation, flushing toilets, or other uses.

Benefits of Rainwater Harvesting:

- **Water Conservation:** Reduces reliance on municipal water supply and groundwater, helping to conserve these vital resources.
- **Cost Savings:** Lowers water bills and can reduce the need for expensive infrastructure for water supply.
- **Flood Mitigation:** Helps manage stormwater runoff, reducing the risk of flooding and erosion.
- **Environmental Impact:** Promotes sustainable water management practices and can improve local ecosystems.
- **Drought Resilience:** Provides an alternative water source during dry periods, enhancing community resilience to climate variability.

RAINWATER HARVESTING

Environmentally-friendly materials or green building materials

The adoption of sustainable green building materials continues to accelerate, driven by environmental concerns and economic benefits. The construction industry faces a pivotal moment. As climate change accelerates, the need for sustainable building practices has never been more urgent. Traditional construction materials like concrete and steel contribute significantly to global carbon emissions.

Our relentless pursuit of environmentally responsible building practices reflects our commitment to preserving the planet and represents a significant advocacy for utilising renewable resources and energy-efficient solutions.

It could reduce energy consumption by 50% or more by 2050. By focusing on sustainable building materials, we're not just constructing buildings but laying the foundations for future generations to thrive in harmony with the environment.

However, a new wave of sustainable building materials offers hope for a greener future. This article explores the top sustainable building materials and their environmental benefits.

Perspective on Sustainable Construction

Construction activities worldwide consume approximately 3 billion tonnes of raw materials annually, accounting for 40% of global use. In the UK alone, annual construction output requires 170 million tonnes of primary materials and products, 125 million tonnes of quarry products, and 70 million tonnes of secondary recycled and reclaimed products.

Manufacturing and delivering these products consumes 6 million tonnes of energy and generates 23 million tonnes of CO₂. Significant waste also occurs, with 30% of all building materials ending as waste. These staggering figures highlight the urgent need for sustainable alternatives in the construction industry.

However, sustainable building practices can lead to reduced operating costs, with some projects reporting 21-23% decreases in the first 12 months and 43-49% decreases within five years.

Environmentally-friendly materials (also known as green building materials) are those in which, for their production, placing and maintenance, actions of **low environmental impact** have been performed.

They have to be **durable, reusable or recyclable, include recyclable materials** in their composition and have to be from resources of the area where the building activity will take place –they have to be local materials.

These materials also have to be **natural** (soil, adobe, wood, cork, bamboo, straw, sawdust, etc.) and must not be spoilt by cold, heat or humidity.

The best sustainable materials for construction

- 1) Bamboo
- 2) Cork
- 3) Hempcrete
- 4) Mycelium

- 5) Precast concrete
- 6) Recycled glass
- 7) Recycled plastic
- 8) Recycled steel
- 9) Recycled or reclaimed wood
- 10) Terrazzo
- 11) Terracotta

Sustainable Materials Transforming Construction

Buildings with cool roofs require less air conditioning, leading to reduced energy bills and enhanced indoor comfort during hot weather. These materials contribute to healthier and more sustainable urban environments by mitigating urban heat.

1) Bamboo: The Fast-Growing Marvel

Bamboo is a top sustainable material due to its rapid growth and versatility. Unlike traditional timber, bamboo can mature in 3-5 years. Its high strength-to-weight ratio makes it suitable for various construction applications, including flooring, panelling, scaffolding, roofing, concrete reinforcement and other structural elements. With strength comparable to steel and flexibility, it enhances versatility.

Bamboo's fast growth and ability to absorb more CO₂ than trees make it eco-friendly for sustainable construction. Its rapid growth and minimal environmental impact position bamboo as a key player in green building.

2) Cork: Renewable and Resilient

Cork, harvested from the bark of cork oak trees, regenerates every few years without harming the tree. This renewable material is lightweight, water-resistant, fire-retardant, and provides excellent insulation.

Cork's unique properties make it ideal for flooring, insulation, and acoustic panels, contributing to energy-efficient buildings. Architects and designers favour cork due to its natural antimicrobial properties and aesthetic appeal. The tree can absorb up to five times more CO₂ during bark regeneration and limit the spread of flames, enhancing building safety.

3) Hemp Crete: Carbon-Negative Insulation

Hemp Crete, a bio-composite material from hemp fibres mixed with lime, offers excellent thermal and acoustic insulation. It is lightweight and carbon-negative, absorbing more CO₂ than it emits during its lifecycle. Hemp Crete's use in construction helps reduce buildings' carbon footprint while providing durable and efficient insulation.

Buildings constructed with hemp Crete benefit from improved indoor air quality and energy efficiency. As the hemp industry grows, hemp Crete's availability and cost-effectiveness are expected to improve, making it an increasingly viable option for eco-conscious builders.

4) Reclaimed Wood: Character and Conservation

Reclaimed wood, sourced from old buildings and structures, reduces the need for new timber and conserves forests. This material adds character and warmth to buildings and is often used for flooring, furniture, and decorative elements. Repurposing wood can reduce landfill waste and promote sustainable building practices.

Moreover, it lessens the demand for new timber, helping to preserve our forests and reduce deforestation. Therefore, finding a reputable supplier is crucial. Local suppliers or salvage yards often stock quality reclaimed wood

5) Recycled Steel: Infinite Reusability

Recycled steel is a durable material that can be recycled indefinitely without losing strength. It is used in various structural applications and helps reduce the carbon footprint associated with steel production. Using recycled steel in construction projects promotes resource conservation and sustainability.

Builders use recycled steel for structural applications, ensuring longevity and sustainability. Its endless recyclability makes it a cornerstone of circular economy principles in construction. In addition, recycling steel dramatically cuts the need for raw materials; it saves about 2,500 pounds of iron ore, 1,400 pounds of coal, and 120 pounds of limestone per ton of steel recycled.

The process conserves between 60 and 74% of the energy that would have been used to produce new steel, thereby reducing the carbon footprint. Over 500 million tonnes of steel are recycled annually worldwide, demonstrating its global acceptance and the effectiveness of recycling programs.

6) Rammed Earth: Ancient and Efficient

Rammed earth, an ancient building technique uses natural materials like soil, clay, and sand to create sturdy, durable structures. This method provides excellent thermal mass, making buildings energy-efficient and ideal for passive solar design. Rammed earth construction reduces the need for synthetic materials and promotes sustainability.

Modern rammed earth buildings combine traditional methods with contemporary engineering, resulting in aesthetically pleasing and environmentally friendly structures. The low carbon footprint and local sourcing of materials make rammed earth an attractive option for eco-conscious builders. Its non-toxic nature makes it an excellent choice for eco-conscious builders and residents.

7) Mycelium: The Fungal Frontier

Mycelium, the root structure of fungi, can be grown around agricultural by-products to create lightweight, strong, and biodegradable building materials. It is used for insulation, packaging, and even structural components. Mycelium's ability to decompose naturally makes it eco-friendly for sustainable construction.

Lightweight yet strong, mycelium acts as a natural adhesive and can be moulded into various shapes. Its potential applications range from insulation to structural components, showcasing the innovative possibilities of bio-based materials in construction.

8) Recycled Plastic: Turning Waste into Resources

Recycled plastic, processed from consumer and industrial waste, can create building materials such as bricks, lumber, and panels. This approach helps reduce plastic pollution and landfill waste while providing durable and versatile construction materials.

The versatility and durability of recycled plastic materials make them increasingly popular in residential and commercial construction. As recycling technologies advance, we expect to see more creative applications of this abundant waste resource.

9) Straw Bales: Natural Insulation

Straw bales are a renewable resource that offers highly insulated walls. They provide excellent thermal insulation and can be used in passive solar designs. Building with straw bales reduces the reliance on synthetic insulation materials and promotes energy efficiency.

Straw bale construction creates durable, fire-resistant structures with superior acoustic insulation when adequately sealed and moisture-protected. This method repurposes agricultural waste and sequesters carbon, enhancing its environmental benefits.

10) Terrazzo: Aesthetic and Eco-Friendly

Terrazzo, a composite material made from marble, granite, quartz, glass, and other materials, is used for flooring, countertops, and stairways. Its durability and use of repurposed raw materials make it an eco-friendly option. Terrazzo's unique appearance and long lifespan contribute to sustainable building practices.

Terrazzo comprises naturally occurring aggregates, recycled materials (like glass or plastic), and cement or epoxy binders. This composition contributes to its eco-friendly profile, with binders constituting only 25-30% of the floor's volume. Using recycled materials and low embodied energy makes terrazzo a sustainable choice for green building material projects.

11) Solar Tiles: Integrating Renewable Energy

Solar tiles represent a seamless way to incorporate renewable energy into building aesthetics. These photovoltaic cells, designed to resemble traditional roof tiles, generate electricity while blending with the overall structure.

By harnessing solar power, buildings can reduce reliance on conventional energy sources and decrease electricity bills. Solar roof tiles promote sustainable practices and contribute to the transition towards clean, renewable energy solutions.

12) High-Performance Windows and Glazing Enhance Energy Efficiency

Advanced window systems are crucial in creating energy-efficient buildings. High-performance windows and glazing technologies help regulate indoor temperatures, reduce heat loss, and minimise reliance on artificial lighting.

These innovative windows contribute to lower energy bills and improved comfort for occupants. As buildings account for significant global energy consumption, efficient windows become essential in achieving sustainability goals.

13) Cross-Laminated Timber (CLT) Revolutionises Wood Construction

CLT has gained traction as a sustainable alternative to traditional building materials like steel and concrete. This engineered wood product comprises solid-sawn lumber-lued layers, offering strength, lightweight properties, and

sustainability.

Studies show CLT buildings can reduce global warming potential by an average of 26.5% compared to concrete structures. CLT construction also allows for faster build times and less waste, reducing environmental impact.

14) Structural Insulated Panels (SIPs) Lead the Way

SIPs stand out as frontrunners in sustainable construction. These panels consist of a foam core sandwiched between two rigid boards, typically made of oriented strand board. SIPs provide excellent thermal performance, significantly reducing energy consumption for heating and cooling. Their resource-efficient manufacturing process ensures a renewable source of raw materials.

Builders appreciate SIPs for their versatility in walls, roofs, and floors. The integrated system offers structural support and insulation, streamlining construction processes. SIP components can be recycled or repurposed at the end of a building's lifecycle, minimising waste and extending material lifespan.

15) Cool Roofing Materials Mitigate Urban Heat Island Effect

Cool roofing materials reflect more sunlight and absorb less heat than standard roofs. This technology improves energy efficiency and helps combat cities' urban heat island effect.

Buildings with cool roofs require less air conditioning, leading to reduced energy bills and enhanced indoor comfort during hot weather. These materials contribute to healthier and more sustainable urban environments by mitigating urban heat.

16) Earth-packed tires

A niche home construction design known as earth ship homes relies on recycled tires filled with earth bags for insulation. While this architecture may be difficult to insure in certain areas of the country due to its unconventional design, some states, such as New Mexico, are open to the idea – and even have their own earth ship communities.

Benefit of earth-packed tires:

- Natural energy: Earth ships are popular off-grid dwellings because they can provide their own cooling and heating properties, eliminating the need for electricity.
- Versatility: You can design your earth ship to be an unusual shape, such as a dome, that eliminates the need for

traditional roofing and extra construction materials.

17) Up cycled plastic

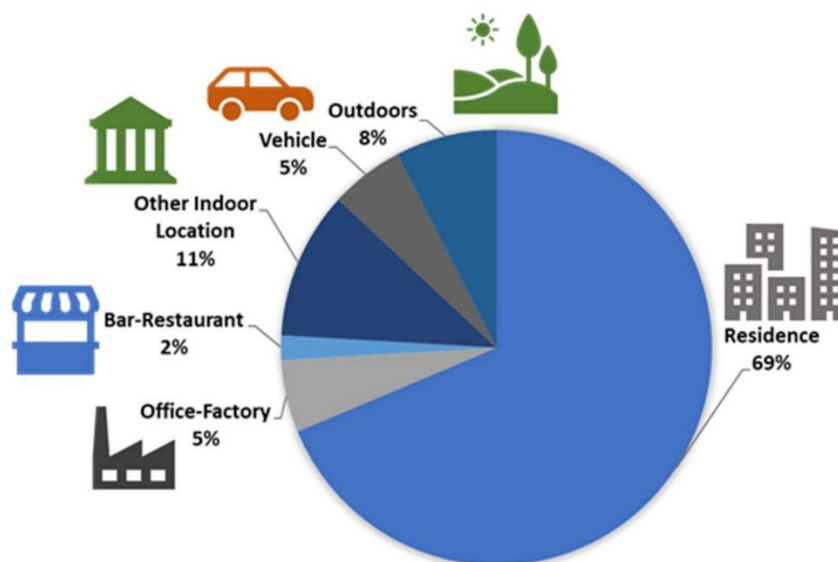
Every day, nearly 8 million pieces of plastic go into the ocean.[10] Plastic is terrible for wildlife and the environment when it's cast away as waste, but recycled plastic sheets and plastic lumber may provide sustainable building solutions with less impact. It's worth noting that plastic builds are generally considered non-standard properties, making home insurance more difficult to obtain.

Benefits of up cycled plastic:

- Speed: Recycled plastic bricks can be laid much faster than brick, and piled in a LEGO-like fashion.
- Nontoxic: While traditional lumber must be sprayed with a preservative sealant that contains toxins, plastic polyethylene doesn't need to be.

Indoor air quality

Indoor air quality (IAQ) refers to the air quality within and around buildings, significantly impacting the health and comfort of occupants. Poor IAQ can lead to various health problems, and understanding its sources and solutions is crucial for maintaining healthy indoor environments. Worldwide people tend to spend approximately 90% of their time in different indoor environments. Along with the penetration of outside air pollutants, contaminants are produced in indoor environments due to different activities such as heating, cooling, cooking, and emissions from building products and the materials used. As people spend most of their lives in indoor environments, this has a significant influence on human health and productivity. As people spend a majority of their time in indoor environments, exposure to indoor air pollutants has a significant impact on both human health and effectiveness in the workplace. However, research on air quality has mostly focused on the outdoors, whereas indoor air quality (IAQ) and its impacts have received considerably less attention until the last decade. Recently, both scientists and the public have focused on risks associated with IAQ because research has established that indoor air is more contaminated than outdoor air. Due to continuous changes in living style and the materials used in indoor environments, there have been significant changes in terms of the nature and complex compositions of indoor air pollutants, which opens up avenues that need to be investigated in detail.



Primary Causes of Indoor Air Problems

Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems. Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the area. High temperature and humidity levels can also increase concentrations of some pollutants.

Pollutant Sources

There are many sources of indoor air pollution. These can include:

- Fuel-burning combustion appliances
- Tobacco products
- Building materials and furnishings as diverse as:
- Deteriorated asbestos-containing insulation
- Newly installed flooring, upholstery or carpet
- Cabinetry or furniture made of certain pressed wood products
- Products for household cleaning and maintenance, personal care, or hobbies
- Central heating and cooling systems and humidification devices
- Excess moisture
- Outdoor air pollution.

The relative importance of any single source depends on how much of a given pollutant it emits and how hazardous those emissions are. In some cases, factors such as how old the source is and whether it is properly maintained are significant. For example, an improperly adjusted gas stove can emit significantly more carbon monoxide than one that is properly adjusted.

Some sources, such as building materials, furnishings and products like air fresheners, can release pollutants more or less continuously. Other sources, related to activities like smoking, cleaning, redecorating or doing hobbies release pollutants intermittently. Unvented or malfunctioning appliances or improperly used products can release higher and sometimes dangerous levels of pollutants indoors. Controlling indoor air temperature is essential for comfort, health, and energy efficiency. Here's a comprehensive guide on how to achieve

and maintain your desired indoor temperature:

Insulation:

- **Attic Insulation:** A well-insulated attic is crucial for preventing heat gain in summer and heat loss in winter. Ensure you have the recommended R-value for your climate.
- **Wall Insulation:** Insulating exterior walls helps to maintain a consistent indoor temperature by reducing heat transfer.
- **Floor Insulation:** Especially important for rooms above unheated spaces like garages or basements.
- **Window and Door Sealing:** Seal any gaps or cracks around windows and doors with weatherstripping or caulk to prevent drafts and air leaks.

Ventilation:

- **Natural Ventilation:** Open windows and doors strategically to create cross-breezes when the outdoor temperature is comfortable. This helps to flush out warm air and bring in cooler air. Be mindful of air quality and security.

Mechanical Ventilation:

- **Exhaust Fans:** Use kitchen and bathroom exhaust fans to remove hot, humid air.
- **Whole-House Ventilation Systems:** Consider systems like Heat Recovery Ventilators (HRVs) or Energy Recovery Ventilators (ERVs) for controlled ventilation while minimizing energy loss. These are particularly useful in tightly sealed homes.

Heating and Cooling Systems:

- **Air Conditioning (AC):**
- **Central AC:** Cools the entire house through ductwork. Ensure proper sizing, maintenance (regular filter changes), and thermostat settings.
- **Window AC Units:** Cool individual rooms. Choose the right BTU rating for the room size and seal gaps around the unit.
- **Ductless Mini-Splits:** Offer zoned cooling and heating without the need for ductwork. Energy-efficient and provide individual room control.

Heating Systems:

- **Furnaces (Gas, Electric, Oil):** Heat air and distribute it through ductwork. Regular maintenance is vital for efficiency and safety.
- **Heat Pumps:** Transfer heat from one place to another. They can both heat and cool and are generally energy-efficient.
- **Radiant Heating (e.g., underfloor heating):** Provides even and comfortable heating.
- **Space Heaters:** Used for heating specific areas. Use them safely and turn them off when leaving the room or going to sleep.
- **Smart Thermostats:** Allow for programmable temperature schedules, remote control, and energy usage monitoring, helping to optimize heating and cooling.

Window Treatments:

- **Curtains and Drapes:** Heavy, insulated curtains can block sunlight and heat gain in summer and reduce heat loss in winter. Close them during the hottest parts of the day in summer and at night in winter.
- **Blinds and Shades:** Adjustable blinds and shades allow you to control the amount of sunlight entering a room. Light-colored blinds reflect more heat.
- **Reflective Window Films:** Applied directly to window glass, these films can significantly reduce solar heat gain.
- **Exterior Shutters and Awnings:** Provide an extra layer of insulation and shade, especially for south-facing windows.

Appliances and Lighting:

- **Reduce Heat-Generating Appliances:** Limit the use of heat-producing appliances like ovens and stovetops during the hottest parts of the day. Consider using microwaves or outdoor grills.
- **Energy-Efficient Lighting:** Switch to LED bulbs, which produce significantly less heat than incandescent bulbs.
- **Unplug Electronics:** Many electronics continue to draw power and generate heat even when turned off. Unplug them when not in use.

Landscaping:

- **Plant Trees and Shrubs:** Strategically placed trees and shrubs around your home can provide shade, reducing solar heat gain on walls and windows. Deciduous trees are ideal as they lose their leaves in winter, allowing sunlight to warm your home.
- **Green Roofs:** Can help to insulate your home and reduce the urban heat island effect.

Home Design and Materials:

- **Passive Solar Design:** Consider incorporating passive solar principles in new construction or renovations, such as south-facing windows, thermal mass materials, and overhangs.
- **Cool Roofs:** Roofing materials designed to reflect more sunlight and absorb less heat can significantly reduce attic temperatures.

Roof treatment with vacuum creation on mother slab by providing earthen pot. this system reduces up to 6 degree temperature

**Cavity wall construction and exterior wall cladding on west side and south side**

Waste management is a crucial aspect of green building, aiming to minimize the environmental impact associated with construction, renovation, operation, and demolition of buildings. It encompasses strategies and practices to reduce waste generation, promote reuse and recycling, and ensure responsible disposal of remaining waste.

Here's a breakdown of waste management in green building:

Key Strategies and Practices:**Waste Minimization at the Source:**

- **Design for Waste Reduction:** Architects and designers consider material efficiency, standardization, and modular design to minimize waste.
- **Material Selection:** Choosing materials with less packaging, longer lifespans, and recycled content reduces waste.

Construction Waste Management:

- **Waste Management Plan:** Developing a plan that outlines waste separation, collection, and disposal procedures for the construction site.

- **Waste Segregation:** Implementing separate bins for different waste streams (e.g., wood, metal, concrete, plastic, paper) to facilitate recycling.
- **Recycling and Reuse:** Prioritizing the recycling of construction and demolition (C&D) waste materials on-site or off-site. This includes materials like concrete, wood, metals, and drywall.
- **Deconstruction:** Carefully dismantling existing buildings to salvage materials for reuse in new construction or for resale.
- **Waste Reduction Programs:** Implementing strategies within the building to minimize waste generated by occupants, such as reducing paper consumption and encouraging reusable items.
- **Recycling Infrastructure:** Providing accessible and clearly labelled bins for different recyclable materials throughout the building.
- **Composting:** Establishing systems for composting organic waste (e.g., food scraps, yard waste) in suitable buildings.
- **Education and Awareness:** Educating building occupants about proper waste management practices.

End-of-Life Waste Management (Design for Deconstruction):

Designing buildings with the end of their lifespan in mind, making it easier to dismantle and recover materials for reuse or recycling in the future. This involves using mechanical fasteners instead of adhesives and simplifying connections.

Benefits of Effective Waste Management in Green Building:

- **Reduced Landfill Waste:** Diverting waste from landfills conserves valuable land and reduces the environmental problems associated with landfill decomposition (e.g., methane emissions, leachate).
- **Resource Conservation:** Reusing and recycling materials reduces the demand for virgin resources, saving energy and minimizing the environmental impact of extraction and manufacturing.
- **Reduced Environmental Impact:** Lowering waste generation and promoting recycling reduces pollution, greenhouse gas emissions, and the overall carbon footprint of the building.
- **Cost Savings:** Efficient waste management can lead to cost savings through reduced disposal fees, potential revenue from selling recyclable materials, and lower material purchasing costs when using reclaimed or recycled content.
- **Improved Project Efficiency:** Organized waste management on construction sites can improve workflow and safety.
- **Enhanced Reputation:** Demonstrating a commitment to sustainable waste management enhances the reputation of the building owner, developer, and occupants.

Compliance with Regulations and Green Building Certifications: Many green building rating systems (e.g., LEED, BREEAM, Green Star) have specific requirements and credits related to waste management. Adhering to these practices helps achieve certification.

In conclusion, waste management is an integral component of green building, contributing significantly to environmental sustainability, economic benefits, and the overall performance of buildings throughout their life cycle.

By implementing comprehensive waste management strategies, green buildings minimize their negative impact on the planet and promote a more circular economy.

Green building rating systems

Green building rating systems often assign points or credits for meeting specific criteria within each parameter. The accumulation of points determines the level of certification, such as Certified, Silver, Gold, or Platinum, in many rating systems.

Green building rating systems are frameworks that assess and certify the environmental performance of buildings. These systems are designed to promote sustainable construction practices, reduce environmental impact, and improve the overall efficiency and performance of buildings. Different countries and regions have their own green building rating systems, but many share common principles. In India, the green building rating system that is widely used and recognized is the Indian Green Building Council's (IGBC) Green Building Rating System. The IGBC is a part of the Confederation of Indian Industry (CII) and promotes sustainable practices in the building industry. The IGBC Green Building Rating System is based on the principles of LEED (Leadership in Energy and Environmental Design) but has been adapted to suit Indian construction practices and environmental conditions.

Parameters for Green Building Rating System

- a) Site Selection and Planning
- b) Water Efficiency
- c) Energy Efficiency
- d) Materials and Resources
- e) Indoor Environmental Quality
- f) Innovation and Design Process
- g) Regional Priority

Credits:

Within each category, specific credits are available for compliance. These credits cover various aspects, such as site design, water conservation, energy-efficient systems, and use of recycled materials, indoor air quality, and innovation.

Work Flow Process of IGBC Green Building Rating System

- **Types of Buildings:** The IGBC Green Building Rating System is applicable to various types of buildings, including residential, commercial, industrial, and institutional.
- **Rating Levels:** Similar to LEED, the IGBC rating system has different levels of certification based on the number of points earned. The certification levels include Certified, Silver, Gold, and Platinum.



IGBC Green Buildings

- The Indian Green Building Council (IGBC) provides LEED ratings to structures in India
- Each rating system divided into different level of certification is as follows:
- ‘Certified’ to recognise best practices.
- ‘Silver’ to recognise outstanding performances.
- ‘Gold’ to recognise national excellence.
- ‘Platinum’ to recognise global leadership

- [8] Argunhan Z., Avci A.S. Statistical evaluation of indoor air quality parameters in classrooms of a university. Adv.

3. Conclusion

In conclusion, embracing green home construction isn't just an environmental choice; it's a smart and responsible way to build a sustainable future. By using eco-friendly materials and sustainable practices, we can reduce our carbon footprint, save money, and create healthier living spaces. Sustainable construction offers numerous benefits, from environmental preservation to long-term cost savings and improved well-being. However, it also presents challenges such as cost constraints, complex collaboration, and limited awareness.

References

- [1] D.J. Sailor, A green roof model for building energy simulation programs, Department of Mechanical and Materials Engineering, Portland State University, USA February 2008.
- [2] Doreen E. Kalz, Sebastian Herkel, Andreas Wagner the impact of auxiliary energy on the efficiency of the heating and cooling system: Monitoring of low-energy buildings, Fraunhofer Institute for Solar Energy Systems ISE, Germany, University of Karlsruhe, Building Science Group, Englerstr. 7, D - 76131 Karlsruhe, Germany.
- [3] ENVJS Centre on Human Settlements, Status of Green Buildings in Cities of India, School of Planning and Architecture, New Delhi – 110002.
- [4] Fadi Chlela, Ahmad Husaunndee, Christian Inard, Peter Riederer A new methodology for the design of low energy buildings, University of La Rochelle, Av. Michel Cre'peau, 17042 La Rochelle, France.
- [5] Heekin, D., & Meyers, D. (2001). Green building: Principles and practice (Working paper). University of Florida Levin College of Law
- [6] WHO Household Air Pollution and Health. [(accessed on 28 January 2020)];
- [7] Kumar P., Imam B. Footprints of air pollution and changing environment on the sustainability of built infrastructure. Sci. Total Environ. 2013; 444: 85–101. doi: 10.1016/j.scitotenv.2012.11.056.