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Department of Civil Engineering

Green Buildings

UNIT-I

- Green Buildings within the Indian Context, Types of Energy, Energy Efficiency and Pollution, Better Buildings, Reducing energy consumption, Low energy design.

Green Buildings within the Indian Context:

- The Green Building movement was pioneered in Great Britain with the rating system called BREEAM (which was first launched in 1990.
- This system was later adopted in the U.S when the US Green Building Council was formed.
- LEED (Leadership in Energy and Environmental Design) was loosely adopted from the BREEAM system and came into existence sometime in March 2000.
- In India, this movement was adopted by the Confederation of Indian Industry (CII) in the early part of this decade.
- They formed the Indian Green Building Council which is actively involved in promoting the Green Building concept in India.

- The Leadership in Energy and Environmental Design (LEED-INDIA) Green Building Rating System is a nationally and internationally accepted benchmark for the design, construction and operation of high performance green buildings.
- It promotes a whole-building approach to sustainability by recognizing performance in key areas:
  - Sustainable site
  - Water efficiency
  - Energy efficiency and renewable energy
  - Conservation of materials and resources
  - Indoor environmental quality
  - Regional Priority

- LEED India was launched in India in 2003 and since then has grown exponentially.
- This has created a large network of smaller stakeholders which includes the construction industry comprising corporate, government & nodal agencies, architects, developers, builders, products manufacturers and most interestingly green building consultants whose profession was almost unheard of a decade ago

What is green building?

- A green building is defined as one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier space for occupants compared to conventional buildings.
- It is an environmentally sustainable building, designed constructed and operated to minimize total environmental impacts.
- A green building aims to lower environmental impacts, maximize social and economic value over a building life cycle through site selection, design, construction, operation, maintenance, renovation and demolition

Why are green buildings so relevant now?

- There is no debating that the human race is growing faster than the planet earth can sustain.
- This unsustainable growth is clearly causing certain environmental changes that need to be reversed or at least slowed down.
- Now, there are many different things we can do by correcting our ways and by minimising environmental degradation.
- India is a large country with a large population and big problems.
- We are a water deficient country and the energy crisis seems to be perennial in nature.

- Moreover, the unsustainable energy and water policies are not helping the cause.
- Hence to insulate oneself from the resource crunch and strive towards self-sufficiency and smarter living.
- This realization has contributed immensely to the growth and promotion of green buildings.
- Apart from that, green buildings offer the developers, builders and architects an opportunity to get out of the rut that has come about due to the lack of differentiation in projects.
- Green building has now become “something new” that was not done in the past.
- Developers are trying hard to leverage their green building credentials for branding purposes and tapping into the new niche market

Green building ratings in India

- ***Green Rating for Integrated Habitat Assessment (GRIHA)***
  - Green Rating for Integrated Habitat Assessment (GRIHA) is India's own rating system jointly developed by TERI and the Ministry of New and Renewable Energy, Government of India.
  - It is a green building design evaluation system where buildings are rated in a three-tier process.
  - The GRIHA Rating System contains 34 evaluation criteria with 100 points.

- These criteria have been categorized into
  - Site Planning including conservation and efficient utilization of resources, health and wellbeing during building planning and construction stage
  - Water Conservation
  - Energy Efficiency including energy embodied & construction and renewable energy
  - Waste Management including waste minimization, segregation, storage, disposal and recovery of energy from waste and
  - Environment for good health and wellbeing.
- Commonwealth Games Village, New Delhi, Fortis Hospital, New Delhi, CESE (Centre for Environmental Sciences & Engineering) Bldg, IIT Kanpur have received GRIHA ratings

- ***Leadership in Energy & Environmental Design India (LEED India)***
  - LEED is an internationally recognized green building certification system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most: Energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality and stewardship of resources and sensitivity to their impacts.
  - The Indian Green Building Council has adapted LEED system and has launched LEED India version for rating of new construction.

- ***Bureau of Energy Efficiency (BEE)***
  - BEE developed its own rating system for the buildings based on a 1 to 5 star scale. More stars mean more energy efficiency.
  - The ECBC (Energy Conservation Building Code) provides design norms for:
    - Building envelope, including thermal performance requirements for walls, roofs, and windows;
    - Lighting system, including daylighting, and lamps and luminaire performance requirements;
    - HVAC system, including energy performance of chillers and air distribution systems;
    - Electrical system; and
    - Water heating and pumping systems, including requirements for solar hot-water systems.

- BEE has developed the Energy Performance Index (EPI).
- The unit of Kilo watt hours per square meter per year is considered for rating the building and especially targets air conditioned and non-air conditioned office buildings.
- The Reserve Bank of India's buildings in Delhi and Bhubaneshwar, the CII Sohrabji Godrej Green Business Centre and many other buildings has received BEE 5 star ratings.

Types of Energy

- The word energy is derived from the Greek en (in) and ergon (work).
- Energy is defined as 'the capacity to do work' – that is, the capacity to move an object against a resisting force.
- The scientific unit of energy is the joule.
- The concept of energy reveals the common features in processes as diverse as burning fuels, propelling machines and charging batteries.

- These and other processes can be described in terms of diverse forms of energy, including:
  - Thermal Energy (Heat),
  - Chemical Energy (In Fuels Or Batteries)
  - Kinetic Energy (In Moving Substances)
  - Electrical Energy
  - Gravitational Energy
  - Nuclear Energy

- Solar power, both in the form of direct solar radiation and in indirect forms such as bioenergy, water or wind power, was the energy source upon which early human societies were based.
- When our ancestors first used fire fuelled by burning wood, they were harnessing the power of photosynthesis, the solar-driven process by which plants materials such as wood are created from water and atmospheric carbon dioxide.
- Societies went on to develop ways of harnessing the movements of water and wind, both caused by solar heating of the oceans and atmosphere respectively.
- As civilizations became more sophisticated, architects began to design buildings to take advantage of the Sun's energy by enhancing their natural use of its heat and light, so reducing the need for artificial sources of warmth and illumination.

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- As civilizations became more sophisticated, architects began to design buildings to take advantage of the Sun's energy by enhancing their natural use of its heat and light, so reducing the need for artificial sources of warmth and illumination.
- Technologies for harnessing the power of the Sun, firewood, water and wind continued to improve right up to the early years of the Industrial Revolution, but by then, the advantages of coal, the first of the *fossil fuels to be exploited on a large scale, had become apparent.*

- These highly concentrated energy sources soon displaced wood, wind and water in the homes, industries and transport systems of the industrial nations.
- Today the fossil fuel trio of coal, oil and natural gas provides around 80% of the world's energy.
- Concerns about the adverse environmental and social consequences of fossil fuel use have been voiced intermittently for several centuries, but it was not until the 1970s that humanity began to take more seriously the prospect of fossil fuels 'running out', and that their continued use could be affecting the planet's natural ecosystems and global climate.

- The development of nuclear energy following the Second World War raised hopes of a cheap, plentiful and clean alternative to fossil fuels.
- But nuclear power's contribution to electricity supply has in some countries stalled in recent years, due to concerns about safety, cost, waste disposal and weapons proliferation.
- In other nations nuclear power supplies continue to expand
- These concerns have been a major catalyst of renewed interest in the renewable energy sources in recent decades.

- Renewable energy can take a variety of these forms, and can be defined as: energy obtained from the continuous or repetitive currents of energy recurring in the natural environment (Twidell and Weir, 1986) or as energy flows which are replenished at the same rate as they are 'used' (Sorensen, 2000)
- sustainable energy source can be defined as
  - one that is not substantially depleted by continued use
  - does not produce significant pollution or other environmental problems
  - does not cause health hazards or social injustices.

- In practice, few energy sources come close to these ideals, but renewable energy sources are generally more sustainable than fossil or nuclear fuels:
- They are essentially inexhaustible, and their use usually involves fewer health hazards and much lower emissions of greenhouse gases and other pollutants.
- Renewable energy sources are derived principally from the enormous power radiated by the Sun. principal source is solar radiation
- The Sun's radiation comes from nuclear fusion reactions between hydrogen atoms in its very hot interior. However, this very high temperature is not due to nuclear fusion
- Rather, the radiation pressure from nuclear fusion prevents the Sun from getting hotter
- The Sun should continue to radiate in this way for another five billion years

- Two non-solar renewable energy sources are
  - Motion of the ocean tides, principally driven by the gravitational pull of the Moon, the source of *tidal energy*.
  - The other is *geothermal energy from the Earth's interior, which manifests itself in heat emerging from volcanoes and hot springs, and in heat from hot rocks.*

Energy Efficiency& Pollution

Pollution Prevention methods for Energy Efficiency

Opportunities for substantial reduction of energy use, and cost savings, abound across all building systems, and energy-efficiency technologies are continually improving, ensuring a steady flow of viable alternatives.

- HVAC performance, for example, can be improved by replacement or repair of worn-out or inefficient equipment with energy-efficient components.
- Many new, highly efficient HVAC technologies are continually being introduced.
- occupancy sensors, variable-speed drives, automated ventilation control, heat exchangers, and efficient motors—can reduce energy consumption by adjusting the levels of heating and cooling to maintain a healthy and comfortable environment.

- Lighting also offers numerous opportunities for energy conservation. In some office buildings, it can represent 40 to 60 percent of total energy costs.
- Use natural daylight whenever possible, reduce excessive illumination levels, limit hours of operation, and increase lighting efficiency.
- Use ENERGY STAR certified compact fluorescent lighting (CFL).
- By replacing your light fixtures with energy conserving compact fluorescent bulbs, you will save 75 percent of the energy used with incandescent bulbs.
- LED lighting differs from incandescent and compact fluorescent lighting in several ways.
- When designed well, LED lighting can be more efficient, durable, versatile and longer lasting. Use ENERGY STAR certified LED light bulbs.

CANDLE LIGHT

EFFICIENCY

LIFESPAN

COLOR RENDERING

INCANDESCENT

EFFICIENCY

LIFESPAN

COLOR RENDERING

CFL

EFFICIENCY

LIFESPAN

COLOR RENDERING

LED

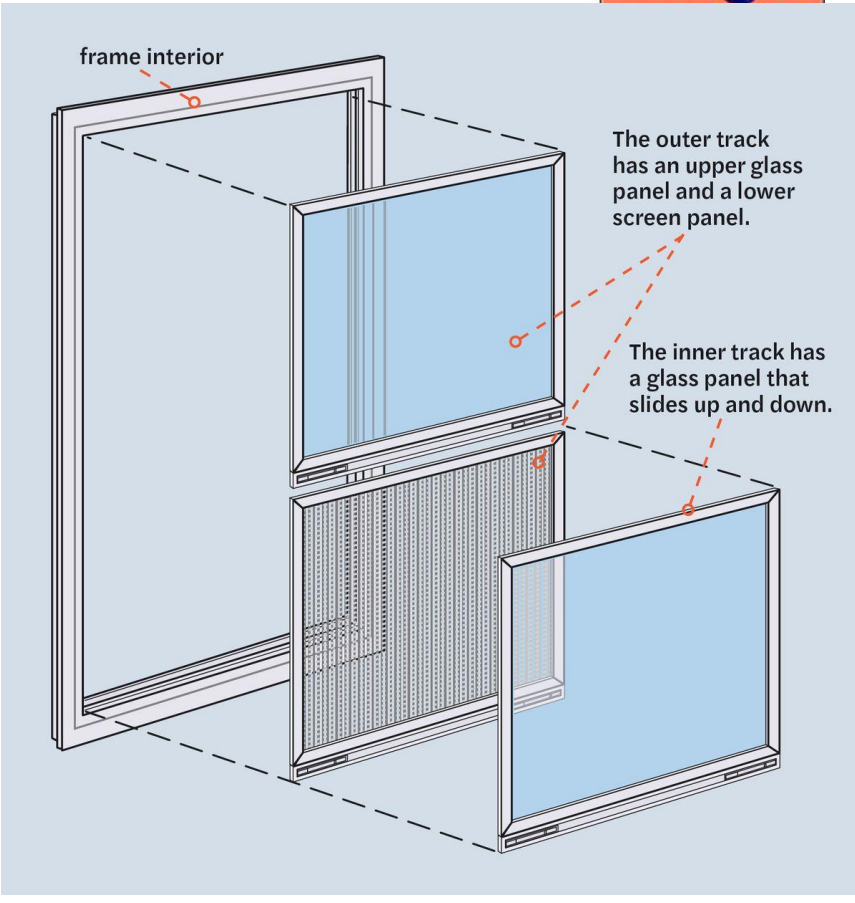
EFFICIENCY

LIFESPAN

COLOR RENDERING

- Additional energy savings can be found in a building's water treatment and distribution systems.
- In general, water-heating energy is conserved by reducing load requirements and distribution losses and improving the performance of water-heating equipment.
- Conserve energy by encouraging occupants to select appliances and office equipment with high energy-efficiency ratings.
- Purchase Energy Efficient Products and Equipment. By looking for the Energy Star label on products and equipment, you can reduce your energy bill by 30 percent and your electric lighting charges by 40 percent while cutting pollution.

- Insulate the house. Make sure your house is well insulated and, if heated or cooled, never leave windows or doors open.
- Raise shades on winter days; lower them in the summer.
- Seal all leaks.
- Block windows and doors with weatherstrip tape and inexpensive door sweeps and install blinds to reduce outside heat transfer.
- Install storm windows—they are added insulation for your home.


frame interior
The outer track has an upper glass panel and a lower screen panel.
The inner track has a glass panel that slides up and down.

- Insulate pipes and fixtures.
- Insulate the hot water heater and heating and cooling pipes.
- An insulation blanket for a water heater will pay for itself in a year or less and will reduce heat loss by 25-40 percent.
- Seal little holes around water pipes and stuff insulation into big holes around plumbing fixtures.
- Replace your showerhead. By using a low-flow showerhead, you reduce water consumption and energy usage to heat the water.

Cut down your 9 minutes shower to a quick 6.

The standard shower head uses 2.5 gallons per minute. Your 6 minute shower just used 15 gallons of water!

versus

Buy a low-flow shower head and stick with your 9 minute shower.

The typical low-flow shower head uses 1.5 gallons per minute. Your 9 minute shower used 13.5 gallons.

You're saving almost 550 gallons per year!

Really Being Green!

- Turn unused appliances and equipment off. Turn off equipment and lights at night and on the weekend, unplug appliances when they are not in use
- Clean or replace filters regularly. Be sure to check furnace, air conditioner and heat pump filters regularly.
- By cleaning your heating, ventilation and air-conditioning equipment, your units will last longer, avoid costly down time and improve indoor air quality.
- Increase natural light. Paint your exterior and interior walls in a light color so more light is reflected.
- Paint the edges of the window in white so more light reflected inside.

- During the day, open blinds to bring in natural light instead of turning on lights.
- Reduce paper usage. By double siding on copiers, reusing single-sided paper, using electronic mail and circulating documents with routing slips, an organization can save a significant amount of energy and natural resource
- Use public transportation or carpool. Not only does this save energy costs, but it extends the life of your vehicle.

BETTER BUILDINGS

- The United States Department of Energy (DOE) started the Better Buildings Initiative in 2011.
- Improving the energy efficiency of the nation's commercial buildings, responsible for 20% of the United States' energy use at that time.
- The program is part of DOE's Office Energy Efficiency and Renewable Energy.
- Better Buildings aims to make commercial, public, industrial, and residential buildings 20 percent more energy efficient over the next decade.
- This means saving billions of dollars on energy bills, reducing greenhouse gas emissions, and creating thousands of jobs.
- Through Better Buildings, public and private sector organizations across the country are working together to share and replicate positive gains in energy efficiency.

- The Energy Department is currently pursuing strategies within 4 interrelated key areas to catalyze change and investment in energy efficiency.
  - Developing innovative, replicable solutions with market leaders
  - Making energy efficiency investment easier
  - Developing a skilled clean energy workforce
  - Leading by example in government.

REDUCING ENERGY CONSUMPTION

To promote energy efficiency at building level and at city level the following aspects need to be considered

- Day light design of building with natural ventilation, green roof and passive climate design
- Adoption of BEE Guidelines, EC building code, Standards and specifications for buildings, energy and equipments
- Promoting the utilization of exhaust heat from incinerations plants and sewerage treatment
- Unser renewable energy for buildings, street lighting, hoardings, mass cooking, climate controls
- Replace coal based power generation to natural gas/non polluting alternative fuels

- Observe strictly safety controls and instructions
- Check transmission and distribution losses
- Incentive decentralized power generation and energy conservation
- Various passive techniques have been put in perspective, and energy saving passive strategies can be seen to reduce interior temperature and increase thermal comfort, reducing air conditioning loads.
- In regions where heating is important during winter months, the use of top-light solar passive strategies for spaces without an equator-facing façade can efficiently reduce energy consumption for heating, lighting and ventilation.

Passive techniques

- High levels of insulation and air tightness are used to reduce heat loss from the building, and hence the need for heating during winter.
- Using dense materials in the building construction creates 'thermal mass', which reduces temperature fluctuations by storing heat and releasing it later in the day, helping limit overheating during hot weather or times when there are a lot of people in the building.
- Buildings can be designed to make the best use of sunlight by orientating them relative to south and arranging windows to maximize daylight and allow sunlight in during winter, but to limit direct sunlight penetration during summer when it can cause overheating.

- The use of high efficiency, low emissivity glazing allows high levels of daylight in whist reducing heat losses through windows.
- Passive design can use wind-driven and stack-driven natural ventilation to provide cooling in summer without the need for air conditioning.
- To minimize heat losses during cold weather, airflow is reduced to the minimum needed to provide fresh air.

Renewables

- Renewable heating systems including biomass boilers, active solar water heating and ground source heat pumps can be used to supply heating and hot water needs with reduced greenhouse gas emissions
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- Solar photovoltaics can be mounted on or integrated in the building roof, to provide renewable electricity.
- Wind turbines can be included within the site as another means of providing renewable electricity.
- Energy efficiency brings health, productivity, safety, comfort and savings to homeowner, as well as local and global environmental benefits.

LOW ENERGY DESIGN

- “energy-efficient building” or “low-energy building” refer to the building’s energy performance.
- These terms put an emphasis on the building’s envelope and its technical installations, underlining thermal insulation, energy-efficient windows, and technical schemes (e.g., a heat-recovery ventilation system, solar panels, etc.).
- Also, in order to provide good indoor comfort, a proper ventilation scheme must be installed
- A low-energy building is defined as “a building that uses 25% less energy for space heating1 than stipulated in the building code, while a very low-energy building must use 50% less energy for space heating than stipulated in the building code

- Energy is used in buildings to deliver comfortable conditions for occupants and to power appliances: this is known as ‘energy-in-use’. Energy is also used in the production of building materials and during construction: this is known as ‘embodied energy’
- Low energy buildings use a mixture of passive techniques and active systems to deliver a comfortable environment with low energy use and low greenhouse gas emissions.
- Passive techniques relate to the shape of the building and the materials that it is built with, while active systems use machinery to provide services to the building which minimize energy use.

- Incorporating renewable energy generation on site can reduce emissions further.
- However, low energy use should be the first priority, since this is the cheapest way to cut greenhouse gas emissions.
- In addition, low energy use makes the adoption of renewable energy technologies more viable because less capacity is required to meet the building demand.
- It's possible to reach the point where a building produces net zero greenhouse gas emissions in use, known as 'zero carbon in use'.
- Embodied energy can also be reduced by using low-carbon building materials and construction methods.

- Natural ventilation is rapidly becoming a significant part in the design strategy for non-domestic buildings because of its potential to reduce the environmental impact of building operation, due to lower energy demand for cooling.
- Naturally ventilated building can readily provide a high ventilation rate. On the other hand, the mechanical ventilation systems are very expensive.
- However, a comprehensive ecological concept can be developed to achieve a reduction of electrical and heating energy consumption, optimise natural air condition and ventilation, improve the use of daylight and choose environmentally adequate building materials.
- The use of renewable energy resources could play an important role in this context, especially with regard to responsible and sustainable development.

- General principles of energy efficient building design or low energy design comprise the following:
  - Integration of energy concept from project outset, demand and management
  - Compact shape, minimize power requirement
  - Day light design
  - Energy efficient lighting, ventilation and space conditioning, site planning and landscape design
  - Shading, green roof, building envelop
  - Fenestration and window/ openings design , glazing design
  - Efficient use of passive solar energy, renewable energy

- Energy efficient and easy to use technical systems
- Low water use sanitary ware
- Low energy electrical appliances
- Use of low embodied energy, recyclable construction materials
- Increased insulation, elimination of thermal bridges wherever possible
- Safety against fire and other hazards