Shirpur Education Society's

R. C. Patel College of Engineering & Polytechnic, Shirpur

Department of Civil Engineering

Name of Subject: - **ENERGY CONSERVATION & GREEN BUILDING (ECG)**

Course Code: - **315316**

Scheme:- **CE-5K**

Semester:- **Fifth**

Unit No. 03

Sustainable Building Materials and Technologies

CO3 - Suggest the relevant construction material and techniques for the green building construction

Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
III	Sustainable Building Materials and Technologies	CO3	6	2	8	0	10

THEORY SYLLABUS CONTENT

Unit - III Sustainable Building Materials and Technologies

3.1 Sustainable building Materials: (Bamboo, Hempcrete, Recycled Plastic Lumber, Ferrock, Cross-Laminated Timber (CLT) etc) Uses, characteristic, advantages, benefits and limitations, Criteria for selecting sustainable materials.

3.2 Energy-Efficient Technologies: a. Building envelope improvement system: Insulation, windows and glazing, air sealing, Cool roofs and green roofs system. b. Building management system: energy management. c. Lighting: LED and daylighting strategies. d. HVAC unit in green Building: Concept and importance

3.3 Ethics and Professional Responsibility: Ethical considerations in sustainable design and construction, The role of professionals in promoting sustainability.

Subject Incharge

Mr. D. B. Wagh

Unit NO. 05

Sustainable Building Materials and Technologies

* Sustainable building Materials :-

1) Bamboo
2) Hempcrete
3) Recycled plastic Lumber (RPL)
4) Ferrock
5) Cross-Laminated Timber (CLT)

1) Bamboo :-

Bamboo is a rapidly ~~the~~ renewable plant species classified as a woody grass, capable of reaching full maturity in as little as 3-5 years, depending on the variety and region. This fast growth rate makes it an excellent alternative to traditional hardwoods, which can take decades to makes.

→ Common Uses :-

a) Flooring (perquet tiles, laminated panels)
b) Wall panelling and celling coverings.
c) Roofing frameworks
d) Structural supports
e) Scaffolding

→ Technical characteristics :-

a) Compressive strength about 70-120 MPa (higher than concrete)
b) Tensile strength is comparable to mild steel (400mpa in some species)
c) Lightweight and easy to transport.
d) Highly flexible, suitable for seismic zones.

→ Advantages :-

a) Rapid Renewability (i.e harvesting cycles)
b) Minimal energy required for processing
c) Absorbs large amounts of CO_2 during growth
d) Naturally decompose without polluting.

→ Limitations :-

a) Requires a seperate load-bearing frame.
b) Takes weeks to set and dry completelly.
c) Durability issues as it is susceptible to termites and rot if untreated.
b) Fire Resistance is low; needs chemical treatment for fire safety
c) Natural variation in properties can complicate design.
d) Requires proper finishing to avoid swelling and decay.

2] Hemporete :-

Hemporete is a bio-composite material made by mixing the woody inner core of the hemp plant with a lime-based binder and water. It is non-load bearing but highly valued for insulation and indoor climate regulation.

→ Common Uses :-

a) Wall insulation infill between timber framings.
b) Roof and floor insulation
c) Acoustic barrier in Interiors

→ Technical characteristics :-

a) Thermal conductivity 0.06 – 0.08 W/m·K (excellent insul.)
b) Density about 275–700 kg/m³
c) Breathability allows vapour diffusion; prevents condensation
d) Fire resistance is High - due to lime content.

→ Advantages :-

a) Carbon-Negative as it absorbs more CO_2 during growth and curing it emits.
b) Lightweight and Reduces foundation load and transportation costs.
c) NO Toxic Emissions

3) Recycled Plastic Lumber (RPL)

RPL is manufactured from post-consumer plastic waste, often mixed with wood fibers or other additives. It mimics wood in appearance and function but is resistant to decay, making it ideal for outdoor and water-exposed applications.

⇒ Common Uses :-

a) Decking and patios
b) Benches and fencing
c) Marina docks and outdoor structures
d) Land scape edging

⇒ Technical characteristics :-

a) Durability as it lasts 2-5 times longer than timber in outdoor conditions.
b) Waterproof & UV-resistant

⇒ Advantages :-

a) Diverts plastic from oceans and landfills.
b) No needs for painting or sealing
c) Ideal for tropical or wet climates

⇒ Limitations :-

a) Can warp or expand in hot climates
b) Unsuitable for primary structural elements.
c) Slippery when wet unless textured.

4] Ferrock :-

i. Ferrock is a sustainable construction material made from recycled materials like steel dust and silica from ground-up glass.
ii. It acts as a cement alternative and hardens through a process of absorbing and reacting with carbon dioxide (CO_2) making it a carbon-negative material
iii. It was developed as a green alternative to portland cement particularly for applications where strength, durability and sustainability are essential.

⇒ Common uses of ferrock

a) flooring systems and pavements.
b) Retaining walls and bridges
c) Remarine structures (piers, docks)
d) structural repairs and patching
e) Eco-Friendly construction projects.

⇒ Technical characteristics :-

a) composition ; Primarily iron-rich waste (steel dust) and silica, absorbs CO_2 during curing (carbon-negative)
b) Compressive strength ; Higher than portland cement (40mpa)
c) Durability ; Excellent resistance to cracking, corrosion, and weathering
d) Density is high.

⇒ Advantages :-

a) Environmentally friendly ; made from 100% Industrial waste and sequesters CO_2
b) Stronger than concrete ; Better tensile and compressive strength
c) Durable and corrosion-resistance : Ideal for coastal or marine environments.

⇒ Limitations :-

a) limited availability ; Not yet produce at a large scale.
b) cost ; more expensive
c) Lack of standardazation
d) Heavy weight due to iron content.

5) Cross-Laminated Timber (CLT)

It is an advanced wood based construction material made by gluing multiple layers of solid-sawn lumber, with each layer laid perpendicular to the one below it. This cross-wise configuration significantly enhances the panel's strength, diamensional stability and load bearing capacity.

⇒ Common Uses :-

a) multi-storey buildings and modular homes
b) Prefabricated wall and floor systems
c) schools, offices and public buildings
d) Bridges and Footpaths & Retrofit and expansion projects

⇒ Technical characteristics :-

a) Composition: multiple layers of timber (usually 3, 5 or 7) cross laminated.
b) Panel size: can be manufactured in large diamension (i.e 3X16m)
c) Strength: high load bearing capacity both vertically and horizontally.
d) Fire resistance and Thermal Insulation.

⇒ Advantages :-

a) Sustainable material: Made from renewable Wood, stores carbon
b) Lightweight and Strong: Easier to Transport and install
c) Speed of construction: Prefabrication allows rapid work
d) Design flexibility and seismic performance.
e) Aesthetic Appeal: exposed Wood enhanced interior design.

* Limitation

a) Moisture sensivity :- Rot if not properly sealed or maintained
b) Cost :- may be more expensive than traditional wood
c) Building code : Limited recognition in some region and codes
d) Fire perception :- not enough to resistance offered to fire.

Criteria for selecting sustainable Materials

When choosing sustainable materials for construction or manufacturing, several important criteria should be consider to ensure minimal environmental impact, efficient use of resource and long-term performance.

1) Resource Efficiency:-
2) Recyclability and Reusability
3) Low Embodied energy
4) Durability and lifespan
5) Non-Toxic and safe
6) Locally Available
7) Enviromental certification
8) Lifecycle Impact
9) Energy efficiency performance.

1) Resource Efficiency:-

a) Materials should be come from renewable or abundant sources.
b) Prefere materials that use and conserve raw materials

2) Recyclability and Reusability:-

a) Select materials that can be reused or recycled at the end of their lifecycle
b) This reduces landfill waste and conserves raw materials

3) Low Embodied Energy

-Choose materials that requires minimal energy for extraction, production, and transportation.

4) Durability and Lifespan:-

- Sustainable materials should be long-lasting and require low maintenance.

5) Non-Toxic and safe:-

- Materials should be free from harmful chemicals and VOC's (volatile organic compounds)
- This ensures heathier indoor air quality and safer living conditions.

Energy - Efficient Technologies

1] Building envelope improvement system :
Insulation, windows and glazing, air sealing, cool roofs and green roofs system.

2] Building management system:
Energy management

3] Lighting : LED and daylighting strategies

4] HV AC unit in green Building :
Concept and importance

1] Building envelope improvement system:

A] Insulation :-
Insulation resist the flow of heat, keeping buildings warmer in winter and cooler in summer. By maintaining stable internal temperature, it reduces the demand on HVAC system and helps lower energy consumption.

Material	Description	Thermal conductivity (W/m·K)
fiberglass	made from fineglass fibres	0.035 – 0.045
Rock wool	Made from molten Basalt rock	0.035 – 0.045
polyurethene foam	Spray-applied; fills small gaps	0.025 – 0.03
cellulose	made from recycled paper	0.04 – 0.045

Benefits :-
i) Improve Energy Efficiency
ii) Noise Reduction
iii) Reduced Utility Bills
iv) Fire Resistance

B) Window and Glazing :-

Windows are weak points in a buildings thermal envelope. Without proper treatment, they lead to significant heat loss or gain, solar, glare, and UV damage to interiors.

Types of Glazing :

i) Double / Triple Glazing :- Two or three glass panel with gas (argon, Krypton) in between act as insulators.

ii) Low-E (Low-Emissivity) coating :- microscopic metal or metallic oxide layers that reflect infrared (heat) but allow visible light.

* Benefits

a) Thermal insulation :- Prevents heat loss in winter and heat gain in summer.

b) Enhanced Daylighting :- Allows natural light minimizing glare.

c) UV protection :- Reduces fading of fabrics and finishes.

d) Acoustic control : Glazing adds to noise reduction, especially in urban zones.

C] Air sealing

Even well-insulated buildings can lose efficiency due to air leaks around doors, windows, utility penetrations, and joints. Air sealing involves plugging these leaks to prevents conditioned air from escaping and unconditioned air from entering.

* common air sealing material :-

a) caulking b) Weather stripping c) moisture protection.

Benefits :-

a) Reduced Energy Waste :- prevents drafts and HVAC overuse

b) Enhances comfort :- Eliminates cold or hot spots near openings

c) Moisture protection :- prevents condensation and mold growth.

1] Cool Roofs and Green Roofs

a) Cool Roofs

Roofs are the largest surface exposed to direct sunlight, especially in hot climates, their design significantly affects building heat gain.

→ i) constructed with light-coloured or reflective material (e.g. white coatings, aluminimum tiles)

→ ii) High solar Reflectance and thermal emittance.

b) Green roofs

i) It consists of multiple layers: waterproofing, drainage, growing medium, and vegetation.

ii. Also called vegetated or living roofs.

2] Building Management System (BMS) :-

i) BMS is a centralized control platform that integrates the building's mechanical, electrical, and security systems.

ii) It enables automated monitoring, control, and optimization of energy usage and indoor conditions.

a) Energy and Utility monitoring
b) Lighting control
c) HVAC management.
d) security

3] Energy-Efficient Lighting:

⇒ Lighting accounts for 15-20% of electricity use in residential buildings and up to 40% in commercial spaces. switching to high-efficiency lighting systems is one of the quickest and most cost-effective ways to reduce energy consumption.

a) LED lighting :-

Advantages

i) Low power consumption :- Uses 75-80% less energy than incandescent bulbs.

ii) Long lifespan :- Operates for 25,000-50,000 hrs.

iii) Cool operation :- produces less heat, reducing load on cooling system.

b) Daylighting strategies :-

- Day lighting refers to the passive use of natural sunlight to illumate indoor spaces, effective daylighting design minimizes the need for artificial lighting and creates healthier spaces.

Techniques

i) Skylights :- Openings in the roofs for direct overhead light.
ii) clerestory windows :- High-positioned vertical windows
iii) Light Tubes (Sun Tunnels) :- Reflective tubes that channel light
iv) Light shelves :- Horizontal surface that reflect sunlight deeper into rooms.

Applications :-

i) Energy Savings : Reduces lighting load during daytimes
ii) Human well-being :- Exposure to daylight improves mood, productivity, and health.
iii) Circadian Rhythm Regulation :- supports natural sleep-wake cycles.
iv) Visual comfort :- Reduces glare and creates balanced illumination.

4 HVAC systems in Green Buildings

- HVAC (Heating, Ventilation, and air conditioning) systems are energy-intensive, often accounting for 30-60% of a building's energy use
- modern green buildings prioritize HAVC optimization through design, equipment efficiency, and smart controls.

Benefits-

i) Improved Indoor Air quality (IAQ) :- filters and fresh air supply reduce allergens and pollutants.
ii) Reduced Operating costs :- Efficient systems lower electricity and maintenance expenses.
iii) Thermal comfort :- Maintains consistent, comfortable indoor conditions.
iv) Energy conservation : smart zoning and load matching prevent energy waste.

Ethics and Professional Responsibility

*Ethical considerations in sustainable design and construction.

1) Avoid Green Washing
2) Transparency in sourcing and life cycle Impact
3) Ensure safety and well-being of occupants
4) Promote fairness in Labour and Material sourcing.

1) Avoid Green washing

Green washing refers to the misrepresentation or exaggeration of environmental benefits to appears more eco-friendly than one actually is.

⇒ This unethical practice
i) misleads clients and the public
ii) Undermines genuine sustainable efforts
iii) Erodes trust in green certifications and standards.

2) Transparency in sourcing and Life cycle Impact:

⇒ i) Professionals must disclose origine of materials & processing details
ii) END of life Impact: can materials be reused, recycled, or safety decomposed.

3) Ensure Safety and well-being of occupants

i) Green building provide air, natural lighting, thermal comfort and safe materials (low-VOC, non-toxic)
ii) consider the psychological and physiological health of users, particularly in residential buildings, schools, and hospitals.
iii) Ethical professionals poioritize human health over aesthetics or cost-cutting

4) promote fairness in Labour and material sourcing

i) It ensures fair wages, safe working conditions, and non-discriminatory practices on site
ii) Responsible sourcing of materials that are not linked to child labor, ecological destruction, or human rights violations.

The role of professionals in promoting sustainability :-

1) Architects
2) Civil & Environmental Engineers
3) Project Managers
4) Policy Advocates and Regulators.

1) Architects

Ethical responsibilities :-
a) Use passive design (Orientation, daylighting, natural ventilation)
b) choose sustainable materials and reduce waste
c) Design for well-being, accessibility, and community connection.

2) Civil & Environmental Engineers :-

Ethical responsibilities
a) Life-cycle assessments of materials and systems.
b) Design for efficiency : Energy, water, renewable integration, climate resilience.
c) Ensure compliance with codes and environmental laws.

3) project Managers :-

Ethical Responsibilities
a) Balance time, cost, and quality while meeting sustainability goals
b) Advocate for sustainable alternatives in planning and procurement
c) Block cost-cutting that harms environmental or social standard

4) Policy Advocates & Regulators :-

Ethical Responsibilities
a) Develop & Update green building codes and rating systems.
b) Enforce compliance fairly, without corruption or bias.
c) Promote inclusive policies that support marginalized communities.

Assignment Questions

Unit No. 03
Sustainable Building Materials and Technologies

1. Enlist various sustainable materials and state uses and characteristics of any two of them.
2. Explain advantages and benefits of bamboo as a sustainable material.
3. Enlist advantages and limitations of Hemperete.
4. Explain in detail cross-laminated timber.
5. Enlist various energy efficient technologies. Explain any in detail.
6. Explain building management systems.
7. Explain the concept and importance of HVAC units in green buildings.
8. Explain ethical consideration in sustainable design and construction.
9. Explain the role of professionals in promoting sustainability.
10. Explain the importance of professional responsibility in suitability.
11. Define sustainable building materials and explain their role in reducing the environmental impact of the construction industry.
12. Describe the life cycle assessment (LCA) approach and its significance in selecting sustainable construction materials
13. Compare bamboo, hempcrete, and recycled plastic lumber in terms of their properties, environmental benefits, and limitations.
14. List and explain any five key criteria for selecting sustainable building materials for a green building project.
15. Discuss how Building Management Systems (BMS) contribute to optimizing energy and indoor Environmental quality.