Green Building Technology

UNIT - 1

1. **Introduction to Green Buildings**:
    - Definition of green buildings and sustainable development
    - Typical features of green buildings
    - Benefits of green buildings towards sustainable development.
2. **Green building rating systems:**
    - GRIHA, IGBC and LEED
    - Overview of the criteria as per these rating systems

UNIT- II

1. **Site selection and planning**:
    - Criteria for site selection, preservation of landscape, soil erosion control, minimizing urban heat island effect.
2. **Water conservation and efficiency**:
    - Rainwater harvesting methods for roof & non-roof
    - Reducing landscape water demand by proper irrigation systems
    - Water efficient plumbing systems, water metering, waste water treatment, recycle and reuse systems.

UNIT-III

1. **Energy Efficiency**:

- Environmental impact of building constructions, Concepts of embodied energy, operational energy and life cycle energy.

2. **Methods to reduce operational energy**:
   - Energy efficient building envelopes
   - Efficient lighting technologies, energy efficient appliances for heating and air-conditioning systems in buildings, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings.

UNIT - IV

1. **Building materials**: Methods to reduce embodied energy in building materials:
   - (a) Use of local building materials
   - (b) Use of natural and renewable materials like bamboo, timber, rammed earth, stabilized mud blocks,
   - (c) use of materials with recycled content
   - (d) reuse of waste and salvaged materials
2. **Waste Management**:
   - Handling of construction waste materials, separation of household waste, on-site and off-site organic waste management

UNIT-V

1. **Indoor Environmental Quality for Occupant Comfort and Well being**:
   - Daylighting, air ventilation, exhaust systems, low VOC paints, materials & adhesives, building acoustics.
   - Codes related to green buildings: NBC, ECBC, ASHRAE, UPC etc.

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1. What is sustainable development in the context of green building?

- Sustainable development maintains a delicate balance between improving lifestyles and preserving natural resources and ecosystems for current and future generations.
- Green buildings ensure efficient use of natural resources like building materials, water, and energy, while minimizing non-degradable waste.
- The goal of sustainable development is to regenerate, maintain, and improve planetary resources for use by future generations.

2. State the importance of green building

- Green buildings ensure efficient use of natural resources like building materials, water, and energy and minimize non-degradable waste.
- Green building design can lead to reduced energy and water consumption.

- They help in conserving and restoring natural resources, protecting biodiversity and ecosystems.
- Green buildings enhance comfort and health for occupants and are aesthetically pleasing.

3. State the benefits of landscaping

- Sustainable landscape design can provide benefits beyond aesthetics, acting as an effective microclimate modifier.
- Good landscape design provides shading, helps modulate air flows, and can directly receive runoff and captured water.
- Landscaping helps filter and clean storm water and can include rain gardens in parking areas.
- Using plants can help absorb rainwater and reduce the heat urban island effect.

4. What is heat island reduction?

- Heat island reduction minimizes the negative impact on micro-climate.
- Using materials with a high solar reflective index (SRI) to cover at least 75% of the exposed roof area is one method to achieve this.
- Providing vegetation to cover at least 50% of the exposed roof area, including covered parking can also reduce the heat island effect.
- Other methods include using light-coloured roofs, shading with trees or sun blockers and minimizing open parking lots.

5. What is operational energy?

- Operational energy is the energy consumed by a building to satisfy the demand for heating, cooling, ventilation, lighting, equipment, and appliances.
- It is the energy required for maintaining comfort conditions and day-to-day maintenance of buildings, including energy for HVAC, domestic hot water, and lighting.
- Operational energy varies based on required comfort levels, climatic conditions, and operating schedules.

6. State reasons to reduce embodied energy

- Reducing embodied energy can significantly reduce the overall environmental impact of a building.
- As the energy efficiency of a building increases, the embodied energy of the building materials becomes increasingly important.
- Reducing embodied energy helps to lower CO_2 emissions, which contributes to decreasing greenhouse gas emissions.

7. State the importance of natural day lighting

- Natural day lighting can improve test scores of children.

- It is the most desirable and sustainable solution for interior lighting, provided that windows and openings do not incur excessive heat gain.
- It helps in reducing the need for artificial lighting during daylight hours without causing heating or cooling problems.

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1. Mention different building rating systems available in India and add a brief note about them

There are three primary green building rating systems in India: **GRIHA, IGBC, and BEE**.

- **GRIHA (Green Rating for Integrated Habitat Assessment)** is India's national rating system, developed jointly by TERI and the Ministry of New and Renewable Energy. It evaluates buildings based on 34 criteria, including site selection, resource conservation, building operation, and innovation. To qualify for GRIHA certification, a project must score at least 50 points out of 100.
- **IGBC (Indian Green Building Council)** was formed by the Confederation of Indian Industry (CII) in 2001. IGBC has licensed the LEED Green Building Standard from the USGBC and offers various rating systems for different building types.
- **BEE (Bureau of Energy Efficiency)** has developed its own rating system based on a 1 to 5 star scale, with more stars indicating greater energy efficiency. BEE has also developed the Energy Performance Index (EPI), which is measured in kilowatt hours per square meter per year and is used to rate buildings, especially air-conditioned and non-air-conditioned office buildings.

2. What is the procedure to acquire a green rating for a building?

The general procedure to acquire a GRIHA green rating for a building involves the following steps:

- **Registration**: Register the building project on the GRIHA website early in the project cycle.
- **Pre-documentation stage**: A team from ADaRSH (Association for Development and Research of Sustainable Habitats) and the client's Integrated Design Team meet to determine the points targeted by the project during an orientation workshop.
- **Post-documentation stage**: Submit all necessary documents as proof for the points targeted under various criteria. The documents are evaluated by third-party regional evaluators.
- **Due diligence visits**: During the construction phase, ADaRSH team members conduct three visits to check on-site compliance with GRIHA criteria.
- **Evaluation**: After uploading the necessary documentation and commissioning systems on-site, the building undergoes a three-tier evaluation process. A team of experts from ADaRSH performs a preliminary evaluation, checking mandatory points and estimating achievable points. An evaluation committee, comprising external experts, independently reviews and awards points, after which a provisional GRIHA rating is awarded.
- **Final Rating**: The final score is presented to the National Advisory Committee for approval and the final rating is awarded after receiving and evaluating post-occupancy performance audit reports, which are conducted after one year of building occupancy. The rating is valid for five years from the building's commissioning.

3. What is soil erosion? Write brief notes on methods to control soil erosion on construction sites

Soil erosion is the process of weathering and transport of solids, such as sediment, soil, and rock particles, in the natural environment, which can lead to serious problems like water sedimentation and ecosystem damage.

Methods to control soil erosion at construction sites:

- **Pre-Construction Measures**: Schedule construction work and erosion control during dry weather. Install sedimentation collection and drainage systems before construction begins. Protect existing vegetation by preventing disturbance or damage to specified areas. Mandatory topsoil removal and preservation for projects larger than 1.00 hectare, stockpiling it for later use in landscaping. Create spill prevention and control plans, including measures to contain spills and dispose of contaminated material and hazardous wastes.
- **Measures During Construction**: Construct a temporary sedimentation basin at the lowest point of the site to collect and trap sediment. Implement contour trenching which involves creating embankments parallel to the contours of a slope to reduce runoff velocity and increase moisture retention. Use mulching with seeding and planting in steep slope areas, using materials like straw and compost to stabilize soils and reduce storm water runoff. Implement gee-grids which are netlike polymeric materials to confine unconsolidated materials within cells and prevent their movement on steep slopes.

4. What about rainwater harvesting for roof and non-roof areas?

Rainwater harvesting involves capturing runoff from roof and non-roof areas to enhance the groundwater table and reduce municipal water demand.

Key aspects include:

- **Design**: Design the rainwater harvesting system to capture at least one day's rainfall runoff volume from both roof and non-roof areas. One-day rainfall is derived from a percentage of average peak month rainfall.
- **Rainfall Information**: Refer to Indian Meteorological Department data for rainfall information.
- **Runoff Volume**: Calculate runoff volume using the formula: Surface area x Runoff Coefficient x Rainfall.
- **Filtering**: Ensure filtering of suspended solids by providing suitable filtering media before letting the water into collection tanks or water bodies.
- **Rainwater Harvesting Guidelines**: Consider guidelines from the National Building Code (NBC) of India, Part 11, Section 7.2.
- **Collection**: In areas with limited water percolation, collection tanks or water bodies may be provided.

5. Deduce an insight into the design of energy-efficient building

An insight into the design of an energy-efficient building involves a **holistic, systems-based approach** that considers various interconnected elements.

Key considerations include:

- **Site Selection and Placement**: Prioritise proximity to public transport and local shopping to reduce private vehicle use. Build near existing infrastructure to conserve resources.
- **Building Orientation**: Optimise building orientation and placement of windows and rooflines for energy efficiency. In the Northern Hemisphere, major glazing areas should face south to maximise solar heat gain during winter, while warmer climates should limit south-facing glazing and install overhangs.
- **Building Envelope**: Implement a continuous layer of insulation (CI) around the building envelope. Use high-quality insulation like spray foam. Utilise advanced house framing techniques to reduce lumber use and improve energy efficiency. Use structural insulated panels (SIPs) to save up to 50% in energy costs.
- **Cool Roofs**: Use cool roof coatings or light-coloured roofs to reflect sunlight and reduce heat absorption. Consider green roofs for urban buildings with flat or shallow-pit roofs.
- **Glazing Systems**: Purchase energy-efficient windows appropriate for the climate zone. Use low-emissivity (low-e) window glazing to control solar heat loss and gain.
- **Ventilation**: Include an energy recovery ventilation system to minimise energy loss. Install localised exhaust fans in kitchens and bathrooms.
- **Heating and Cooling Systems**: Choose a high energy-efficient heating, ventilation, and air conditioning (HVAC) system. Install a programmable thermostat. Seal ducts with sealant or metal-backed tape and wrap them in insulation.
- **Water Heating**: Install a tank-less water heater or a high-efficiency storage (tank) water heater.
- **Renewable Energy Sources**: Install grid-tied solar photovoltaic (PV) panels.
- **Energy-Efficient Lighting**: Switch to light-emitting diode (LED) light bulbs. Install timers and photocells to turn lights off when not in use.
- **Energy-Efficient Appliances**: Select ENERGY STAR® appliances.
- **Landscaping**: Incorporate energy-efficient landscaping to protect the building from direct sunlight during the summer and allow more sunlight to reach windows during the winter.

6. Explain the concept of global warming and add a brief note on ozone depleting potential materials

Global warming refers to the modern-day rise in global temperature near the Earth's surface, caused by increasing concentrations of greenhouse gases in the atmosphere. These gases, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and fluorinated gases, trap heat and redirect it back to the Earth's surface, leading to an increase in global temperatures.

Ozone depleting substances (ODS) are used in refrigeration, air conditioning, building insulation, and fire-fighting equipment. HCFCs (Hydro chloro fluoro carbons), which are currently in use, are

scheduled to be phased out by 2030 for developed countries and 2040 for developing countries. Selecting zero-ODP (ozone depleting potential) and low-GWP (low-global warming potential) alternatives is the way forward to achieve environmental benefits in an integrated manner.

7. Explain about wind and solar energy harvesting

Wind energy harvesting involves installing a small wind system either connected to the electric grid through a power provider or stand-alone (off-grid). A small wind electric system can lower electric bills by 50 to 90 percent.

Solar energy harvesting involves installing grid-tied solar photovoltaic (PV) panels as a cost-effective form of renewable energy. Solar photovoltaic can power all the energy needs of a building, including lighting, heating and cooling systems, appliances, and hot water.

8. Explain in detail about construction and demolition waste management

Construction and demolition (C&D) materials are generated when new building and civil-engineering structures are built and when existing buildings and civil-engineering structures are renovated or demolished.

Construction and Demolition Waste Management Rules, 2016:

- These rules apply to everyone who generates construction and demolition waste.
- Waste generators must segregate construction and demolition waste and deposit it at collection centres or hand it over to authorised processing facilities. They must also ensure that there is no littering or obstruction to traffic or public areas.
- Large generators (those who generate more than 20 tons per day or 300 tons per project per month) must submit a waste management plan and obtain approvals from the local authority before starting work. They must also have an environment management plan to address environmental issues and segregate waste into streams such as concrete, soil, steel, wood, plastics, bricks, and mortar.

Duties of Service Providers and Contractors:

- Service providers must prepare a comprehensive waste management plan for waste generated within their jurisdiction. They must remove all construction and demolition waste in consultation with the local authority.

Duties of State Government and Local Authorities:

- The Secretary, UDD in the State Government, must prepare a policy for managing construction and demolition waste within one year. Local authorities must procure and utilise 10-20% of materials made from construction and demolition waste in municipal and government contracts. They must also place appropriate containers for waste collection, ensure regular removal, and transport waste to processing and disposal sites.

Waste Handling and Management:

- Waste should be sorted into containers provided by service companies that specialise in managing specific types of waste. Loads containing unacceptable materials may be rejected.

Job Site Waste Reduction:

- Up to 10-12% of a project's construction waste stream can be cardboard alone, so recycling cardboard is important.
- Volatile materials should be protected from spoilage.
- Damaged components, products, and materials should be recycled or disassembled into their constituent materials for recycling.
- A return or buy-back arrangement with suppliers should be established.
- Develop the project schedule to accommodate salvage, reuse, or recycling.

9. Explain in detail about waste sorting or waste separation

Waste sorting, also known as waste classification or waste segregation, is the process of dividing waste into different categories. It can be done manually, such as at home or through kerbside collection programmes, or automatically in materials recovery facilities. The purpose of waste sorting is to reflect local disposal systems.

Common categories for waste sorting include:

- Paper
- Cardboard
- Glass (clear, tinted, but not including light bulbs or window panes)
- Plastics
- Textiles
- Wood, leather, rubber
- Scrap metal
- Compost
- Special/hazardous waste
- Residual waste

Organic waste can also be separated:

- Leftover food that has come into contact with meat can be collected separately to prevent the spread of bacteria. Meat and bone can be retrieved by organisations responsible for animal waste.
    - Fruit and vegetable peelings and scrapings can be composted along with other degradable matter such as cut flowers, corks, coffee grounds, tea bags, eggshells and nutshells, and paper towels.
- Used cooking oil and fats can be collected by specialist companies for reuse.

Waste sorting can also occur at civic amenity sites. Efficient identification and sorting of materials is an important factor in managing the economic viability of diverting construction debris from disposal. Waste segregation at the source reduces the segregation load at dumping yards.

10. What are advantages of using local building materials?

Using local building materials can reduce the embodied energy of construction. Embodied energy refers to the total energy required for the extraction, processing, manufacture, and delivery of building materials to the building site. Using locally sourced materials reduces transport, which in turn reduces embodied energy.

11. How can natural ventilation be used for achieving sustainable construction?

Natural ventilation involves using passive strategies to supply outdoor air to a building's interior for ventilation and cooling without using mechanical systems. Natural ventilation is a healthy and cost-effective way to save energy and provide fresh air for building occupants. It has become a key component of green building and is required for certification by LEED and the Living Building Challenge.

During the preconstruction phase of a project, research is done to determine the best positioning of the building to allow adequate ventilation from prevailing winds. Design elements must be incorporated into a building to allow free air access. Factors such as building positioning, prevailing winds, upper clerestory, and window and door placement must be taken into account to provide the most comfortable and energy-efficient environment for building occupants. The primary purpose of natural ventilation is to allow the outside ambient weather to provide low humidity, moderate temperature wind currents as an alternate cooling source for the building and provide air circulation throughout. By using this method, building owners can save on energy costs by turning off the HVAC system when the temperatures are right.

12. Explain in detail about any two green building codes

- **International Green Construction Code (IgCC)**: The International Code Council's (ICC's) IgCC is an overlay code that is written to be used with all other ICC codes. It includes provisions for site development and land use, energy efficiency, water conservation, material resource conservation and efficiency, indoor environmental quality and comfort, commissioning and operations and maintenance, and existing buildings. The U.S. Department of Energy (DOE) develops changes designed to increase energy efficiency in commercial buildings and participates in code hearings.
- **ASHRAE Standard 189.1**: ASHRAE Standard 189.1, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*, addresses site sustainability, water use efficiency, energy use efficiency, indoor environmental quality, and the impact on the atmosphere, materials and resources by buildings, as well as high-performance operation. All ASHRAE standards are revised according to a consensus process developed and maintained by ASHRAE and reviewed by the American National Standards Institute. The U.S. Department of Energy is a member of the ASHRAE 189.1 Standing Standards Project Committee (SSPC) and participates in updating and maintaining Standard 189.1.