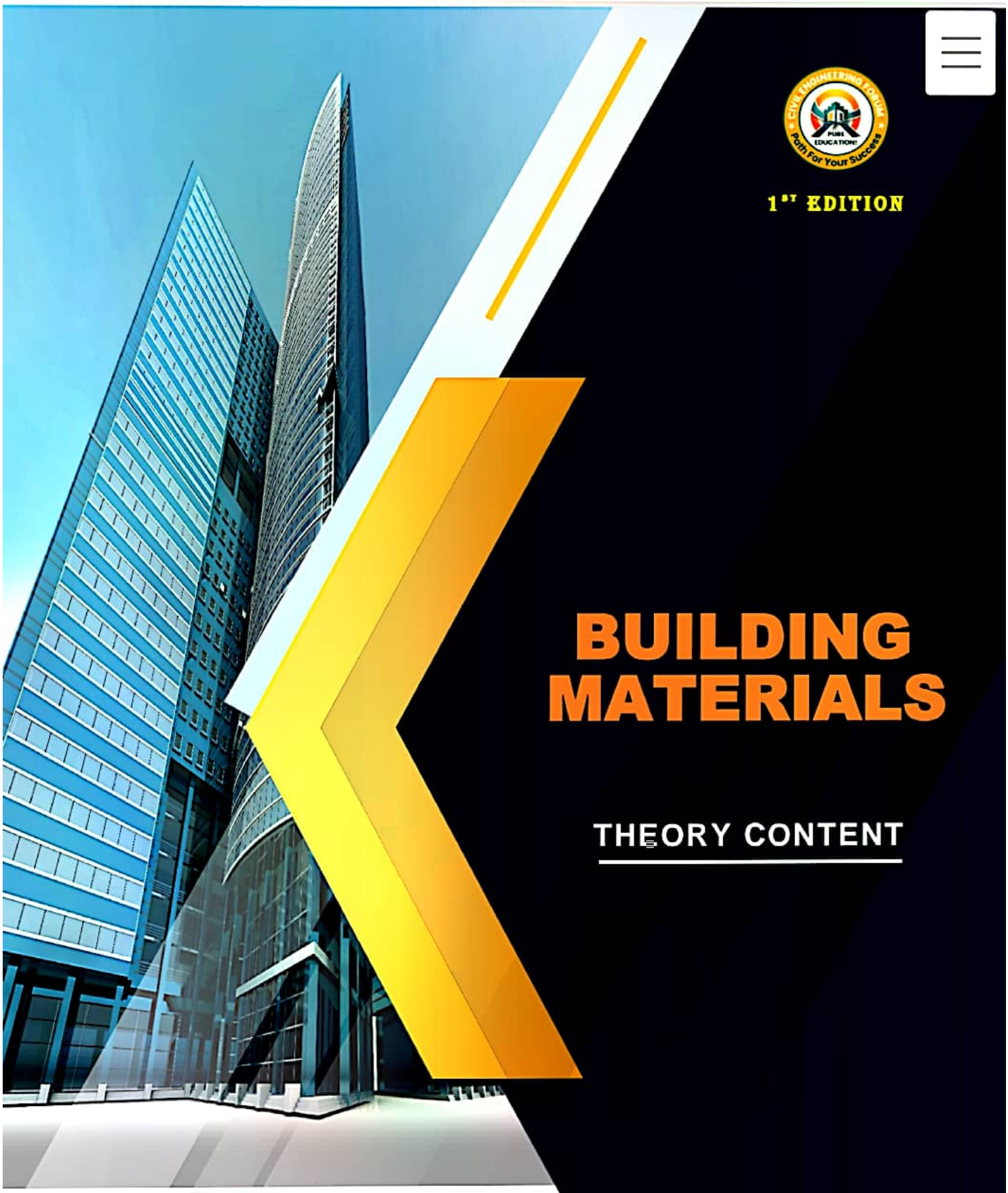


1ST EDITION

BUILDING MATERIALS

THEORY CONTENT

CIVIL ENGINEERING FORUM

- Useful for WBPSC, WBMSC (KMC), KMDA, NS, RRB JE, SSC JE, STATE AE/JE & any other examination of Civil Engineering.
- Colour content with highlighted important points.
- Easy language for understanding with several pictures and table format.

Index

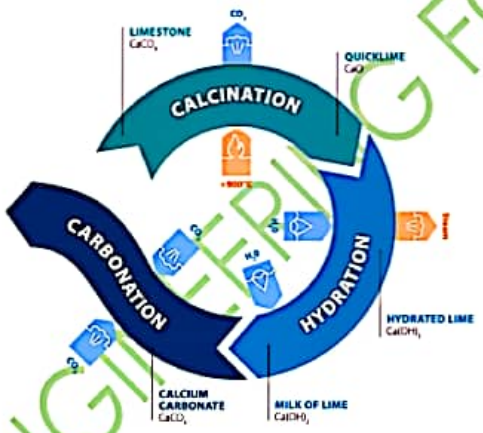
Chapter 1

Lime

General Information:

- Amphorous (No shape & size naturally occur) & Calcareous material.
- Types: Non hydraulic lime (Do not harden without air being present i.e., under water) & hydraulic lime.
- For slaking of 10 kg of lime, the theoretical amount of water required is 3.2 kg.
- 10 kg lime required per 100 m^2 for white washing.
- The chemical formula of lime or Quick lime is CaO (Calcium Oxide).
- The chemical formula of lime water is $Ca(OH)_2$ (Calcium Hydroxide).

Lime Cycle:



- When limestone (Calcium Carbonate) ($CaCO_3$) is heated Carbon dioxide (CO_2) is driven off leaving calcium oxide (CaO) which is also known as Quick lime/Caustic lime/Lump lime.

1. $CaCO_3 \xrightarrow[800-900^oC]{\text{Calcination}} CaO + CO_2\uparrow$

- Quicklime is chemically unstable and caustic. When quick lime is mixed with water (H_2O) (a process called Hydration or Slaking) heat and steam are released and the quick lime turns into calcium hydroxide $Ca(OH)_2$. Calcium hydroxide is also known as Slaked lime/Hydrated lime/Milk of lime.

2. $CaO + H_2O \xrightarrow{\text{Slaking}} Ca(OH)_2$ [Slaking lime/ Hydrated lime/Milk of lime]

- The slaked lime reacts with carbon dioxide (CO_2) in the air, slowly releasing water and hardening as it reverts back to Calcium carbonate.

3. $Ca(OH)_2 + CO_2 \xrightarrow{\text{Carbonation}} CaCO_3 + H_2O$

Constituents of lime:

1. Clay: Provide hydraulic property, Help in setting, (8 – 30) % good lime.
2. Silica (Soluble): Provide hydraulic property.
3. Magnesium Carbonate: Provide strength. (< 5% gives better result & impart hydraulicity, if excess liable to crack)
4. Sulphate: Accelerates setting process & reduce slaking
5. Iron compounds: Lower the temperature of calcination of limestone

Types of lime:

1. **Fat Lime/Pure lime/Rich lime/Highly caustic lime/White lime:**
   - Purity > 95%, Clay < 5%.
   - Sets slowly.
   - Reacts with water rigorously.
   - Plasticity High.
   - 2 to 2.5 Volume increase (on slaking) when reacts with water.
   - White in colour.
   - Used where appearance is required.
   - It is obtained from calcination of sea-shells.
   - Used in: White washing, plastering etc.

2. **Hydraulic lime/water lime:**
   - Purity: 70 to 95%, Clay: 5 to 30%.
   - Obtained from calcination of kankar.
   - Off white colour less rigorous in nature than fat lime.
   - Used where strength is required.
   - Capable of setting in water and in damp locations.
   - Used in: Brick Masonry, Stone Masonry, under water construction etc.
   - Types:

Properties	Feebly Hydraulic Lime	Moderately Hydraulic Lime	Eminently Hydraulic Lime
Clay (%)	5-10	11-20	21-30
Slaking time	Few minutes	One or Two hours	Slakes with difficulty
Setting time (In water)	3 weeks or so	1 week or so	A day or so
Hydraulicity	Feeble	Moderate	Eminent
Application	Ordinary masonry work	Superior masonry work	Damp places (Under water construction)

3. **Poor lime:**
   - Purity < 70%, Clay > 30%.
   - Reaction process retard/slow.
   - Muddy White colour.
   - Does not undergo slaking.
   - Obtained from calcination of Dolomite stone.

Chapter 2 — Cement

General Information:

- Invented by: Joseph Aspdin 1824
- Weight per bag: 50 Kg (1 ton = 20 bags)
- Bulk density: 1440 kg/m^3 (or 1.44 g/cm^3)
- Specific gravity: 3.15 (OPC)
- Volume of 1 bag: 0.0347 m^3 = 35 cm^3 = 35 litres = 1.226 cft.
- 1 m^3 cement = 28.8 bags ≈ 30 bags
- Grade of cement: 33, 43, 53 number denotes 28 days compressive strength
- Percentage of voids in cement approximately 40%
- Particle size: < 90μ (90% particle size < 45μ)
- Average particle size: 15μ
- Batching tolerance as per IS: 456: ± 2%
- If absorb moisture > 5% cement will be rejected
- 1 Bag of cement required approximately 22.5 litres of water. (0.45 W/C ratio)
- After storage, the strength of cement decrease. (should be used within 3 month)

Time	*Strength reduction (%)*
Fresh	0
3 months	20
6 months	30
12 months	40
24 months	50

Cement bag details

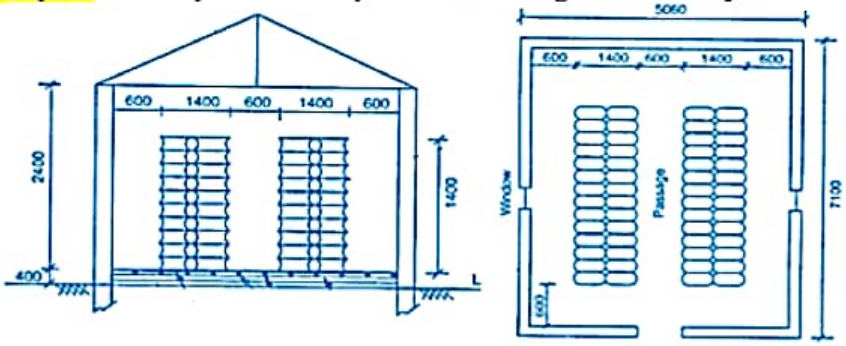
Dimension: Length: 0.7 m, Width: 0.42 m and Height: 0.18

Floor area occupied: 0.3 m^2 per bag

Volume: 0.054 m^3 per bag

Warehouse Stacking: (IS: 4082-1996)

- Max. stack: 8-10 bags
- Space between stacks and from wall: 600 mm
- Width of stack: Maximum 4 bags or 3 m
- Cement bags shall be stacked off the lean concrete floor (150 mm) on wooden planks in such a way as to keep about 150 mm to 200 mm clear above the floor.
- 'Warehouse pack' means pressure compaction of the bags on lower layers.



Heat of Hydration:

- The heat of hydration during chemical reaction with cement with water is known as heat of hydration.
- Reaction: Exothermic
- Heat of Hydration: 89-90 cal/gm (7 days) and 90-100 cal/gm (28 days)
- Depends on: Fineness of cement
- In hydrated cement paste the principal strength contributing compound is C-S-H (calcium silicate hydrate or tobermorite gel)

Water requirement in Heat of Hydration	
Bound water	23% (required for complete chemical reaction
Gel pores water	15%
Total water required	38% by weight of cement to complete heat of hydration

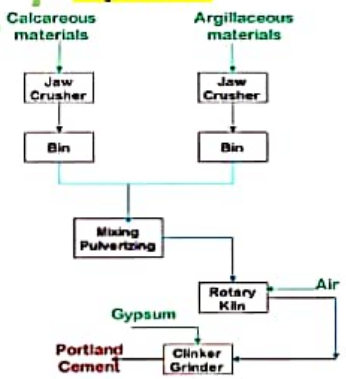
Manufacturing Process:

- Mixing: Argillaceous (35%) and Calcareous (65%) (1:2)
- Argillaceous: Blast furnace slag, Marl, Shale and clay etc.
- Calcareous: Lime stone, Chalk, Cement rock, Marine shells etc.
- Process: Wet (obsolete) and dry
- Manufacturing step: Mixing of raw materials → Burning → Grinding → Storage & packing

Dry process & Wet process:

Properties	*Dry process*	*Wet process*
Raw material uses	Harder	All type of material
Time consumed	Less	High
Fuel consumption	Less	High
Physical state	Solid raw material use	Raw material used in slurry form
Quality achieved	Inferior quality	Superior quality
Fusion Temperature	1400-1500^{0}C	1500-1600^{0}C
Cost of production	High	Low

Dry Process



Wet Process