

Energy Conservation and Green Building (315316)

MSBTE Diploma · K-Scheme · Model Question Paper — Set B · Model Answers

How to use: Answers are written point-wise in MSBTE model-answer style. Facts about rating systems (GRIHA, IGBC, LEED), codes (ECBC/ECSBC) and government schemes change from time to time — they are given as on Oct 2026; points marked 'check current version' should be verified from the official website before quoting exact numbers.

Q.1

a) Two objectives of energy conservation.

2 M

1. To reduce wastage of energy and lower energy bills.
2. To save limited fossil fuel resources (coal, oil, gas) for future generations.
3. To reduce greenhouse-gas emissions and air pollution, and so slow down climate change.
4. To reduce peak demand on power plants and improve energy security of the country.

(Any two, 1 M each)

b) Define green building; two salient features.

2 M

Green building: A green building is a building which, in its design, construction, operation, maintenance and demolition, uses less energy, water and materials, produces less waste and pollution, and provides a healthy and comfortable indoor environment for its occupants, thereby reducing its overall impact on the environment.

Salient features:

- **Renewable energy** — roof-top solar PV and solar water heater.
- **Efficient lighting and equipment** — LED lights, daylight sensors, star-labelled appliances, efficient HVAC.
- **Water conservation** — rainwater harvesting, low-flow taps and dual-flush cisterns, recycling of grey water.

(Definition 1 M, any two features 1 M)

c) Four benefits of green building.

2 M

1. Reduced energy use and greenhouse-gas emissions.
2. Conservation of water through efficient fixtures and rainwater harvesting.
3. Lower electricity and water bills (lower operating cost).
4. Better health and comfort of occupants (daylight, fresh air).
5. Higher market/rental value of the building.

(Any four, ½ M each)

d) Meaning of IEQ.

2 M

Indoor Environmental Quality (IEQ) is the quality of the environment inside a building — indoor air quality, thermal comfort, lighting, acoustics and ergonomics — as it affects the health,

comfort and productivity of the occupants.

It includes indoor air quality, thermal comfort, lighting (daylight) and acoustic comfort.

(Meaning 2 M)

e) Two characteristics of bamboo.

2 M

1. Fast-growing grass, harvestable in about 3–5 years (rapidly renewable).
2. High tensile strength-to-weight ratio, light and flexible.
3. Low embodied energy; absorbs CO₂ while growing.

(Any two, 1 M each)

f) Two objectives of green building audit.

2 M

1. To find the present level of energy, water and resource use of the building.
2. To identify wastage and opportunities for saving.
3. To check compliance with codes and rating requirements.
4. To recommend cost-effective improvement measures with payback.

(Any two, 1 M each)

g) Two future trends in green building.

2 M

1. Net-zero energy and net-zero water buildings.
2. Smart buildings using IoT sensors and AI-based building management.
3. Low-carbon materials (geopolymer concrete, CLT, recycled aggregates) and embodied-carbon accounting.
4. Building-integrated photovoltaics (BIPV) and energy storage.

(Any two, 1 M each)

Q.2

a) Four principles of green building.

4 M

1. **Sustainable site design:** select a suitable site, protect top soil and trees, reduce heat-island effect, provide access to public transport.
2. **Energy efficiency and conservation:** orient the building correctly, use passive design, insulation, efficient lighting and HVAC, and renewable energy (solar).
3. **Water efficiency and conservation:** low-flow fixtures, rainwater harvesting, waste-water recycling, drip irrigation and native landscaping.
4. **Materials selection and life cycle:** use local, recycled, rapidly renewable and low-embodied-energy materials; consider the whole life cycle of each material.
5. **Indoor environmental quality (IEQ):** good daylight, fresh air, thermal comfort, low-VOC paints and low noise for health of occupants.
6. **Waste reduction:** reduce, reuse and recycle construction and operational waste; segregation of waste at source.

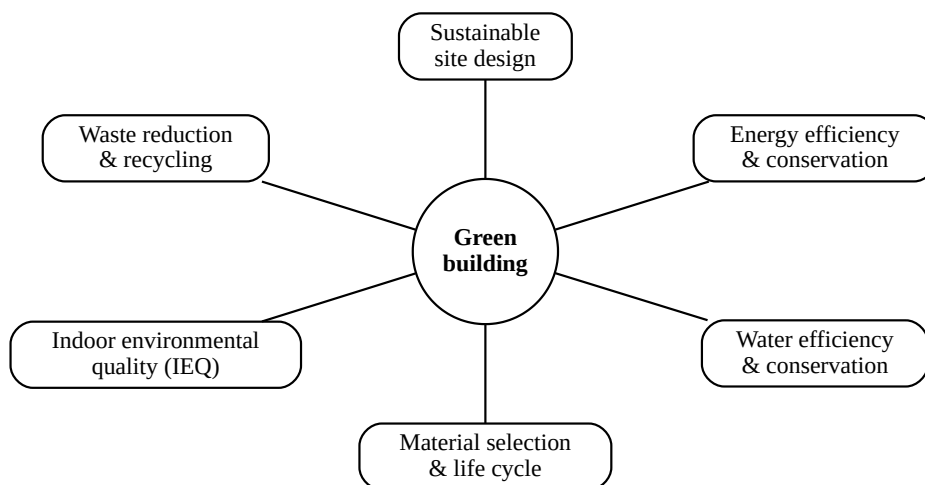


Fig.: Principles of green building

(Any four principles, 1 M each)

b) Sustainable construction — three dimensions.

4 M

Sustainable construction is the planning, design, construction, operation and demolition of buildings in a way that uses resources efficiently and reduces harm to the environment, while being economically viable and socially beneficial over the whole life cycle.

1. **Environmental dimension:** Minimise use of natural resources (land, energy, water, materials), reduce emissions and waste, protect ecology.
2. **Economic dimension:** Keep life-cycle cost low, give value for money, durability and low running cost.
3. **Social dimension:** Provide health, safety and comfort to occupants and workers, respect local culture and community, generate local employment.

Examples — environmental: fly-ash bricks, RWH; economic: life-cycle costing, low running cost; social: safe site, daylight, local labour.

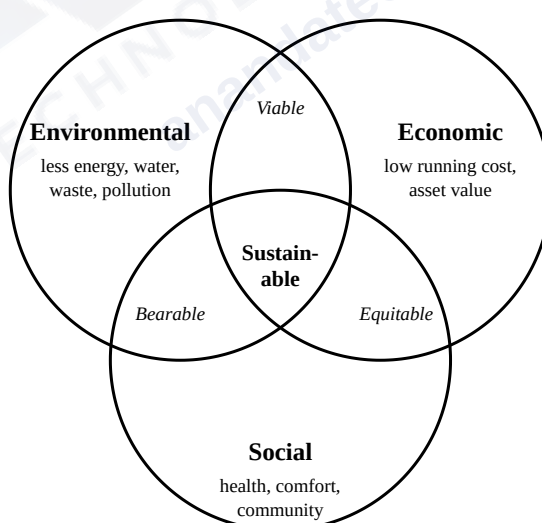


Fig.: Three dimensions of sustainable development / construction

(Definition 1 M, three dimensions 3 M)

c) Energy efficiency and energy conservation in green building.

4 M

Energy efficiency means using less energy to give the same service (e.g. a 20 W LED tube gives about the same light as a 40 W fluorescent tube). **Energy conservation** means avoiding wasteful use of energy by behaviour and controls (e.g. switching off lights in empty rooms). Green buildings use both:

1. **Reduce demand by design:** orientation, shading, insulation, cool roof, daylighting, natural ventilation.
2. **Efficient systems:** LED lighting, BLDC fans, star-rated inverter ACs, efficient pumps and motors with VFDs.
3. **Controls and monitoring:** occupancy/daylight sensors, timers, BMS, sub-metering.
4. **Renewable energy:** roof-top solar PV and solar water heaters meet the remaining demand.
5. **Occupant behaviour:** awareness, AC set-point 24–25 °C, switching off idle equipment.

(Concept 2 M, measures 2 M)

d) Four key provisions of the Energy Conservation Act, 2001.

4 M

1. **Bureau of Energy Efficiency (BEE):** The Act set up BEE (operational from 1 March 2002) under the Ministry of Power as the statutory body to frame policies and programmes for energy efficiency.
2. **Designated consumers:** Energy-intensive users notified under the Act (e.g. thermal power stations, cement, iron & steel, aluminium, fertiliser, textile, pulp & paper, chlor-alkali, railways) must appoint a certified energy manager, get mandatory energy audits done by accredited energy auditors, report energy use and meet the energy-consumption norms given to them.
3. **Standards and labelling:** The Central Government can specify energy-consumption standards for equipment and appliances and make the energy label (star label) compulsory, and can stop the sale of appliances that do not meet the standards.
4. **Energy Conservation Building Code (ECBC):** Energy-efficiency norms for new commercial buildings above a threshold load; State Governments may modify the code for local climate and enforce it.
5. **State Designated Agencies (SDA):** Each State Government designates an agency (in Maharashtra: MEDA) to co-ordinate, regulate and enforce the provisions of the Act in the state.
6. **Energy Conservation Funds:** A Central Energy Conservation Fund and State Energy Conservation Funds for promoting energy-efficiency activities.

(Any four provisions, 1 M each)

Q.3

a) Advantages and limitations of four sustainable materials.

4 M

Material	Advantages	Limitations
Recycled plastic lumber	Does not rot, absorb water or get attacked by termites; needs no painting. Diverts plastic waste from landfills.	Lower stiffness than timber, may sag/creep; expands with heat; not for main structural members.

Fly-ash bricks	Uniform size, smooth finish, less mortar and plaster needed. Saves top soil (unlike burnt clay bricks) and uses industrial waste.	Quality depends on fly ash; lower early strength if poorly cured.
AAC blocks	Good thermal insulation and fire resistance. Reduce dead load and steel in the structure.	Brittle; need special adhesive mortar; absorb water if not plastered.
Cross-laminated timber (CLT)	High strength and dimensional stability; prefabricated, so fast and clean construction. Stores carbon; much lighter than concrete.	Needs sustainably sourced timber; fire and moisture protection required; high cost and limited availability in India.

(Each material 1 M)

b) Importance of HVAC in design and operation of green building.

4 M

At design stage:

1. **Right sizing:** a good envelope and shading reduce the cooling load, so smaller HVAC plant is needed.
2. **Energy-efficient equipment:** high-COP chillers / star-rated or inverter ACs, VFDs on fans and pumps, efficient motors.
3. **Eco-friendly refrigerants:** low ODP and low GWP refrigerants reduce harm to the ozone layer and climate.
4. **Zoning and fresh-air design:** separate zones by use/orientation; fresh-air quantity as per standards for IEQ.

At operation stage:

1. **Controls:** thermostats, CO₂ (demand-controlled) ventilation, occupancy sensors and BMS schedules avoid wastage.
2. **Maintenance:** clean filters and coils, check leaks and commission the system for efficient operation.
3. **Largest energy user:** in air-conditioned buildings HVAC is usually the largest single electricity load, so its efficiency decides the building's energy performance.

(Any four points, 1 M each)

c) Steps in planning an audit for a green building.

4 M

1. **Pre-audit planning:** objectives, scope, team, checklist, collection of past bills and drawings.
2. **Walk-through (preliminary) survey:** quick inspection to understand the building and spot obvious wastage.
3. **Detailed on-site audit / data collection:** measurement of energy, water, lighting levels, temperature, CO₂; interviews and observation.
4. **Analysis:** compare data with benchmarks (EPI, norms), find losses and saving potential.
5. **Recommendations:** list of measures with cost, saving and payback period.
6. **Reporting:** audit report and presentation to management.
7. **Implementation and follow-up:** corrective actions, monitoring and re-audit for continuous improvement.

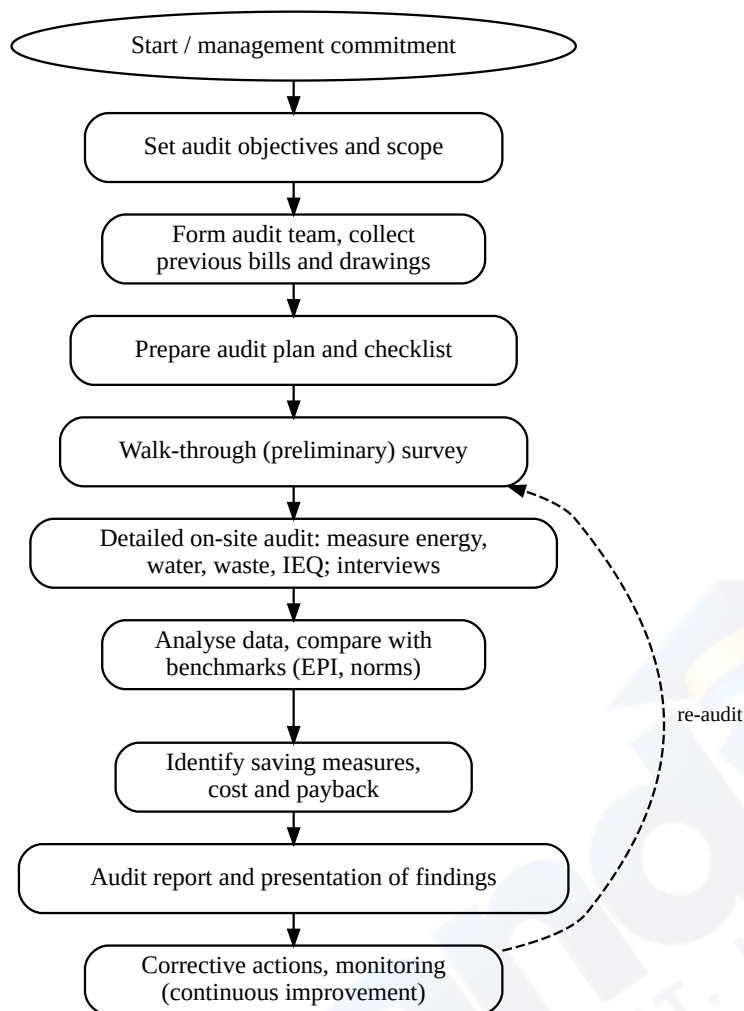


Fig.: Steps of a green building audit (flow chart)

(Steps 3 M, flow chart 1 M)

d) Data collection methods in green building audit.

4 M

1. **Document review:** study of electricity and water bills (at least 12 months), drawings, equipment specifications, maintenance logs, previous audit reports.
2. **Interviews:** discussions with owner, facility manager, electricians, housekeeping staff and occupants about operation hours, problems and practices.
3. **Observation / walk-through:** physical inspection with checklist and photographs — lights left ON, leaking taps, condition of insulation, waste segregation.
4. **Measurement / instrumentation:** portable instruments — power analyser (kW, kWh, power factor), lux meter, thermometer and hygrometer, CO₂ meter, water flow meter, thermal camera.
5. **Surveys / questionnaires:** occupant comfort surveys about temperature, light, noise and air quality.
6. **Metering / BMS data:** data from sub-meters and BMS trends of energy and water use.

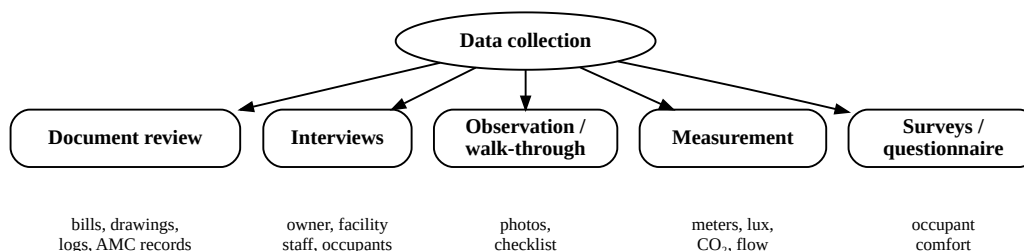


Fig.: Data collection methods in a green building audit

(Any four methods, 1 M each)

Q.4

a) GRIHA vs IGBC on four bases.

4 M

Sr.	Basis	GRIHA	IGBC
1	Original development	Developed by TERI (The Energy and Resources Institute) with MNRE; adopted as the national rating system in 2007; now run by GRIHA Council.	Set up in 2001 by CII (Confederation of Indian Industry); industry-led council.
2	Rating validity	Usually stated as 5 years (performance data to be submitted after occupancy).	Usually stated as 3 years, after which re-certification is needed (check rating version).
3	Certification levels	1 to 5 stars (★ to ★★★★★) according to points scored.	Certified, Silver, Gold, Platinum (points per level depend on the rating type/version).
4	Area of assessment	Sections such as site planning, construction management, energy optimisation, occupant comfort, water, solid waste, materials, life-cycle costing, socio-economic strategies, performance monitoring.	Categories such as sustainable architecture & design, site selection & planning, water conservation, energy efficiency, building materials & resources, IEQ, innovation.

Note: Validity periods are as commonly stated in textbooks; they depend on the rating type and version — check the current manual.

(Each basis 1 M)

b) Role of MNRE in promoting renewable energy in buildings.

4 M

- Nodal ministry** of Government of India for all matters of new and renewable energy — solar, wind, small hydro, bio-energy, green hydrogen. (Set up as Ministry of Non-Conventional Energy Sources in 1992; renamed MNRE in 2006.)
- Schemes and financial support:** subsidies/central financial assistance, e.g. roof-top solar programme (PM Surya Ghar: Muft Bijli Yojana, 2024), PM-KUSUM for solar pumps (scheme names as on 2026 — check MNRE website).
- Solar water heaters and roof-top solar** on residential, institutional and commercial buildings promoted through schemes, awareness and approved vendors.

4. **Promotion of green buildings:** supported development of GRIHA with TERI; promotes solar water heaters and solar systems in buildings.
5. **Research and development:** through national institutes — NISE (solar), NIWE (wind), NIBE (bio-energy).
6. **Implementing and financing agencies:** SECI (Solar Energy Corporation of India) and IREDA (finance) work under MNRE.

(Any four roles, 1 M each)

c) LEED criteria for operation and maintenance.

4 M

LEED O+M (Operations and Maintenance) rates **existing, occupied buildings** on their actual performance (measured data, typically 12 months) — not only design. Criteria:

1. **Location and Transportation:** track and reduce commuting by car; promote public transport, cycling, car-pooling.
2. **Sustainable Sites:** site management plan, rainwater management, heat-island reduction, light-pollution reduction, integrated pest management.
3. **Water Efficiency:** measure total water use (meters), indoor water-use reduction, cooling-tower and irrigation water management.
4. **Energy and Atmosphere:** energy-efficiency best practices, minimum energy performance (benchmark e.g. ENERGY STAR score), building-level energy metering, refrigerant management, renewable energy, ongoing commissioning.
5. **Materials and Resources:** purchasing policy for green products, solid-waste management policy, waste performance (diversion from landfill).
6. **Indoor Environmental Quality:** minimum fresh-air ventilation, no-smoking policy, green cleaning, occupant comfort survey, thermal comfort and lighting quality.
7. **Innovation and Regional Priority:** extra points for innovative operation practices and regional issues.

Levels: Certified, Silver, Gold, Platinum. Performance must be re-verified periodically to keep the certification.

Note: Credit names and scoring differ between LEED v4, v4.1 and v5 (released 2025).

(Any four criteria, 1 M each)

d) Role of MEDA in energy conservation.

4 M

1. **About:** Maharashtra Energy Development Agency, set up in 1985 by the Government of Maharashtra (head office Pune), works as the **State Designated Agency (SDA)** under the Energy Conservation Act, 2001 and as the **state nodal agency for renewable energy**.
2. **Enforcing the EC Act in the state:** co-ordinates with BEE, monitors designated consumers, promotes ECBC for buildings in Maharashtra.
3. **Energy audits:** promotes and supports energy audits of government buildings, municipal bodies, industries and institutions.
4. **Municipal energy efficiency (in the city):** energy-efficient street lights, efficient water-pumping systems, solar systems on municipal buildings.

5. **Renewable energy promotion:** roof-top solar, solar water heaters, solar pumps, wind, small hydro, biomass and bagasse co-generation projects; implements state and MNRE schemes.
6. **Awareness and training:** Energy Conservation Week, seminars, training programmes for engineers and students.

(Any four roles, 1 M each)

e) Audit steps applied to water efficiency of a hospital.

4 M

1. **Plan:** objective — reduce water use per bed; scope — wards, OT, laundry, kitchen, HVAC cooling tower, garden; team with plumber and facility manager; checklist and flow meter.
2. **Collect data:** 12 months of water bills / tanker records, meter readings, number of beds and staff, drawings of plumbing; interviews with housekeeping and laundry staff.
3. **Walk-through and measurement:** check leaking taps, overflowing tanks, running cisterns; measure flow of taps and showers; check RO reject water and cooling-tower bleed-off.
4. **Analyse:** calculate litres per bed per day and compare with norms / previous years; find major users (laundry, cooling tower).
5. **Recommend:** repair leaks, aerators and sensor taps, dual-flush cisterns, reuse RO reject and treated water (STP) for flushing/gardening, rainwater harvesting, sub-meters.
6. **Report and follow-up:** report with cost and payback; monitor monthly water use after implementation.

(Any four steps applied, 1 M each)

Q.5

a) Building envelope and its key components.

6 M

Building envelope is the physical separator between the conditioned interior of a building and the outside environment. It consists of walls, roof, windows, doors, floor and foundation. It controls the flow of heat, air, moisture, light and noise, and so it largely decides the heating/cooling load of the building.

Key components:

1. **Walls:** insulated or cavity walls, AAC blocks; reduce heat gain through conduction.
2. **Roof:** roof insulation, cool-roof (high-reflectance) coating or green roof; the roof gets maximum sun in Indian climate.
3. **Windows and glazing:** double glazing, low-E glass with low SHGC, proper window-to-wall ratio, shading.
4. **Doors:** well-fitted, insulated doors with weather stripping.
5. **Floor and foundation:** insulation and damp-proofing below floor where needed.
6. **Air sealing:** sealing gaps around windows, doors, ducts and pipes to stop air leakage (infiltration).

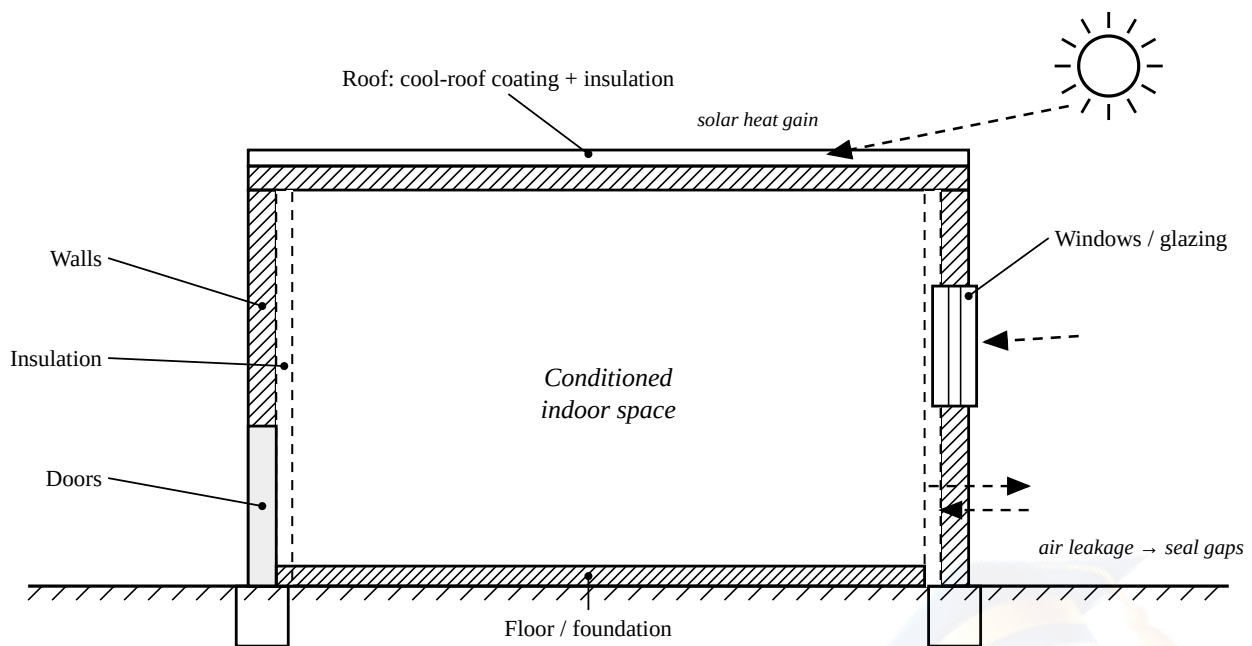


Fig.: Building envelope — components and heat flow paths

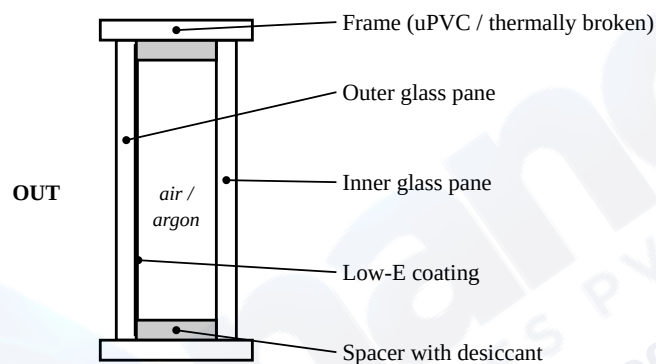


Fig.: Double-glazed window unit (section)

(Explanation 2 M, components 2 M, sketch 2 M)

b) Roof-top rainwater harvesting — sketch and calculation.

6 M

Rainwater harvesting (RWH) is collecting and storing rainwater falling on roofs and paved areas for later use or for recharging the ground water.

Components: catchment (roof) → gutters → down-pipe → first-flush device (rejects the first dirty rain) → filter (sand, gravel, charcoal) → storage tank, and overflow to recharge pit / bore well.

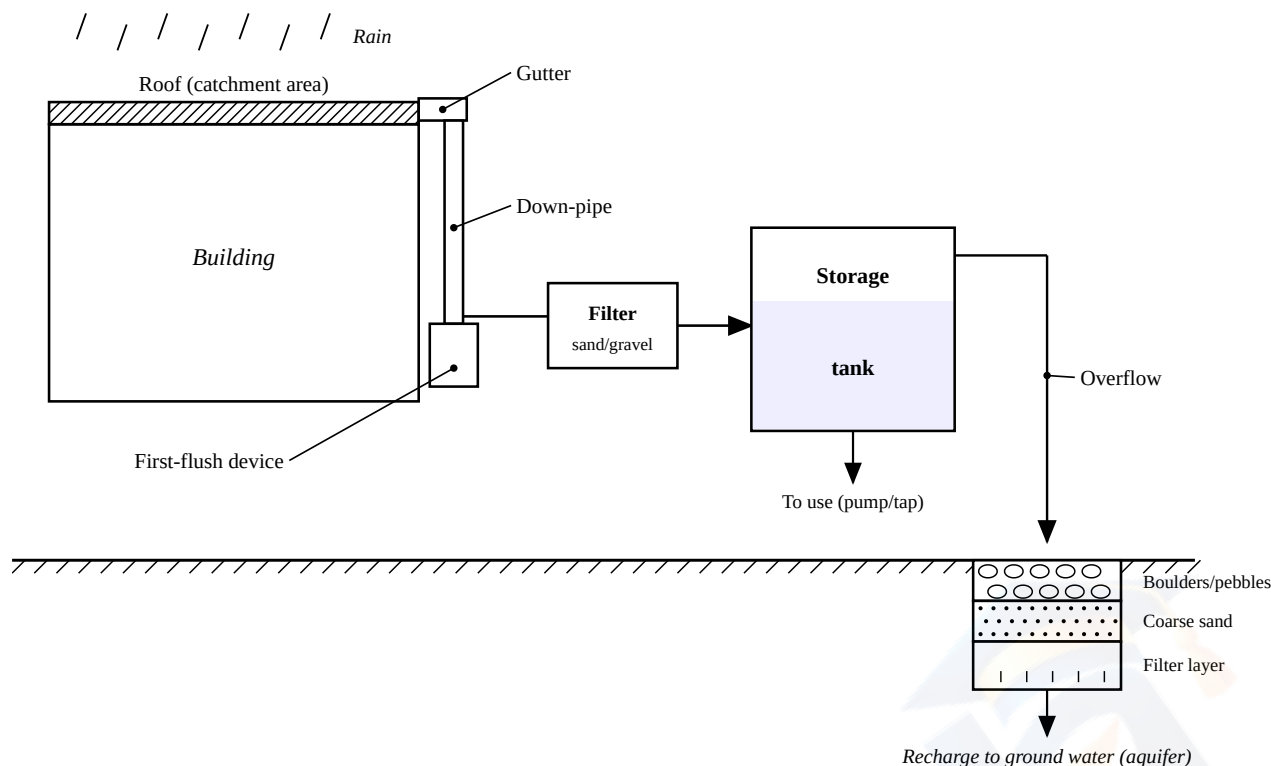


Fig.: Roof-top rainwater harvesting system

Calculation: Harvestable water $V = \text{Catchment area} \times \text{Annual rainfall} \times \text{Runoff coefficient}$

$$V = 450 \text{ m}^2 \times 0.750 \text{ m} \times 0.85 = \mathbf{286.88 \text{ m}^3} = \mathbf{2,86,875 \text{ litres per year}}$$

$$\text{Daily demand} = 60 \text{ students} \times 45 \text{ L} = 2,700 \text{ L/day}$$

$$\text{Number of days} = 2,86,875 \div 2,700 = \mathbf{106.2 \text{ days} \approx 106 \text{ days}}$$

So the roof water can meet the flushing and gardening demand for about three and a half months, saving the same quantity of municipal / bore-well water.

(Explanation 1 M, sketch 2 M, calculation 3 M)

c) Sample checklist for auditing a green building.

6 M

Green Building Audit Checklist — Building: _____ Date: _____ Auditor: _____

Area	Check point	Status	Remarks
Energy	Monthly kWh and bill (12 months) collected?	☐ Yes ☐ No	
	Lights / fans OFF in empty rooms?	☐ Yes ☐ No	
	Type of lamps (LED / CFL / tube)	☐ Yes ☐ No	
	AC set-point and star rating	☐ Yes ☐ No	
	Solar PV / solar water heater present?	☐ Yes ☐ No	
Water	Monthly water consumption recorded?	☐ Yes ☐ No	
	Leaking taps / pipes?	☐ Yes ☐ No	
	Low-flow fixtures and dual-flush?	☐ Yes ☐ No	
	Rainwater harvesting working?	☐ Yes ☐ No	
	Waste-water recycling?	☐ Yes ☐ No	

IEQ	Daylight adequate (lux)?	☐ Yes ☐ No	
	Cross-ventilation / fresh air?	☐ Yes ☐ No	
	Low-VOC paints used?	☐ Yes ☐ No	
	Thermal comfort complaints?	☐ Yes ☐ No	
	Noise level acceptable?	☐ Yes ☐ No	
Waste	Segregation at source?	☐ Yes ☐ No	
	Composting of organic waste?	☐ Yes ☐ No	
	E-waste disposal through authorised recycler?	☐ Yes ☐ No	
	Construction waste reused?	☐ Yes ☐ No	
Site / materials	Trees and green cover %	☐ Yes ☐ No	
	Permeable paving / green roof?	☐ Yes ☐ No	
	Local / recycled materials?	☐ Yes ☐ No	
	Parking for cycles / EV?	☐ Yes ☐ No	

The checklist is filled during the walk-through survey; 'No' items become the basis of recommendations.

(Proper format with at least five areas, 6 M)

Q.6

a) Functions of BEE and its benefits.

6 M

Functions:

- 1. Statutory body** under the Ministry of Power, set up on 1 March 2002 under the Energy Conservation Act, 2001, to reduce the energy intensity of the Indian economy.
- 2. Standards and Labelling (S&L) programme:** star labels (1 to 5 stars) for appliances such as ACs, refrigerators, fans, LED lamps, motors; mandatory for several appliances.
- 3. Building codes:** Energy Conservation Building Code (ECBC 2007, updated 2017) for commercial buildings; Eco-Niwas Samhita (2018) for residential buildings; the Energy Conservation and Sustainable Building Code (ECSBC) after the 2022 amendment (check latest notification); star rating of existing buildings.
- 4. Industry:** PAT (Perform, Achieve and Trade) scheme for designated consumers; energy audits and energy managers.
- 5. Certification:** national examination for energy managers and energy auditors; accreditation of energy auditors.
- 6. Demand-side management** programmes for municipalities, agriculture and SMEs.

Benefits in energy efficiency:

1. Consumers can choose efficient appliances easily using star labels — lower bills.
2. Lower energy demand reduces need for new power plants and fuel imports (energy security).
3. Reduction in CO₂ emissions.

4. Energy-efficient buildings through ECBC — lower operating cost.

(Functions 4 M, benefits 2 M)

b) How rating systems contribute to long-term sustainability.

6 M

1. **Set clear performance targets** for energy, water, materials, waste and IEQ at design stage, so sustainability is built in from the start.
2. **Life-cycle thinking:** credits for life-cycle cost, durable and recycled materials, reduce long-term resource use.
3. **Third-party verification and commissioning** make sure the systems actually work as designed.
4. **Metering and monitoring:** credits for sub-meters and performance reporting keep track of consumption during the whole life.
5. **Re-certification / validity period** forces owners to maintain performance (e.g. LEED O+M, GRIHA performance data).
6. **Occupant health and comfort** requirements improve well-being and productivity throughout use.
7. **Market value and awareness:** recognition motivates owners to keep the building green; creates trained professionals and green products market.
8. **Climate resilience:** credits for renewable energy, RWH and site design make buildings less dependent on scarce resources.

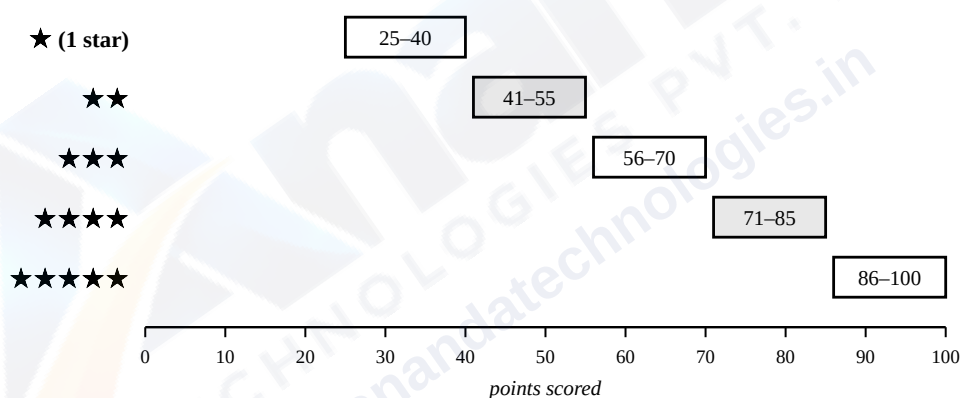


Fig.: GRIHA star rating thresholds (points) — v2015/v2019; check current version

(Any six points, 1 M each)

c) Sustainable site design strategies.

6 M

1. **Site selection:** avoid ecologically sensitive land, flood-prone areas and prime agricultural land; prefer developed sites near public transport and services.
2. **Preserve top soil and existing trees:** store top soil during excavation and reuse it for landscaping; transplant trees if unavoidable.
3. **Building orientation and layout:** long axis East–West, use of prevailing wind and daylight, minimum disturbance to natural contours.
4. **Reduce heat-island effect:** trees, green roofs, high-reflectance (cool) roofs and light-coloured or open-grid paving.

5. **Storm-water management:** permeable paving, swales, rainwater harvesting and recharge pits to reduce run-off.
6. **Erosion and sedimentation control during construction:** silt fences, sedimentation basins, covering of stockpiles.
7. **Native landscaping:** drought-tolerant local plants with drip irrigation.
8. **Reduce light pollution:** outdoor lights directed downwards, with timers.
9. **Transport:** pedestrian paths, cycle stands, EV charging and limited parking to reduce car use.

(Any six strategies, 1 M each)

Note: This is a **model question paper prepared by Ananda Technologies** only for practice and exam preparation, based on the pattern of previous MSBTE question papers and the K-scheme syllabus. It is **not an official MSBTE paper**, and it does **not** mean that these questions will come in the exam. Answers follow standard textbook points; marks shown are indicative. Free for students — anandatechnologies.in