MAH M Arch CET Building Technology Sample Paper — 3

Questions: 10	**Duration:** 12 min	**Max Marks:** 20	**Mode:** CBT

Instructions

- This paper contains **10 multiple-choice questions (MCQs)**, each with four options (A–D).
- Each correct answer carries **+2 marks**. There is **no negative marking**.
- Only **one** option is correct per question; do not mark more than one.
- Total duration: **12 minutes** (approximately 72 seconds per question).
- In the actual examination, responses are recorded on a **Computer-Based Test (CBT)** platform.

Section: Building Technology

Q1. Cross-Laminated Timber (CLT) is a mass timber product increasingly used for structural floors, walls, and roofs. Which of the following correctly describes the **key structural principle** of CLT that distinguishes it from conventional sawn timber?

(A) All timber layers in CLT are oriented with the grain running in the *same* direction, maximising strength along one axis.

(B) CLT panels can only be used as flooring elements and are unsuitable for wall or roof construction due to their low shear resistance.

(C) Adjacent layers in CLT are stacked with their grain at **right angles** to each other, providing structural strength and dimensional stability in *both* principal directions.

(D) CLT has lower structural performance than conventional solid timber of the same cross-sectional thickness because of the adhesive bond planes.

Q2. Which of the following properties **most significantly** differentiates Autoclaved Aerated Concrete (AAC) blocks from traditional burnt clay bricks in building construction?

(A) AAC blocks have a much **lower density** (approximately 500–700 kg/m^3) compared to clay bricks (approximately 1800–2000 kg/m^3), making them lighter and offering superior thermal insulation.

(B) AAC blocks have a higher compressive strength per unit volume than clay bricks, making them the preferred choice for high-load-bearing masonry walls.

(C) AAC blocks absorb less water than clay bricks, resulting in lower mortar consumption and reduced need for surface plastering.

(D) AAC blocks are fired in kilns at temperatures exceeding 1200 °C, which is significantly higher than the curing temperature used for clay bricks.

Q3. Which waterproofing system operates through a **chemical reaction with the concrete substrate**—producing insoluble crystalline compounds that permanently block capillary pores and hairline cracks throughout the concrete depth, including on the negative (wet-side) face?

(A) Torch-on bituminous felt membrane

(B) Self-adhesive HDPE (High-Density Polyethylene) waterproofing sheet

(C) Liquid-applied polyurethane elastomeric coating

(D) Crystalline (cementitious reactive) waterproofing treatment

Q4. A **raft (mat) foundation** is most appropriately selected over individual pad footings or pile foundations in which of the following site conditions?

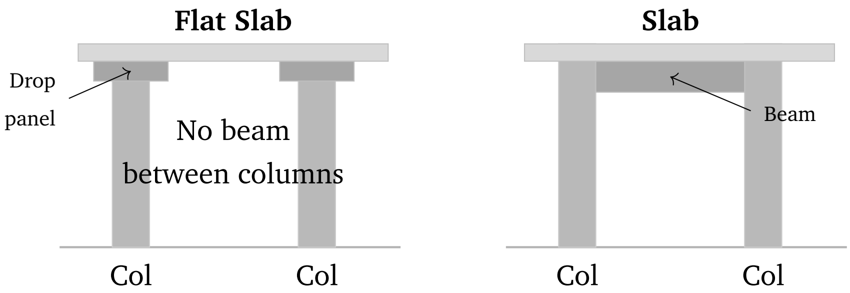
(A) The underlying bedrock is at shallow depth (within 1 m of the surface) and possesses very high safe bearing capacity.

(B) The soil has **low or non-uniform bearing capacity** and the combined footprint of individual column footings would cover more than 50% of the building plan area.

(C) The structural loads are large and concentrated at a few isolated column points, demanding deep load transfer.

(D) Rock strata suitable for end-bearing are encountered within 3 m of the finished ground level.

Q5. The diagram below shows cross-sections of a **flat slab** system and a **conventional beam-slab** system. Which structural failure mode is a *primary design concern unique to the flat slab system* that does *not* arise in the conventional beam-slab system?



(i) Flat Slab System **(ii) Conventional Beam-Slab System**

(A) Bending moment at mid-span of the slab panel

(B) Torsion in edge beams along the building perimeter

(C) **Punching shear** failure at the column-to-slab interface

(D) Excessive deflection at the mid-span of the primary beams

Q6. The **Indian Green Building Council (IGBC)** rating system provides certification for green buildings across a range of typologies (homes, factories, townships, campuses, etc.). Which organisation administers the IGBC?

(A) Bureau of Energy Efficiency (BEE), under the Ministry of Power, Government of India

(B) The Energy and Resources Institute (TERI), New Delhi

(C) National Buildings Construction Corporation (NBCC), a Government of India enterprise

(D) Confederation of Indian Industry (CII), headquartered in Hyderabad at the CII–Sohrabji Godrej Green Business Centre

Q7. The Bureau of Energy Efficiency (BEE) uses the **Energy Performance Index (EPI)** to benchmark and star-rate commercial buildings (offices, hotels, hospitals, retail complexes). In which **unit** is the EPI expressed?

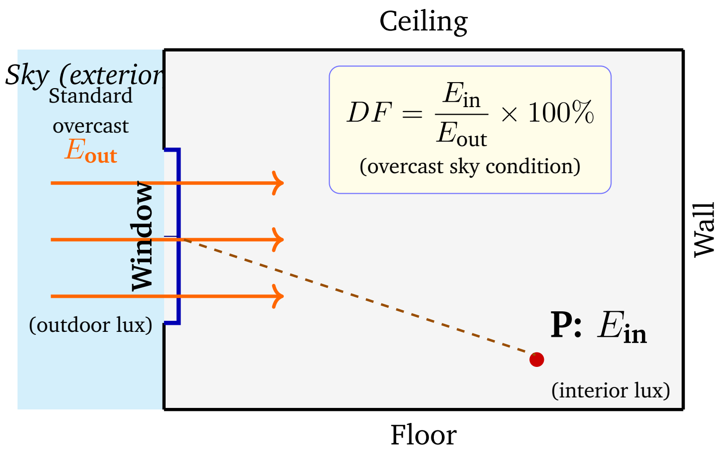
(A) Kilowatt-hours per square metre per year (kWh/m^2/year)

(B) Kilowatts per square metre (kW/m^2)

(C) Megajoules per kilogram (MJ/kg)

(D) Watts per metre-kelvin (W/m·K)

Q8. The diagram below illustrates the **Daylight Factor (DF)** concept for a room with a window on one wall. Which of the following correctly **defines** the Daylight Factor at an interior reference point P?



(A) The ratio of indoor illuminance to simultaneous outdoor illuminance measured under a *clear (sunny) sky*, expressed as a percentage.

(B) The ratio of indoor illuminance at a reference point to the simultaneous unobstructed outdoor horizontal illuminance under a **standard CIE overcast sky**, expressed as a percentage.

(C) The total illuminance level (in lux) measured at the geometric centre of the room on a bright sunny day at solar noon.

(D) The window-to-floor area ratio multiplied by the visible light transmittance (VLT) of the glazing, expressed as a dimensionless coefficient.

Q9. In passive building ventilation design, the **stack effect** (chimney effect) is a buoyancy-driven air movement mechanism. Which physical phenomenon **primarily drives** the stack effect?

(A) Positive wind pressure on the windward façade forcing fresh air into the low-level inlet openings.

(B) Mechanical exhaust fans creating a sustained negative pressure zone at high-level outlet vents, drawing air upward.

(C) The **temperature difference** between warmer, less-dense indoor air and cooler outdoor air causes the indoor air to rise and escape through high-level openings, drawing cooler air in through low-level inlets.

(D) Cross-ventilation through aligned openings on opposite walls at approximately the same floor level, driven by pressure difference across the building envelope.

Q10. In building plumbing, an **indirect water supply system** incorporates an Overhead Storage Tank (OHT) positioned above the highest served floor. What is the **primary functional purpose** of the OHT in this system?

(A) To heat the incoming cold water using solar energy before distributing it to sanitary fixtures.

(B) To filter sediment, chlorine, and biological contaminants from the municipal main supply before distribution.

(C) To directly boost municipal supply pressure in the rising main so that upper floors receive adequate flow rate.

(D) To provide a **buffer storage** that supplies water by **gravity** to all fixtures at consistent pressure, independent of municipal supply pressure fluctuations or temporary interruptions.

Detailed Solutions

Sol. 1.

Solution

Difficulty: Intermediate • Chapter: Timber Construction — CLT and Mass Timber

Quick Solution: CLT = alternating timber layers bonded at 90° — each layer perpendicular to the next. Cross-lamination provides two-way structural strength and stiffness, unlike Glulam (single direction). **Answer: (C).**

Concept — Cross-Laminated Timber (CLT): CLT is an engineered mass timber product composed of an odd number of layers (typically 3, 5, or 7) of kiln-dried solid timber boards. The defining manufacturing characteristic is that each successive layer is glued at **90°** to the adjacent layer (cross-lamination). This orthogonal arrangement gives CLT structural strength and stiffness in *both* the longitudinal and transverse directions, unlike conventional sawn timber, LVL (Laminated Veneer Lumber), or Glulam, which are predominantly strong along one grain axis.

Key attributes of CLT:

- High strength-to-weight ratio; large prefabricated panels for rapid on-site erection.
- Good dimensional stability — cross-lamination resists shrinkage and warping.
- Applicable for floors, load-bearing walls, and roof diaphragms (two-way spanning).
- Favourable fire behaviour — large cross-sections char predictably (char rate ≈0.7 mm/min for softwood).

Why other options are wrong:

- **Option A:** Same-direction grain is the description of LVL or Glulam, not CLT; CLT specifically requires cross-laminated layers.
- **Option B:** CLT panels are extensively used for wall, roof, and floor elements in multi-storey mass timber construction worldwide.
- **Option D:** The cross-lamination and adhesive bonds *enhance* performance; CLT typically out-performs conventional solid timber of equivalent thickness.

Final Answer: CLT layers are bonded at right angles, providing bi-directional strength ⇒ $\boxed{\text{C}}$

Answer: (C) Go Back to Q1

Sol. 2.

Solution

Difficulty: Intermediate • Chapter: Masonry — AAC Blocks vs Clay Bricks

Quick Solution: AAC density ≈500–700 kg/m^3 vs clay brick ≈1 800–2 000 kg/m^3; thermal conductivity ≈0.15 vs ≈0.75 W/m·K. AAC is dramatically lighter and a far superior thermal insulator. **Answer: (A).**

Concept — AAC Blocks vs. Traditional Clay Bricks: Autoclaved Aerated Concrete (AAC) is manufactured by aerating a slurry of Portland cement, lime, fly ash (or sand), and aluminium powder. The aluminium reacts with lime to release hydrogen bubbles, creating a cellular pore structure. The product is then cured in a high-pressure autoclave at approximately 180 °C and 8–12 bar. This process yields a product with a very large proportion of entrapped air pores.

Comparative properties:

- **Density:** AAC ≈ 500–700 kg/m^3; Clay brick ≈ 1800–2000 kg/m^3 (AAC is 3–4× lighter).
- **Thermal conductivity:** AAC ≈ 0.12–0.20 W/m·K vs. clay brick ≈ 0.6–0.9 W/m·K — AAC is a far superior insulator.
- **Compressive strength:** AAC 2–6 N/mm^2; clay brick 3.5–17.5 N/mm^2 (brick is generally stronger in absolute terms).
- **Water absorption:** AAC is more porous and absorbs more water than clay bricks; it requires rendering or plaster for weather protection.

Why other options are wrong:

- **Option B:** Clay bricks generally have higher compressive strength per unit cross-section.
- **Option C:** AAC absorbs *more* water than clay bricks due to its porous structure, not less.
- **Option D:** Autoclaving is at ≈180 °C; kiln-firing of clay bricks is at 900–1100 °C — clay bricks require the higher manufacturing temperature.

Final Answer: The most significant differentiator is AAC's much lower density and resulting thermal insulation advantage ⇒ $\boxed{A}$

Answer: (A) Go Back to Q2

Sol. 3.

Solution

Difficulty: Advanced • Chapter: Waterproofing — Crystalline and Membrane Systems

Quick Solution: Crystalline waterproofing penetrates concrete and reacts with $Ca(OH)_2$ to form insoluble C-S-H crystals inside capillary pores. Other systems (bitumen, HDPE, PU) form surface barriers only. **Answer: (D).**

Concept — Waterproofing Systems: Different waterproofing technologies function through fundamentally different mechanisms:

Classification by mechanism:

- **Bituminous membrane (torch-on or self-adhesive):** A pre-formed mat of bitumen-impregnated fabric bonded to the concrete surface. Acts as a physical barrier; no chemical reaction with the substrate.
- **HDPE/EPDM sheet:** Mechanically anchored or fully adhered impermeable sheet; again a surface barrier with no chemical reaction inside the concrete.
- **Liquid-applied polyurethane (PU) coating:** Applied as a liquid that cures to a seamless elastomeric film at the surface. Accommodates movement/cracks through flexibility; no pore crystallisation.
- **Crystalline waterproofing:** Contains Portland cement, silica sand, and proprietary reactive chemicals (alkali metal silicates, amine complexes). When wet, these chemicals diffuse into the concrete and react with $Ca(OH)_2$ and unhydrated cement particles to form insoluble calcium silicate hydrate (C-S-H) crystals that permanently fill capillary pores and micro-cracks. It is active (self-sealing), can be applied to positive or *negative* (blind-side) faces, and remains effective throughout the structure's life.

Why other options are wrong:

- **Option A:** Torch-on bituminous membrane forms a surface barrier; no crystal growth inside concrete.
- **Option B:** HDPE sheet is a physical membrane; no chemical interaction with concrete porosity.
- **Option C:** PU coating cures to an elastic surface film; it does not penetrate and crystallise within the concrete mass.

Final Answer: Crystalline treatment creates insoluble crystals inside concrete pores $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q3

Sol. 4.

Solution

Difficulty: Intermediate • Chapter: Foundation Types — Raft Foundation

Quick Solution: Raft = continuous RC slab over full plan. Selected when soil has low/variable bearing capacity or individual footings cover >50% of plan area. Piles required only when soft soil extends to great depth. **Answer: (B).**

Concept — Raft (Mat) Foundation: A raft foundation is a large, continuous reinforced concrete slab (or ribbed slab) that covers the entire plan area of a structure. By spreading the total structural load over the maximum possible ground contact area, it reduces the unit bearing pressure on the soil to a level the soil can safely sustain.

When a raft is the appropriate choice:

- Soil with **low or variable safe bearing capacity** (soft clays, silts, fills, waterlogged ground) where individual pad footings would be excessively large.
- When the sum of individual column footings would cover >50% of the building plan area — a continuous raft becomes more economical and structurally efficient.
- Where differential settlement must be controlled across the plan.
- As a combined structural-waterproofing basement slab ("tanked" raft).

Raft vs. pile foundation: Piles are preferred when a competent load-bearing stratum is deep (>4–5 m) and a raft cannot mobilise adequate resistance at the surface.

Why other options are wrong:

- **Option A:** Shallow bedrock with high capacity $\Rightarrow$ shallow pad or strip footings suffice; a raft would be over-designed.
- **Option C:** Concentrated, very high loads at isolated points favour piles or caissons transferring load to deep strata.
- **Option D:** Rock at <3 m depth favours pad footings bearing directly on rock, or short rock-socketed piles.

Final Answer: Raft is chosen when soil has low/non-uniform capacity and footings cover >50% of plan $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q4

Sol. 5.

Solution

Difficulty: Intermediate • Chapter: Structural Systems — Flat Slab Design

Quick Solution: In flat slabs, load transfers directly from slab to column with no beams. This concentrates shear around the column perimeter, creating risk of punching-shear (two-way shear) failure unique to flat slabs. **Answer: (C).**

Concept — Flat Slab: Punching Shear: In a **conventional beam-slab** system, the slab transfers its load to the beams along the full beam length; the beams then transfer to columns. The slab-to-beam interface is distributed, so no concentrated shear exists at a single point.

In a **flat slab** system, the slab transfers its load *directly* to column heads over a small perimeter zone. This creates a large concentrated shear force acting on the slab cross-section around the column perimeter — the mechanism by which the column can "punch through" the slab, known as **punching shear** (two-way shear) failure.

Design response to punching shear in flat slabs:

- **Drop panels:** local thickening of the slab above each column (visible in diagram (i)) increases effective depth, lowering punching shear stress.
- **Column capitals:** flared column heads that enlarge the effective shear perimeter.
- **Shear reinforcement:** shear studs or bent-up bars around columns.

Why other options are wrong:

- **Option A:** Mid-span bending moment is a design requirement in *both* flat slab and beam-slab systems.
- **Option B:** Torsion in perimeter edge beams is a concern in beam-slab systems (spandrel beams), not in flat slabs (which have no edge beams by definition).
- **Option D:** Excessive mid-span beam deflection is a concern in beam-slab systems; flat slabs have no beams.

Final Answer: Punching shear at the column-slab junction is unique to flat slab systems $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q5

Sol. 6.

Solution

Difficulty: Beginner • Chapter: Green Building Rating Systems — IGBC

Quick Solution: IGBC (Indian Green Building Council) was founded in 2001 as a constituent body of the Confederation of Indian Industry (CII). It administers LEED India and other green rating programmes. **Answer: (D).**

Concept — Indian Green Building Council (IGBC): The IGBC was established in 2001 as a constituent of the **Confederation of Indian Industry (CII)**. It is headquartered at the CII–Sohrabji Godrej Green Business Centre in Hyderabad — itself a LEED Platinum landmark. IGBC's mission is to enable a sustainable built environment across India by developing India-specific rating systems, training, and advocacy.

IGBC rating programmes (examples):

- IGBC Green Homes
- IGBC Green Factory Buildings
- IGBC Green Townships
- IGBC Green Campus
- IGBC Green Healthcare

How IGBC differs from other organisations:

- **GRIHA** (Green Rating for Integrated Habitat Assessment) — developed and administered by TERI (The Energy and Resources Institute) in partnership with MoHUA; adopted as India's national rating system.
- **BEE** — administers energy star labelling and the EPI-based star rating for buildings; it is *not* a comprehensive green building rating authority.
- **NBCC** — a construction company (PSU); it does not administer ratings.

Why other options are wrong:

- **Option A:** BEE rates energy performance only; IGBC is a broader sustainability certification.
- **Option B:** TERI administers GRIHA, not IGBC.
- **Option C:** NBCC is a government construction agency, not a rating body.

Final Answer: IGBC is administered by the Confederation of Indian Industry (CII) $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q6

Sol. 7.

Solution

Difficulty: Beginner • Chapter: Building Energy Efficiency — EPI and ECBC

Quick Solution: EPI = total annual energy consumption ÷ conditioned floor area, expressed in kWh/m²/year. Lower EPI = better energy performance. Used by BEE/ECBC to benchmark and rate commercial buildings. **Answer: (A).**

Concept — Energy Performance Index (EPI): The EPI is defined as the **total annual energy consumption** of a building (all end-uses: HVAC, lighting, plug loads, lifts, etc.) divided by its conditioned floor area:

$$EPI = \frac{\text{Total annual energy consumption (kWh)}}{\text{Conditioned floor area (m}^2\text{)}} \longrightarrow \mathbf{kWh/m^2/year}$$

How BEE uses EPI: BEE has established EPI benchmarks for different commercial building types (offices, hotels, hospitals, retail malls) and climate zones. Buildings that achieve an EPI at or below the benchmark receive star ratings (1 to 5 stars); a **lower EPI indicates better energy efficiency**. The star label programme was launched in 2007 and is periodically updated.

Context: EPI ranges for office buildings (illustrative):

- 5-star: EPI $\leq 70\,\text{kWh/m}^2\text{/year}$
- 1-star: EPI $\leq 150\,\text{kWh/m}^2\text{/year}$
- (Values vary by building type and climate zone)

Why other options are wrong:

- **Option B:** kW/m^2 is instantaneous electrical power density — not an annual performance index.
- **Option C:** MJ/kg is the unit for specific calorific value or specific enthalpy of fuel/refrigerants.
- **Option D:** W/m·K is thermal conductivity (λ-value) of materials, unrelated to building energy performance.

Final Answer: EPI is expressed in kWh/m^2/year $\Rightarrow \boxed{\text{A}}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q7

Sol. 8.

Solution

Difficulty: Intermediate • Chapter: Daylighting and Fenestration — Daylight Factor

Quick Solution: DF = (indoor illuminance ÷ outdoor illuminance) × 100%. Here DF = (150 ÷ 5000) × 100 = 3%. DF of 2–5% is adequate for task areas per daylighting standards. **Answer: (B).**

Concept — Daylight Factor (DF): The Daylight Factor is a dimensionless quantity that expresses how much daylight a point inside a room receives relative to what is available outdoors. The standard measurement condition is the **CIE standard overcast sky** (not a clear sky), which provides a reproducible, orientation-independent and time-independent reference.

Definition:

$$DF = \frac{E_{\text{in}}}{E_{\text{out}}} \times 100\%$$

where:

- E_{in} = horizontal illuminance (lux) at the interior reference point P
- E_{out} = simultaneous unobstructed horizontal illuminance (lux) outdoors under the standard overcast sky

Design thresholds:

- DF $< 2\%$: poor — supplementary electric lighting required most working hours.
- DF 2–5%: adequate for general tasks.
- DF $> 5\%$: good — space can be daylit for the majority of occupied hours.

Why other options are wrong:

- **Option A:** DF uses an *overcast* sky reference, not a clear sky — an overcast sky is chosen because its luminance distribution is predictable and sun position-independent.
- **Option C:** DF is a *ratio* (percentage), not an absolute lux value; it is also not restricted to the room centre.
- **Option D:** Window-to-floor ratio × VLT is a first-approximation design guide parameter, not the rigorous definition of DF; the formula ignores room geometry, obstruction angles, and inter-reflections.

Final Answer: DF = indoor lux / outdoor lux (overcast sky) × 100% ⇒ $\boxed{\text{B}}$

Answer: (B) Go Back to Q8

Sol. 9.

Solution

Difficulty: Intermediate • Chapter: Natural Ventilation — Stack Effect

Quick Solution: Stack effect = buoyancy-driven airflow caused by temperature difference between indoor and outdoor air. Warm indoor air rises and exits at the top; cool outdoor air enters at the bottom. Driving force increases with building height and ΔT. **Answer: (C).**

Concept — Stack Effect (Chimney Effect): The stack effect is a **buoyancy-driven** natural ventilation phenomenon. When the interior air is warmer than the exterior air, it is *less dense* and rises. If high-level exhaust openings (clerestory vents, roof monitors, atrium glazing) are provided, the warm indoor air escapes upward. This creates a lower-pressure zone at the base of the space, drawing cooler, denser outdoor air in through low-level inlet openings, establishing a continuous *thermally-driven* circulation without any mechanical equipment.

Governing parameters:

$$\Delta P_{\text{stack}} \propto h \cdot (T_{\text{in}} - T_{\text{out}})$$

where h = height between inlet and outlet; T = absolute temperature (K).

Key design implications:

- **Vertical separation** of inlet (low) and outlet (high) is essential.
- Greater building height and larger ΔT produce stronger stack effect.
- Effective in atria, stairwells, solar chimneys, and Trombe walls.

Distinction from cross-ventilation: Cross-ventilation relies on *wind pressure differences* between opposite façades with openings at similar levels, not on temperature-driven buoyancy.

Why other options are wrong:

- **Option A:** Wind pressure on the windward façade drives *cross-ventilation* and wind-driven infiltration — not the stack effect.
- **Option B:** Mechanical fans negate the "passive" nature of the stack effect by definition.
- **Option D:** Opposite-wall same-level openings describe *cross-ventilation*; stack effect requires vertical inlet–outlet separation.

Final Answer: Stack effect is driven by temperature-difference-induced buoyancy of indoor air $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Sol. 10.

Solution

Difficulty: Beginner • Chapter: Building Services — Water Supply Systems

Quick Solution: Indirect system: municipal supply → underground sump → pump → overhead tank (OHT) → gravity-fed distribution. OHT provides consistent pressure and acts as storage buffer for supply interruptions. **Answer: (D).**

Concept — Indirect Water Supply System: In an **indirect (overhead) supply system**, the municipal or borewell supply feeds a ground-level sump. A pump delivers water from the sump to an **Overhead Storage Tank (OHT)** positioned above the highest served floor. All sanitary fixtures in the building are then supplied *by gravity* from the OHT, through a downfeed distribution network.

Primary functional role of the OHT:

- **Buffer storage:** The OHT holds a reserve (typically 1–2 days' demand) so that supply to fixtures continues uninterrupted even when the municipal main is cut off or at low pressure.
- **Gravity pressure:** Fixtures are supplied at a pressure proportional to the static head (height of OHT water surface above the fixture); this is consistent and predictable.
- **Surge protection:** Isolates the building distribution from pressure surges in the municipal main.

Direct vs. Indirect system comparison:

- **Direct supply:** Fixtures served directly at mains pressure — instant response, no storage, but depends entirely on mains continuity and pressure.
- **Indirect supply:** Gravity-fed from OHT — consistent, resilient, but requires pump energy and tank maintenance.

Note on drainage traps: Traps (P-trap, S-trap, bottle trap) at each fixture outlet retain a water seal to block sewer gases from entering occupied spaces — a separate plumbing design requirement unrelated to the supply system.

Why other options are wrong:

- **Option A:** Water heating is performed by solar water heaters, geysers, or heat pumps — not by the OHT.

- **Option B:** Filtration is performed by water treatment plant, sand/carbon filters, or UV systems — not the OHT.
- **Option C:** The OHT works by gravity (passive, hydrostatic pressure); it does *not* boost mains pressure.

Final Answer: The OHT provides gravity-fed buffer storage independent of mains pressure $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q10

Answer Key

Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans
1	C	2	A	3	D	4	B	5	C
6	D	7	A	8	B	9	C	10	D