

# Concrete Technology

## 1. Classification of Sand According to IS : 650

Zone	Size of Agg.	Type of Sand	Use
Zone-I	4.75 - 2	Coarse sand	Concrete work
Zone-II	2-0.425	Medium sand	
Zone-III	0.425-0.075	Fine sand	Masonry work
Zone-IV	< 0.075	Very fine sand	Plastering

### Workability

Workability  $\propto$  W / C ratio.

Types of workability	Water cement ratio
Unworkable concrete	W/C ratio < 0.40
Medium workable concrete	0.40 - 0.55
High workable concrete	>0.55

### Factors Affecting Workability-

- i. Water content or W/C ratio
- ii. Admixture
- iii. Size of Aggregate
- iv. Temperature
- v. Shape of aggregate
- vi. Grading of aggregate
- vii. Time period
- viii. Air entraining agents

### Modulus of elasticity of concrete

$$E_c = 5700\sqrt{f_{ck}} \text{ N/mm}^2 \text{ [IS.456:1978]}$$

$$E_c = 5000\sqrt{f_{ck}} \text{ N/mm}^2 \text{ [IS.456:2000]}$$

### Target mean strength of concrete

$$f_{cm} = f_{ck} + 1.65\sigma$$

$\sigma$  = Standard deviation

$F_{cm}$  = Target mean strength

$f_{ck}$  = Characteristic strength

### Permissible shear stress of reinforced concrete

$$= \frac{f_{ck}}{30}$$

### Standard deviation of concrete

Concrete grade	Standard deviation (cr) N/mm <sup>2</sup>
M-10toM-15	3.5
M-20 to M-25	4.0
M-30 to M-55	5.0

### Long-Term Modulus of Elasticity

$$E_{ce} = \frac{E_c}{1 + \theta}$$

Where,

$E_c$  = Short term elastic modulus

$\theta$  = Creep coefficient

### Permissible limit for solids in concrete water as per IS 456-2000

Material	Permissible Limit
Organic	200 mg/l
Inorganic	3000 mg/l
Sulphate	400 mg/l
<b>Chlorides</b>	
(i) RCC	500 mg/l
(ii) PCC	2000 mg/l
Suspended	2000 mg/l

### Finishing Operation of Concrete

Screeding	Levelling operation or removing/ striking excess
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	concrete humps and hollows of uniform concrete surface.
Floating	Removing irregularities from the surface of concrete left after screeding.
Trowelling	Final operation of finishing. It is done to create smooth, hard and dense surfaces.

### Special Types of Concrete

Self healing/ bacterial or bioconcrete	Described as a material that is capable of repairing itself when cracked.
Green (Fresh) concrete	Concrete which is eco-friendly to the environment. It is made by adding waste materials as a partial or complete replacement for cement.
Cellular/Aerated/foam Concrete	It is made by using air or gas into slurry.
Ferro-Cement	It is a composite material prepared by using closely spaced one or multiple layers of wire mesh.

### Test of Hardened Concrete

Non-destructive Test	To obtain various properties of hardened concrete of existing structure without damaging or dismantling.
Rebound Hammer method	To determine uniformity and compressive strength.
Ultrasonic pulse velocity method	It measure time of travel of the ultrasonic pulse, which is indicate the quality of concrete.

Radioactive method	Thickness of the concrete is measured by this method.
Penetration/Windsor probe test	It is used to measure the surface hardness and hence the strength of the surface and near surface layer.
Core test	To check the compressive strength of concrete in situ condition.

### Maturity of Concrete

Concrete maturity =  $\Sigma(\text{Time} \times \text{Curing Temperature})$

- Datum temperature =  $-11^{\circ}\text{C}$
- Day temperature =  $T^{\circ}\text{C}$
- Curing temperature =  $T - (-11) = (T + 11)^{\circ}\text{C}$

### Environmental exposure conditions

(Clauses 8.2.2.1 and 35.3.2)

Environment	Exposure condition
Mild	Concrete surfaces protected against weather or aggressive conditions.
Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wet. Concrete exposed to condensation and rain. Concrete continuously under water. Concrete in contact or buried under non-aggressive soil/ground water. Concrete surfaces sheltered from saturated salt air in coastal area.
Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in sea water. Concrete exposed to coastal environment.

Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet. Concrete in contact with or buried under aggressive sub-soil/ground water.
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Extreme	Surface of members in tidal zone. Members in direct contact with liquid/solid aggressive chemicals.
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**For Maximum 20 mm Nominal Size Aggregate**

Exposure Condition	Min. Cement Content (Kg/m <sup>3</sup> )		Min. Grade of Cone.		Max. Water Cement Ratio		Min. Concrete Cover (mm)
	P.C.	RCC	P.C.	RCC	P.C	RCC	
Mild	220	300	-	M-20	0.60	0.55	20
Moderate	240	300	M-15	M-25	0.60	0.50	30
Severe	250	320	M-20	M-30	0.50	0.45	45
Very severe	260	340	M-20	M-35	0.45	0.45	50
Extreme	280	360	M-25	M-40	0.40	0.40	75

**Note-** P.C. - Plain Concrete,

RCC- Reinforced Cement Concrete

**Workability, Slump and Compacting Factor of Concrete with 20 mm and 40 mm Size of Aggregate.**

Workability	Slump in mm	Compaction factor	Ve e Bee second	Use for which Conc.is Suitable
Very Low	0-25	0.78	20-40	Used in road making, roads vibrated by power operated machines
Low	25-50	0.85	10-20	For foundations with light reinforcement, Roads vibrated by hand operated Machines
Medium	50-100	0.92	7- 10	manually compact flat slabs using crushed aggregate. Normal reinforced concrete manually compacted and heavily reinforced sections with vibrations
High	100-175	0.95	<7	for sections with congested Reinforcement, not normally suitable for vibration.

**Types of admixture**

Plasticizer	<p>↑ Workability &amp; strength of concrete at the same water content.</p> <p><b>Ex.-</b> Ligno Sulphonic acid, polyglycol ester, Sodium and Ammonium acid.</p>
Super Plasticizer	<p>Used in making high strength concrete.</p> <p><b>Ex.-</b> Acrylic polymer, sulphonated melamine formaldehydes (SMF).</p>
Accelerators	<p>↑ Rate of strength &amp; hydration.</p> <p><b>Ex.-</b> CaCl<sub>2</sub>, NaCl, Al<sub>2</sub>C<sub>13</sub>, Sodium Sulphate, Sodium Carbonate, Sodium Hydroxide.</p>
Retarder	<p>↓ Rate of hydration cement &amp; ↑ setting time.</p> <p><b>Ex.-</b> Gypsum, Sugars, Starches, Cellulose products, salts of acids, NII<sub>4</sub>Cl, ferric chloride (FeCl<sub>3</sub>).</p>
Air Entainers	<p>↑ Workability &amp; durability.</p> <p>↓ Bleeding, Segregation and Laitance.</p> <p><b>Ex.-</b> Resins, water soluble soap, steric acid, Sulphonic acid.</p>

**Effect of Fly ash in concrete -**

- i. Improve workability.
- ii. Decrease water demand.
- iii. Reduce heat of hydration.
- iv. Increase ultimate strength.
- v. Reduce permeability.
- vi. Improve durability.

**Creep increases when-**

- i. Aggregate content is low.

- ii. Cement content is high.
- iii. Water cement ratio is high.
- iv. Air entrainment is high.
- v. Temperature is high.
- iv. Relative humidity is low.

**Creep coefficient value based on age of concrete-**

Age of concrete	Creep coefficient
> 7 days	2.2
> 28 days	1.6
> 1 year	1.1

**Water Cement Ratio**

$$W/C \text{ ratio} = \frac{\text{Wt. of water}}{\text{Wt. of cement}} = \frac{1}{\text{Concrete strength}}$$

**Formwork related terminology**

Shuttering	Vertical temporary structure used as a mould for a structure.
Centering	It is done during construction to support the formwork for horizontal surfaces including floor beams and slabs. It provides shape of horizontal surface.
Staging	Temporary structure which is used to support form work.
Raking shore	It is a inclined member which provide lateral support to to unsafe structure.
Stripping time	Required minimum period before sticking formwork

**Min. Grade of Conc. Required for Various Types of Construction**

Minimum Grade	Types of Construction
M-5, M-7.5	Lean concrete base
M-15	Plain cement concrete
M-20	RCC (General construction)
M-30	Water tank, Domes



M-30	RCC in sea water and Post-tensioned
M-40	Pre-tensioned