

Concrete Technology

Functions of ingredients of OPC Raw material

Ingredient	oxide	%	Property	Excess quantity
Lime	CaO	63	Sound & Strong	Unsound, Expand & Disintegrate
Silica	SiO_2	22	Provide strength due to formation of C_2S & C_3S	Setting slowly
Alumina	Al_2O_3	6	Quick Setting and lowers the clinkering temp	
Iron oxide	Fe_2O_3	3	Colour, Hardness & strength Helps in fusion of raw materials during manufacture of cement.	
Magnesium oxide	MgO	2	Hardness & Colour	Unsound
Sulphur trioxide	SO_3	2	Sound	Unsound
Alkalies	K_2O , Na_2O	1	No use, Hence should be present in small quantity	Efflorescence

Bogue's Compounds

The above mentioned ingredients/oxide are presents in Raw materials [like Limestone, clay shale] used for the manufacture of cement.

These oxide interact with each other in the kiln at high temperature to form more complex compounds, identified by R.H. Bogue, hence it is called 'Bogue's Compounds'.

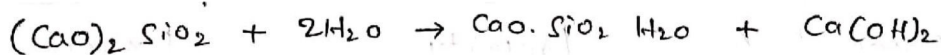
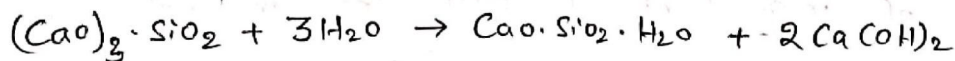
Name of compounds (Major)	Formula	Abbreviated formula	%	Also called
Tricalcium Silicate	$3\text{CaO} \cdot \text{SiO}_2$	C_3S	45	Alite
Dicalcium Silicate	$2\text{CaO} \cdot \text{SiO}_2$	C_2S	25	Belite
Tricalcium Aluminate	$3\text{CaO} \cdot \text{Al}_2\text{O}_3$	C_3A	11	Celite
Tetracalcium Allumino ferrite	$4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$	C_4AF	9	Felite

② Minor Compounds

Alkalies $\rightarrow \text{K}_2\text{O}$ and Na_2O

Sulphate attack

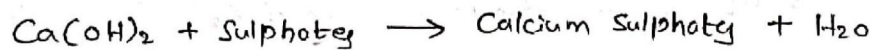
Step ① Formation of Calcium hydroxide Ca(OH)_2 , due to C_3S & C_2S



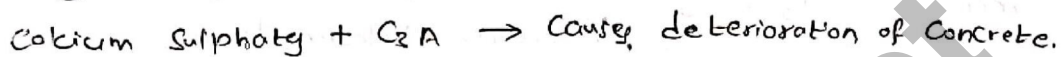
($\therefore \text{CaO} \cdot \text{SiO}_2 \cdot \text{H}_2\text{O}$ is called C-S-H gel & also called Tobermorite gel)

→ Hence, C_3S produces more Ca(OH)_2 , hence it is more responsible than C_2S

Step ② Formation of Calcium Sulphate.



Step ③ Finally reacts with C_3A



→ Hence to Reduce Sulphate attack by Reducing C_3A (nearly 5%).

Ca(OH)_2

By using fly ash, silica fume... etc, may reduce the bad effect of Ca(OH)_2 in concrete.

The only advantage is that Ca(OH)_2 being alkaline in nature,

maintain pH around 13 in the concrete, which resist the corrosion of Reinforcement

* Functions of Bogue's Compounds.

1) C_3S	<ol style="list-style-type: none"> 1. Hydrates more rapidly, hence Generate large heat of hydration. 2. Responsible for Early strength of Concrete.
2) C_2S	<ol style="list-style-type: none"> 1. Hydrates slowly, hence Generates less heat of hydration. 2. Responsible for Later strength of Concrete. 3. provide good ultimate strength.
3) C_3A	<ol style="list-style-type: none"> 1. It is the 1st compound reacts with water, hence Cause initial setting of Cement. 2. Harmful to the durability of Concrete, especially where the Concrete attacked by Sulphates.
4) C_4AF	<ol style="list-style-type: none"> 1. It reacts slowly with water and Generates very small amount of heat of hydration. 2. Hence, it has poor cementing value.

Case (i) High % of C_3S and low % of C_2S , results

1. Rapid hardening → High early strength
2. Produces high heat of hydration
3. Less resistance to Sulphate attack.

Case (ii) Low % of C_3S and High % of C_2S , results

1. Slow hardening → Much more ultimate strength
2. produces less heat of hydration
3. Greater resistance to Sulphate attack.

Types of Cements

a) Ordinary Portland Cement (OPC)

1. There are three types OPC 33, 43 & 53 grades (eg: 28 days strength $\geq 33 \text{ N/mm}^2$)
 2. It has adequate resistance to dry shrinkage & cracking.
 3. But has less resistance to chemical attack, Hence should not be used for where Sulphate in the soil/water.
- Cement mortar - 1:3
Cube size - 7.07 cm
Surface Area - 50 cm²

b) Rapid Hardening Portland Cement

1. It develops some strength in 3 days, as expected of OPC in 7 days.
2. By making High % of C_3S & low % of C_2S .
3. Used in Road repair works, Cold weather concrete, early formwork...etc.
4. Do not used in mass concrete construction

c) Sulphate Resisting Cement

→ Generally limits the C_2A content to 5% & $2C_2A + C_4AF \leq 25\%$.

Recommended under following conditions.

1. Marine Conditions (i.e Alternate wetting & drying). Like Culverts, lined canals..
2. Sewage treatment works, like sewer pipes.
3. Basements & foundations having Sulphate attack.

d) Low heat Portland Cement

Is achieved by reducing the % of C_3S & C_2A and increasing C_2S .

1. Useful for mass concrete works, such as Dams.
2. Also called Low Hardening Portland Cement, but great ultimate strength.

e) High Alumina Cement

Achieved by increasing Alumina % $\approx 35\%$.

1. Useful in chemical plants & sea water
2. Used in having high temperature like furnaces, kilns, chimneys...etc.

f) Blast Furnace slag Cement

It is cheap & economical, although safe upto M20

1. Useful in mass concrete works
2. It causes efflorescence, due to the presence of Alkaline.

g) Pozzolona Cement (PPC)

It is made by integrating (70% OPC + 30% Pozzolona). Pozzolona is essentially a silicious material containing clay upto 80%.

1. Widely used for Hydraulic structure, such as Dams, weirs...etc.

h) Coloured Cement

Prepared by adding 5-15% of suitable Colouring Pigment before the cement is finally placed on ground. Also called "Colocrete".

1. Widely used for finishing of floors, external surfaces...etc.

Testing of Portland Cement

1. Field / Physical Testing

Only used for Minor work. (it gives some idea about Good/Badness of Cement)

1. Colour of Cement should normally be Greenish grey.
2. The bag looking good Surface, do not have any lumps.
3. Handfull of Cement thrown into bucket of water, it float for some time before they sink.
4. Thrust your hand into cement bag. It must give you a cool feeling.
5. Rubbed in b/n fingers, it feels smooth.

2) Fineness Test

Finer Cement ($3-25\mu$) has great functioning than Coarser Cement ($>100\mu$) due to the least void ratio and more cohesiveness/adhesiveness.

a) Sieve method (Finer cement has quicker action with water & gain early strength)

Weight of residue left after sieve through IS Sieve No. 9 (90μ)

$\nless 10\%$ for OPC

$\nless 5\%$ for PPC

b) Air permeability method

Accurate method. Finess can be found by passing Dry air through the bed of Cement. "Blain air permeability apparatus" is more commonly employed in India.

Specific Surface $\nless 2250 \text{ cm}^2/\text{gm}$ \rightarrow OPC

$3000 \text{ cm}^2/\text{gm}$ \rightarrow PPC

$3200 \text{ cm}^2/\text{gm}$ \rightarrow Rapid & low heat

3) Consistency Test

This test is conducted to determine the Percentage of water (P) required for preparing Cement paste of Standard Consistency for other tests (eg: Setting time, Soundness & Compressive Strength test)

\rightarrow Vicat's Apparatus used to determine the (Initial setting time, Final setting time & Normal Consistency) of the Cement.

\rightarrow For this consistency test Vicat's apparatus consists of a plunger having 10mm dia & 50mm length.

Test!

\rightarrow Take 500gm of Cement & mixed with water 25%. (For first trial) the paste filled into the Vicat's mould within 3-5 minutes.

\rightarrow Release the plunger from the top surface of Cement paste.

\rightarrow observe the penetration of plunger.

\rightarrow The Cement paste is said to be Standard Consistency if the plunger is penetrates for a depth of 33-35 mm from top.

\rightarrow If not satisfied increase/decrease the water by 1-2% & conduct trials.

$\therefore P =$ Percentage of water required to produce a Cement paste of Standard Consistency.

4) Setting Time Test

Instrument - Vicat's apparatus

Cement Sample - 500gm

% of water = 0.85p

Room temperature = $27 \pm 2^\circ\text{C}$

Stop watch started - From the addition of water to Cement.

a) Initial Setting Time ≥ 30 min

Penetration needle - Square needle ($1\text{ mm} \times 1\text{ mm}$)

Permissible penetration level = 5mm from bottom.

Stop watch stopped - when the needle stops penetration at 5mm

b) Final Setting Time ≥ 10 hrs

→ also called "Annular Collar".

Penetration needle - Circular needle (1mm dia) having sharp end

Stop watch stopped - when the needle stops penetration at 0.5 mm from the top.

5) Soundness Test

Instrument - Le-Chatelier apparatus

% of water - 0.78p

Unsound Cause - Due to the presence of Excess Lime & Magnesia

→ The difference b/n two readings (initial & after cooling the boiled concrete with water) indicates the Expansion of Cement.

∴ This Expansion $\geq 10\text{ mm}$

6) Compressive Strength Test

Mortar - 1:3, Cube size - 7.07 cm , Surface area - 50 cm^2

% of water = $\left(\frac{P}{4} + 3\%\right)$ of Combined weight of (Cement + Sand)

→ Compressive Strength $\geq 11.5\text{ N/mm}^2$ at the end of 3 days

17.5 N/mm^2 at the end of 7 days.

7) Tensile Strength Test

→ Tensile Strength $\geq 2\text{ N/mm}^2$ 3 days

2.5 N/mm^2 7 days

Mortar - 1:3
% of water - $\left(\frac{P}{5} + 25\%\right)$

Aggregates

Natural Aggregates - Sand, Gravel, Crushed rock are used for R.C.C

Artificial aggregates - Furnace clinker, coke breeze, Saw dust and Foamed Slag are used for concrete of low density.

Shape of aggregate [Size $> 75\text{mm}$ - called Cyclopean aggregate]

1. Round shape aggregate (River & Sea shore gravel)

Has minimum voids $\rightarrow 32-38\%$

2. Irregular aggregate (Pit sand & gravel)

Has high % of voids $\rightarrow 35-38\%$

3. Sharp & Angular aggregate (Crushed rock)

Has Maximum voids $\rightarrow 38-40\%$

4. Flaky aggregates

Thickness is very small as compared to length/width.

Least dimension (Thickness) $\leq \frac{3}{5}$ of mean dimension

5. Elongated aggregates

Length is very large as compared to width/thickness.

Greatest dimension (Length) $> 1.8 \times$ mean dimension.

(\therefore Mean dimension = Avg Sieve size, of aggregate is 1st retained & last passing)

Weight of aggregates

1. Normal weight

Sands, Gravels & Crushed rocks of Granite, Basalt, quartz, Sandstone & limestone.

Sp.gr - 2.5 - 2.7 Concrete (γ) = 23 - 26 kN/m³

2. Heavy weight

Hematite, magnetite, Gneissite, baryte, Scrap iron... etc.

Sp.gr - 2.8 - 3.0 Concrete (γ) = 28 - 30 kN/m³

\rightarrow These are not appropriately graded.

3. Light weight

Cinder, pumice, volcanic, diatomite... etc & artificial aggregate

Unit wt of only aggregate $\approx 12 \text{ kN/m}^3$

\rightarrow It provides high resistance to fire

Dryness of aggregates

Very dry aggregate - Zero moisture in pores & surface

Dry aggregate - May be moisture in pores, but surface dry.

Saturated-surface dry aggregate - Fully moisture in pores, but surface dry

Moist aggregate - pores & surface both fully wet.

Specific gravity

Apparent specific gravity = $\frac{\text{Weight of oven dry aggregates}}{\text{Absolute volume, Excluding natural pores in aggregate}}$

Bulk specific gravity = $\frac{\text{Weight of oven dry aggregates}}{\text{Absolute volume, Including natural pores in aggregate}}$

Testing of aggregate

a) Impact Value Test

To determine the Toughness of the aggregate.

→ Hammer is lifted up 38cm & Subjected to 35 15 blows (14kg's)

b) Crushing Value Test

To determine the Crushing Strength of the aggregate.

→ Constant load of 40 tons applied at the rate of 4 tons/minute

→ Crushing value < 30% for concrete used for road pavements
45% for other structure

∴ Aggregate crushing/Impact value = $\frac{\text{Wt passing through 2.36 mm sieve after test}}{\text{Overall weight of aggregate}}$

c) Abrasion Value

To determine the resistance of an aggregate to wear (i.e. Hardness) when it is rotated in a cylinder of about 1000 revolutions.

by using Los Angeles machine.

Abrasion value = $\frac{\text{Wt passing through 1.7mm sieve after test}}{\text{Original overall wt of aggregate}}$

(abrasion test) Hardness = $20 - \frac{\text{Wt through 1.7mm (i.e. loss in grams)}}{3}$

→ Abrasion value < 30% for wearing surface
50% for Non-wearing surfaces.

d) Bulking of Sand

The increase in volume of sand due to the presence of moisture upto certain extent is called bulking of sand.

Bulking factor = $\frac{\text{Volume of moist sand}}{\text{Volume of dry sand}} = 1 - e$

e) Deleterious materials in aggregate

They produce bad effect on the function & properties of aggregate.

∴ The sum of % of all deleterious materials ≠ 5%

f) Fineness Modulus $\left[\% \text{ of F.A} = \frac{F_{CA} - F}{F - F_{FA}} \times 100 \right]$

It gives some idea of the average size of particles in the aggregate.

Fine sand : 2.2 - 2.6

Medium sand : 2.6 - 2.9

Coarse sand : 2.9 - 3.2

A sand having fineness modulus (F.M) more than 3.2 will be unsuitable for making satisfactory concrete.

Admixtures

1. Accelerators (Calcium Chloride CaCl_2)

Used to accelerate the initial setting time of concrete
→ Needed when concrete placed at low temperature

2) Retarders (Calcium Sulphate & Gypsum)

Used to delay the hydration process → initial setting time.
→ Needed in hot weather and long transportation time.

3) Plasticizers (Carbohydrates)

Also called "water reducers".

→ Needed at high workability cause segregation & bleeding.
*) Other important plasticizers = Calcium, ammonium & Sodium ligno Sulphonates.
→ They permit water reduction upto 5-15%.

4) Super plasticizers (Modified ligno Sulphonate & Acrylic polymer)

Are the improved version of plasticizers.

→ They permit water reduction upto 30%.
→ Mostly used for flow, self levelling, self compacting concrete
→ It can be mixed with Air-entrainment agents for reducing air entrainment and increasing the workability.

5) Air-Entraining (Animal & vegetable fats, oils and their fatty acids)

Entraining - Air added/distributed evenly in the entire mass of concrete, ranging from 5-80%.

Entrapped - Voids present in the concrete due to insufficient compaction

→ These Air-Entraining agent forms bubble in voids, where excess water present. (They can be separated out by capillary pores). Since, the excess water may converted into ice which increase pressure on concrete.
(∵ Ice is 10% more volume than water)

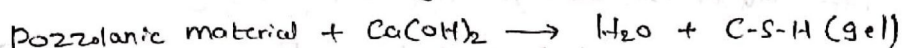
→ Hence, majorly used where alternating freezing & thawing
→ It also increases the workability of concrete.

6) Air-detraining (Tri-butyl-phosphate)

→ Dissipating excess air or other gases and
→ Removing excess entrained air from concrete.

7) Pozzolanic (Finely divided siliceous substances)

→ To reduce the Calcium hydroxide concentration.



8) Corrosion inhibiting (Sodium benzoate, Sodium nitrate.. etc)

→ Is employed to control the corrosion of steel reinforcement in concrete.

Water & water-cement Ratio

Water

Portable water are generally considered satisfactory for mixing & curing of concrete.

pH value of water should be 6-8 & 4-6

Water-cement Ratio (By Duff Abram)

$$W/C \text{ ratio} = \frac{\text{Weight of water}}{\text{Weight of Cement}}$$

0.45 \rightarrow 1:1:2 concrete

0.50 \rightarrow 1:1½:3 "

0.5-0.6 \rightarrow 1:2:4 "

\rightarrow According to Abram lesser the W/c in a workable mix greater will be its strength

\rightarrow if $W/C < 0.45$, the concrete is not workable, causes Honey-combed structure, will be harsh containing a large no. of voids.

Solids in water	Permissible Limit (IS:56)
1. Organic	200 mg/L
2. Inorganic	3000 mg/L
3. Sulphate (as SO_4)	400 mg/L
4. Chlorides (as Cl)	2000 mg/L \rightarrow plain concrete 500 mg/L \rightarrow R.C.C
5. Suspended matter	2000 mg/L

eg: $W/C = 0.5$

\Rightarrow The quantity of mixing water required per one bag of cement

$$= 0.5 \times 50 \text{ kg}$$

$$= 25 \text{ kg or } 25 \text{ litr}$$

Workability

The ease with which it can be mixed, transported and placed in a position in homogeneous state.

\rightarrow Concrete is said to be workable if it is mixable, stable, flowable/movable, compactable & finishable.

a) Water Content

At low W/c not workable. At high W/c it highly workable (but not finishable)

b) Size of aggregate

Large size agg are more workable. (\because F.A require more water for lubrication)

c) Shape of aggregate

Round shape - Increase

Angular, Flaky, elongated - Decrease workability

d) Surface Texture of aggregate

Smooth surface increase workability

e) Void ratio

Uniform void ratio (ie well graded aggregate) increase workability.

f) Air entraining agents

Produced air bubbles act as rollers and thus increase workability.

g) Admixtures

The use of plasticizers will increase the workability

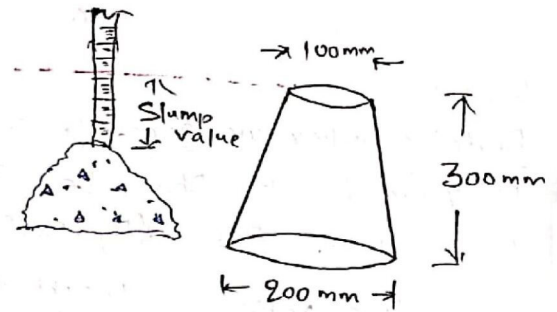
h) Temperature

workability of concrete mix reduce at higher temperature.

Measurement of Workability

1. Slump Test

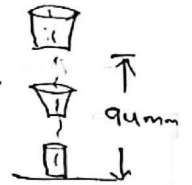
- Suitable only for Medium-High workability
- Max size of agg \neq 38 mm
- Slump value increase - workability increase.



2. Compaction factor test

- Suitable for Medium-low workability
- Concrete can be compacted by pulling from upper cone - lower cylinder.

$$\text{Compaction Factor} = \frac{\text{Weight of Partially Compacted Concrete}}{\text{Weight of Fully Compacted Concrete}}$$



3. Vee-Bee test

- Suitable for stiff concrete having low-Very low workability
- The time required for the shape of concrete change from Slump Cone shape to Cylindrical shape in seconds is known as Vee-bee time.



Placing Conditions	Degree of Workability	Slump (mm)	Compaction Factor	Vee-bee (Seconds)
1. Building Concrete, Shallow sections Pavements using pavers	Very Low	< 25	0.75-0.80	20-10
2. Mass Concrete, Lightly reinforced sections in slabs, beams, walls, columns & floors, Hand placed pavements, Canal lining & strip footings	Low	25-75	0.80-0.85	10-5
3. Heavily reinforced sections in slabs, beams, walls & columns. Slip formwork, pumped concrete	Medium	50-100 75-100	0.85-0.92	5-2
4. Trench Fill, In-situ piling	High	100-150	> 0.92	2-0
5. Tremie Concrete (Device lowered into water to deposit)	Very High	> 150		

Process of Manufacture of Concrete

1. Batching (or) Measurement of materials

a) Volume Batching

It is an approximate method, Hence used for small jobs.

→ The volume of one bag of cement is taken as 35 litry. for agg proportion (But cement is always measured by weight. It is never measured in volume).

→ Wooden gauge boxes (called Farmas) are used for measuring F.A & C.A

For measuring 50 lit of aggregate, inner dimension of Farma = $31 \times 31 \times 52$ cm.

[Floor area of 1 bag of Cement = 0.3 m^2 + Height = 0.18 m]

b) Weight Batching

Strictly speaking, weight batching is correct method of measuring materials, Hence adopted for important concrete work.

eg: for concrete mix of 1:2:4, the material req

50 kg (Cement) : 70 litres (F.A) : 140 litry (C.A)	Volume batching
50 kg (Cement) : 100 kg (F.A) : 200 kg (C.A)	Weight batching

2. Mixing

Concrete mixers are designed to run at a speed of 15-20 rev/min (Normal mix)
25-30 rev/min (Well designed mix)

3. Transporting

Concrete is transported by pumps for concreting of tunnel lining.

→ The concrete can be lifted by pumps through a maximum vertical distance of 50m.

→ While transporting by pumps the W/C should be 0.5 - 0.65.

4. Placing

→ Concrete should not be drop from a height more than 1.5m. (IS 456)

→ Placing of concrete starts from width wise in RCC slabs from one end.

5. Compaction

Is the process adopted for expelling the entrapped air from the concrete.

a) Hand Compaction

Only adopted for small & unimportant works

b) Internal Vibrator (Also called Immersion or Needle or Packer vibrator)

Consists of a power unit, a flexible shaft and a needle at end.

→ Used for large section of mass concrete work.

c) External vibrator (Also called Form work or Shutter vibrator)

The vibration is given to the formwork so that the concrete in the vicinity of the shutter gets vibrated.

→ Used for columns, lateral tie, & heavily reinforced sections & thin walls.

→ Care shall be taken for bleeding & leakages.

d) Surface or Screed Board Vibrators

A small vibrator placed on the screed board gives an effective method of compacting & levelling of thin concrete members.

- Such as mostly, Floor slabs & roof slabs of thickness $\leq 15\text{ cm}$.
- For slabs of $> 15\text{ cm}$ thickness "Double beam screed board vibrators" are may be used.

e) Table vibrator

Concrete is so placed on the table, it can be vibrated.

- These are commonly used in laboratories for making cubes, cylinders etc.
- Platform vibrator

Is nothing but a table vibrator, but it is large in size.

- Used in the manufacture of large pre-fabricated concrete elements such as electric poles, railway sleepers, roofing elements etc.

f) Vibratory Roller

A vehicle containing roller, which vibrates the concrete.

- Generally to compact the base-course of the road.

Note

- Vibrators are most suitable for low-medium workable concrete.
- For high workable concrete it may lead to segregate.

6. Curing

Concrete derives its strength by the hydration of cement particles.

Note:

- Cement req. a w/c of 0.23 for hydration & 0.15 for filling the voids
- Hence minimum requirement of w/c = 0.38
- Although practically req. of w/c = 0.50
- By applying heat (it will accelerate the hydration) by keeping concrete wet will result faster curing.
- Concrete gains strength upto 100% after the curing of 28 days.
- Concrete should be kept constantly wet for at least
 - 7 days → Normal OPC
 - 10 days → Where admixture or blended cement are used
 - 10 days → Concrete exposed to dry & hot weather condition
 - 14 days → Admixture & hot condition.

7. Finishing

The results of finishing are good if slump is about 50mm

- Screeding: It is the levelling operation that removes humps & hollows and give a true and uniform concrete surface.
- Floating: It is the process of removing the irregularities from the surface of concrete left after screeding.
- Trowelling: It is the final operation of finishing the concrete surface. It is performed where smooth and dense surface is required. (1:4) mortar

8. Stripping of Formwork

- Formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking.
- Forms shall not be released/removed until the concrete has achieved a strength of at least Twice the stress to which the concrete may be subjected at the time of removal of formwork.

Type of Formwork	Minimum period before Stripping.
a) Vertical formwork to Columns, walls & beams.	16-24 h
b) Soffit formwork to Slabs (props to be refixed immediately after removal of form work)	3 days
c) Soffit formwork to beams (props to be refixed immediately after removal of form work)	7 days
d) props to Slabs	7 days
1) Spanning upto 4.5m	14 days
2) Spanning over 4.5m	
e) props to beams & arches	14 days
1) Spanning upto 6m	21 days
2) Spanning over 6m	

Durability of Concrete

It is the property by which concrete possesses same strength throughout its life time without much shrinkage & cracking.

* Factor affecting durability are W/c & Cement content.

→ Maximum Cement content = 450 kg/m³

→ Minimum Cement content = is based on Exposure Conditions.

Exposure Condition	Plain Concrete			Reinforced Concrete		
	Grade (min)	W/C (max)	Min Cement	Grade (min)	Max W/c	Min Cement
Mild	M15	0.60	220	M20	0.55	300
Moderate	M15	0.60	240	M25	0.50	300
Severe	M20	0.50	250	M30	0.45	320
Very Severe	M20	0.45	260	M35	0.45	340
Extreme	M25	0.40	280	M40	0.40	360

→ above values are specified for Aggregate of 20mm Nominal max size.

→ +40kg/m³ → 10mm -30kg/m³ → 40mm Should be adjusted for Cement.

Concrete Grades

Type of Concrete

1. Ordinary Concrete $M_{10} - M_{20}$
2. Standard Concrete $M_{25} - M_{55}$
3. High strength Concrete $\geq M_{60}$

→ Grade $\geq M_{30}$, rate of increase of compressive strength with age shall be based on actual investigation
 → Grade $> M_{55}$, fck will be determined by specialized experimental results.

Mix proportion

- a) Design Mix Concrete (For any Grade of Concrete)
- b) Nominal mix Concrete $\leq M_{20}$ (may be used with the permission of Engineer-in-Charge, if design mix not needed)

Note:

- For Nominal mix, proportion of F:A:C is generally 1:2, but subjected to an upper limit of $1:1\frac{1}{2}$ and lower limit of $1:2\frac{1}{2}$.
- Max size of aggregate for $1:1\frac{1}{2}$, $1:2$ and $1:2\frac{1}{2}$ are 10mm, 20mm, 40mm respectively.

Type of Construction.	Minimum Grade	Grade	Nominal mix (IS 456-1978)
1. Lean Concrete bases	$M_5 + M_{7.5}$	M_5	1:5:10
2. plain concrete Cement (PCC)	M_{10}	$M_{7.5}$	1:4:8
3. RCC general construction	M_{15}	M_{10}	1:3:6
4. Water tanks, domes, Folded tanks.	M_{20}	M_{15}	1:2:4
5. In Sea water	M_{30} (RCC) M_{20} (PCC)	M_{20}	$1:1\frac{1}{2}:3$
6. post-tensioned PSC	M_{30}	M_{25}	1:1:2
7. pre-tensioned PSC	M_{40}		