Under the Guidance of –
Mr. Dhyan Pal (IES AIR-179 ,GATE AIR-93&145 ,UPPSC AE Rank -02 GWD, SSC JE selected)

SHORT NOTES

Building Materials

Useful for objec ve and conven onal types exams like ESE, GATE, UPPSC-AE, SSC-JE, RRB Exams etc

Topics Covered- Cement, brick, Lime, Mortar, Rock, Stone, Brick Masonary, Stone Masonary, Aggregate, Paint, Timber, Glass, plastics, ceramics

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Cement

(raw material)

Argillaceous material (Binding)
mainly Silica, Alumina, oxides of Iron
↓
Clay & shale
(Slate, blast furnace slag)

Calcareous material (strength)
compounds of Calcium & Magnesium
↓
limestone, chalk, marine shell
(cement rock, marl)

note :- Sometimes Silicious material also included in above classification.

Note : The modern cement $\xrightarrow{\text{known as}}$ ordinary portland cement
∵ after setting it resembles in color and Quality with 'Portand stone' quarried in Dorset - UK.

cement Manufacturing steps

1. proportioning of Raw material
2. Grinding, intimate mixing
3. Buring in a large 'Rotary kiln' at 1400-1500°C
   purpose → to produce $\underbrace{\text{'clinker'}}_{\text{fused material (3-20mm)}}$
4. clinker grinding (Add Gypsum before this)

note : Ball mill / Tube mill ⟶ Used for grinding

(wet process में) (Dry process में) } Process of manufacturing

note :- Modern Cement plant use dry method
∵ dry process ⟶ economical
in wet process ⟶ longer kiln used which consume more fuel

note :- Gysum (2-3%) of clinker is added at the beginning of clincker griding
purpose ⟶ increase the setting time of cement
retard setting / reaction
to avoid flash set (Quickset)

cement

- **Hydraulic cement** → Portland cement
  - sets & becomes hard when mixed with water
  - can harder even under water
- **non hydraulic cement**
  - does not set in water
  - harden only in air
  - Ex :- POP (plaster of paris)
    ⇓
    Used for finishing and decoration
    not for structural work

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chemical composition of Portland cement

main Items (elements): lime, Silica, Alumina + others: Ironoxide, magnesia, Alkalis, Sulpher trioxide

Trick : L-SAI-MASt

oxide	(%) composition	function
Lime (CaO)	60-65	• control strength & soundness • deficiency reduces strength & setting time Exess ⟶ unsoundness & cracks
Silica (SiO_2)	17-25	• Gives strength Excess ⟶ slow setting
Alumina (Al_2O_3)	3-8	• helps in quick setting ~~• Acts as flux (helps material melt & combine in kiln)~~ Excess ⟶ reduce strength
Iron oxide (Fe_2O_3)	0.5-6	• Gives color • helps in fusion of different ingradients (act as flux)
Magnesia (MgO)	0.5-4	• Imparts color & hardness Excess ⟶ cracks in mortar & concrete
Alkalis (Na_2O+K_2O)	0.5-1.3	• small quantity generally present as impurity (residues) इसमें नहीं मिलाते हैं। Excess ⟶ efflorescence & cracking
Supher trioxide (SO_3)	1-2	excess ⟶ cement unsound

Bouge compound : cement clinker is formed by burning raw materials, which combine to form special compounds that set & harden when mixed with water. They control strength & setting of cement.

1- C_3S (Alite) Tricalcium Silicate ($3CaO \cdot SiO_2$) hydrates Quickly ∴ responsible of early strength	25-50% (normally 40%) of cement. • Best cementing material • develops early hardness & strength (mainly 7 days) ∵ faster rate of reaction • cement that has high C_3S is good for cold weather concreting & road construction. • increases resistance to freezing & Thawing • Heat of hydration = 500 J/g
2- C_2S (Belite) Di-calcium Silicate ($2CaO \cdot SiO_2$)	• 25-40% (normally 32%) • hydrates & harden slowly • gives long term strength (Ultimate Strength) to cement. • Impart resistance to chemical-attack. • contribution of it takes place after 7days & may continue for upto 1 year • Used in dam & hydraulic structure. (weir, bridge etc) • Less heat of hydration (260 Joule/gram)

3- C_3A (celite)
Tricalcium Aluminate ($3CaO \cdot Al_2O_3$)
⇓
highly reactive
⇓ ∴
responsible for many undesirable Properties of cement.

- (5-11%) (normally 10.5%)
- Quickest one to react with water.
- Responsible for flash setting.
- very high heat of hydration (865 J/g)
- formed within 24 hr. of addition of water.
- C_3A↑ ⇒ will help in Quick setting cement.
- does not contribute to the development of the strength of the concrete sample.
- more susceptible to sulphate attack.
- responsible for IST of cement.

4- C_4AF (Felite)

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- Tetra Calcium Alumino ferrite
- 8-14% (normally 9%)
- poorest cementing value (so provide less or nil strength)
- responsible for flash set but generates less heat (420 J/g)
- C_4AF↑ ⇒ reduce strength slightly

Flash set (Quick set): due to inadequate gypsum, Premature hardening of cement happens
Large amount of heat produced during this.
Reasons: (i) Gypsum ↓ (ii) C_3A ↑
(iii) Presence of Alkalis.

False set: It means cement paste becomes stiff quickly but without much heat.
- The mix loses workability at first but becomes workable again after remixing (not permanent like flashset)

Reason: Intergrinding too hot clinker, gypsum dehydrates & forms gypsum hemihydrates ($CaSO_4 \cdot \frac{1}{2}H_2O$)
$CaSO_4 \cdot 2H_2O$

Hydration of cement: when water is added to cement, a chemical reaction b/w water & cement takes place ⟶ hydration of cement.
- In this reaction heat Liberated ⟶ $\boxed{\text{Exothermic reaction}}$
- product of hydration {- CSH gel (Tobermorite gel)
Calcium silicate hydrate ($CaO\ SiO_2\ H_2O$)
⇓
$\boxed{\text{responsible for cement strength}}$

hydrated crystals are extremely small, fibrous, Platey, tubular shape less than 2μm to 10μm or more.

Water Requirement for hydration

$\boxed{\text{Total water req. for complete hydration} \Rightarrow 38\%}$ (by wt. of cement)

- Bound water (23%)
  {$C_3S \to 24\%$, $C_2S \to 21\%$}
  → reacts chemically with cement compound during hydration
- Gel water (15%)
  ↓
  Physically held inside the tiny Pores of cement gel.

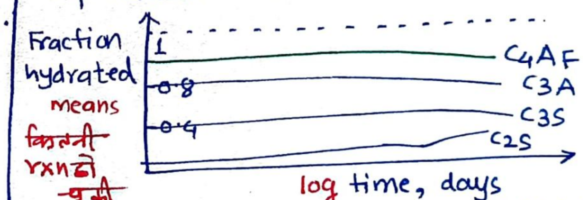
note: if excess water present, it will lead to capillary cavity.

Rate of Heat evolution ⇒ $C_3A > C_3S > C_4AF > C_2S$
(J/g) 865 500 420 260
if equal Amount of each is taken
Trick: 3+1 = 4 जूल/ग्राम

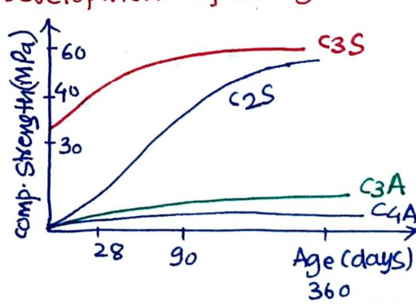
note: if C_2S↑ Then Heat of hydration decreases

Rate of hydration ⇒ $C_4AF > C_3A > C_3S > C_2S$
when total heat evolved same
Trick: 4-3 = 1

note: rate of hydration increases when fineness of cement increases



Development of strength



{Early strength → C_3S
late strength → C_2S
C_4AF & C_3A → minor role in strength

Remember: Basic element of cement (Ca, O_2, Si, Al, Fe)
↓
(during burning) ← oxides of element (CaO, SiO_2, Al_2O_3, Fe_2O_3)
↓
(C_3S, C_2S, C_4AF, C_3A) cement compounds / Bouge compound
clinker compounds
↓
reaction of cement with water
(C-S-H) + ($Ca(OH)_2$) + (Heat)

IS 4031 (Part 1 to 15): methods of physical Tests for hydraulic cement

IS 4032: method of chemical analysis of hydraulic cement

IS 269:2015 ⇒ ordinary portland cement - specification

Laboratory Tests of cement

1) Fineness Test:

Fineness↑ surface area↑ faster hydration↑
High heat evolution↑ strength develop faster↑
Greater drying shrinkage of concrete↑

(measure grain size) Fineness Test

- By sieve method
  - dry sieving (IS 4031 Part-1) ⇓ 90 μm sieve
  - wet sieving (IS 4031 part-15) ⇓ 45 μm sieve
  - fineness as represented by mass of residue left on std. sieve size.
- By specific surface area ($unit = \frac{cm^2}{gram} = \frac{surface\ area}{weight}$)
  - Blaine air-Permeability method (IS 4031 Part-2) (Lea & Nurse Apparatus)
  - Wagner Turbidimeter Test (Sedimentation method)

Sieve no:- Grain size is expressed in terms of sieve number.
→ no. of openening per linear inch

∴ $\boxed{\text{Grain Size} \propto \frac{1}{\text{Sieve no.}}}$

Grain Type	Sieve no.	Examples of sieve no.
Coarse	10-24	10, 12, 14, 16, 20, 24
medium	30-60	30, 36, 46, 54, 60
fine	70-180	80, 100, 120, 150, 180
Very fine	220-600	220, 240, 280, 320, 400, 500, 600

Cement type	% of residue by weight on 90 μm sieve (maximum)	
OPC (all grade)	10	(ordinary portland cement)
PPC	5	(Portland Puzzolona ")
RHC	5	(Rapid Hardening ")

cement type	Min specific surface area ($\frac{cm^2}{gram}$)	
✓ OPC (all grades), HAC, SRC	2250	High Alumina -
✓ PPC	3000	
LHC →	3200 3250	Low Heat cement -
✓ RHC		
✓ SSC	4000	supersulphated cement

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note :-

IS 5513: 1996 Vicat Apparatus specification

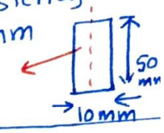
note :- IST & FST are the Rheological properties of cement because they describe how cement flows & workability change with time

2- Consistency Test (IS 4031 Part-4)

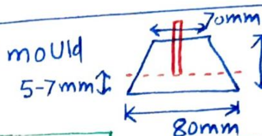
To find quantity of water to form a paste of normal consistency. → By Vicat Apparatus

(P) normal consistency → % water requirement of cement paste the viscosity of which will be such that the vicat's plunger penetrates upto a point 5-7 mm from bottom of vicat's mould
or
33-35 mm from top of vicat's mould.

→ Plunger G used for standard consistency:
weight = 300 gram   diameter = 10 mm
length = 50 mm   Brass



→ vicat mould



→ Temp. = 27 ± 2°C   → Relative humidity = ~~65~~ ± 5 % (amendment: Min 65 %) (60-70) %

→ Gauging time = 3 to 5 min (min. max.)

• normal consistency (P) of OPC ≃ 30 % (Generally) (no any value given by IS code)

$P = \left(\frac{\text{wt. of water}}{\text{wt. of dry cement}} * 100 \right)$

note :- after consistency Test, we can perform IST, FST, soundness, strength of cement Test

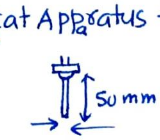
3- Initial Setting time (IST) Test : (IS 4031 Part-5)

↳ time taken by cement paste to start losing it's plasticity after adding water 'or' time up to which cement remains workable.

IST:- Period elapsing b/w the time when water is added to the cement & the time at which needle of 1 mm² (~~XXXXX~~) square section fails to pierce the test block to a depth of 5-7 mm from bottom of vicat mould.   area = 1 mm²

Apparatus → vicat Apparatus + needle 'C'

$\boxed{\text{water added} = 0.85P}$



{round of dia. 1.13 ± 0.05 mm
length = 50 ± 1 mm}

{Temp. & relative humidity → same as consistency Test.

cement type (all grades)	IST (min)	FST (max)
SRC, SSC, OPC, RHC	30 min	10 hr.
Low heat cement	1 hr	10 hr.
Quick setting cement	5 min	30 min
High Alumina cement (HAC)	3.5 hr (3.5-4 hr)	5 hr (5-5.5 hr)

IST tells us last safe time to place concrete.

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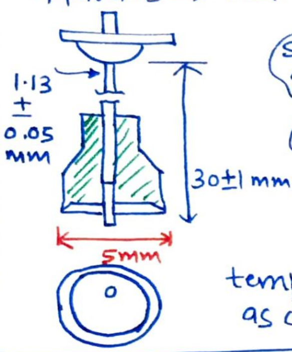
4- Final Setting time (FST) Test (IS4031 | Part-5)

after FST cement becomes hard & stable
So it tells us when formwork removal can start.

FST indicates → complete loss of plasticity

FST → Period elapsing b/w the time when the water is added to the cement & the time at which the needle makes an impression on the test block while attachment fails to make it.

Apparatus → Vicat Apparatus + Needle F



Same as IST ← Needle (1mm) + Annular collar (5mm)

(but length = 30mm) only

$\boxed{\text{water added} = 0.85P}$ *

temp. & Relative humidity same as consistency Test.

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5)- Soundness Test (IS4031 Part-3)

(water Added = 0.78P)

- Lechatelier method → {detect expansion due to Excess lime only}
- Autoclave method (when magnesia > 3%) → (lime + magnesia) both

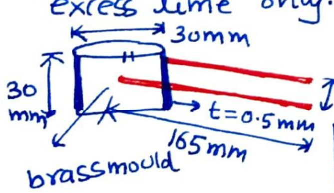
Unsoundness → change in volume of cement after setting ∴ cracks ✓ durability loss.
no Test for unsoundness due to Sulpher (SO_3)

Soundness → Ability to resist volume expansion and it is an indication of durability.
→ due to lime, magnesia, sulpher

a) Lechatelier method:

detect expansion due to excess lime only. (water added = 0.78P)

(Split cylinder used) Brass



expansion = final distance − Initial dist. (unsoundness)

① mould → put in water at 27±2°C → Then measure initial dist. b/w 2 indicator points.

② again mould in water → Boil for 3hr → Then measure final dist. b/w 2 indicator points.

cement type	max. expansion (Lechatilier Test)	% Expansion (Autoclave) (max)
OPC, PPC, RHC, LHC, SRC	10 mm	0.8%
HAC, SSC	5 mm	–

note :- Lechatelier flask → Specific gravity (cement) $\left\{ SG = \frac{\text{weight of cement}}{\text{Displaced volume of liquid}} \right\}$

b) Autoclave method :

→ (lime + magnesia) both
→ (0.78P)

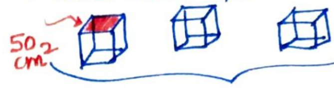
mould = 25*25*282 mm

{Autoclave ⇒ High pressure steam boiler equipped with suitable safety device.}

note :- for opc, an increase in size of any side should not exceed 0.8%.

6- compressive strength Test- (IS 4031 part-6):

→ Three cube specimen taken.



cube size = 7.06 cm (each side)
surface area = 50cm²

→ Cube making, material used for {Test → in UTM}

- cement 200gm.
- Standard Sand 600gm → Ennore sand
- water → $\left(\frac{P}{4}+3\right)$% of combined mass of cement & sand → [basically mortar]

(cement: sand = 1:3)

→ time of mixing = min 3 minute
→ Vibration = Min 2 minute → 12000 ±400 Vibration per minute
→ temperature = 27 ± 2°C
→ relative humidity < Lab 65 ± 5% ; moist room 90% (min)
→ water in which the cubes are submerged shall be renewed every 7 days.

Rate of loading = zero to [redacted] 35 MPa/min

→ result expressed to nearest 0.5 MPa

$$\text{compressive strength (MPa)} = \frac{\text{max. Load at failure}}{\text{Area } (50cm^2)}$$

IS: 269 year 2015 : Min compressive strength (MPa)

cement Type	3day ± 1hr	7day ± 2hr	28day ± 4hr
OPC (33 grade)	16	22	33
OPC (43 grade)	23	33	43
OPC (53 grade)	27	37	53

max comp. strength after 28 days ± 4hr

Imp. {
OPC (33) → 48MPa
OPC (43) → 58 MPa
OPC (53) → not specified }

IS 10262: 1982 comp. strength of OPC after 28 days, 5 grades defined

LHC (Min) comp' str.
3days – 10MPa
7days – 16 MPa
28days – 35 MPa

OPC group	28 days comp. strength (MPa)
A	31.9 – 36.8
B	36.8 – 41.7
C	41.7 – 46.6
D	46.6 – 51.5
E	51.5 – 56.4
F	56.4 – 61.3

36 +5 41 +5 46 +5 51

Trick :- ACE 33 43 53

note: over the time, The strength of cement decreases due to aging as follows—

Period	reduction in strength
3 month	20 %
6 "	30 %
12 "	40 %
24 "	50 %

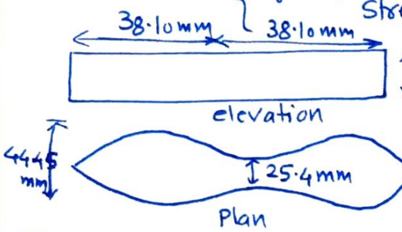
(7) Tensile strength Test

- generally used: Briquette Test for rapid Hardening (RHC) cement.
- Split Tensile Strength Test

Generally Tensile strength = 10-15% of comp. strength.

Briquette method: → Briquette Taken = 12 (Total)

- 6 No. {for 3 days Tensile Strength} ⇒ Take avg. of 6 specimens
- 6 No. {for 7 days Tensile strength}



failure area = 25.4 mm * 25.4 mm = 6.45 cm^2

[12 Briquette = 600 gm] Briquette making

- cement, sand → 1:3
- water → $\left(\frac{P}{5}+2.5\right)$% of combined mass of cement & sand

Rate of Loading = zero to 3.5 MPa/Min or 0.7 N/mm^2 in 12 sec

for opc cement Min Tensile strength
3 days ⟶ 2 MPa
7 days ⟶ 2.5 MPa

8) Heat of hydration Test: (IS4031 part-9)
↳ By "calorimeter" (1 cal = 4.186 J)

Low heat cement (LHC) IS 12600:
7 days ≯ 272 kJ/kg or 65 cal/gram
28 days ≯ 314 kJ/kg or 75 cal/gram

① Rate of heat evolution (when equal amount is taken)
↳ $C_3A > C_3S > C_4AF > C_2S$
865 500 420 260 Joule/gram
Trick: 3+1=4

② Rate of hydration ⇒ $C_4AF > C_3A > C_3S > C_2S$ (when total heat evolve same)
4 3 1 2
Trick: 4-3=1

9) Specific gravity Test: (IS4031 Part-11) By Le chatelier flask

OPC specific gravity = 3.15
OPC Bulk density = 1440 kg/m^3

cement bag = 50 kg
Volume of cement bag = 0.035 m^3

Chemical Requirements for OPC (IS 269:2015)

As per IS 269:2015 OPC has 5 grades → 33, 43, 53, 43S, 53S (43S, 53S: Sleeper grade)

note: IS4032:1985 method of chemical analysis of hydraulic cement

1- Ratio of % of lime to % of Silica, Alumina, Iron oxide $\frac{CaO - 0.7SO_3}{2.8SiO_2 + 1.2Al_2O_3 + 0.65Fe_2O_3}$ (Lime saturation factor (LSF))	OPC 33 & 43: 0.66–1.02 OPC 53: 0.80–1.02
Ratio of % of Alumina to that of Iron oxide (Trick A:I)	Min 0.66
Insoluble residue (% by mass)	max 5% (R15)
Magnesia (% by mass)	max 6% (M6)
Total sulpher content (as SO_3) sulpher anhydride (% by mass)	max 3.5%
Loss on ignition (% by mass) (note:- safe side ⇒ 4% Ans.)	max OPC 33,43 — 5% OPC 53 — 4%
Chloride content (% by mass)	max 0.1% = 0.1%
content made by To The Point by Dhyan Pal	max 0.05% for prestress structure
Alkali content expressed as (Na_2O + 0.658K_2O) (% by mass)	max 0.6%

(note chemical composition → comes under Lab Tests)

field Test for cement

1- color → color should be uniform.
↳ Grey color with a light greenish shade

2- physical properties:
(a) cement should be feel smooth when touched or rubbed in b/w finger. if rough → "Adultration with sand"
(b) if hand is inserted in a bag/heap of cement, it should feel 'cool'.
(c) if small quantity of cement is thrown in bucket of water, it should sink and should not float on the surface.

3- Presence of Lump → free from hard lump [lump formed due to moisture absorbtion from atm.]

4- Strength: roughly checked by briquette (75 * 25 * 12mm) with lean/weak mortar (1:6)
• Briquette are immersed in water for 3 days if cement is of sound quality, such Briquette will not broken easily and It will be difficult to convert them into powder form.

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IS4082:1996 Recommendation on stacking and Storage of construction materials & components at site.

Storage of cement :

(i) moisture - building / shed → dry, → Leak proof, → moisture proof.

(ii) Period of storage
↳ avoid storing of cement in Jute bags for a period longer than 3 months. (otherwise strength reduces)

(iii) Piles :
→ Bag staked on wooden planks.
→ Planks to keep bags 150 - 200 mm above floor.

floor types:
- Lean cement concrete
- 2 layers of dry bricks on consolidated earth

→ Minimum 600 mm clear space b/w Stack & exterior wall.

→ Max. height of stack ⇒ 10 bags height (to prevent possibility of lumping up under pressure)

→ max. stack width = Min (4 bag length, 3 m)

→ if stack is higher than 8 bags Then bags must be placed Alternately (one layer lengthwise, next layer crosswise)

→ advisable to remove cement in order of it's storage period [First In, First out]

Types of cement :

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1) Rapid Hardening Cement (RHC) IS 8041 :

- It attain high strength in early days

∵
- → burning at higher temp.
- → increased lime content in cement composition
- → very fine grinding (min - 3250 cm²/gram) RHC SSA

- C_3S ↑ (≃ 56%) (Tricalcium silicate ↑)
- Cost of RHC = 10% more the OPC
- Suitable for repair of roads & bridges & when load applied in a short period of time.

Properties : (i) IST min = 30 min FST_{max} = 10 hr
(ii) Soundness Test: expansion ≯ 10 mm & 0.8%
(iii) Comp. strength
1 day (24 hr ± 30 min) = Min 16 MPa
3 days (72 hr ± 1 hr) = Min 27 MPa

RHC attain same strength in one day which opc may attain in 3 days.

(iv) Fineness ≯ 5% (residue %)
Min 3250 cm²/gram

note :- RHC emit heat during setting ∴ RHC not suitable for mass concreting. RHC subjected to large shrinkage also.

2) Extra rapid Hardening cement : (Ultra ") (calcium chloride cement)

- made by RHC clinker + 2% $CaCl_2$ (Accelerator)
- strength at 1 day ⟶ +25% ↑ (RHC)
  7 days ⟶ + 20% ↑ (RHC)
- rate of strength development is accelerated ; a higher % of $CaCl_2$ causes excessive shrinkage.

very suitable for cold weathers

3) Sulphate resisting portland cement (SRC) IS 12330

- offer higher resistance to sulphate attack than OPC
- product of finely ground mixture of granulated blast furnace slag not less than 70%, $CaSO_4$ (gypsum) & small quantity of portland cement
- C_3A kept below 5-6%. (< 5%)

note : high pressure steam curing improves the resistance of concrete to sulphate attack.

Uses : (i) concrete in sea water or exposed directly to sea coast (marine)
(ii) concrete in contact with soils & ground-water containing excessive amount of sulphates.
(iii) Str. in sea water / marshy land / Sewage / canal lining / culvert / siphon

4) Super sulphated cement (SSC) (IS 6909 : 1990)

- granulated slag (80-85%) + $CaSO_4$ (10-15%) (gypsum) + portland cement clinker (5%)
- C_3A < 3.5%. • SSC use restricted if temp. < 40°C

Use: * Rcc pipes in ground water
* concrete str. in sulphate bearing soil
* Sewers carrying Industrial effluents
* concrete exposed to concentrated sulphates of weak mineral acid.

Property	SRC	SSC
IST min.	30 min	30 min
FST max.	10 hr.	10 hr
Fineness (min)	2250 cm²/g	4000 cm²/g
soundness (expansion)	≯ 10 mm ≯ 0.8%	≯ 5 mm —
comp. strength 3 day	≮ 10 MPa	≮ 15 MPa
7 day	≮ 16 MPa	≮ 22 "
28 day	≮ 33 MPa	≮ 30 "

5) High Alumina cement (HAC): (IS 6452)

- manufactured by fusing 40% Bauxite, 40% lime, 15% Iron oxide with little % of ferric oxide and silica, magnesia etc at very high temperature

- Total Alumina content (Al_2O_3) ≮ 32%
  {like Bauxite} ⟶ min 32%

- HAC can not be used with admixtures.
- HAC ⟶ heat of hydration very high
  ∴ steam curing cannot be applied.
- Resistance to fire, chemical, sulphate, acidic water
  acid attack.
- Used as refractory concrete
  (resistance to high temp.)

- HAC used in a colder region (continuously ≤ 18°C)

- Since C_3A ⟶ absent hence good resistance to sulphate attack

- It can not be used in mass construction as it evolves great heat and as it sets soon.

- Used in Industries & widely for precasting.

Properties :-

(i) fineness ≮ 2250 $cm^2/gram$

(ii) IST min = 30 min (3.5hr) ⟶ Book
code   Range- 3.5-4hr

(iii) FST max = 10hr (5hr) ⟶ Book
code   Range-(5-5.5hr)

(iv) Soundness expansion ≯ 5mm

(v) comp. strength (1:3) & (10.5-11%) water
CS

{ 1day ≮ 30 MPa
3day ≮ 35 MPa }

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6) Low heat cement (IS 12600):

{ C_3A↓ C_2S↑
C_3S↓ C_4AF↑ }

- Less heat is evolved during setting
∴ most suitable for large mass concrete work (dam, large raft foundation)

- Rate of development of strength is slow but the ultimate strength is same

Properties :-

(i) fineness ≮ 3200 cm^2/g

(ii) Soundness expansion < ≯ 10 mm
≯ 0.8%

(iii) IST min = $\boxed{1hr}$* FST max = 10hr.

(iv) comp. strength (1:3) & $(P/4+3)$% water

3 day ≮ 10 MPa
7 day ≮ 16 MPa
28 day ≮ 35 MPa

note :- SRC ⟶ 10, 16, 33

(v) Heat of hydration

Imp

7days → ≯ 272 KJ/kg	or 65 cal/g
28days → ≯ 314 KJ/kg	or 75 cal/g

(1 KJ/kg = 1 J/g)

7) Quick setting cement

- Gypsum ↓ and Aluminium Sulphate added
- Addition of aluminium sulphate & fineness of grinding responsible for accelerating the setting action of cement.

Properties : (i) IST = 5 min
(ii) FST = 30 min } Imp.

Use ⟶ This cement is used to lay concrete under static water / running water.

8) Portland puzzolona cement (PPC) :-

{ IS 1489 (Part-1) : 1991 ⟶ PPC: flyash Based
IS 1489 (Part-2) : PPC: calcined clay Based }

Pozzolona itself is not cement (alone with water) But can not set or harden becomes useful when cement is present.
Pozzolanic material- fly ash, burnt clay, shale

PPC made

{ Portland clinker + Pozzolona }   { OPC + fine pozzolona }

**

- Pozzolona material varies 10-30%.

- PPC has Low heat evolution and is used in place of mass concrete Such as dams and in places of high temperature.

- PPC useful for marine structure. ∵ resistance to chemical attack.
- also used in sewage works and for laying concrete under water.

Properties (PPC) :-

(i) Fineness ≮ $\boxed{3000\ cm^2/g}$ $\boxed{\not> 5\%\ \text{Residue}}$

(ii) Soundness expansion ≯ 10 mm, ≯ 0.8%

(iii) IST min = 30 min
FST max = 10 hr.

(iv) comp. strength (1:3) & (P/4 + 3)%

3 day	≮ 16 MPa	same as OPC(33)
7 day	≮ 22 MPa	
28 day	≮ 33 MPa	

(v) $\boxed{\text{Average drying shrinkage} \not> 0.15\%}$

Remember :- PPC Possesses–
(i) Higher resistance to chemical attack
(ii) Lower heat of hydration
(iii) Lower shrinkage on drying
(iv) water tightness (reduce permeability)
(v) PPC develops strength at a slower rate initially but achieves higher long term strength due to pozzolanic reaction continuing overtime.

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note :-

flyash → It is fine powder that is by product of burning pulverised coal in power plant.

flyash

Siliceous Pulverised flyash	main constituent	Calcareous Pulverised fly ash
($CaO < 10\%$) Anthracite	$SiO_2 + Al_2O_3 + Fe_2O_3$	($CaO > 10\%$) lignite
min ⇒ 70%		min = 50%
Silicon dioxide min ⇒ 35% (SiO_2)		→ min = 25%

soundness expansion ≯ 0.8%

% R max = 34%

SSA min = 3200 cm^2/gram

Lime reactivity Min Comp. strength = 4.5 MPa

min comp. strength = 80% of plain cement mortar strength

(9) Blast furnace slag cement :

{ Blast furnace slag → by product obtained while smelting iron ore in blast furnace ($45\%\ CaO + 35\%\ SiO_2$)

- cement clinkers are ground with 60-65% of slag.
- its strength in early days is less hence requires longer curing period.

Uses :- • underwater str.
- high resistance against chloride & sulphate attack
- offer high water tightness & reduced permeability
- ∴ Application is mass concreting of hydraulic str.

(10) Air Entraining cement :

- ordinary cement + vinsol resin/vegetable fats and oil and fatty acid
- These materials entrain air in the form of fine tiny air bubbles in concrete

→ Increase resistance against freezing & Thawing.
→ Improve workability & (w/c) reduced
∴ reduced shrinkage

(11) Hydrophobic cement (water repellent cement) ⇒ It contains admixtures that decrease the wetting ability of cement grains.

- Hydrophobic admixture → acidol, napthene soap, oxidised petrolatum etc

↳ Use :- most suitable for Basement & for making – water tight concrete.

(12) White cement (snowcrete) :- Just ordinary cement & use those material which are free from Fe, Mn, Cr
high temp. needed (1600 – 1700°C)

- white cement prepared from pure limestone (chalk) and clay which are free from (Fe, Mn, Cr) oxides.

Use :- floor finish, plaster work, ornamental work

(13) colored cement :- ordinary cement + coloring pigments

Color pigment = (5-10%) & ≯ 10%
otherwise strength affected

Pigment	color
Chromium oxide	Green
Cobalt	Blue
Iron oxide	Brown, red, yellow
MnO_2	Black or Brown

note :-
cement C_3S ↑
Then higher corrosion resistance
∵ $Ca(OH)_2$ ↑

(14) Expanding cement : ordinary cement + Expanding medium (Sulpho Aluminate)

(This cement expands while rest shrinks)

⇒ used in elimination of shrinkage cracks
⇒ Treatment of expansion Joint & for grouting
⇒ Construction of water retaining structures
⇒ for repairing of damaged concrete surface.

Brickwork

IS 1077 : 1992	Common burnt clay Building - Bricks - specification
IS 2180 : 1988	Specification for heavy duty Burnt clay building bricks
IS 5454 : 1978	methods for sampling of clay - Building brick
IS 3495 (Part 1 to 4) year 1992	methods of Tests of Burnt clay Building Bricks Part-1 compressive strength Part-2 water absorption Part-3 efflorescence Part-4 warpage $\boxed{\text{Trick: CWEW}}$
IS : 1200 (Part-3) year 1978	method of measurement of Building and civil engineering works part-3 Brickwork

Bricks :- masonary unit for which { L ≯ 30 cm, B ≯ 15 cm, H ≯ 10 cm }

common building solid bricks frog ≯ 20% of Brick volume

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Classes of common Burnt clay bricks - Total $\boxed{11}$

Class designation	3.5	5	7.5	10	12.5	15	17.5	20	25	30	35
Avg. comp. Strength not less than (MPa)	3.5	5	7.5	10	12.5	15	17.5	20	25	30	35

class designation based on Avg. Comp. Strength

note :- 1 MPa = 1 N/mm² = 10 kgf/cm² (Approx)

Example :- 3.5 MPa = 35 kgf/cm²

→ source IS 1077 (1992)

Heavy duty brick : Bricks required for masonary in heavy engineering work (bridge, industrial-foundation & multistorey building) having high durability, high compressive strength & Low water absorption.

Class Designation	Average compressive strength (MPa)	
	not less than (Min)	Less than (~~Max~~)
40	40	45
45	45	-

{ 1 N/mm² = 10 kgf/cm² }

Partition → min brick wall = 10 cm

min. Avg. comp. strength of common burnt clay brick ⇒ 3.5 MPa

source: IS 875 (part-1)

unit weight of some common building material

material	unit weight KN/m³ or kg/m³
cement ✓ ordinary & Aluminous ✓ RHC	 1440 kg/m³ 1280 kg/m³
Sand (Fine Aggregate) ✓ dry clean ✓ river	 1540 - 1600 kg/m³ 1840 kg/m³
Coarse Aggregate Broken Stone ballast (dry, well shaken)	1600 - 1870 kg/m³
cement mortar	2080 kg/m³ (20.40 KN/m³)
cement concrete (prestress)	2400 kg/m³ या 23.50 KN/m³
cement concrete (reinforce) vary based on % of steel	2310 - 2700 kg/m³ या 22.75 - 26.50 KN/m³ 1% ... ज्यादा steel 5%
common burnt clay brick	1600 - 1920 kg/m³ 15.70 - 18.85 KN/m³
Heavy duty brick	2500 kg/m³ (24.50 KN/m³)
Brick dust (surkhi)	1010 kg/m³ (9.90 KN/m³)
Brick masonary (using common brick)	1920 kg/m³ (18.85 KN/m³)
stone masonary	2080 - 2700 kg/m³ 20.40 - 26.50 KN/m³

common brick → hand moulded or machine moulded

(made by)

But Heavy duty Brick → Pressing or extrusion

Grade	Crushing strength of Bricks
A	7 - 14 MPa
AA	> 14 MPa

Common Brick (IS 1077)

- Standard modular size
  - 19 * 9 * 9 (cm)
  - 19 * 9 * 4 (cm)
- non modular size
  - 23 * 11 * 7 (cm)
  - 23 * 11 * 3 (cm)

Standard size = 19 * 9 * 9 cm

Nominal size of Brick - with mortar = 20 * 10 * 10 cm

note :- conventional Brick size = 22.4 * 11.4 * 7.6 cm

note :- Average Brick weight = 3 to 3.5 kg

1 m³ Brickwork < 500 Standard Brick [19 * 9 * 9], 435 nonmodular [23 * 11 * 7]