

Concrete Technology (313322)

MSBTE K-Scheme · Model Question Paper — Set A · Model Answers

Q.1 Attempt any FIVE of the following:

a) Chemical formulae of Bogue's compounds

2 M

Compound	Chemical formula	Short form
Tricalcium silicate	$3\text{CaO} \cdot \text{SiO}_2$	C_3S
Dicalcium silicate	$2\text{CaO} \cdot \text{SiO}_2$	C_2S
Tricalcium aluminate	$3\text{CaO} \cdot \text{Al}_2\text{O}_3$	C_3A
Tetracalcium aluminoferrite	$4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$	C_4AF

(½ M each)

b) Fineness modulus — definition and range for medium sand

2 M

Fineness modulus is an empirical number which indicates the mean size (coarseness or fineness) of an aggregate. It is the sum of cumulative percentages retained on the standard IS sieves (80 mm ... 150 µm) divided by 100.

Range for medium sand: 2.6 to 2.9 (fine sand 2.2–2.6, coarse sand 2.9–3.2).

(Definition 1 M, range 1 M)

c) Field applications of rapid hardening cement

2 M

Type of cement	Field applications
Rapid hardening cement (IS 8041)	<ul style="list-style-type: none"> • Where formwork is to be removed early and reused quickly • Road and pavement repair works, where traffic must be allowed early • Precast concrete products (pipes, poles, blocks) • Cold weather concreting and urgent / emergency repairs

(Any two, 1 M each)

d) Workability — definition

2 M

Workability is the property of fresh concrete which determines the ease with which it can be mixed, transported, placed, compacted and finished without segregation and bleeding. IS 6461 defines it as the property which determines the amount of useful internal work necessary to produce full compaction.

(Definition 2 M)

e) Stripping time of formwork (IS 456)

2 M

Type of formwork (IS 456:2000, Cl. 11.3.1)	Minimum period before striking
Vertical formwork to columns, walls, beams	16 – 24 h
Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days

Valid for OPC and ambient temperature not below 15 °C; for other cements and lower temperatures the periods are increased suitably.

i) Vertical faces of columns: **16 – 24 hours**; ii) Soffit of slabs (props refixed): **3 days**.

(1 M each)

f) Bleeding — definition

2 M

Bleeding is the rising of mixing water (with some fine cement particles) to the surface of freshly placed concrete, because the solid particles settle down and cannot hold all the water. It forms a weak, porous layer called **laitance** at the top. It is a form of segregation and is caused mainly by high w/c ratio and lack of fines.

(Definition 2 M)

g) Mineral admixtures

2 M

1. Fly ash (pulverised fuel ash)
2. Silica fume (micro-silica)
3. Ground granulated blast furnace slag (GGBS)
4. Metakaolin
5. Rice husk ash

(Any four, ½ M each)

Q.2 Attempt any THREE of the following:

a) Initial and final setting time by Vicat apparatus

4 M

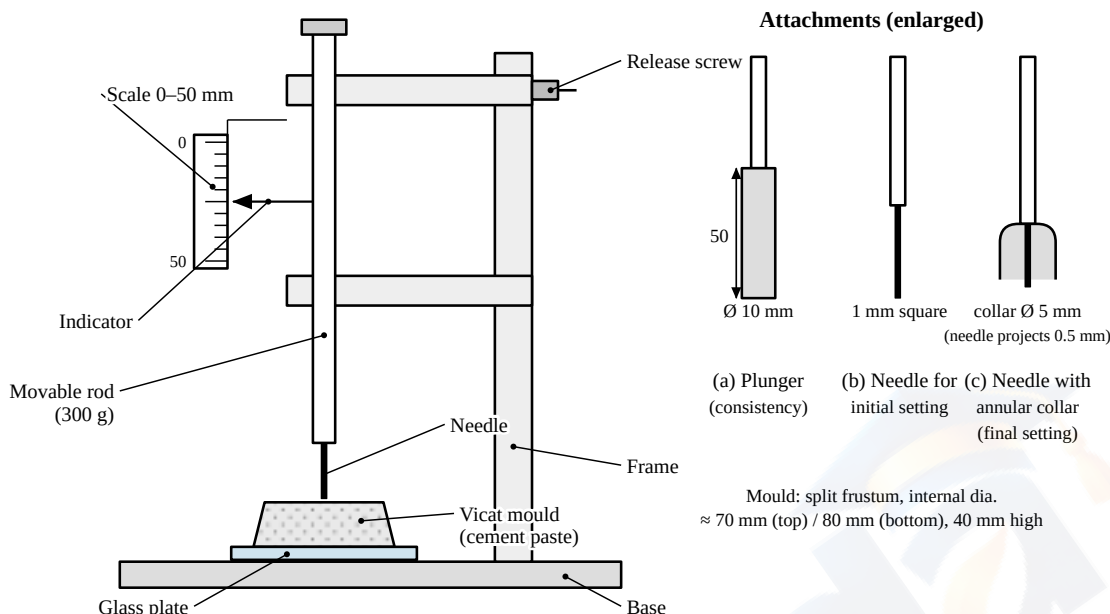


Fig.: Vicat apparatus (IS 5513) with attachments

Apparatus: Vicat apparatus (IS 5513) with Vicat mould, initial-setting needle (1 mm square), final-setting needle with annular collar, glass plate, balance, measuring cylinder, stop watch. (IS 4031 Part 5)

Preliminary: Find standard consistency (P) of cement using the 10 mm plunger — the % water at which the plunger penetrates up to 5 to 7 mm from the bottom of the mould.

Initial setting time:

1. Take 400 g of cement and add **0.85 P** water (by mass). Start the stop watch when water is added.
2. Gauge the paste (gauging time 3–5 min) and fill the Vicat mould resting on a glass plate; level the top.
3. Lower the 1 mm square needle gently on the surface and release it quickly; note the penetration.
4. Repeat at intervals (at different points) until the needle fails to pierce the block beyond **5 ± 0.5 mm from the bottom** of the mould.
5. The time from adding water to this stage is the **initial setting time** (OPC: not less than 30 minutes).

Final setting time:

1. Replace the needle by the needle with annular attachment.
2. Lower it gently on the surface at intervals.
3. Cement is finally set when the needle makes an impression but the annular collar **fails to make an impression**.
4. Time from adding water to this stage is the **final setting time** (OPC: not more than 600 minutes).

Test at 27 ± 2 °C and relative humidity 65 ± 5 %.

(Sketch 1 M, initial setting $1\frac{1}{2}$ M, final setting $1\frac{1}{2}$ M)

b) Field tests on cement

4 M

1. **Date of manufacture:** Check the date on the bag; fresh cement (preferably used within about 3 months) should be used, as stored cement loses strength.
2. **Colour:** Cement should have a uniform greenish-grey colour.
3. **Physical feel (rubbing):** When rubbed between fingers it should feel smooth, not gritty.
4. **Hand insertion:** When the hand is pushed into a bag of cement it should feel cool, not warm.
5. **Lumps:** Cement should be free from hard lumps (lumps show it has absorbed moisture / set partly).
6. **Float test:** A pinch of cement thrown into a bucket of water should float for some time before sinking.
7. **Setting test:** A thick paste made into a cake on a glass plate and kept under water should set without cracking (in about 24 h).
8. **Strength test (block):** A block of cement paste $25 \text{ mm} \times 25 \text{ mm} \times 200 \text{ mm}$, cured in water for 7 days and placed on supports 150 mm apart, should carry a load of about 340 N (34 kg) without failure.

(Any four tests, 1 M each)

c) Fineness modulus of fine aggregate

4 M

Fineness modulus (FM) = Σ (cumulative % retained on standard IS sieves 4.75 mm ... 150 μm) $\div$ 100. Material on the pan is not included.

Total mass of sample = 1000 g

IS sieve	Mass retained (g)	% retained	Cumulative % retained	% passing
4.75 mm	40	4.0	4.0	96.0
2.36 mm	110	11.0	15.0	85.0
1.18 mm	210	21.0	36.0	64.0
600 μm	260	26.0	62.0	38.0
300 μm	220	22.0	84.0	16.0
150 μm	120	12.0	96.0	4.0
Pan	40	4.0	—	—

Σ cumulative % retained = $4.0 + 15.0 + 36.0 + 62.0 + 84.0 + 96.0 = 297.0$

FM = $297.0 / 100 = 2.97$

Result: FM = 2.97 $\rightarrow$ the sand is **coarse sand (2.9 – 3.2)**.

(Table 2 M, calculation 1 M, result 1 M)

d) Requirements of good aggregates

4 M

1. **Clean:** free from clay, silt, dust, organic matter and other deleterious materials (mica, coal, salts).

2. **Strong and hard:** strength more than the required concrete strength; resistant to crushing, impact and abrasion.
3. **Durable and sound:** should not disintegrate under weathering, wetting–drying or freezing.
4. **Proper shape:** cubical or rounded; not flaky or elongated.
5. **Well graded:** suitable size distribution so that voids and cement content are minimum.
6. **Chemically inert:** should not react with alkalis of cement (alkali–aggregate reaction).
7. **Low water absorption** and suitable surface texture for good bond with cement paste.

(Any four, 1 M each)

Q.3 Attempt any THREE of the following:

a) Abrams' law with graph

4 M

Duff Abrams' water–cement ratio law (1918): For fully compacted concrete made with given materials and tested at a given age and curing condition, the strength of concrete depends only on the water–cement ratio; strength is inversely related to w/c ratio.

$$S = A / B^x$$

where S = compressive strength, x = water–cement ratio (by mass), A and B = empirical constants depending on cement, age and curing.

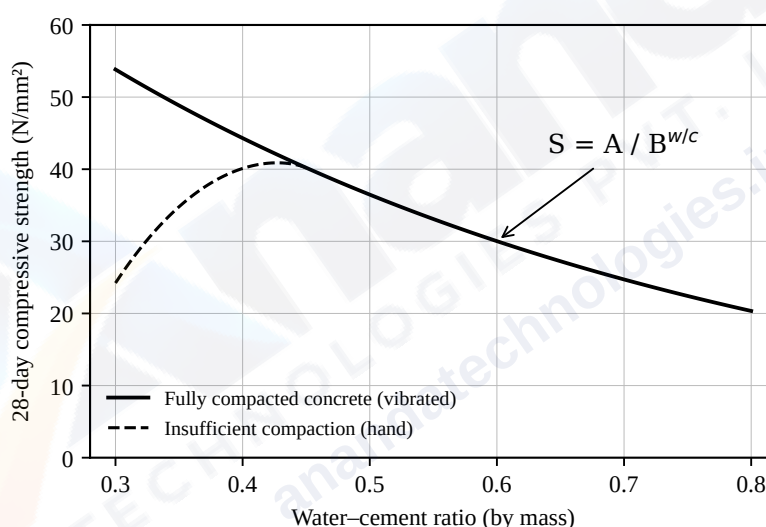


Fig.: Relation between w/c ratio and compressive strength (Abrams' law) — illustrative curve, $A = 96.5 \text{ N/mm}^2$, $B = 7$ (typical values only)

Explanation of graph: As w/c ratio increases, strength decreases (curve falls). Extra water evaporates and leaves capillary pores, so the concrete becomes porous and weak. At very low w/c ratio the law holds only if full compaction is possible (vibration); with hand compaction the mix is too dry, voids remain and strength falls (dashed curve).

(Statement 1 M, equation 1 M, graph 1 M, explanation 1 M)

b) Slump cone test

4 M

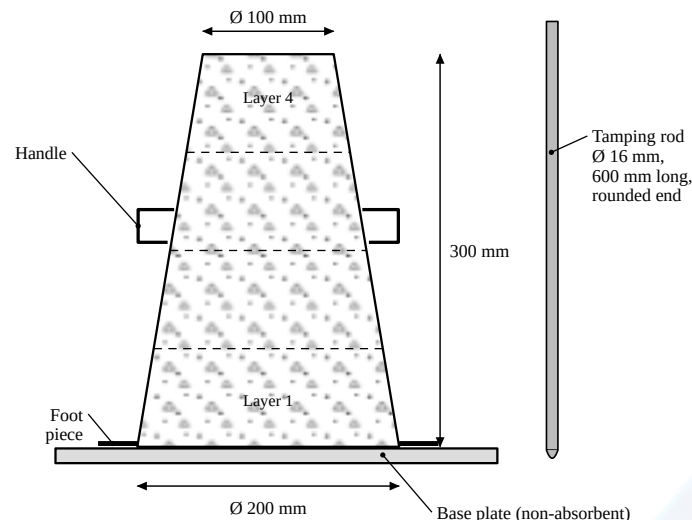


Fig.: Slump cone and tamping rod (IS 1199)

Procedure (IS 1199):

1. Clean the inside of the slump cone and base plate; keep the cone on a smooth, horizontal, non-absorbent surface and hold it firmly by the foot pieces.
2. Fill freshly mixed concrete in **four layers**, each about one-fourth of the height.
3. Tamp each layer **25 times** with the tamping rod (16 mm dia, 600 mm long), strokes uniformly spread over the section.
4. Strike off the top level with a trowel and clean the concrete around the base.
5. Lift the cone **slowly and vertically** (in 5–10 s) without disturbing the concrete.
6. The concrete subsides. Measure the difference between the height of the mould and the highest point of the subsided concrete — this is the **slump (mm)**.

Dashed outline = original cone (300 mm); slump = fall of top of concrete

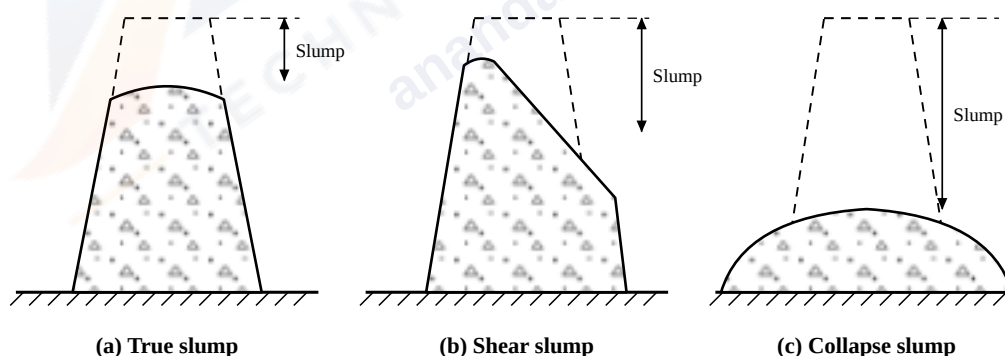


Fig.: Types of slump

- **True slump:** concrete subsides evenly keeping its shape — the test is valid.
- **Shear slump:** half of the cone slides along an inclined plane — shows lack of cohesion; repeat the test.
- **Collapse slump:** concrete collapses completely — very wet / high workability mix.

(Sketch 1 M, procedure 2 M, types / result 1 M)

c) Aggregate impact value

4 M

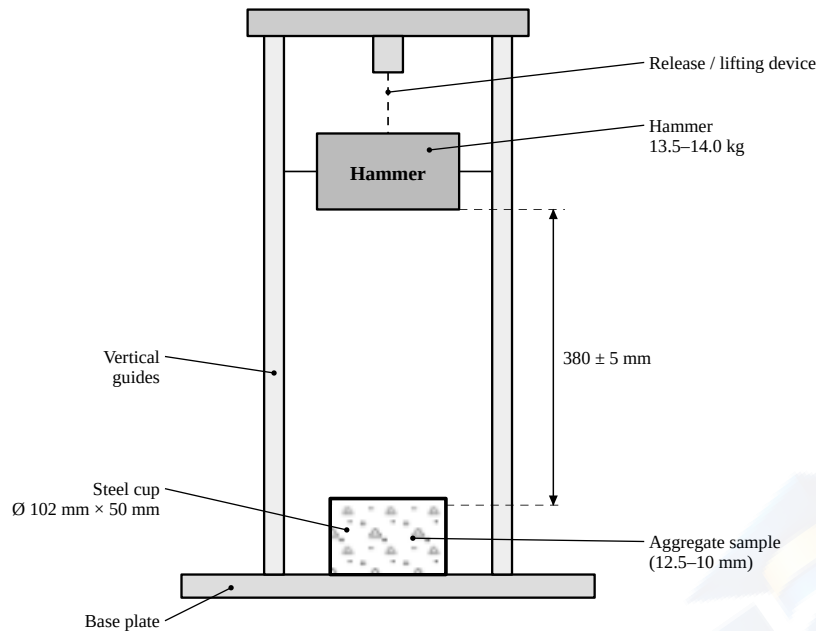


Fig.: Aggregate impact testing machine (IS 2386 Part IV)

Object: To determine the toughness (resistance to sudden shock) of coarse aggregate. (IS 2386 Part IV)

1. Take aggregate passing 12.5 mm and retained on 10 mm IS sieve, oven-dried (100–110 °C).
2. Fill the cylindrical measure (75 mm dia × 50 mm deep) in 3 layers, each tamped 25 times with the tamping rod; strike off. Weigh this sample = W_1 .
3. Transfer the sample to the steel cup of the impact machine in 3 layers, tamping each layer 25 times.
4. Raise the hammer (13.5–14.0 kg) and let it fall freely from a height of 380 ± 5 mm. Give **15 blows**, each at an interval of not less than 1 second.
5. Remove the crushed aggregate and sieve it on a 2.36 mm IS sieve. Weigh the fraction passing = W_2 .
6. Aggregate impact value (AIV) = $(W_2 / W_1) \times 100 \%$.

Limits (IS 383): AIV not more than 45 % for concrete other than wearing surfaces and not more than 30 % for wearing surfaces (roads, runways, floors).

(Sketch 1 M, procedure 2 M, formula / limit 1 M)

d) Necessity of supervision

4 M

Necessity of supervision in concreting operations:

1. To ensure that **materials** (cement, aggregates, water, admixtures) are of specified quality and properly stored.
2. To ensure correct **batching** (preferably by weight), correct w/c ratio and allowance for bulking / moisture.
3. To check proper **mixing, transporting and placing** within the setting time, without segregation.

4. To ensure proper **compaction** (vibration) and finishing so that there is no honeycombing.
5. To check **formwork and reinforcement** (cover, spacing, lap, supports) before concreting.
6. To ensure adequate **curing** and correct time of removal of formwork.
7. To take **cube samples**, slump tests and keep records; to ensure safety and economy.

(Any four points, 1 M each)

Q.4 Attempt any THREE of the following:

a) Types of vibrators

4 M

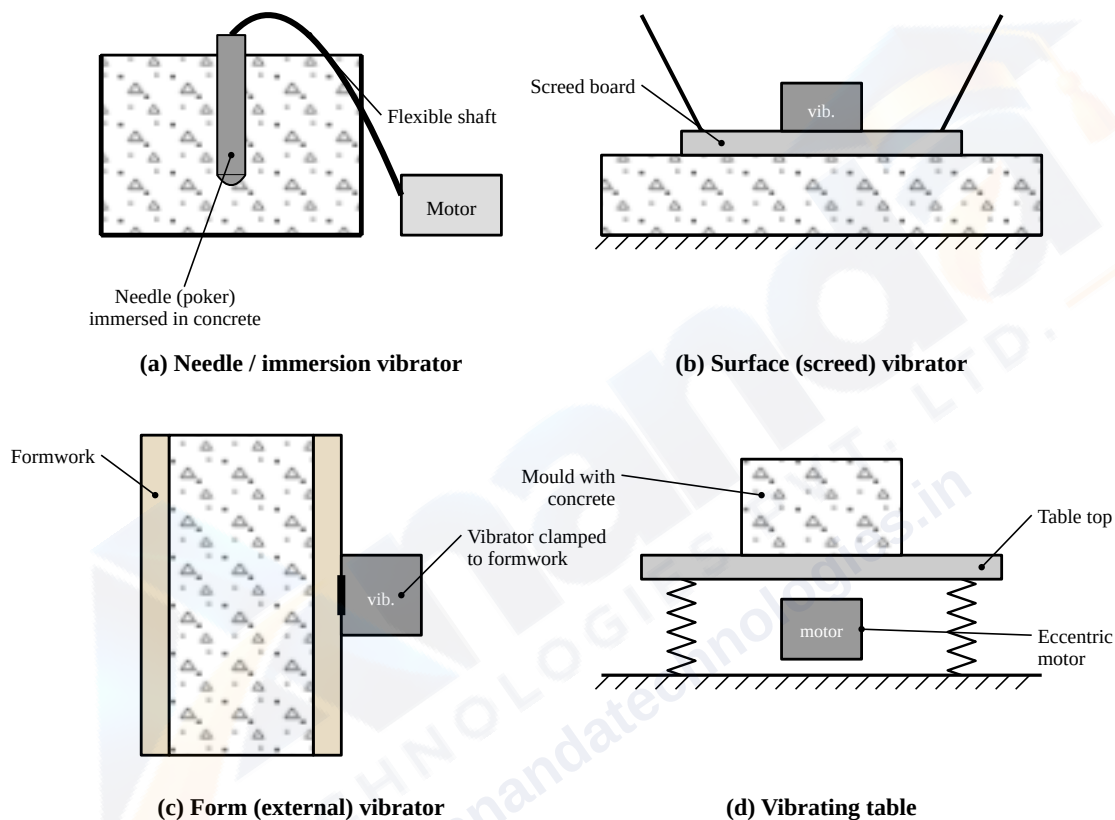


Fig.: Types of vibrators used for compaction

1. **Internal (needle / immersion) vibrator:** a vibrating needle (poker) connected to a motor by a flexible shaft is immersed in concrete. Used for beams, columns, slabs, walls and mass concrete — most common at site.
2. **Surface (screed) vibrator:** vibrating unit mounted on a screed board, placed on the concrete surface. Used for slabs, floors and road pavements of small thickness (effective up to about 150 mm depth).
3. **Form (external / shutter) vibrator:** clamped to the outside of the formwork; vibrates the form and the concrete. Used for thin walls, heavily reinforced and congested sections, tunnel lining, precast members where needle cannot be inserted.

4. **Vibrating table:** a rigid table on springs vibrated by an eccentric motor; moulds are placed on it. Used for precast products — blocks, kerbs, pipes, cubes and laboratory specimens.

(Each type with use 1 M (sketch included))

b) Admixture — definition and classification

4 M

Admixture is a material other than cement, water and aggregates that is added to the concrete batch immediately before or during mixing to modify one or more properties of fresh or hardened concrete (IS 9103).

Types:

Chemical admixtures (IS 9103)	Mineral admixtures
Accelerating admixtures (accelerators)	Fly ash (pulverised fuel ash)
Retarding admixtures (retarders)	Silica fume
Water-reducing admixtures (plasticizers)	Ground granulated blast furnace slag (GGBS)
Superplasticizers (high-range water reducers)	Metakaolin
Air-entraining admixtures	Rice husk ash
Others: waterproofing, bonding, corrosion-inhibiting, viscosity-modifying	Surkhi / calcined clay pozzolana

(Definition 1 M, classification 3 M)

c) Fly ash as mineral admixture

4 M

Fly ash: Fine powder collected by electrostatic precipitators from the flue gases of coal-based thermal power plants; a pozzolana (IS 3812 Part 1). Class F (low lime) and Class C (high lime).

- Reacts with $\text{Ca}(\text{OH})_2$ released during hydration to form additional C-S-H gel (pozzolanic reaction).
- Spherical particles improve workability and pumpability; reduce water demand.
- Reduces heat of hydration — good for mass concrete.
- Reduces permeability; improves resistance to sulphate and chloride attack; long-term strength increases.
- Early strength gain is slow; longer curing needed.
- Used as 15–35 % replacement in PPC, and as mineral admixture in RMC; saves cement and utilises waste (eco-friendly).

(Description 1 M, any three effects 3 M)

d) Self-compacting concrete

4 M

Self-compacting concrete (SCC) is a highly flowable, non-segregating concrete that flows under its own weight, fills the formwork completely and passes through congested reinforcement without any vibration.

Constituents: high powder content (cement + fly ash / GGBS / stone powder), superplasticizer (PCE), viscosity-modifying agent, smaller size coarse aggregate (usually ≤ 20 mm), low w/p ratio.

Tests: slump flow (spread commonly 550–850 mm), T500 time, V-funnel, L-box, J-ring.

Advantages:

- No vibration needed — saves labour and reduces noise.
- Fills congested reinforcement and complicated shapes; good surface finish.
- Faster placing; better homogeneity and durability.
- Healthier and safer working conditions.

(Definition 1 M, constituents 1 M, advantages 2 M)

e) Steel vs timber formwork

4 M

Point	Steel formwork	Timber formwork
Initial cost	High	Low
Number of reuses	Very large (100 + uses)	Few (about 5–10 uses)
Strength / rigidity	Strong, rigid; no warping, shrinkage or swelling	Can warp, shrink or swell with moisture
Surface finish	Smooth, uniform finish; less plaster needed	Rough finish; marks of boards
Weight / handling	Heavy; needs cranes for big panels	Light; easy to cut and make any shape
Suitability	Repetitive works — columns, slabs, tunnels, culverts	Small / non-repetitive works and odd shapes
Other	May rust; heat loss in cold weather	Good insulation; affected by termites / fire

(Any four points, 1 M each)

Q.5 Attempt any TWO of the following:

a) Mix design procedure (IS 10262:2019)

6 M

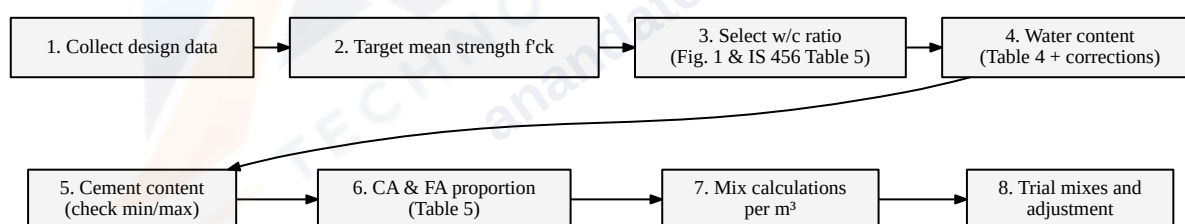


Fig.: Steps of concrete mix design (IS 10262:2019)

Step-by-step procedure (IS 10262:2019 with IS 456:2000):

- 1. Collect design data:** grade (fck), type/grade of cement, maximum size of aggregate, workability (slump), exposure condition, minimum cement content and maximum w/c ratio, type of aggregate, method of placing, admixtures, specific gravities and water absorption.
- 2. Target mean strength:** $f'_{ck} = f_{ck} + 1.65 s$ or $f'_{ck} = f_{ck} + X$, whichever is higher (s = standard deviation, Table 2; X factor, Table 1).
- 3. Water–cement ratio:** from Fig. 1 of IS 10262 (or from experience) for the target strength; check with maximum w/c of IS 456 Table 5 for the exposure; adopt the lower value.

4. **Water content:** from Table 4 for the maximum aggregate size (for 50 mm slump, angular aggregate); increase about 3 % for every additional 25 mm slump; reduce for rounded aggregate or for water-reducing admixture.
5. **Cement content** = water content $\div$ w/c ratio. Check with the minimum cement content of IS 456 Table 5 and maximum 450 kg/m³; adopt the higher of calculated and minimum value.
6. **Proportion of coarse and fine aggregate:** volume of CA per unit volume of total aggregate from Table 5 (depends on max size and zone of FA, for w/c = 0.50); change by 0.01 for every ± 0.05 change in w/c (lower w/c $\rightarrow$ more CA). Reduce up to 10 % for pumpable concrete. FA = 1 – CA.
7. **Mix calculations per m³:** volume of all-in aggregate = (1 – entrapped air) – (volume of cement + water + admixture), where volume = mass / (specific gravity $\times$ 1000). Mass of CA and FA = volume $\times$ proportion $\times$ specific gravity $\times$ 1000.
8. **Trial mixes:** prepare trial mix, check slump and cube strength; adjust water, w/c or proportions till requirements are met. Finally correct for moisture content and water absorption of aggregates at site.

(Any eight correct steps with explanation (IS 10262:2019); flowchart optional)

Illustration (for understanding — M25): 20 mm angular CA, slump 75 mm, moderate exposure, OPC 43, FA Zone II, SG: cement 3.15, CA 2.74, FA 2.65, no admixture.

Step	Working	Result
Target mean strength	$f_{ck} + 1.65 s = 25 + 1.65 \times 4.0 = 31.60$; $f_{ck} + X = 25 + 5.5 = 30.50$	$f'_{ck} = 31.60 \text{ N/mm}^2$
w/c ratio	Assumed from Fig. 1 = 0.45; IS 456 max for moderate exposure = 0.50	Adopt 0.45
Water	Table 4 (20 mm) = 186 kg for 50 mm slump; +3 % for 75 mm slump = 191.58 kg	191.6 kg/m ³
Cement	$191.6 / 0.45 = 425.7 \text{ kg}$; min. (IS 456) = 300 kg; max 450 kg	425.7 kg/m ³
CA proportion	Table 5, 20 mm, Zone II = 0.62 at w/c 0.50; correction for w/c 0.45 = +0.010	CA = 0.630, FA = 0.370
Volumes (m ³)	air = 0.01; cement = $425.7 / (3.15 \times 1000) = 0.1352$; water = 0.1916	all-in aggregate = 0.6633
Coarse aggregate	$0.6633 \times 0.630 \times 2.74 \times 1000$	1144.9 kg/m ³
Fine aggregate	$0.6633 \times 0.370 \times 2.65 \times 1000$	650.3 kg/m ³

Mix proportion (by mass) — cement : FA : CA = 1 : 1.53 : 2.69, w/c = 0.45 (per m³: cement 426 kg, water 192 kg, FA 650 kg, CA 1145 kg).

Note: Table values used (IS 10262:2019): s — Table 2 (M10–M15: 3.5; M20–M25: 4.0; M30–M60: 5.0 N/mm²); X — Table 1 (M10–M15: 5.0; M20–M25: 5.5; M30–M60: 6.5); water — Table 4 (10 mm: 208, 20 mm: 186, 40 mm: 165 kg/m³); entrapped air — Table 3 (20 mm: 1 %); CA volume — Table 5 (20 mm: 0.66/0.64/0.62/0.60 for Zone IV/III/II/I). The w/c of the illustration is an assumed graph reading from Fig. 1, not a code value. IS 456 Table 5 limits for RCC: mild 300 kg & 0.55, moderate 300 kg & 0.50, severe 320 kg & 0.45. Students should verify table values from their own copy of the code; the older IS 10262:2009 procedure is the same except the X-factor and entrapped-air steps.

b) Compressive strength of concrete cubes

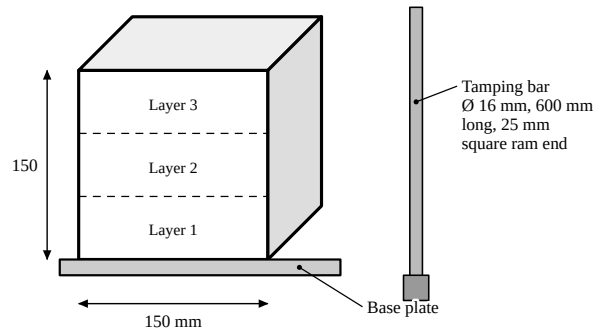


Fig.: Cube mould 150 mm with tamping bar

i) Preparation of test specimen (IS 516):

1. Use 150 mm cube moulds (100 mm cubes allowed if max. aggregate size ≤ 20 mm); clean and oil the inner faces and tighten the bolts.
2. Take a representative sample of concrete (from the mixer / site) and fill the mould in **3 layers** of about 50 mm each.
3. Compact each layer with not less than **35 strokes** of the standard tamping bar (16 mm dia, 600 mm long) for 150 mm cubes, or by vibration till full compaction.
4. Finish the top surface level with a trowel; mark identification.
5. Store the cubes in moist air (≥ 90 % RH) at 27 ± 2 °C for $24 \pm \frac{1}{2}$ hours, then demould.
6. Cure the cubes in clean water at 27 ± 2 °C until the time of test (usually 7 and 28 days). Three cubes are tested for each age.

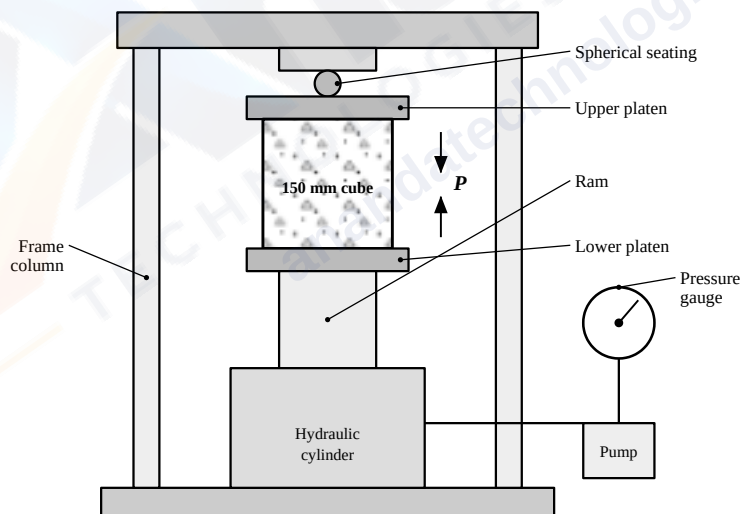


Fig.: Compression testing machine with 150 mm concrete cube

ii) Procedure of testing:

1. Take the cube out of water just before testing, wipe off surface water and grit; measure dimensions and weigh.
2. Clean the platens of the compression testing machine. Place the cube centrally so that the load is applied on the two **opposite side faces** (not on the top/bottom faces as cast).

3. Bring the upper platen in contact; apply the load gradually without shock at about **14 N/mm² per minute** (140 kg/cm²/min) until the cube fails.
4. Note the maximum load P and the type of failure.

iii) Interpretation of results: Compressive strength = P / A . Average of 3 cubes is the test result. If an individual result varies by more than $\pm 15\%$ of the average, that sample result is treated as invalid (IS 456 cl. 15.4). The 28-day result is compared with the characteristic strength f_{ck} (acceptance criteria of IS 456 Table 11). Normal pyramidal (hour-glass) failure indicates a satisfactory test.

Example (28 days, M25): $A = 150 \times 150 = 22500 \text{ mm}^2$

Cube	Load P (kN)	Strength P/A (N/mm ²)	Deviation from average
1	742	32.98	+0.0 %
2	768	34.13	+3.6 %
3	715	31.78	-3.6 %

Average compressive strength = **32.96 N/mm²**; all deviations are within $\pm 15\%$, so the result is valid and it is more than $f_{ck} = 25 \text{ N/mm}^2$.

(Preparation 2 M, testing 2 M, interpretation / result 2 M)

c) Segregation and bleeding — causes and prevention

6 M

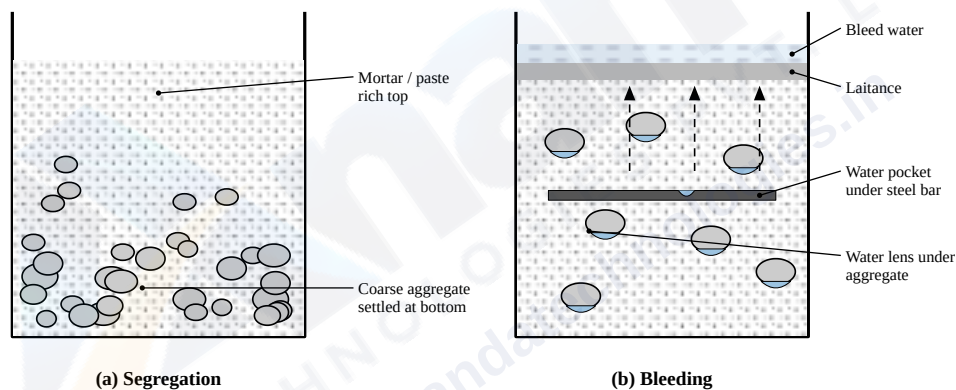


Fig.: Segregation and bleeding in fresh concrete

Segregation: Separation of the constituents of concrete from one another, so that the mix is no longer uniform (e.g. coarse aggregate separating from mortar, or paste separating in wet mixes).

Bleeding: A form of segregation in which water (with some cement) rises to the surface of freshly placed concrete because the solids settle and cannot hold all the mixing water. It leaves a weak layer of **laitance** on top and water pockets below aggregates and reinforcement.

	Segregation	Bleeding
Causes	Excess water / badly proportioned mix; dropping concrete from height; long transport on chutes or conveyors; over-vibration; poorly graded aggregate	High w/c ratio; lack of fines in sand; coarse cement; over-vibration or over-trowelling; lean mix
Prevention	Proper grading and cohesive mix; place concrete near its final position; avoid free fall more than about 1.5 m; correct vibration time; use admixtures	Low w/c; well-graded sand with enough fines; finer cement / pozzolana; air-entraining agent; proper vibration; do not finish while bleed water is present

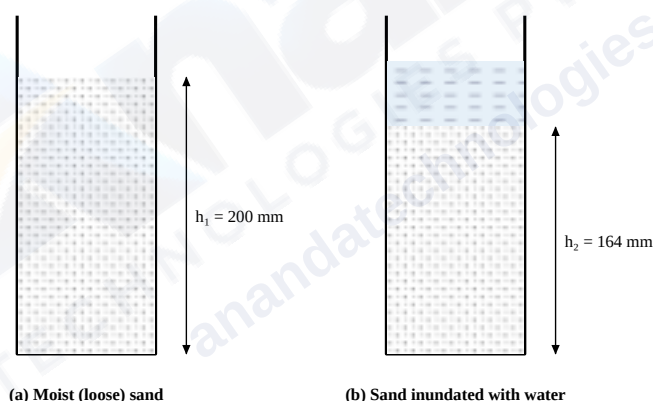
(Definitions 2 M, causes 2 M, prevention 2 M)

Q.6 Attempt any TWO of the following:

a) Bulking of sand — sketch, calculation, effects

6 M

Bulking of sand: Increase in volume of dry sand due to presence of moisture. The thin film of water around sand particles keeps them apart, so the volume increases. Bulking increases with moisture up to about 4–6 % and then decreases; fully saturated (inundated) sand shows almost no bulking. Fine sand bulks more than coarse sand.



$$\text{Bulking (\%)} = (h_1 - h_2) / h_2 \times 100$$

Fig.: Bulking of sand — container method

Procedure (container method):

1. Fill a container (or 250 ml measuring cylinder) about two-thirds with loose moist sand without compacting. Level the top and measure the height h_1 .
2. Take the sand out (keep it), fill the container partly with water and pour the same sand back slowly, stirring, so that the sand is fully inundated.
3. Level the sand and measure its new height h_2 (less than h_1).
4. $\text{Bulking (\%)} = (h_1 - h_2) / h_2 \times 100$.

Calculation: $h_1 = 200 \text{ mm}$, $h_2 = 164 \text{ mm}$

Bulking = $(200 - 164) / 164 \times 100 = 36 / 164 \times 100 = 21.95 \%$

So in volume batching, the volume of this moist sand should be increased by about 22 % to get the designed quantity of sand.

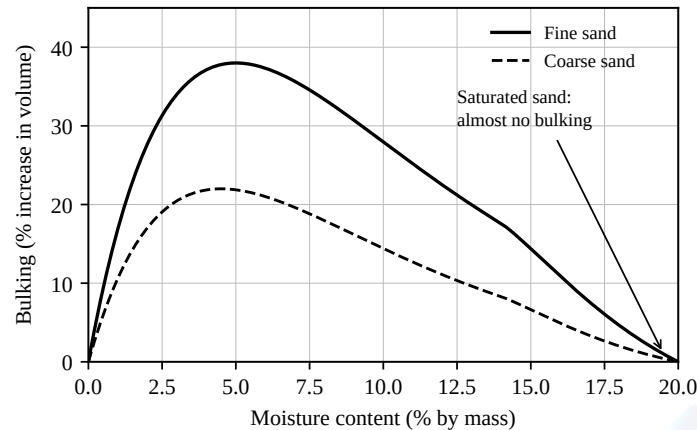


Fig.: Typical bulking of sand with moisture content (illustrative)

Effects of bulking on concrete:

- If bulking is ignored in volume batching, less sand goes into the mix → harsh, under-sanded mix with more voids, honeycombing and segregation.
- Yield of concrete is reduced and the mix becomes richer in cement and coarse aggregate than designed; proportions go wrong.

(Definition 1 M, sketch 1 M, procedure 2 M, calculation 1 M, effects 1 M)

b) Curing — methods and period

6 M

Curing is the process of maintaining satisfactory moisture and temperature in concrete for a definite period after placing, so that hydration of cement continues and concrete develops its strength and durability.

Period (IS 456 Cl. 13.5.1): keep exposed surfaces continuously moist for at least **7 days** with OPC and at least **10 days** when mineral admixtures or blended cements are used; at least 10 days in hot and dry weather (14 days recommended for blended cements).

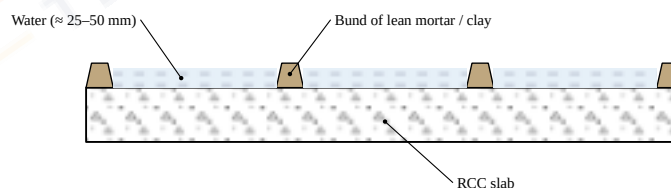


Fig.: Curing of slab by ponding

1. **Water curing:** (a) *Ponding* — small bunds of lean mortar/clay on slabs and water filled in; (b) *Immersion* — precast members and cubes kept in a water tank; (c) *Sprinkling / fogging* — water sprayed at intervals on walls, columns; (d) *Wet covering* — hessian, gunny bags, sand kept wet.
2. **Membrane curing:** liquid curing compound (wax / resin based) sprayed on the surface forms an impervious film that prevents evaporation; plastic or polyethylene sheets also used. Useful where water is scarce and on vertical surfaces.

3. **Steam curing:** precast members are kept in chambers with steam at atmospheric pressure (or high pressure — autoclave); gives rapid strength gain.

4. **Other methods:** infrared curing, electrical curing and use of formwork left in place.

(Definition 1 M, methods 4 M, period 1 M)

c) Joints in concrete

6 M

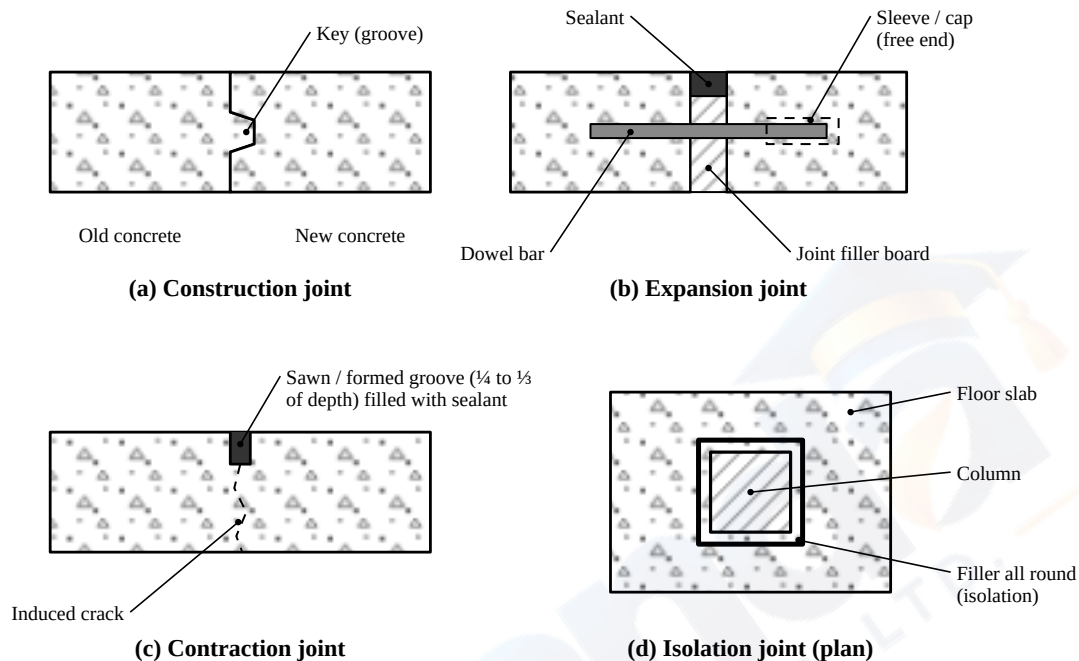


Fig.: Joints in concrete

1. **Construction joint:** provided where concreting is stopped (end of day / interruption). Placed at a point of minimum shear (near middle of span in beams and slabs; in columns a little below the beam soffit). Surface roughened or keyed to bond new concrete.
2. **Expansion joint:** a full-depth gap (about 20–25 mm) between two parts of a structure to allow expansion due to temperature; filled with compressible filler and sealed at top; dowel bars with a sleeve on one side transfer load in pavements.
3. **Contraction joint:** a groove (sawn or formed, about $\frac{1}{4}$ to $\frac{1}{3}$ of the depth) that creates a plane of weakness so that shrinkage cracks form along it in a controlled straight line; sealed with sealant.
4. **Isolation joint:** separates a slab from columns, walls or machine foundations so that they can move independently; filled with joint filler.

(Types 2 M, sketches 2 M, explanation 2 M)

Joint filling materials: Bitumen-impregnated fibre board, Cork sheet / compressed cork, Rubber strips / PVC water stops (water bars), Bitumen / mastic sealing compound, Polysulphide or polyurethane sealant.

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