

Youth Competition Times

Civil Engineering

CAPSULE

Useful for All Competitive AE/JE Exam :

- UPPSC AE • UKPSC AE • BPSA AE • CGPSC AE • MPPSC AE • RPSC AE • UPSSSC
- SSC JE • DMRC JE • LMRC JE • JMRC JE • BMRC JE • DSSSB JE • UP Jal Nigam
- UKSSSC JE • RSMSSB JE • MPPEB SUB ENGINEER • HPSSC JE • HSSC JE
- Punjab JE • CGPEB SUB ENGINEER • BSSC JE • DRDO JE • ISRO JE
- UPPCL AE/JE • UPRVUNL AE/JE • JVUNL JE • SAIL JE
- GAIL JE • BHEL JE • NTPC JE • DFCCIL
- COAL INDIA LTD. JE • RRB JE etc.

Chief Editor

Mr. Anand Mahajan

Compiled & Written by


Er. Maneesh Kr. Yadav
Er. Pradeep Kumar Gupta
Er. Sanjeet Maurya, Er. Rohit Singh

Computer Graphics by

Balkrishna, Charan Singh

Editorial Office

Youth Competition Times
12, Church Lane Prayagraj-211002

 **Mob. : 9415650134**

Email : yctap12@gmail.com

website : www.yctbooks.com

Publisher Declaration

Edited and Published by A.K. Mahajan for YCT Publications Pvt. Ltd.
and printed by Roop Printing Press, Prayagraj. In order to publish the book,
full care has been taken by the editor and the publisher,
still your suggestions and queries are welcomed.

In the event of any dispute, the Judicial area will be Prayagraj.

Rs. : 60/-

INDEX

❑ Building Material-----	3
❑ Concrete Technology -----	10
❑ CPM & PERT-----	12
❑ Building Construction and Maintenance Engineering -----	13
❑ Fluid Mechanics & Hydraulic Machine-----	15
❑ Strength of Materials-----	28
❑ Applied Mechanics-----	34
❑ Soil Mechanics -----	36
❑ Highway Engineering-----	43
❑ Railway Engineering-----	48
❑ Bridge Engineering-----	50
❑ Airport Engineering -----	51
❑ Tunnel Engineering -----	52
❑ Reinforced Cement Concrete -----	53
❑ Steel Structure-----	58
❑ Structure Analysis -----	62
❑ Building Estimate, Costing & Evaluation-----	64
❑ Public Health Engineering -----	68
❑ Surveying Engineering -----	70
❑ Irrigation & Hydrology Engineering -----	77

Civil Engineering Capsule

BUILDING MATERIALS

Rock minerals-

Quartz, Mica, Gypsum, Dolomite, Amphibole, Calcite, Feldspar etc.

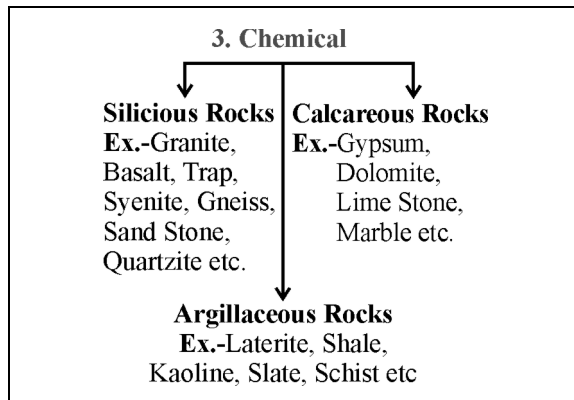
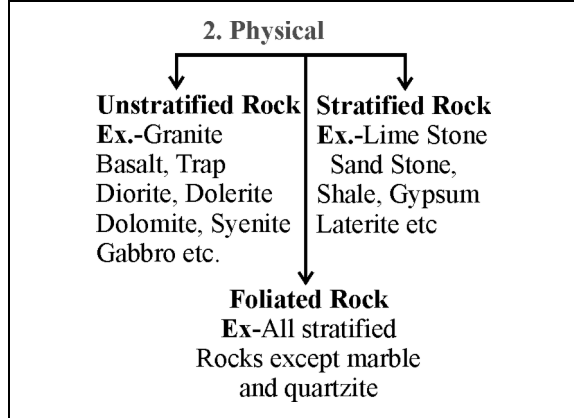
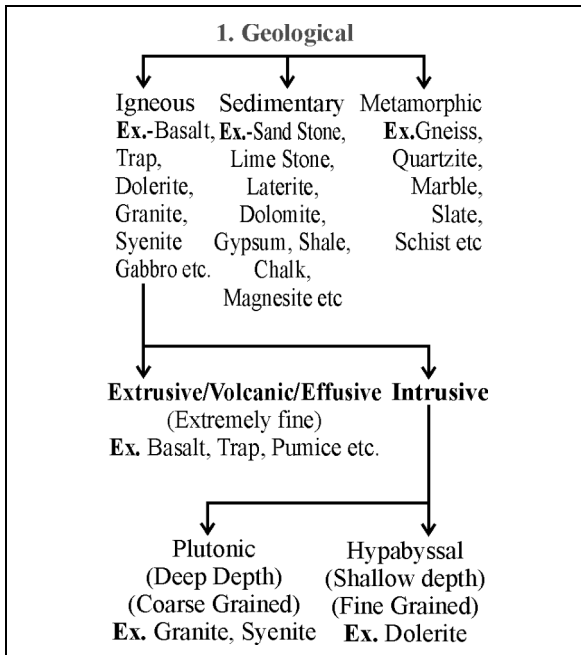
Hardness of stone based on Moh's scale-

Talc	1	} Scratched by the finger nail
Gypsum	2	
Calcite	3	} Scratched by knife
Fluorite	4	
Apatite	5	
Feldspar	6	} Scarcely scratched by knife
Quartz	7	
Topaz	8	} Not scratched by knife
Corundum	9	
Diamond	10	

Properties of Minerals-

Cleavage	Measurement of the capability of some minerals to split along certain planes parallel to the crystal faces
Streak	Colour of the mineral in powder form
Lustre	Shine on the surface due to reflection of light of a mineral

Classification of Rocks-



Classification of Rocks on the Basis of Mineral Available-

Name of Rock	Example
Mono mineralic Rocks (Composed of only one mineral)	Quartzite, Marble & Gypsum
Polymineralic Rocks	Granite, Trap, Basalt, Shale, Sand Stone, Shale, Slate

Metamorphism of Rocks-

Original Rock	Metamorphic form
Granite	Gneiss
Syenite	Gneiss
Sand Stone	Quartzite
Lime Stone	Marble
Marl	Marble
Dolomite	Marble
Shale	Slate
Mud Stone	Slate
Dolerite/Basalt	Schist

Descriptive	Elasticity (kg/cm ²)
Very stiff rock	8×10 ⁵ - 16×10 ⁵
Stiff rock	4×10 ⁵ - 8×10 ⁵
Medium stiffness rock	2×10 ⁵ - 4 ×10 ⁵
Less stiffness rock	1×10 ⁵ - 2×10 ⁵
Yielding rock	0.5×10 ⁵ - 1×10 ⁵
High yielding rock	0.25×10 ⁵ - 0.5×10 ⁵

Types of rock/soil	Max. bearing capacity (tonne/m ²)
Lime stone	400
Schist and shale	300
Clay shale	100
Compacted sand stone	45
Loose gravel	25
Soft clay	10

■ **Compressive strength of different types of stones-**

Stone	Compressive strength (in MPa)
Trap	350-380
Gneiss	206-370
Basalt	150-185
Slate	75-207
Dolerite	90-150
Syenite	90-150
Granite	75-127
Lime stone	54
Sand stone	64

■ **Use of various types of stone-**

Name of Rock	Use
Granite	Railway ballast, Roofing, Abutment, Pier and Sea walls
Marble	Ornamental work
Lime Stone	Manufacture of cement
Slate	Flooring, roofing
Quartzite	Retaining wall
Basalt	Marine work, Rubble masonry
Kankar	Manufacture of Hydraulic lime

■ **Tools Used in Quarrying of Stone-**

Jumper	To make hole
Scraping spoon	For Cleaning hole
Dipper	For making deep hole
Priming Needle	To make space for fuse
Tamping Rod	For tamping of explosive Length- 600 mm Dia (φ)- 16 mm

■ **Steps for Blasting-**

Boring → Cleaning → Charging → Tamping → Firing

■ **Quantity of Explosive-**

$$\begin{aligned}
 N &= [L.L.R(\text{in m})]^2 \times 1.5 \text{ (in gm.)} \\
 &= \frac{[L.L.R(\text{in m})]^2}{0.008} \\
 &= \frac{[L.L.R(\text{in cm})]^2}{61}
 \end{aligned}$$

■ **Explosive Material Used in blasting-**

Name of Explosive	Chemical Composition
Blasting Gelatine	Nitroglycerine (93%) + Gun-cotton (7%) Use- In deep wells, underground works, in wet conditions.
Gun Cotton (Most powerful)	Cotton with the solution of (HNO ₃ +H ₂ SO ₄) Use- where demolitions are required
Dynamite	Nitroglycerine (75%) + Fine sand (25%) Use- Both under water and surface blasting
Blasting/ Gun powder	Potassium nitrate (65%) + Sulphur (25%) + Charcoal powder 20% Use- In quarrying large blocks
Rock-a-Rock	Potassium Chlorate (79%) + Nitro benzol (21%) Use- Under water and damp situation blasting

■ **Stone crusher and equipment-**

Crusher Type	Equipment
Primary	Jaw, Impact and Gyratory crusher and Hammer mill
Secondary	Roll crusher, Cone crusher
Tertiary	Ball mill, Roll mill and Rod mill

■ **Specific Gravity of Various Types of Stone-**

Name of Stone	Specific gravity
Sand Stone	2.65 - 2.95
Marble	2.7 - 2.85
Granite	2.65 - 2.79
Basalt	2.6 - 3
Slate	2.72 - 2.89
Laterite	2 - 2.2
Lime Stone	2 - 2.75
Gneiss	2.5 - 2.7

■ **Various types of test and purpose for stone-**

Type of Test	Determine for
Abrasion Test (By Dorry Testing Machine)	wearing resistance
Attrition Test (By Deval Testing Machine)	Hardness, Toughness and rate of wearing resistance
Crushing Strength Test (By C.T.M) (IS : 1121-1974)	Compressive strength
Smith's Test	Soluble minerals/ Muddy matter
Brard's Test	Frost resistance
Acid Test	Weather resistance
Crystallization Test (IS : 1126-1974)	Durability
Hardness Test (Moh's Scale)	Hardness
Impact Test (By Page Impact Machine)	Toughness
Water Absorption Test (IS 1124-1974)	% Voids (≠5% for good stone)

■ **Dorry Testing Machine Test-**

Friction Factor	Type of Rock
0-14	Soft rock
14-17	Medium hard
> 17	Hard rock

■ **Impact Test-**

Toughness coefficient	Toughness
19 or More	Very tough
16 to 17	Moderate tough
16 or below	Poor tough

■ **Attrition Test-**

Friction Co-efficient	Quality of Stones
2%	Good
3%	Medium
5% or More	Useless

■ **Common Brick Size-**

Brick Classification	Usual size	Nominal size
Conventional/ Traditional/ user size	9"×4 $\frac{3}{8}$ " × 2 $\frac{3}{4}$ " (23×11.2×7.0) cm	9"×4 $\frac{1}{2}$ " × 3" (23×11.4×7.6) cm
Standard/ Modular/ Normal size	(19×9×9) cm	(20×10×10) cm

■ **Ingredients of Good Brick Earth-**

Ingredients	% in brick
Silica (SiO ₂)	50 - 60
Alumina (Al ₂ O ₃)	20 - 30
Lime (CaO)	2 - 5
Iron Oxide (Fe ₂ O ₃)	3 - 5
Magnesia (MgO)	<1
Alkalies	<1

■ **Functions of Various Brick Ingredients-**

Ingredients	Function
Silica	Imparts Strength Excess -Brittle (Due to loss of cohesion)
Alumina	Impart plasticity Excess -Cracks developed, corner deformed
Lime	Used as flux (Reduce melting point) Excess - Brick over burnt and shape changed
Iron Oxide	Red colour, Used as flux Excess - Provide dark blue or blackish colour
Magnesia	Yellow colour and its prevent to shrinkage, Excess -Give yellowish colour

■

Frog	10 cm × 4 cm × 1 or 2 cm
Stock Board (To make frog)	21 cm × 10 cm × 6 cm
Pallet Board (To dry the brick)	30 cm × 12 cm × 1 cm

■ **Sequence for the Preparation of Brick Earth-**

Unsoiling → Digging → Weathering→

Blending → Tempering/Kneeding

■ **Burning Zone of Bricks-**

Burning Temperature- 900 - 1200°C		
Dehydration Zone 400-650°C	Oxidation Zone 650-900°C	Vitrification Zone 900-1200°C

■ **Efficiency of Kiln-**

Types of kiln	I st Class Brick outcome	Remark
Pazawah	50-60%	—
Allahabad kiln	60-70%	Intermittent
Bull's Trench kiln	70-80%	Semicontinuous
Hoffman's kiln	80-90%	Continuous

■ **Class of Brick on the Basis of Strength-**

IS : 10719557-1970

Class	Comp. Strength
Grade A	⩾ 105 kg/cm ²
Grade AA	⩾ 140 kg/cm ²
Grade B	⩾ 70 kg/cm ²
Grade C	⩾ 35 kg/cm ²

■ **Types of Refractory Bricks and its composition-**

Bricks	Composition
Acid Refractory	Silica- 95-97%, Lime- 1-2%
Basic Refractory	Magnesia- 85% (max) CaO- 25%(max) Silica- 5.5%(max)
Neutral Refractory	Chrome + Iron ore + Bauxite ore+ Silica + Magnesia

■ **Efflorescence Test- According to IS 3495 (part-III) : 1992**

White patches	Alkalies
Up to 10%	Slight
10 - 50%	Moderate
>50%	Severe
Presence in large amount	Serious

■ **Sample Required for Various Brick Test-**













Bricks Test	I.S. Code	No. of Sample
Compressive strength test	3495-Part I	6
Water absorption test	3495-Part II	5
Efflorescence test	3495-Part III	—
Warpage test	3495-Part IV	10
Dimension test	1077	20

Note- Tolrance in brick dimension test -

Length - 380 ± 8 cm

Width - 180 ± 4 cm

■ **Special Forms of brick-**

Figure	Brick Name	Figure	Brick Name
	Rounded ended		Cant
	Double cant		Compass
	Bull nosed		Perforated
	Hollow		Coping
	Queen closer		King Closer
	$\frac{3}{4}$ Brick		Bat

■ **General Data about bricks-**

Types of bricks	Water absorption (%)	Compressive Strength (Kg/cm ²)	Use
1 st Class	≤ 20	>105	Facing work R.B.Slab
2 nd Class	≤ 22	>70	Hidden Structure
3 rd Class	> 25	>35	Temporary brick masonry
4 th Class (Jhamma or over burnt bricks)	10 -12	350	Bricks ballast, lime concrete foundation, road metals
Perforated Bricks (IS 2222)	15	70	Partition Wall
Hollow Bricks (IS 3952)	20	35	For making heat proof, sound proof, damp proof walls
Paving Bricks (IS 3583)	<5	350	Road pavement
Soling Bricks (IS 5779)	< 20	50	Soling of road
Refractory Bricks (IS 6902)	4 -10	350	Kiln lining, furnace boiler combustion

Engineering Brick Class-A	4 -5	>125	D.P.C
Class-B	7	75	Multistorey building
Sundry bricks	-	15-25 ≈ 21	-

■ **Type of Lime Obtained After Calcination-**

Pure lime stone	Pure lime
Dolomite	Magnesia lime
Kankar	Hydraulic lime
Chalk	Pure lime
Gypsum	Pure lime
Calcined lime stone	Quick lime
Calcined dolomite stone	Non-hydraulic lime
Shale	Pure lime

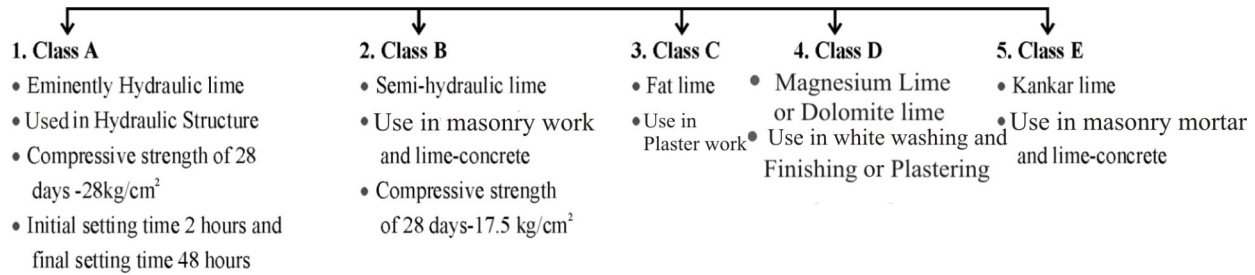
Chemical Formula	Name of lime
Calcium carbonate [CaCO ₃]	Lime Stone
Calcium oxide [CaO]	Quick lime, Lump lime, white lime, Rich lime, Pure lime
Calcium Hydroxide [Ca (OH) ₂]	Slaked lime, Fat lime
Calcium Sulphate [CaSO ₄ · $\frac{1}{2}$ H ₂ O]	Plaster of Paris
Calcium Sulphate [CaSO ₄ · 2H ₂ O]	Gypsum

■ **Chemical Reaction of Lime**

- $\text{CaCO}_3 \xrightarrow[\text{Calcination}]{816^\circ\text{C}} \text{CaO} + \text{CO}_2 \uparrow$
Pure lime
- $\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2$
- $\text{Ca}(\text{OH})_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{Heat}$

Item description	Feebly Hydraulic lime	Moderate Hydraulic lime	Eminently Hydraulic Lime
% impurities	05 to 10%	11 to 20%	21 to 30%
Slacking action	Few minutes	1 or 2 hours	1 day or more
Setting action	3 week or more	1 week or more	1 days or more
Hydraulicity	Feebly	Moderate	Eminently
Use	Used for ordinary masonry work	For superior type of masonry work	Use in very damp places

Classification of lime as Per B.I.S. (IS :712)



■ Chemical Components of Portland Cement-

Oxide/Composition /Average composition	Function
Lime (CaO) 60-65% ≈ 63%	Strength & soundness control
Silica (SiO ₂) 17-25% ≈ 20%	Due to excess reduces strength
Alumina (Al ₂ O ₃) 3-8% ≈ 6%	Responsible for quick setting excess of its lowers strength
Iron oxide(Fe ₂ O ₃) 0.5-6% ≈ 3%	Used as flux
Magnesia (MgO) 0.1- 4% ≈ 2%	Imparts colour & hardness
Gypsum 3-6% ≈ 3%	Used as retarder
Sulphur (SO ₃) 1-3% ≈ 1%	Impart soundness
Alkalies 0.2-1% ≈ < 1%	Used as flux & Imparts efflorescence

■ Chemical Compositions or Bogue's compound of cement-

Chemical/Bogue's Compound	Composition /Avg. composition	Function
C ₃ S (Alite)	25-50% ≈ 42%	7 days hardness & strength
C ₂ S (Belite)	20-45% ≈ 32%	Ultimate strength
C ₃ A (Celite)	8-12% ≈ 11.5%	Flash set
C ₄ AF (Felite)	6-10% ≈ 9%	Poorest cementing value

■ Minimum Surface Area of Various Cement-

Cement type	Surface area cm ² /gm
OPC	2250
PPC	3000
LHC	3200
HAC	2250
SSC	4000
Hydrophobic cement	3500

■ According to IS: 10262:1982 compressive strength for various grade of OPC-

Grade	Compressive 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

■ Decreasing order of Bogue's compound based on the following properties:

Strength	C ₃ S > C ₂ S > C ₃ A > C ₄ AF
Reaction with water	C ₃ A > C ₄ AF > C ₃ S > C ₂ S
Heat of hydration	C ₃ A > C ₃ S > C ₄ AF > C ₂ S
Rate of hydration	C ₄ AF > C ₃ A > C ₃ S > C ₂ S

■ Water required for hydration-

- Bound water = 23% by weight of cement
- Gel water = 15% by weight of cement
- Total minimum water for Complete hydration = 38%

Note- Cement reaction is an exothermic.

■ Required Consistency for Various Cement test at (27 ± 2°C)-

Initial & final setting time test	0.85P
Soundness test	0.78P
Compressive strength test After 3 days - 16 N/mm ² After 7 days - 22 N/mm ²	$\left(\frac{P}{4} + 3.5\right)\%$
Tensile strength test After 3 days - 2 N/mm ² After 7 days - 2.5 N/mm ²	$\left(\frac{P}{5} + 2.5\right)\%$

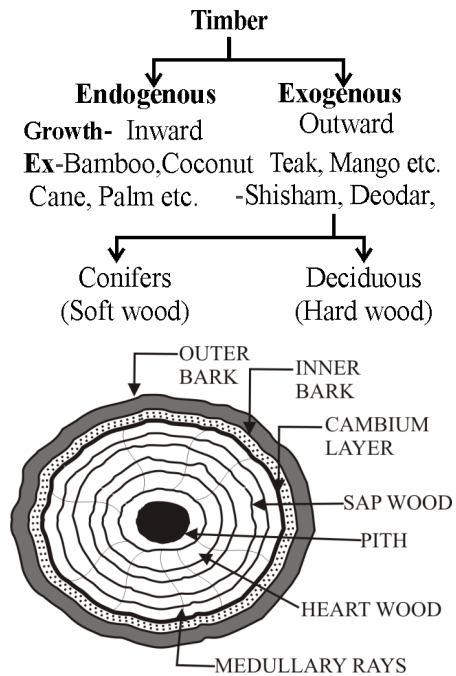
■ Reduction in comp. strength of cement due to aging-

3 months	20%
6 months	30%
12 months	40%
24 months	50%

■ **Setting Time & use of various types of cement-**

Cement Type	Setting time		Use
	Initial	Final	
Rapid Hardening (IS:8041)	30 Min.	10 Hrs.	Bridge, road maintenance or repairing work
High Alumina Cement (IS: 6452)	30 Min - 3.30 Hrs.	5 Hrs.	Precast structure, refractory bricks, used where chemical attacks are more
Quick Setting Cement	5 Min.	30 Min.	Foundation basement, under water structure, mass concrete raft foundation
Low Heat Cement (IS: 12600)	60 Min.	600 Min.	Mass conc. work such as Dam
Portland Pozzolana Cement (IS:1489 P-1)	30 Min.	600 Min.	Running water structure foundation, basement
Super Sulphate Portland Cement (IS: 6909)	30 Min.	600 Min.	Rcc pipes, where sulphate attack is more, Hydraulic structure
Sulphate Resisting Cement (IS:12330)	30 Min.	600 Min.	Sea water works, sewers, lining of canals
Portland Slag Cement (IS: 455-1989)	30 Min.	600 Min.	Mass concreting used as OPC
White Cement Coloured Cement (IS:8042)	Plaster, ceiling Ornamental works Terrazo floor
Hydrophobic Cement (IS:8043)	Water tight structure in basement
Masonry Cement (IS:3466)	90 Min.	24 Hrs.	Masonry works

■ **Timber classification on the Basis of Growth-**



■ **Macro Structure of Exogenous Tree-**

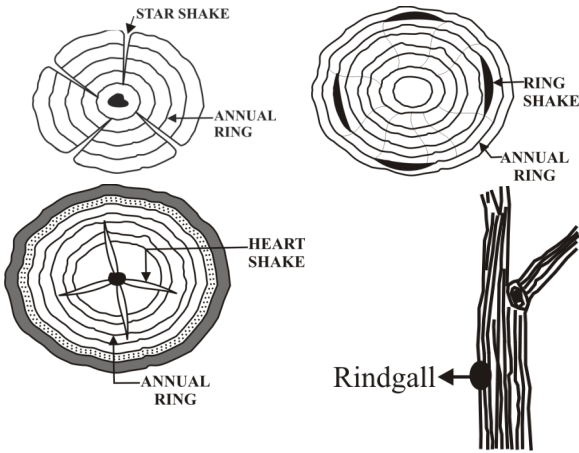
Medulla (Pith)	The innermost part or core of the stem of a tree
Heart wood	Death portion of the tree
Sap wood	Outer layers of a log of wood
Cambium	To growth wood cells
Bark	Protect the wood against mechanical damage
Transverse septa (Medullary rays)	The vascular tissue which Encloses the pith
Annual rings	A cellular tissue and woody fibre arranged in distinct concentric circle

■ **Properties of a Good Timber-**

Density	540 kg/m ³
Specific gravity	1.54
Moisture content	10-12%
Shrinkage	0.1-0.3% along fibers
Swelling	0.1-0.8% along length
Sound Conductivity	2-17 time more than air

■ **Strength of timber at 12% Moisture Content-**

Shear strength	6.5 -14.5 N/mm ²
Bending strength	10.2 -18.2 N/mm ²
Compressive strength	33 -77.5 N/mm ²
Tensile strength	80-190 N/mm ²



■ Defects of Timber-

Checks	Longitudinal cracks which is normal to the annual rings
Shakes	Longitudinal separation b/w the Annual rings.
Star shake	Wide at outside and diminish inside
Heart shake	Wide at center and diminish out side
Cup shake	Caused due to rupture of tissue in circular direction. It is developed due to non uniform growth
Ring shake	When cup shake cover the entire ring.
Radial shake	When timber is exposed to sun for seasoning after being felled down
Knots	These are the base of branches which are broken or cut-off from the trees.
Rind Galls	Abnormal growth or curved swellings on the body of tree.

■ Use of Various type of Timber-

Guava	Scientific instruments
Babool	Agricultural instruments
Mulberry	Sports Goods
Jackfruit	Musical instruments
Benteak	Boat
Plywood	Teak

Note-Swelling of Woods along fiber length-0.1-0.8%

Dry Rot-

- Turning of timber tissues into a dry powder due to fungi attack.
- It is due to imperfect seasoning or ventilation.

Wet Rot-

- Disintegration of tissues of the timber due to alternate wetting and drying.

☞ ASCU Treatment-Developed by Forest Institute Dehradun

☞ Timber can be made fire resistant by Sir Abel's Process.

■ Ingredients of Paint-

Ingredient	Properties
Base	<ul style="list-style-type: none"> • Metallic oxide is the principal constituent • Zinc white is weather resistant. • Aluminium powder used for all aluminium paints <p>Ex.- White lead, Red lead, Zinc oxide, Aluminium oxide, Iron oxide, Lithophone etc.</p>
Vehicle/ Binder	<ul style="list-style-type: none"> • Holds the constituent of paint and spread over surface • It forms the body of the paint • Linseed oil is the most widely used as vehicle <p>Ex.- Linseed oil, Nut oil, Poppy oil and Tung oil</p>
Solvent/ Thinners	<ul style="list-style-type: none"> • Used to thin the paints, increase the covering properties • Turpentine is used extensively <p>Ex.- Petroleum, Spirit, Naptha, benzene, Turpentine oil etc.</p>
Driers/ Plasticizers	<ul style="list-style-type: none"> • Accelerate drying of the vehicle • Quantity limited to 8% • Red lead is best for prime coat over steel. <p>Ex.- Letharge (Oxidized lead), Lead acetate [Red lead (Pb₃O₄)]</p>
Adultrants/ Extenders	<ul style="list-style-type: none"> • Reduce weight, increase durability. • Best Adultrant is Barium Sulphate. <p>Ex.- Barium Sulphate, Calcium Carbonate, Magnesium Silicate and Silica.</p>

■ Colouring Pigments-

Lamp black, Ivory black	Black
Prussian blue, Indigo	Blue
Chrome yellow, Yellow ochre	Yellow
Burnt umber, Burnt Sienna	Brown
Vermillion, Red lead	Red
Copper sulphate, Chromium oxide	Green
White lead Lithophone	White

■ **Ingredient for Different Types of Paint-**

Types of paints	Base	Vehicle	Use
Aluminium Paint	Aluminium powder	Spirit or Oil Varnish	Painting in Poles, Tower, Metal roofs
Asbestos/ Fire proof paint	Asbestos minerals	-	Stopping leakage in sloppy roofs, painting of gutters etc.
Bitumenous Paint	Natural Asphalt or residual bitumen	Mineral spirit or Nephtha	High Water Resistance
Plastic Paint	Plastic powder	Water	Interiors of auditorium, Showrooms and offices.
Cellulose Paint	Methyl or Ethyl Cellulose	Petroleum	Painting cars, ships and aeroplanes.
Cement Paint [IS :5410]	White or Coloured cement	Water	Exterior surface of building
Enamel paint	White Zinc, White Lead	Varnish	Acid resistance, alkalis & water proof
Luminous paint	Calcium Sulphide	Varnish	Metal surface & sign board

Concrete Technology

■ **Stripping Time of Formwork-**

Formwork Types	Stripping time
Vertical formwork to column, wall, beams	16-24 Hours
Soffit formwork to slab	3 days
Soffit formwork to beam	7 days
Props to slab	
(a) span upto 4.5 m	7 days
(b) span over 6 m	14 days
(a) span upto 6 m	14 days
(b) span over 6 m	21 days

☞ $E_c = 5700\sqrt{f_{ck}}$ N/mm² [I.S.456 : 1978]

$E_c = 5000\sqrt{f_{ck}}$ N/mm² [I.S.456 : 2000]

☞ **Target mean strength of concrete**

$$f_{CM} = f_{CK} + 1.65\sigma$$

σ = Standard deviation

F_{CM} = Target mean strength

F_{CK} = Characteristic strength

☞ **Permissible shear stress of reinforced concrete**

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

☞ **Coefficient of variation** $C_v = \frac{\sigma}{\mu}$

Where,

$$\mu = \frac{\sum X}{n} \quad n = \text{No. of sample}$$

■ **Classification and Grades of the concrete-**

Designation	Mix. Proportion (Cement : Sand: Coarse Aggregate)	Characteristic Compressive Strength in N/mm ²	Group	No. of grade
M-5	1:5:10	5	Lean Concrete	2
M-7.5	1:4:8	7.5		
M-10	1:3:6	10	Standard Concrete	7
M-15	1:2:4	15		
M-20	1:1.5:3	20		
M-25	1:1:2	25		
M-30	Design mix Conc.	30	High Strength Concrete	5
M-35		35		
M-40		40		
M-45		45		
M-50		50		
M-55		55		
M-60		60		
M-65		65		
M-70	70			
M-75	75			
M-80	80			