BUILDING MATERIALS

Civil Engineering Materials:

The materials used in civil construction or used to produce others materials for civil construction is called civil engineering materials.

*) TYPES:

A): Depending upon Existance:

i) Natural construction materials:

→ formed by natural proces

Eg: stone, gravels, etc.

ii) Man-made construction materials:

→ formed after manual processing during manufacturing.

Eg: steel, bricks, etc.

B): Depending upon Usage:

i) Structural materials

→ bricks, stones, steel, sand, etc.

ii) Aesthetic materials

Paints, Tiles, Marbles

iii) Special purpose materials:

Pipes, Sanitary fittings.

(C): Depending upon Metallurgy:

Metallurgy is the branch of science and technologies concerned with the properties of metals, their production and purification.

*) Types

a) Metals:
- → Materials having high electrical and thermal conductivity.
- → Malleable and ductile materials.

b) Non-metals:
- Materials not having electrical and thermal conductivity.
- → Non-malleable and non-ductile.

(D): Depending Upon Composition:

a) Ceramics
- → Ceramics are the material neither metallic nor organic.
- → It may be crystalline, glassy or both.
- → Manufactured by baking natural clay and mineral admixtures at higher temperature.

b) Polymers:
- Large molecule which is the composition of smaller units.

Eg: Green House Plastics.

PROPerties of Construction Materials:

A) Physical properties:

i): Dimensions: It explains the shape and size of the materials.

ii): Water Absorption Capacity:

$$W.A.C = \frac{\text{water absorbed}}{\text{Dry wt. of material.}}$$

iii) Specific gravity: The ratio of density of a substance to the standard substance.

$$\text{specific gravity} = \frac{\text{density of material}}{\text{density of material at } 4^{\circ}c}$$

iv): Soundness: The resistance against heat and moisture.

v) Frost resistance: The resistance against repeated cycle of freezing and thawing.

vi) Permeability: The property to permit water to flow through it.

vii) Porosity: The ratio of ~~vo~~ total volume of voids by total volume of substance.

$$\text{porosity} = \frac{\text{volume of voids}}{\text{total volume.}}$$

B) MECHANICAL PROPERTIES:

i) Strength: The capacity to withstand great force or pressure.

ii) Resilience: The energy stored in a material when strained within elastic limit.
→ Area under stress-strain curve upto the point of elastic limit.

iii) Hardness: The ~~fels~~ resistance to penetration of surface.

iv) Toughness:
The ability of the body to absorb energy and get plastically deformed without fracturing or broken.

v) Ductility: The capacity of metal to be made into wire.

vi) Malleability: The property of metal to be beaten down into thin sheets.

vii) Elasticity: The property by which material regains original configuration after removing deforming force.

viii) Creep:
The property of material indicating the tendency of material to move slowly and deform permanently under influence of external mechanical stress.

ix): Fatigue: The weakening of material due to repeated loading of material.

x) Tenacity: The toughness of material to resist breaking.

BRICKS:

Bricks are obtained by molding clay to suitable shape & size and burnt in clamps or kilns.

(*) Composition:

~~Materials~~	~~% Composition~~	~~Use.~~
Silica		

(P.T.O)

Materials	% composition	Uses.
Silica / Sand	50-60%.	Helps retain shape, impart durability, prevents shrinkage. → Excess: makes brittle & weak.
Alumina / Clay	20-30%.	absorbs water, renders clay plastic. → Excess: cracks on burning.
Lime	<10%.	reduces shrinkage, flux for melting silica. → Excess: melt & loose shape.
Alkalis	<10%.	flux to melt brick and quick setting → Excess: efflorescence.
	<7%.	→ gives colour to brick → Excess: dark and blue.
Magnesia	1%.	causes clay to soften at slow. Excess: makes colour yellow.

Short:

Silica (50-60%.) Alumina (20-30%.)
Lime (2-5%.) Iron oxide (<7%.)
Magnesia (<1%.) Alkalis (<10%.)

(*): Based on physical & chemical properties:

1) 1st class brick:
→ IS: 190*90*90
NS: 230*110*55 / 224*108*57
→ WAC: 12-15% of dry weight immersed in cold water for 24 hrs.
→ Compressive strength: >=10 MPa
→ Burnt ~~kiln~~ in Brick kilns.

2) 2nd class bricks:
→ Ground molded.
→ WAC: 16-20% of dry weight immersed in cold water for 24 hrs.
→ 4 >= 7 MPa & <=10 MPa
→ Non-sharp and non-uniform.
→ Burnt in brick kilns.

3) 3rd class brick:
→ Ground molded
→ WAC: 25% of dry weight when immersed 24 hr in cold water
→ Burnt in clamps.
→ Underburnt.
→ C.S: < 7 MPa.
→ Produces dull sound when struck together.

4): 4th class brick:
→ Over burnt and dark.
→ Highly distorted.
→ C.S: very high.

(*) Usage:
Building walls, soiling purpose, lining in furnaces or chimney.

*) Properties of Good Brick:

(a): Colour: It must be uniform and bright.

(b): Shape: It must have plane face, sharp edges, right angled corners.

(c) Size: must be standard size.

(d): Textures: No fissures or cavity in the body.

(e): Strength: No less than 3.5 MPa
Not break when dropped from 0.9 to 1 m

(f): Hardness: Finger scratching must not produce impression.

(g): Water absorption: Not more than 20% of dry weight.

(h) Efflorescence: Not show white patches when soaked for 24 hours in water.

(i): Thermal conductivity should be low.

(ii) Must provide sound insulation and resistive against fire.

STONES:

It is naturally available building materials derived from rocks not having definite shape or chemical composition.

(A): According to Geological Classification:

i) Igneous rocks	ii) Sedimentary rocks.
→ rocks formed from cooling and solidifying rock masses from molten state.	→ rocks formed by graduation decomposition of disintegrate rocks.
Eg: Granite, Basalt	Eg: Limestone, Sandstone, Mudstone.

iii): Metamorphic Rocks: rocks formed by treating igneous and sedimentary rocks at extreme pressure and heat.

(B) According to physical classification:

i) Stratified	ii) Unstratified	iii) Foliated:
→ Layered in structure	→ not layered in structure	→ Tendency to split along definite direction.
Eg: Limestone, sandstone	Eg: Granite, Basalt	Eg: slate, Phyllite.

(C) According to Chemical Classification:

i) Silicious → silica as main content. Eg. granite, sandstone

ii) Argillaceous → alumina as main content. Eg: slate, laterite

iii) Calcareous → $CaCO_3$ as main content. Eg: Limestone, marble

(*): Requirement of Good Building Stone:

a): Strength: Must be capable to resist heavy loads presses on it.
b): Specific gravity: Lie within 2.4 to 2.8.
c) Stiffness: Must resist deformation.
d) Hardness: Must resist wear and tear
e) Durability: Must resist effect of rain, wind, heat.
f) Cost: Easiness in quarries to extract
g) Toughness: Must sustain stress against fracture.

SAND:

Naturally occuring granular material composed of finely divided rock material silica:

Size: 0.75 mm to 4.75 mm IS sieve.

(*): Properties of Good Sand:

i) Clean and coarse
ii) Free from organic matter.
iii) Chemically inert
iv) Well graded.
v) Contain angular sharp coarse grain.

METALS:

Metals provide structural framework for large buildings.

(*): Classification:

(A): Ferrous metals:

→ Iron (Fe) has main constituent:

Types:

i) Cast iron: 1.7 to 4.5 % Carbon content
ii) Wrought iron: 0.05 to 0.15 % Carbon content.
iii) Steel: 0.25 to 1.5 % Carbon content.

(i): Cast iron

→ Compressive strength: 700MPa.
→ Brittle: liable to break easily.
→ Specific gravity: 7.5
→ Coarse crystalline fibrous.
→ Don't rust easily
→ MP = 1200°C

ii) Wrought ion:

Compressive strength = 200MPa
Brittle
Specific gravity: 7.7
→ Coarse crystalline, fibrous.
→ Rust easily.
→ MP: 1500°C.

(iii) Steel:

Alloy of iron and carbon:

(*): Features of structural steel:

i) High tensile strength
ii) Ductility
iii) Malleability
iv) Toughness
v) Weldability
vi) Durability.

(*) Types of steel

1) Mild steel:

- 0.25% C, 0.055% S, 0.55% P
- Malleable & ductile
- welded easily
- strong in tension and compression
- Magnetized permanently.
- Sp gravity: 7.85.

Use: making rolled I, H, T, C section.

2) High Tension:

- 0.80% C, 0.60% Mn
- High strength, strong in tension.
- Use: to built prestress concrete.

3) High Carbon steel

- 0.7 to 1.5% C
→ Hard but easily broken.
→ Difficulty weilding.
→ Strong in compression than tension.

Eg: make drills, chisels.

(B): Non-Ferrous Metals:

→ Metals not containing Iron.

Eg: aluminium, copper, lead, zinc, tine as well as gold and silves.

Advantages:

i) Highly malleable.
ii) Resistance against rust & comosion.
iii) Non-magnetic.

Uses: i) making wires
ii) making pipes and roofing.

CONCRETE:

The mixture formed by mixing cement, fine aggregrate, course aggregrate and water in fixed proportion is called concrete.

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Concrete = Aggregrate [75-80%] + Cement, Water, Air voids [20-25%]

(x): Usage:

i) Building blocks
ii) Making pavement
iii) Using bed concerete.

(x) Disadvantage.

(i): Very poor tensile strength
(ii) Fresh concrete shrinks on drying.

(x) Advantages:

i) High compressive strength
ii) Resistance against water
(iii) Fresh concrete can be molded to various shapes
(iv) Durable and fire resistance.
(v): Safe from Termite attack.

CEMENT:

The binding material that binds aggregrates to form solid mass is called cement.

It is obtained by burning a mixture of calcareous and argillaceous materials at high temperature.

(x): Classification:

a) Hydraulic cement:
→ Hardens when exposed to water.
Eg: OPC, PPC.

b) Non-hydraulic cement:
→ ~~Her~~ Doesn't harden when exposed to wates
Eg: Lime.

Ingredients	Composition	Functions
Lime (CaO)	60-65%.	Controls strength and soundness
Silica (SiO_2)	17-25%.	Gives strength. Excess: Slow setting
Aluming (Al_2O_3)	3-8%.	Quick setting Excess: reduces strength.
Ferrous oxide (Fe_2O_3)	0.5-6%.	Colour gives, Helps to fusion others.
Magnesium oxide (MgO)	0.5-4%.	Gives colour & hardness. Excess: causes cracks.
Sulphur trioxide (SO_3)	1-2%.	Sound.
Alkalis	0.5-1%.	Excess causes cracking.

Manufacture of Cement:

The steps in cement manufacturing are as follows:

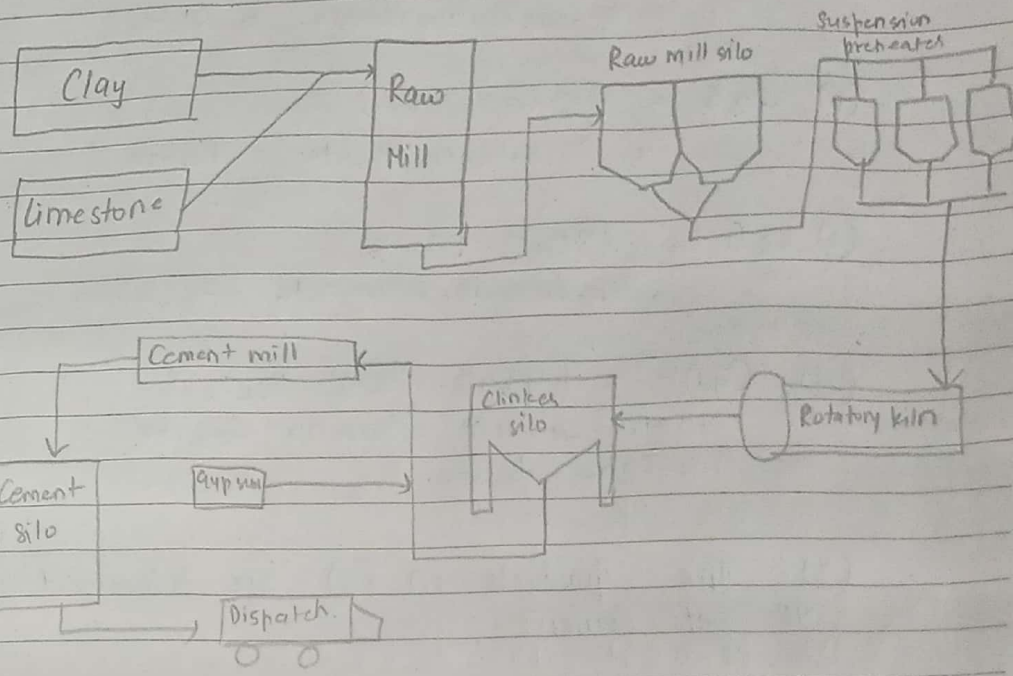

Fig: Cement manufacturing.

1): Limestone is heated with alumina at 1450°C in kiln.

Reactions:

Limestone: $CaCO_3 \longrightarrow CaO + CO_2$

Alumina: $Al_2O_3 + SiO_2 + Fe_2O_3$.

(2): This results in the formation of clinkers:

(a): C_3S = ($3CaO \cdot SiO_2$)
= Tri-calcium silicate. = Alite.

(b) C_2S = ($2CaO \cdot SiO_2$)
= Di-calcium silicate = Belite.

(c) C_3A = ($3CaO \cdot Al_2O_3$)
= Tric calcium aluminate = Celite.

(d): C_4AF = ($4CaO \cdot Al_2O_3 \cdot Fe_2O_3$)
= Tetra calcium Alumino ferrite
= Tetra felite.

(3): The products in (2) are pulverized to get cement.

(P.T.O)

Compounds	Functions
C_3S	- 45% composition - responsible for early concrete setting. - rapid hardening of cement.
C_2S	- @ 25% composition - responsible for late concrete strength
C_3A	- 12% composition - No significant strength contribution. - It has fast set thus, gypsum is added.
C_4AF	- 10% composition. - No strength contribution - Gives volume and reacts slowly.

(*): Properties of Cement:

a) Crushing strength:

43 grade OPC means cement has 28 days compressive strength of minimum 43 MPa at room temperature.

(b): Setting time:

→ 30-60 minutes for initial setting.

Initial setting time: ~~When the~~ The time taken by the sticky paste of concrete to stiffen.

(*): Nominal Mix Design:

Cement : sand : Aggregate. ration.

(a): M10: 1:3:6
(b) M15: 1:2:4
(c) ~~M20~~ M20: 1:1.5:3.

(*) Uses:
i) Filling cracks in concrete structures.
ii) Masonry work, plastering.

(*): OPC PPC.

→ Ordinary portland cement — Pozzolana Portland Cemen

→ costly due to expensive clinkers. — → relatively cheaper.

→ Less finer — → finer.