

Concrete Technology (313322)

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

Q.1 Attempt any FIVE of the following:

a) Full names of Bogue's compounds

2 M

Short form	Compound	Chemical formula
C ₃ S	Tricalcium silicate	3CaO·SiO ₂
C ₂ S	Dicalcium silicate	2CaO·SiO ₂
C ₃ A	Tricalcium aluminate	3CaO·Al ₂ O ₃
C ₄ AF	Tetracalcium aluminoferrite	4CaO·Al ₂ O ₃ ·Fe ₂ O ₃

(½ M each)

b) Bulk density of aggregate

2 M

Bulk density is the mass of aggregate required to fill a container of unit volume, i.e. mass per unit volume **including the voids** between particles. It is found in loose and compacted (rodded) condition (IS 2386 Part III). **Unit:** kg/m³ (or kg/litre). Typical value of aggregates about 1450–1750 kg/m³.

(Definition 1 M, unit 1 M)

c) Creep of concrete

2 M

Creep is the gradual increase in strain (deformation) of hardened concrete with time under a constant sustained load. It increases with higher stress, higher w/c ratio, loading at early age, low humidity and high temperature. Example: long-term deflection of beams and loss of prestress.

(Definition 2 M)

d) Uses of low heat cement

2 M

Type of cement	Field applications
Low heat cement (IS 12600)	<ul style="list-style-type: none"> • Mass concrete works — dams, thick rafts, large foundations, massive retaining walls • Concreting in hot climate to reduce thermal cracking

(Any two, 1 M each)

e) Joint filling materials

2 M

1. Bitumen-impregnated fibre board
2. Cork sheet / compressed cork
3. Rubber strips / PVC water stops (water bars)
4. Bitumen / mastic sealing compound
5. Polysulphide or polyurethane sealant

6. Expanded polystyrene / polyethylene foam board

(Any four, $\frac{1}{2}$ M each)

f) Advantages of admixtures

2 M

- Increase workability without increasing water (plasticizers / superplasticizers).
- Control setting time — accelerate (cold weather) or retard (hot weather, RMC).
- Increase strength and durability by reducing w/c ratio; reduce permeability.
- Improve freeze–thaw resistance (air-entrainment); reduce heat of hydration (mineral admixtures); economy by saving cement.

(Any two, 1 M each)

g) Lightweight concrete

2 M

Lightweight concrete is concrete with a density much lower than normal concrete (about 2400 kg/m³); usually between about 300 and 1850 kg/m³.

Example: AAC blocks, foam concrete, pumice concrete.

(Definition 1 M, density range 1 M)

Q.2 Attempt any THREE of the following:

a) Compressive strength of cement

4 M

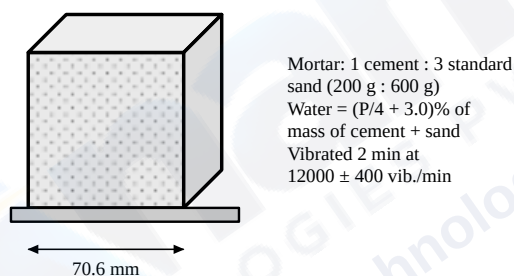


Fig.: 70.6 mm cube mould for cement mortar (face area 5000 mm²)

Reference: IS 4031 (Part 6). Specimen: 70.6 mm mortar cube (face area 50 cm²).

1. Take 200 g cement and 600 g standard sand (IS 650), i.e. mortar 1 : 3 by mass. Mix dry for about 1 minute.
2. Add water = $(P/4 + 3.0)$ % of the combined mass of cement and sand (P = standard consistency) and mix till uniform colour (3–4 min).
3. Place the oiled cube mould on the vibration machine and fill the mortar; compact by vibration for 2 minutes (12000 ± 400 vibrations per minute).
4. Keep the mould in moist air (27 ± 2 °C, ≥ 90 % RH) for 24 hours, then demould and cure the cube in clean water at 27 ± 2 °C.
5. Test three cubes each at 3, 7 and 28 days in the compression testing machine at a loading rate of 35 N/mm² per minute.
6. Compressive strength = Maximum load / Area (N/mm²). Average of three cubes is reported.

Grade of OPC (IS 269)	3 days	7 days	28 days
33	16	22	33
43	23	33	43
53	27	37	53

Minimum compressive strength in N/mm².

(Procedure 3 M, result / sketch 1 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 mm × 25 mm × 200 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) Classification of aggregates

4 M

A) According to size:

- **Fine aggregate:** passes 4.75 mm IS sieve (sand, stone dust/crushed sand).
- **Coarse aggregate:** retained on 4.75 mm IS sieve (10, 12.5, 20, 40 mm etc.).
- **All-in aggregate:** natural mixture of fine and coarse aggregate.
- **Single-size / graded aggregate:** mostly of one size, or containing a range of sizes as per IS 383.

B) According to shape:

Shape	Description / example	Effect
Rounded	Fully water-worn; river gravel, sea-shore	Good workability, less bond
Irregular	Partly rounded; pit sand, gravel	Medium workability
Angular	Sharp edges, crushed rock	Good bond and strength; needs more paste
Flaky	Thickness small compared with width/length	Undesirable
Elongated	Length large compared with other dimensions	Undesirable
Flaky and elongated	Both defects	Undesirable

(Size 2 M, shape 2 M)

d) Aggregate crushing value

4 M

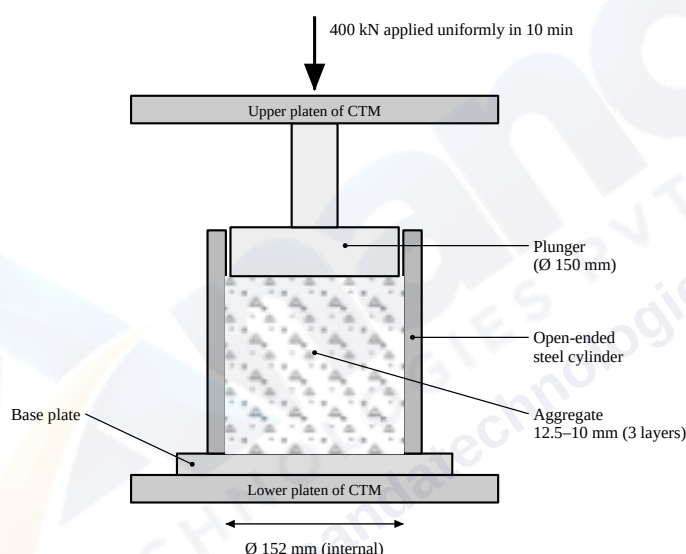


Fig.: Aggregate crushing value apparatus (IS 2386 Part IV)

Object: To find the resistance of coarse aggregate to crushing under a gradually applied compressive load. (IS 2386 Part IV)

1. Take dry aggregate passing 12.5 mm and retained on 10 mm IS sieve.
2. Fill the cylindrical measure (115 mm dia × 180 mm) in 3 layers, 25 tamps each; weigh the sample = W_1 .
3. Put the sample in the steel cylinder (152 mm dia) in 3 layers with 25 tamps each; level and place the plunger on top.
4. Apply load in the compression testing machine at a uniform rate so that **400 kN (40 t)** is reached in **10 minutes**.
5. Release the load, remove the aggregate and sieve on a 2.36 mm IS sieve; weigh the fraction passing = W_2 .

6. Aggregate crushing value = $(W_2 / W_1) \times 100 \%$.

Limits (IS 383): not more than 45 % for concrete other than wearing surfaces and 30 % for wearing surfaces. Lower value means stronger aggregate.

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

Q.3 Attempt any THREE of the following:

a) Abrams' law; effect of w/c on strength and durability

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.

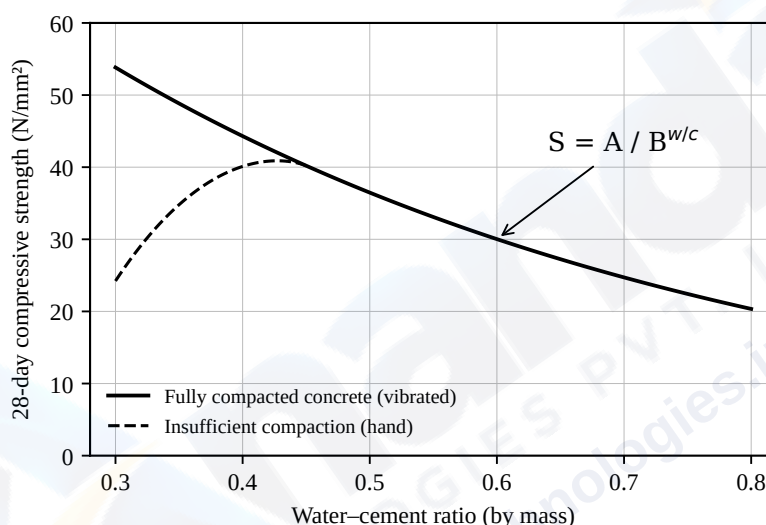


Fig.: Relation between w/c ratio and compressive strength (Abrams' law) — illustrative curve, $A = 96.5 \text{ N/mm}^2$, $B = 7$ (typical values only)

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, effect on strength 1 M, durability 1 M)

b) Workability; factors affecting

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.

1. **Water content** — more water increases workability (but reduces strength).
2. **Mix proportions** — aggregate/cement ratio; leaner mixes are less workable.
3. **Size of aggregate** — larger maximum size needs less paste and gives more workability.
4. **Shape of aggregate** — rounded aggregate gives more workability than angular, flaky or elongated aggregate.
5. **Surface texture** — smooth texture gives better workability than rough texture.
6. **Grading of aggregate** — well graded aggregate with fewer voids gives better workability.
7. **Use of admixtures** — plasticizers, superplasticizers and air-entraining agents increase workability.
8. **Time and temperature** — workability decreases with time after mixing and at higher temperature.

Tests for workability: slump test, compaction factor test, Vee-Bee consistometer test, flow table test.

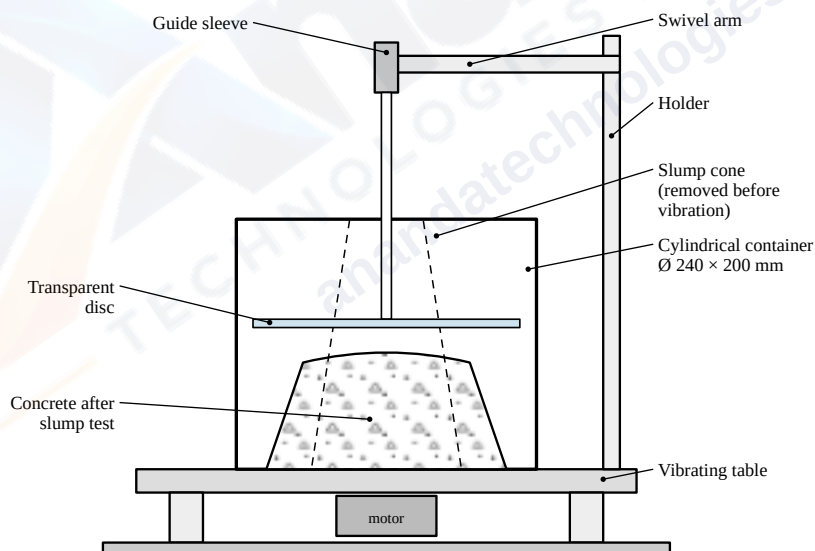


Fig.: Vee-Bee consistometer (for low-workability mixes; result in seconds)

(Definition 1 M, any six factors 3 M)

c) Impermeability of concrete

4 M

Impermeability is the property of concrete to resist the passage of water (or other liquids/gases) through it. Impermeable concrete is durable because harmful water, chlorides and sulphates cannot enter.

Factors affecting impermeability:

1. **Water–cement ratio** — high w/c leaves capillary pores; keep it low.
2. **Degree of compaction** — honeycombing and air voids increase permeability.
3. **Curing** — good curing fills pores with hydration products.
4. **Grading of aggregate and cement content** — dense, well graded mix with adequate cement.
5. **Age of concrete** — permeability reduces with age as hydration continues.
6. **Use of admixtures** — pozzolanas (fly ash, silica fume) and waterproofing admixtures reduce permeability.
7. **Cracks** due to shrinkage, temperature or loading increase permeability.

(Definition 1 M, any six factors 3 M)

d) Concreting operations; mixing

4 M



Fig.: Sequence of concreting operations

Concreting operations in sequence: **1. Batching** → **2. Mixing** → **3. Transportation** → **4. Placing** → **5. Compaction** → **6. Finishing** → **7. Curing**.

Mixing is done to coat all aggregate particles with cement paste and get a uniform mix.

- **Hand mixing:** on a clean water-tight platform; materials turned dry 3 times, then water added and turned again till uniform; about 10 % extra cement is used. Only for small works.
- **Machine mixing:** batch mixers (tilting drum, non-tilting drum, reversing drum, pan type) or continuous mixers. Mixing continued till uniform colour and consistency (normally not less than about 2 minutes after all materials are in).

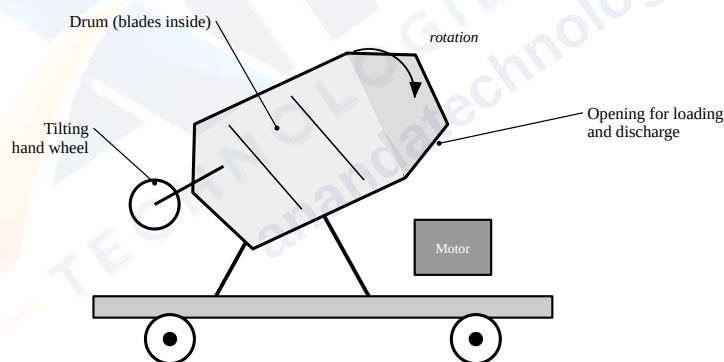


Fig.: Tilting drum batch mixer (schematic)

(Sequence 1 M, mixing 3 M)

Q.4 Attempt any THREE of the following:

a) Air-entraining admixture vs superplasticizer

4 M

Point	Air-entraining admixture	Superplasticizer
Function	Introduces millions of tiny, stable, well-distributed air bubbles (usually 3–6 % air)	Disperses cement particles strongly; high-range water reducer
Water reduction	Small	Large (about 20–30 %)
Effect on strength	Strength reduces slightly (about 5 % per 1 % air)	Strength increases due to lower w/c
Main purpose	Freeze–thaw resistance; better workability and less bleeding	Flowing concrete, SCC, HPC, pumped concrete with low w/c
Examples	Vinsol resin, natural wood resins, fatty acid salts	SNF, SMF, modified lignosulphonates, polycarboxylate ether (PCE)

(Any four points, 1 M each)

b) Cementitious admixtures; GGBS

4 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

Ground granulated blast furnace slag (GGBS): By-product of iron production in blast furnaces; molten slag is quenched rapidly with water (granulated) and ground to fine powder. It has latent hydraulic (cementitious) property.

- Replaces a large part of cement (25–70 % in Portland slag cement, IS 455).
- Lower heat of hydration — suitable for mass concrete.
- High resistance to sulphate and chloride attack — marine and sewage works.
- Lighter colour, better finish; long-term strength and durability increase; early strength slower.

(List 1 M, GGBS 3 M)

c) High performance concrete

4 M

High performance concrete (HPC) is concrete that meets special performance requirements — high strength, high durability and good workability — which cannot be achieved with ordinary materials and methods. Made with low w/c (about 0.25–0.35), silica fume / fly ash / GGBS and superplasticizers.

Properties:

- High compressive strength (generally 60 N/mm² and above) and high early strength.
- Very low permeability and high durability (chloride, sulphate, abrasion resistance).
- High workability without segregation; high modulus of elasticity; low creep and shrinkage.

Applications:

- Columns of high-rise buildings; long-span bridges and flyovers.
- Marine and offshore structures, nuclear and chemical plants.
- Pavements, airport runways, tunnels and precast prestressed members.

(Properties 2 M, applications 2 M)

d) Formwork; removal time for slab and beam

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, slab and beam periods 3 M)

e) Joining old and new concrete

4 M

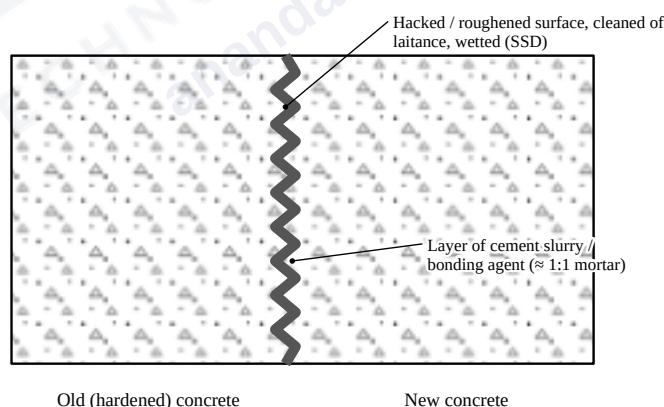


Fig.: Joining old and new concrete at a construction joint

1. Remove loose concrete and the weak top layer (laitance) by hacking / chipping, wire brushing or air–water jet when concrete is still green, so that coarse aggregate is exposed.
2. Clean the surface of dust, oil and debris; wash with water.
3. Keep the surface wet for some hours so that it is saturated but surface-dry (no standing water).

4. Apply a thin layer of cement slurry / rich mortar (or an epoxy / polymer bonding agent) on the joint surface.
5. Place the new concrete immediately, before the slurry sets, and compact it thoroughly against the old surface.
6. Cure the joint properly; locate such joints at points of minimum shear.

(Any four steps 1 M each (sketch preferred))

Q.5 Attempt any TWO of the following:

a) Mix design procedure (IS 10262:2019)

6 M

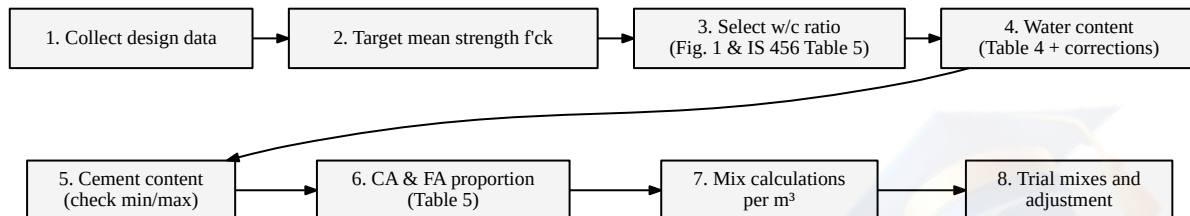


Fig.: Steps of concrete mix design (IS 10262:2019)

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 — M20): 20 mm angular CA, slump 50 mm, mild exposure, OPC 43, FA Zone I, SG: cement 3.15, CA 2.7, FA 2.65, no admixture.

Step	Working	Result
Target mean strength	$f_{ck} + 1.65 s = 20 + 1.65 \times 4.0 = 26.60$; $f_{ck} + X = 20 + 5.5 = 25.50$	$f'_{ck} = 26.60 \text{ N/mm}^2$
w/c ratio	Assumed from Fig. 1 = 0.50; IS 456 max for mild exposure = 0.55	Adopt 0.50
Water	Table 4 (20 mm) = 186 kg for 50 mm slump; +0 % for 50 mm slump = 186.00 kg	186.0 kg/m ³
Cement	$186.0 / 0.50 = 372.0 \text{ kg}$; min. (IS 456) = 300 kg; max 450 kg	372.0 kg/m ³
CA proportion	Table 5, 20 mm, Zone I = 0.60 at w/c 0.50; correction for w/c 0.50 = +0.000	CA = 0.600, FA = 0.400
Volumes (m ³)	air = 0.01; cement = $372.0 / (3.15 \times 1000) = 0.1181$; water = 0.1860	all-in aggregate = 0.6859
Coarse aggregate	$0.6859 \times 0.600 \times 2.7 \times 1000$	1111.2 kg/m ³
Fine aggregate	$0.6859 \times 0.400 \times 2.65 \times 1000$	727.1 kg/m ³

Mix proportion (by mass) — cement : FA : CA = 1 : 1.95 : 2.99, w/c = 0.50 (per m³: cement 372 kg, water 186 kg, FA 727 kg, CA 1111 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) Slump cone test; IS 456 slump values

6 M

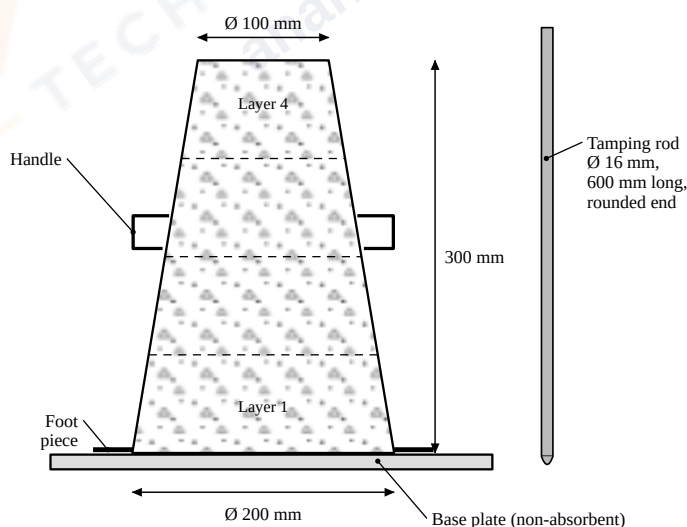


Fig.: Slump cone and tamping rod (IS 1199)

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

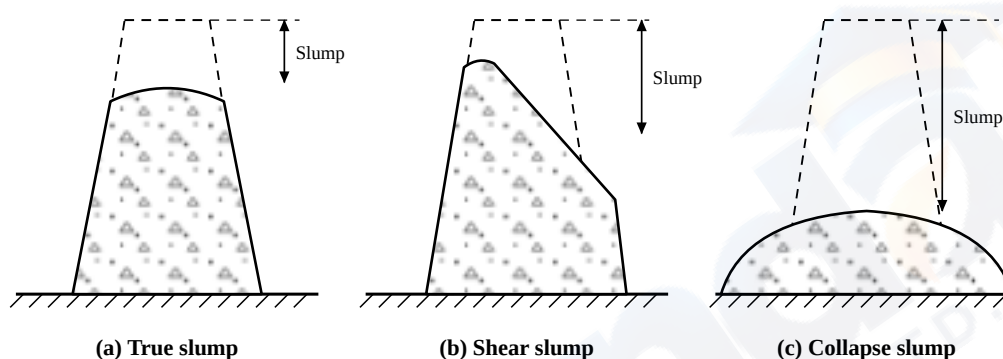


Fig.: Types of slump

- **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.

Workability (slump) recommended by IS 456:2000, Cl. 7.1:

Placing condition	Degree of workability	Slump (mm)
Blinding concrete; shallow sections; pavements using pavers	Very low	See 7.1.1 (compacting factor 0.75–0.80)
Mass concrete; lightly reinforced slabs, beams, walls, columns; floors; hand-placed pavements; canal lining; strip footings	Low	25–75
Heavily reinforced sections in slabs, beams, walls, columns	Medium	50–100
Slipform work; pumped concrete	Medium	75–100
Trench fill; in-situ piling	High	100–150
Tremie concrete	Very high	See 7.1.2 (flow test)

(Sketch 2 M, procedure 2 M, types of slump 1 M, IS 456 values 1 M)

Answer: i) Mass concrete — low workability, slump **25–75 mm**; ii) Heavily reinforced sections — medium, **50–100 mm**; iii) In-situ piling — high, **100–150 mm**.

c) Compressive strength of concrete cubes

6 M

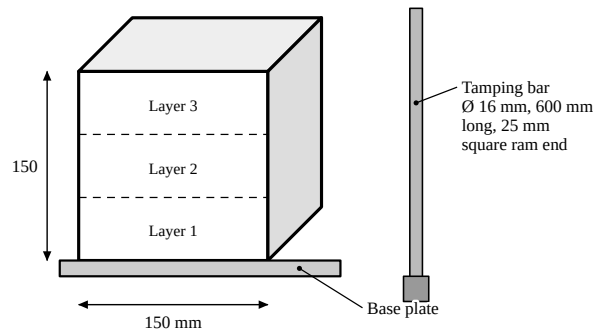


Fig.: Cube mould 150 mm with tamping bar

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 ($\geq 90\%$ RH) at $27 \pm 2^\circ\text{C}$ for $24 \pm \frac{1}{2}$ hours, then demould.
6. Cure the cubes in clean water at $27 \pm 2^\circ\text{C}$ until the time of test (usually 7 and 28 days). Three cubes are tested for each age.

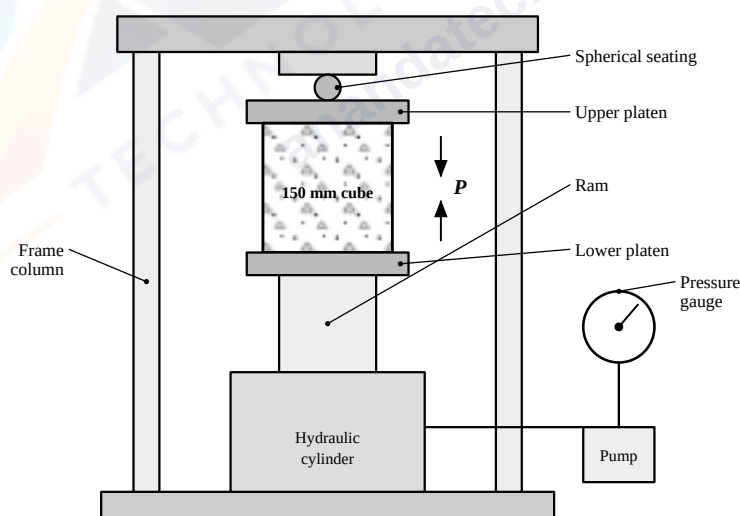


Fig.: Compression testing machine with 150 mm concrete cube

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, M20): $A = 150 \times 150 = 22500 \text{ mm}^2$

Cube	Load P (kN)	Strength P/A (N/mm ²)	Deviation from average
1	512	22.76	-0.6 %
2	538	23.91	+4.5 %
3	495	22.00	-3.9 %

Average compressive strength = **22.89 N/mm²**; all deviations are within $\pm 15\%$, so the result is valid and it is more than $f_{ck} = 20 \text{ N/mm}^2$.

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

Q.6 Attempt any TWO of the following:

a) Fineness modulus, grading zone and grading curve

6 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	150	15.0	19.0	81.0
1.18 mm	240	24.0	43.0	57.0
600 μm	300	30.0	73.0	27.0
300 μm	150	15.0	88.0	12.0
150 μm	90	9.0	97.0	3.0
Pan	30	3.0	—	—

Σ cumulative % retained = $4.0 + 19.0 + 43.0 + 73.0 + 88.0 + 97.0 = 324.0$

FM = $324.0 / 100 = 3.24$

Result: FM = 3.24 $\rightarrow$ the sand is **very coarse sand (above 3.2)**.

Grading zone (IS 383:2016, Table 9): % passing on 600 μm = 27 %, and all sieves lie within the limits of **Zone I**.

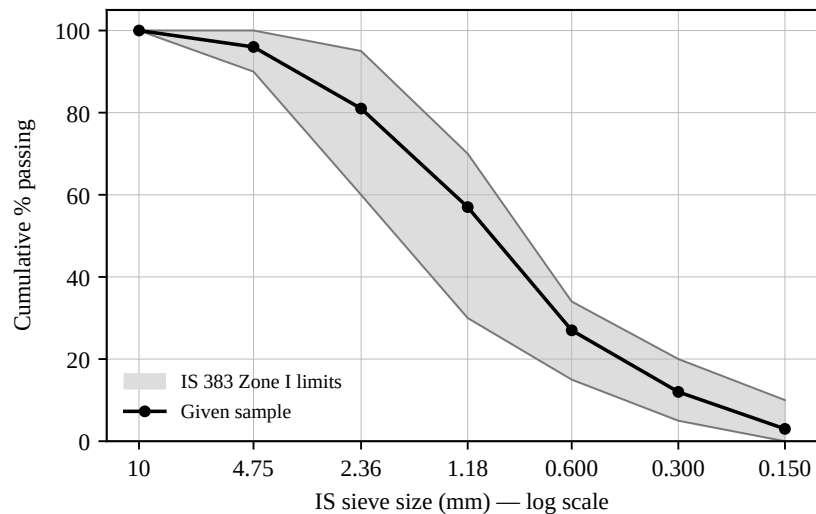


Fig.: Grading curve of the given sand with IS 383 Zone I limits

(Table 3 M, FM 1 M, zone / interpretation 1 M, curve 1 M)

b) Remedial measures for segregation and bleeding

6 M

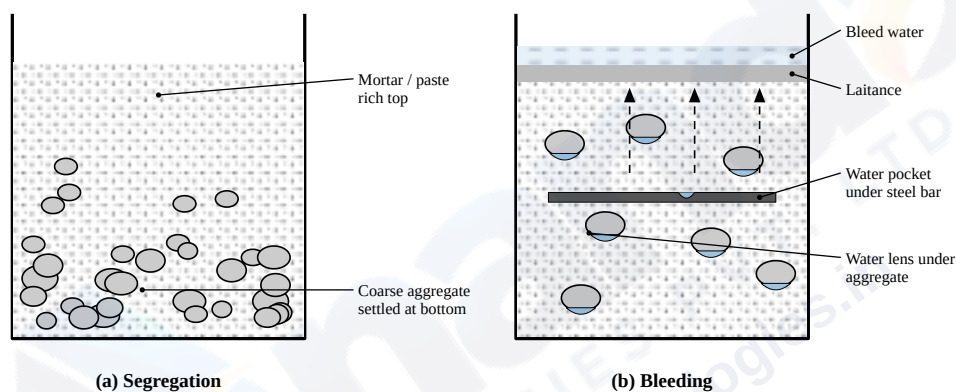


Fig.: Segregation and bleeding in fresh concrete

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.

Remedial measures at site (with reasons):

1. **Reduce water / w/c ratio** and use a plasticizer for workability — less free water means less bleeding and a more cohesive mix.
2. **Use well-graded aggregate with sufficient fines** (or add fly ash / stone dust) — fines hold water and keep coarse aggregate suspended.
3. **Place concrete close to its final position;** avoid free fall more than about 1.5 m and avoid long chutes; use tremie / pump — prevents separation of coarse aggregate.
4. **Correct vibration** — vibrate till the surface just becomes shiny; over-vibration drives water and paste upward.

5. Use **air-entraining admixture or pozzolana** — tiny bubbles and fine particles reduce bleeding and segregation.
6. **Remove bleed water before finishing** and delay final trowelling; re-vibrate if needed — avoids weak laitance and dusting.
7. **Check transit time / remix** in transit mixer before discharge to restore uniformity.

(Any six measures with reasons, 1 M each)

c) Formwork for beam and slab; requirements

6 M

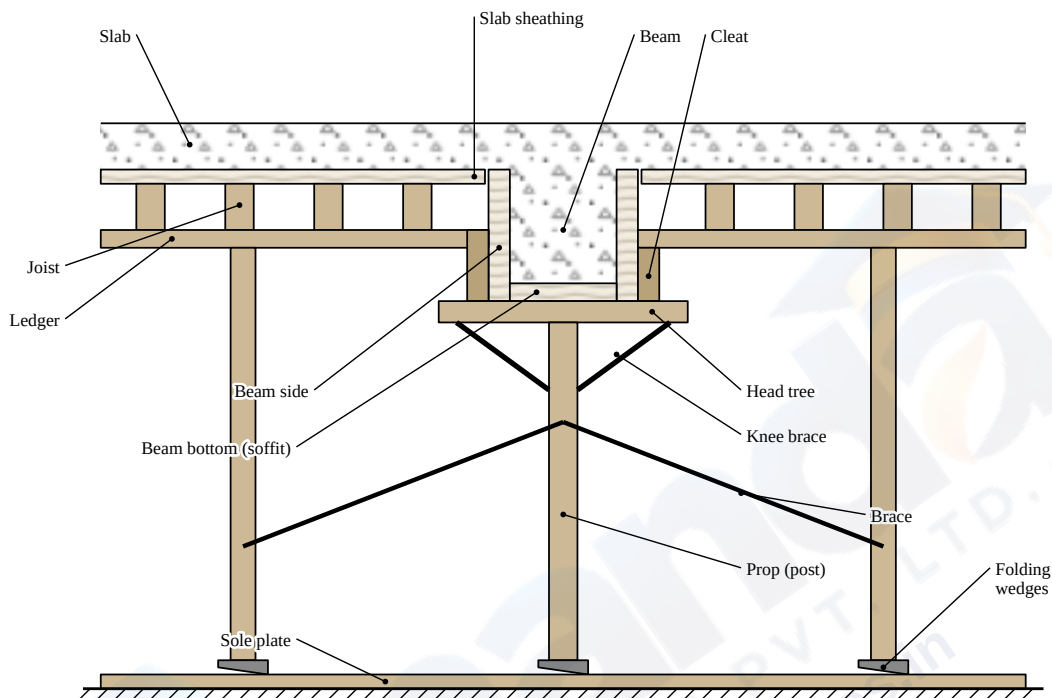


Fig.: Formwork for RCC beam and slab (cross-section)

Description: Slab sheathing rests on **joists**, which rest on **ledgers** supported by props and by **cleats** on the beam sides. The beam box has two **side boards** and a **bottom (soffit) board** resting on a **head tree** carried by a **prop** with knee braces. Props stand on **folding wedges** over a **sole plate** (wedges allow easy levelling and removal); props are braced.

Requirements of good formwork:

- Strong enough to carry the dead load of concrete, live load and vibration without deflection.
- Rigid and well braced so that shape and dimensions are maintained.
- Joints tight (leak-proof) to prevent loss of cement slurry.
- Easy to erect and remove (strip) without damaging concrete; light and economical; reusable.
- Gives the required surface finish; inner surface oiled for easy removal.

(Labelled sketch 4 M, any four requirements 2 M)

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