

Concrete Technology (313322)

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

Q.1 Attempt any FIVE of the following:

a) Bogue's compounds; compound for early strength

2 M

Compound	Short form
Tricalcium silicate	C ₃ S
Dicalcium silicate	C ₂ S
Tricalcium aluminate	C ₃ A
Tetracalcium aluminoferrite	C ₄ AF

C₃S (tricalcium silicate) is responsible for early strength (first 7 days).

(List 1 M, early strength 1 M)

b) Fine and coarse aggregate

2 M

Fine aggregate (FA): Aggregate which passes through a 4.75 mm IS sieve and is retained on 75 µm (practically 150 µm) sieve, e.g. natural sand, crushed stone sand (IS 383).

Coarse aggregate (CA): Aggregate which is retained on a 4.75 mm IS sieve, e.g. crushed stone / gravel of 10, 20, 40 mm size.

(Each definition 1 M)

c) Water–cement ratio

2 M

Water–cement ratio is the ratio of the mass of free water to the mass of cement in a concrete mix.

$$w/c = \text{mass of water} / \text{mass of cement}$$

Example: 180 kg water with 400 kg cement → $w/c = 0.45$. It is the most important factor controlling strength and durability.

(Definition 1 M, expression / example 1 M)

d) Physical properties of OPC

2 M

- Fineness** — Blaine air permeability, not less than 225 m²/kg (IS 269).
- Standard consistency** — water for plunger penetration of 5–7 mm from bottom (usually 26–33 %).
- Setting time** — initial ≥ 30 min, final ≤ 600 min.
- Soundness** — Le Chatelier expansion ≤ 10 mm; autoclave expansion ≤ 0.8 %.
- Compressive strength** — 33 / 43 / 53 N/mm² at 28 days for 33, 43, 53 grade.

(Any four, ½ M each)

e) Grades of concrete (IS 456)

2 M

Grades of concrete (IS 456:2000, Table 2): Grade designation 'M' = mix, number = characteristic

compressive strength of 150 mm cube at 28 days (N/mm²).

Group	Grades
Ordinary concrete	M10, M15, M20
Standard concrete	M25, M30, M35, M40, M45, M50, M55
High strength concrete	M60, M65, M70, M75, M80

(2 M)

f) Applications of sulphate resisting cement

2 M

Type of cement	Field applications
Sulphate resisting cement (IS 12330)	<ul style="list-style-type: none"> • Foundations and basements in soil / ground water rich in sulphates • Marine structures, sewage treatment works and canal linings

(Any two, 1 M each)

g) Fibre reinforced concrete

2 M

Fibre reinforced concrete (FRC) is concrete containing short, discrete fibres uniformly distributed and randomly oriented in it, to improve crack resistance, toughness and impact strength.

Fibres: steel fibres, glass fibres, polypropylene (synthetic) fibres, carbon fibres, natural fibres (coir, jute).

(Definition 1 M, any two fibres 1 M)

Q.2 Attempt any THREE of the following:

a) Soundness by Le Chatelier apparatus

4 M

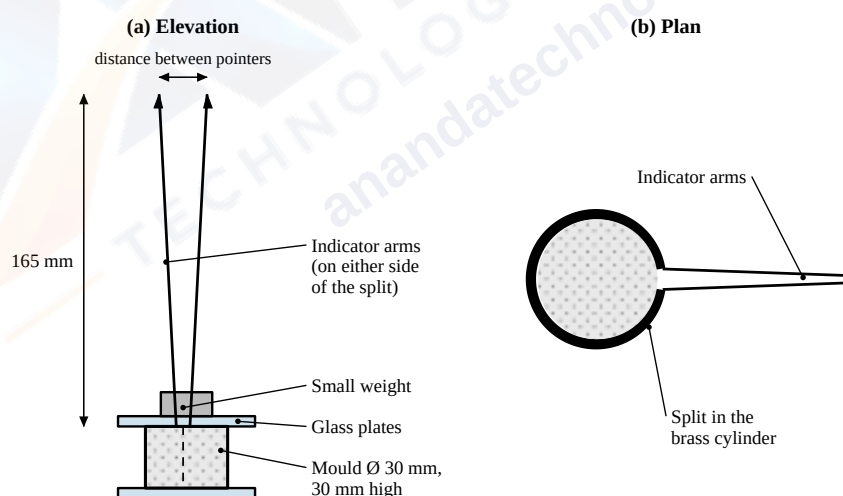


Fig.: Le Chatelier apparatus for soundness (IS 4031 Part 3)

Object: To find the soundness (unsoundness = undesirable expansion after setting, due to excess free lime or magnesia) of cement. (IS 4031 Part 3)

1. Place the lightly oiled Le Chatelier mould on a glass plate.

2. Prepare cement paste with **0.78 P** water (P = standard consistency) and fill the mould; cover with another glass plate and a small weight.
3. Immerse the whole assembly in water at 27 ± 2 °C for **24 hours**.
4. Take out and measure the distance between the indicator points (d_1).
5. Again submerge in water, bring it to boiling in 25–30 minutes and keep it boiling for **3 hours**.
6. Allow to cool and measure the distance between the indicator points (d_2).
7. Expansion = $d_2 - d_1$ (mm). For OPC it should **not exceed 10 mm** (IS 269).

(Sketch 1 M, procedure 3 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) Flakiness index and elongation index

4 M

Flakiness index: Percentage by mass of particles whose **least dimension (thickness) is less than 0.6 times** their mean sieve size.

Elongation index: Percentage by mass of particles whose **greatest dimension (length) is more than 1.8 times** their mean sieve size.

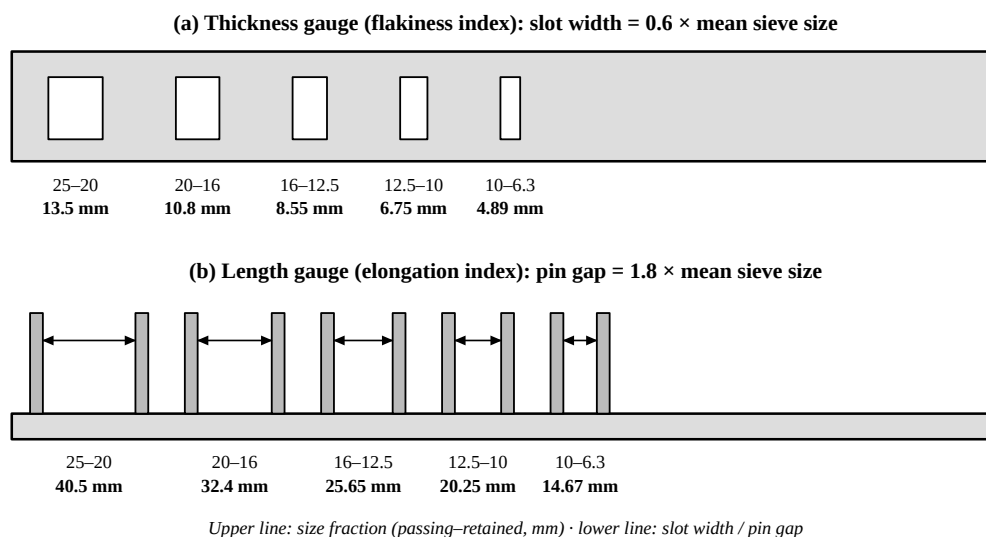


Fig.: Thickness gauge and length gauge (IS 2386 Part I)

Procedure (in brief): Sieve the sample into size fractions. Pass each particle of a fraction through the matching slot of the thickness gauge — particles passing are flaky; try each particle between the matching pins of the length gauge — particles that do not pass lengthwise are elongated. Flakiness index = (mass of flaky particles / total mass) $\times$ 100; Elongation index = (mass of elongated particles / total mass of non-flaky particles) $\times$ 100.

Flaky and elongated particles reduce workability, need more water and cement, and break easily; they should be limited.

(Definitions 2 M, gauges 1 M, procedure 1 M)

d) 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	20	2.0	2.0	98.0
2.36 mm	50	5.0	7.0	93.0
1.18 mm	100	10.0	17.0	83.0
600 μm	180	18.0	35.0	65.0
300 μm	340	34.0	69.0	31.0
150 μm	250	25.0	94.0	6.0
Pan	60	6.0	—	—

Σ cumulative % retained = $2.0 + 7.0 + 17.0 + 35.0 + 69.0 + 94.0 = 224.0$

FM = $224.0 / 100 = 2.24$

Result: FM = 2.24 $\rightarrow$ the sand is **fine sand (2.2 – 2.6)**.

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

Q.3 Attempt any THREE of the following:

a) Workability and compaction factor test

4 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.

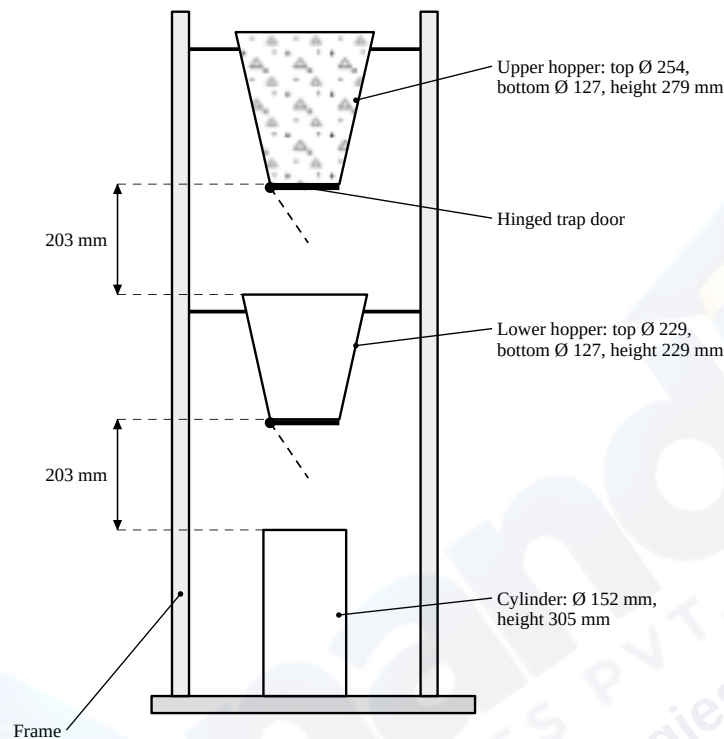


Fig.: Compaction factor apparatus (IS 1199)

Principle: The degree of compaction achieved by a standard amount of work (falling through hoppers) is measured. **Compaction factor** = mass of partially compacted concrete / mass of fully compacted concrete. It is more sensitive than slump for low-workability mixes.

Procedure (IS 1199):

1. Weigh the empty cylinder = W_1 . Close the trap doors of both hoppers.
2. Fill the upper hopper gently with concrete (no compaction) up to the brim.
3. Open the trap door of the upper hopper; concrete falls into the lower hopper.
4. Open the trap door of the lower hopper; concrete falls into the cylinder.
5. Remove the excess concrete above the cylinder top by two trowels sliding from the sides; clean outside. Weigh = W_2 → partially compacted concrete = $W_2 - W_1$.
6. Empty the cylinder, refill it with the same concrete in layers (about 50 mm) fully compacted by rodding / vibration; strike off and weigh = W_3 → fully compacted concrete = $W_3 - W_1$.
7. Compaction factor = $(W_2 - W_1) / (W_3 - W_1)$.

Degree of workability	Compaction factor	Typical use
Very low	0.78	Roads vibrated by power-operated machines
Low	0.85	Roads with hand-operated machines; mass concrete
Medium	0.92	Normal RCC — slabs, beams, columns
High	0.95	Heavily reinforced sections; not suitable for vibration

(Commonly quoted values from Road Note No. 4.)

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

b) W/c ratio law and significance

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.

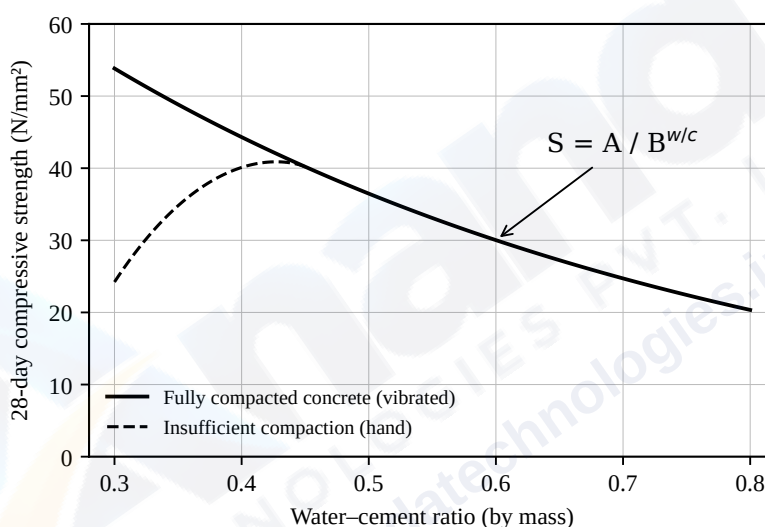


Fig.: Relation between w/c ratio and compressive strength (Abrams' law) — illustrative curve, $A = 96.5 \text{ N/mm}^2$, $B = 7$ (typical values only)

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).

Significance of w/c ratio:

- Controls **strength** — lower w/c gives higher strength (main basis of mix design).
- Controls **durability and impermeability** — IS 456 Table 5 limits the maximum w/c ratio for each exposure (e.g. 0.55 mild, 0.50 moderate, 0.45 severe for RCC).
- Controls **workability** — higher water gives more workability, but beyond a limit causes segregation and bleeding.
- Affects **shrinkage and creep** — higher w/c gives more drying shrinkage and creep.

- Minimum w/c needed for complete hydration is about 0.38 (about 0.23 chemically combined + gel water); extra water is needed only for workability.

(Law 1 M, graph 1 M, significance 2 M)

c) Properties of hardened concrete

4 M

1. **Compressive strength:** most important property; characteristic strength f_{ck} at 28 days (150 mm cubes) decides the grade, e.g. M25.
2. **Tensile / flexural strength:** low, about 10–15 % of compressive strength; flexural strength $f_{cr} = 0.7 \sqrt{f_{ck}}$ (IS 456).
3. **Durability:** ability to resist weathering, chemical attack, abrasion and corrosion of steel during its service life.
4. **Impermeability:** resistance to flow of water through concrete; depends on w/c, compaction and curing.
5. **Modulus of elasticity:** $E_c = 5000 \sqrt{f_{ck}}$ N/mm² (IS 456).
6. **Creep:** slow increase in strain under sustained load.
7. **Shrinkage:** reduction in volume due to loss of water (plastic, drying, autogenous, carbonation shrinkage).
8. **Density / unit weight** (about 2400 kg/m³ for normal concrete) and fire resistance.

(Any four, 1 M each)

d) Precautions while placing concrete

4 M

1. Check formwork, reinforcement, cover blocks and supports before placing; oil the formwork and wet absorbent surfaces.
2. Place concrete as near as possible to its final position; do not drag or throw it.
3. Avoid free fall from large height (more than about 1.5 m); use chutes, tremie or pipes to prevent segregation.
4. Place in uniform layers (about 150–300 mm) and compact each layer before the next; place within the initial setting time.
5. Do not disturb the reinforcement; avoid placing in heavy rain or on frozen / dry absorbent ground.
6. Plan continuous placing; stop only at planned construction joints.

(Any four, 1 M each)

Q.4 Attempt any THREE of the following:

a) Admixture; retarder vs accelerator

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).

Point	Retarding admixture	Accelerating admixture
Function	Delays (slows) setting of cement	Speeds up setting and early strength gain
Early strength	Early strength slightly lower	Early strength higher
Materials	Gypsum, sugar, lignosulphonates, hydroxy-carboxylic acid salts	Calcium chloride (not for RCC/PSC — causes corrosion), calcium formate, triethanolamine
Used for	Hot weather concreting, RMC hauled long distances, mass concrete, avoiding cold joints	Cold weather concreting, early removal of formwork, emergency repairs, precast work
Heat of hydration	Rate of heat release reduced	Rate of heat release increased

(Definition 1 M, any three points 1 M each)

b) Silica fume

4 M

Silica fume (micro-silica): By-product of silicon and ferro-silicon alloy production in electric arc furnaces; extremely fine (about 100 times finer than cement) with more than 85 % amorphous SiO_2 (IS 15388).

- Highly reactive pozzolana; fills the voids between cement grains (micro-filler).
- Gives very high strength and very low permeability — used for high performance concrete.
- Improves resistance to chlorides, sulphates and abrasion; reduces bleeding.
- Usually 5–10 % of cement; increases water demand, so superplasticizer is required.
- Used in high-rise columns, bridges, marine structures, repair mortars, shotcrete.

(Description 1 M, advantages 3 M)

c) Formwork; stripping time (IS 456)

4 M

Formwork (shuttering) is a temporary structure (mould) made of timber, plywood, steel etc. which holds fresh concrete in the required shape and position until it hardens and becomes self-

supporting.

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
Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days
Props to slabs — spanning up to 4.5 m	7 days
Props to slabs — spanning over 4.5 m	14 days
Props to beams and arches — spanning up to 6 m	14 days
Props to beams and arches — spanning over 6 m	21 days

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

(Definition 1 M, stripping times 3 M)

d) Ready mixed concrete

4 M

Ready mixed concrete (RMC) is concrete manufactured in a central batching plant under controlled conditions and delivered to the site in fresh condition by transit mixers (IS 4926). Types: central-mixed, transit (truck) mixed and shrink-mixed concrete.

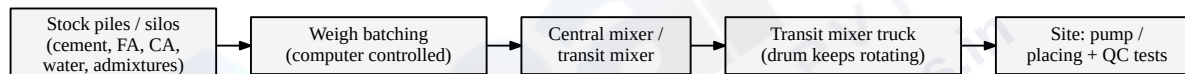


Fig.: Ready mixed concrete — production and delivery

Advantages:

- Better quality control — weigh batching, consistent quality.
- Faster construction; large quantities supplied quickly.
- No storage of materials at site; useful in congested city sites.
- Less wastage of materials, less labour, less noise and dust at site.

Disadvantages:

- Costly for small works; needs an RMC plant within reach.
- Traffic delays may cause loss of workability / setting in transit (retarders used).
- Needs good access roads and planning of placing (pumps, labour) at site.

Uses: high-rise buildings, bridges, flyovers, metro works, roads, industrial and large housing projects.

(Explanation 1 M, advantages 2 M, disadvantages 1 M)

e) Cold weather concreting

4 M

Cold weather concreting: concreting when the ambient temperature falls below about 5 °C (IS 7861 Part 2).

Effects:

- Setting and hardening are delayed; strength gain is very slow, so forms are removed late.
- Water in fresh concrete may freeze; ice expands and causes permanent loss of strength, cracking and scaling.
- Repeated freezing and thawing damages the surface.

Precautions:

- Heat the mixing water / aggregates; use rapid hardening cement or accelerators (no chlorides in RCC); low w/c ratio.
- Use air-entraining agent; do not place concrete on frozen ground; cover and insulate the concrete and formwork; provide heated enclosures.

(Definition 1 M, effects 1½ M, precautions 1½ M)

Q.5 Attempt any TWO of the following:

a) Mix design procedure (IS 10262:2019)

6 M

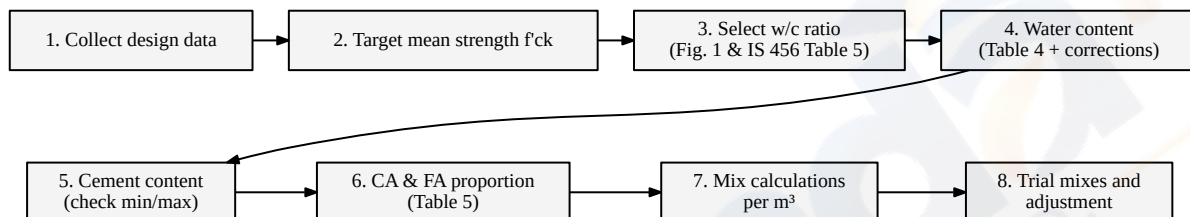


Fig.: Steps of concrete mix design (IS 10262:2019)

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 — M30): 20 mm angular CA, slump 100 mm, severe exposure, OPC 43, FA Zone II, SG: cement 3.15, CA 2.74, FA 2.65, PCE superplasticizer 1 % by mass of cement (SG 1.1) giving 20 % water reduction.

Step	Working	Result
Target mean strength	$f_{ck} + 1.65 s = 30 + 1.65 \times 5.0 = 38.25$; $f_{ck} + X = 30 + 6.5 = 36.50$	$f'_{ck} = 38.25$ N/mm ²
w/c ratio	Assumed from Fig. 1 = 0.42; IS 456 max for severe exposure = 0.45	Adopt 0.42
Water	Table 4 (20 mm) = 186 kg for 50 mm slump; +6 % for 100 mm slump = 197.16 kg; -20 % for superplasticizer	157.7 kg/m ³
Cement	$157.7 / 0.42 = 375.5$ kg; min. (IS 456) = 320 kg; max 450 kg	375.5 kg/m ³
CA proportion	Table 5, 20 mm, Zone II = 0.62 at w/c 0.50; correction for w/c 0.42 = +0.016	CA = 0.636, FA = 0.364
Volumes (m ³)	air = 0.01; cement = $375.5 / (3.15 \times 1000) = 0.1192$; water = 0.1577; SP = $3.76 / (1.1 \times 1000) = 0.0034$	all-in aggregate = 0.7096
Coarse aggregate	$0.7096 \times 0.636 \times 2.74 \times 1000$	1236.6 kg/m ³
Fine aggregate	$0.7096 \times 0.364 \times 2.65 \times 1000$	684.5 kg/m ³

Mix proportion (by mass) — cement : FA : CA = 1 : 1.82 : 3.29, w/c = 0.42 (per m³: cement 376 kg, water 158 kg, FA 685 kg, CA 1237 kg, SP 3.76 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

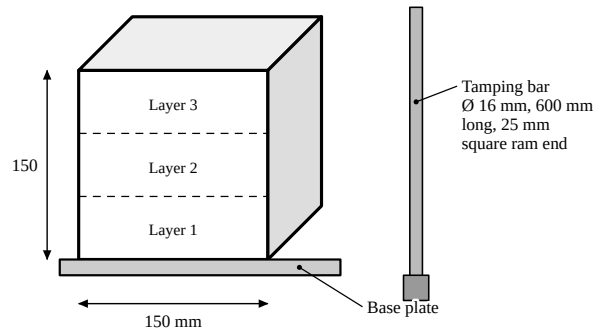


Fig.: Cube mould 150 mm with tamping bar

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.

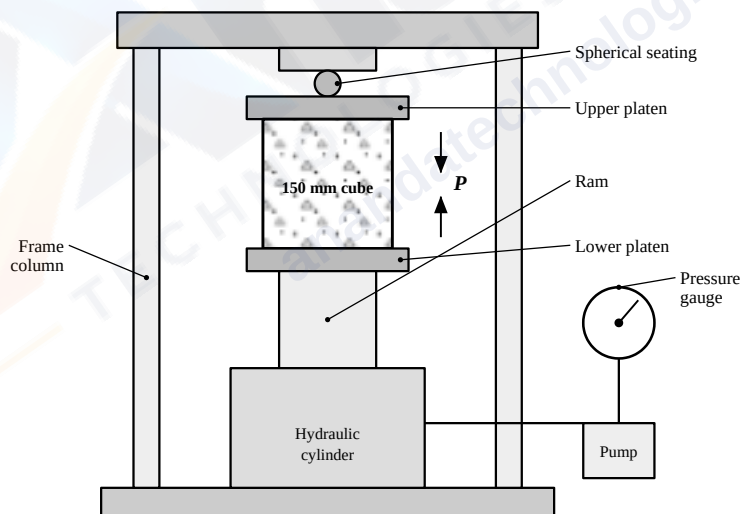


Fig.: Compression testing machine with 150 mm concrete cube

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, M30): $A = 150 \times 150 = 22500 \text{ mm}^2$

Cube	Load P (kN)	Strength P/A (N/mm ²)	Deviation from average
1	860	38.22	-2.5 %
2	905	40.22	+2.6 %
3	880	39.11	-0.2 %

Average compressive strength = **39.19 N/mm²**; all deviations are within $\pm 15\%$, so the result is valid and it is more than $f_{ck} = 30 \text{ N/mm}^2$.

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

c) NDT — importance, methods, rebound hammer

6 M

Non-destructive testing (NDT) means testing concrete in the structure without damaging it.

Importance:

- Estimates in-situ strength and quality / uniformity of concrete in existing structures.
- Detects cracks, voids, honeycombing and deterioration; helps in repair and rehabilitation decisions.
- Quality control of new construction (e.g. doubtful cube results) and checking of precast members.
- Assessment of old / fire- or earthquake-damaged structures; corrosion of reinforcement.

Methods of NDT:

1. Rebound hammer test (surface hardness)
2. Ultrasonic pulse velocity (UPV) test
3. Penetration resistance (Windsor probe) test
4. Pull-out test
5. Core test (partially destructive)
6. Radiographic (X-ray / gamma-ray) test
7. Cover meter / rebar locator
8. Half-cell potential test (corrosion of steel)
9. Carbonation depth test

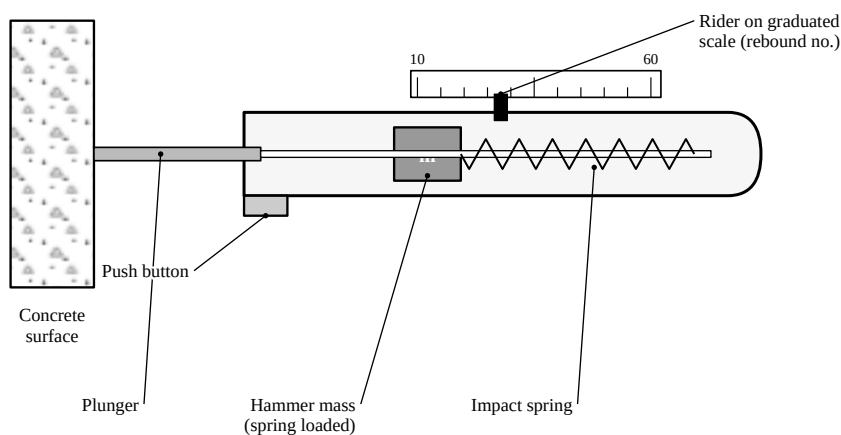


Fig.: Rebound hammer (Schmidt hammer) — schematic section

Rebound hammer test — principle: The rebound of a spring-controlled mass that strikes the concrete surface depends on the hardness of the surface. Surface hardness is related to compressive strength; the rebound number is converted into strength using the calibration graph supplied with the hammer. (IS 13311 Part 2; now IS 516 Part 5)

1. Make the test surface smooth and clean (rub with carborundum stone); avoid honeycombed, plastered or wet areas.
2. Hold the hammer perpendicular to the surface; press the plunger slowly against the surface till the hammer is released and strikes.
3. Read the rebound number on the scale (lock with the push button if required).
4. Take about 6–12 readings in each test area, at points not closer than about 20–25 mm, and find the average.
5. Read the compressive strength from the calibration curve for the hammer position (horizontal / upward / downward).

Average rebound number	Quality of concrete
> 40	Very good hard layer
30 – 40	Good layer
20 – 30	Fair
< 20	Poor concrete
0	Delaminated

(Guide commonly used in practice.)

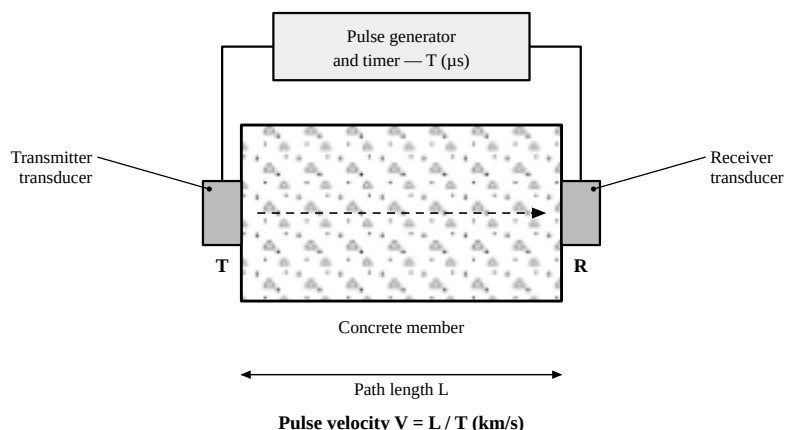


Fig.: Ultrasonic pulse velocity test — direct transmission

UPV test (brief): Time T taken by an ultrasonic pulse to travel path length L is measured; $V = L/T$. As per IS 13311 Part 1: $V > 4.5$ km/s excellent, 3.5–4.5 good, 3.0–3.5 medium, < 3.0 doubtful.

(Importance 1 M, list 1 M, rebound hammer principle and procedure 3 M, sketch 1 M)

Q.6 Attempt any TWO of the following:

a) Transportation methods and vibrators for given works

6 M

i) Method of transportation:

Situation	Suitable method and reason
1) Concrete from RMC plant 15 km away	Transit mixer (truck mixer) — the drum keeps rotating during travel, so concrete does not segregate or stiffen; a retarder may be added for long haul.
2) Lining of a tunnel	Concrete pump with pipeline (or shotcrete) — continuous placing in a confined space behind the tunnel formwork; little room for other equipment.
3) Mass concrete of a dam	Cableway / ropeway with buckets or belt conveyors — large quantities transported over a wide, deep valley quickly.

ii) Type of vibrator:

Situation	Suitable method and reason
1) RCC column	Needle (immersion) vibrator — needle can be lowered into the column and withdrawn slowly.
2) Thin, heavily reinforced wall	Form (external / shutter) vibrator — needle cannot enter between closely spaced bars; vibration is given through the formwork.
3) Precast kerb and paver blocks	Vibrating table (or block-making machine with table vibration) — moulds are placed on the table and vibrated uniformly.

(Each correct suggestion with reason, 1 M)

b) Silt content — field test, calculation, effects

6 M

Silt content is the fine material (clay and silt, finer than $75 \mu\text{m}$) present in sand. The field test is done by the measuring-cylinder method.

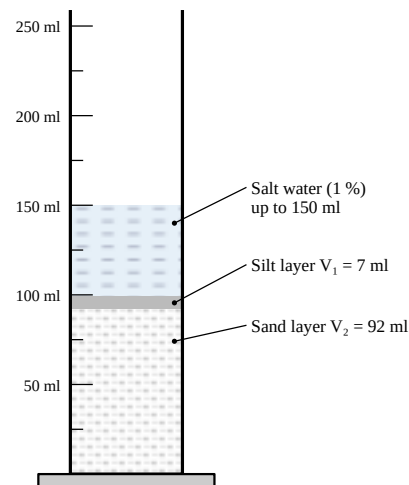


Fig.: Field test for silt content (250 ml measuring cylinder)

Procedure:

1. Take a 250 ml graduated measuring cylinder. Pour about 50 ml of 1 % common salt solution.
2. Add the sand gradually up to the 100 ml mark; add more salt water till the level reaches 150 ml.
3. Shake the cylinder vigorously, place it on a level surface and allow it to stand for about 3 hours.
4. The silt settles as a separate layer above the sand. Measure the volume of silt layer V_1 and of the sand layer below it V_2 .
5. Silt content (%) = $V_1 / V_2 \times 100$.

Calculation: $V_1 = 7 \text{ ml}$, $V_2 = 92 \text{ ml} \rightarrow \text{Silt content} = 7 / 92 \times 100 = 7.61 \%$.

Commonly adopted field limit: silt content should not exceed about 8 % by volume. Here $7.61 \% < 8 \%$ → the sand is acceptable.

Effects of excess silt on concrete:

- Silt coats the aggregate particles and **reduces the bond** between cement paste and aggregate → lower strength.
- Increases the **water demand** (large surface area) → higher w/c ratio and lower strength, more shrinkage.
- Causes **crazing, dusting** and weak surface; reduces durability and abrasion resistance.
- Increases bleeding/laitance and may cause delayed setting and efflorescence.

(Sketch 1 M, procedure 2 M, calculation 1 M, effects 2 M)

c) Column formwork; formwork materials

6 M

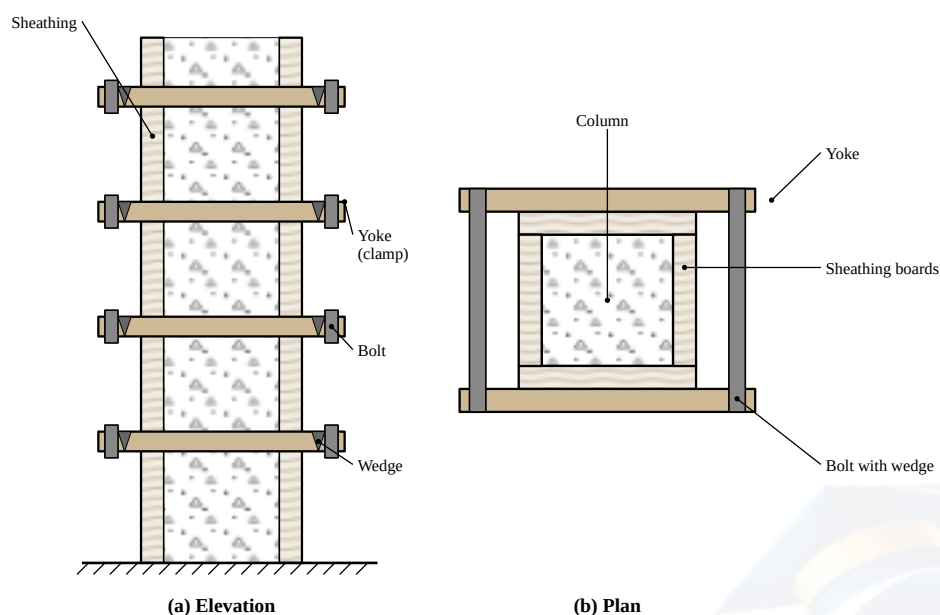


Fig.: Formwork for an RCC column

Description: Column formwork consists of **sheathing** boards (or plywood / steel panels) on all four sides, held together by horizontal **yokes (clamps)** at close spacing (closer at the bottom where pressure is higher), tightened by **bolts and wedges**. The box is fixed at the bottom on a kicker / frame and kept vertical by props or raking braces. A clean-out opening is kept at the bottom.

Materials used for formwork:

1. **Timber** — planks, battens, ballies; cheap, easy to make any shape; limited reuse.
2. **Plywood** — large smooth panels (shuttering ply), fewer joints, good finish.
3. **Steel** — plates and sections; strong, many reuses, smooth finish; costly and heavy.
4. **Aluminium** — light and strong system formwork for repetitive mass housing.
5. **Plastic / fibre reinforced plastic (FRP)** — light, reusable, for complex shapes and waffle slabs.
6. **Others** — fibre board, bamboo, glass fibre moulds, permanent (stay-in-place) formwork.

(Sketch with labels 3 M, description 1 M, materials 2 M)

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