

# CVL3211 : Civil Engineering Materials

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# Cement and its properties

Properties given below will be discussed in this chapter.

- ▶ Manufacturing of cement
- ▶ Chemical composition of cement
- ▶ Properties of cement components
- ▶ Laboratory testing for cement
- ▶ Working/Hydration of cement
- ▶ Admixtures of cement/concrete

# Manufacturing of cement

Material	Chemical Formula	Proportion
Calcareous (calcium minerals)		
Lime	$CaO$	60-70%
Argillaceous (clay/silica minerals)		
Silica	$SiO_2$	20-25%
Alumina	$Al_2O_3$	5-10%
Iron Oxide	$Fe_2O_3$	5-10%

These raw materials are mixed and heated at  $1300^{\circ}C$ - $1500^{\circ}C$  causing them to fuse and form clinker, which is then powdered and packed. Gypsum ( $CaSO_4 \cdot 2H_2O$ ) in 2-4% w/w is added to clinker to act as setting time retarder.

## Chemical composition of cement

Manufactured cement is called Portland Cement based on its place invention. Generally it consists of compounds given below in table with compositions.

Material	Chemical Formula	Short Formula	Proportion
Tricalcium Silicate	$3CaO.SiO_2$	$C_3S$	45 to 60%
Dicalcium Silicate	$2CaO.SiO_2$	$C_2S$	15 to 30%
Tricalcium Aluminate	$3CaO.Al_2O_3$	$C_3A$	6 to 12%
Tetracalcium Aluminoferrite	$4CaO.Al_2O_3.Fe_2O_3$	$C_4AF$	6 to 8%

# Properties of cement components

Compounds given in previous table imparts some specific properties as given in table below.

Compound	Properties
$C_3S$	Initial strength and setting
$C_2S$	Ultimate strength
$C_3A$	Heat of hydration and quick set
$C_4AF$	Sulphate resistance

## Laboratory testing for cement

Laboratory test which determine engineering properties of cement are given in table below.

<b>Test</b>	<b>Determined Property</b>	<b>Apparatus</b>
Standard consistency test	Optimum Water content for workability (Consistency)	Vicat's Apparatus
Initial & final setting time	Time of Attainment of Plastic stage and Rigid stage	Vicat's Apparatus
Fineness test	Surface area of cement particles	IS90 micron sieve
Soundness	Expansion due to free/unreacted lime	Le-chatelier's mould

## Working/Hydration of cement

1.  $C_3S$  and  $C_2S$  are major constituent of cement and their hydration cause C-S-H ( $CaO - SiO_2 - H_2O$ ) molecules to form.
2. These molecules does not have an exact composition and hardens with time to form a neural network of bonds similar to metallic bond.
3.  $C_3A$  hydrates fastest to form C-A-H ( $CaO - Al_2O_3 - H_2O$ ) paste with negligible strength development. This hinders the hydration of  $C_3S$  and  $C_2S$  and reduce overall strength of paste so Gypsum is added to lower setting speed.
4. After setting finishes, cement keeps gaining strength for long time say months. Two kind of pores formed in cement i.e. interlayer (Major) and capillary (Minor).

# Admixtures of cement/concrete

After manufacturing process if required cement/concrete properties can be altered using admixtures they are classified as given in table below.

Admixture	Effect
Chemical Admixtures	
Retarders	Increases the setting time
Accelerators	Decreases the setting time
Water reducing agents /Plasticizer /Superplasticizer	Reduces water content for hydration
Mineral Admixtures	
Fly ash	Extends hydration, increases workability
Slag	Increase cementing action