CEMENT

CEMENT:

NEB Syllabus:

- *Introduction*
- *Raw materials for cement production*
- *Main steps in cement production (crushing and grinding, strong heating and final grinding)*
- *Types of cement- OPC and PPC*
- *Portland cement process with flow-sheet diagram*
- *Cement industries in Nepal*

- Cement was first discovered in England in 1824 by Joseph Aspdin.
- It is essentially a mixture of limestone and clay.
- **A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together.**
- The most popular cement that are used in Nepal are Ordinary Portland Cement (OPC) and Pozzolana Portland Cement (PPC) and white cement.
- The average composition of Portland cement is CaO (50-60%), SiO_2 (20-25%), Al_2O_3 (5-10%), MgO (2-3%), Fe_2O_3 (1-2%) and SO_3 (1-2%)

Raw Materials For Cement Production
Major considerations while selecting Raw Materials

- Composition and uniformity
- Physical characteristics
- Quantity required, location and transportation

- **Raw Materials:**
  - Cement contains four types of essential constituents. They are silicon, aluminum, iron, and calcium.

- i. Calcareous materials (which supply lime) e.g. limestone, cement rock (a soft argillaceous limestone), chalk, clay or marine shales and waste calcium carbonate from industrial process.

ii. Argillaceous materials (which supply silica (SiO_2), aluminates (Al_2O_3) and iron oxides (Fe_2O_3). E.g. clay, shale, blast furnace slag.
iii. Gypsum ($CaSO_4.2H_2O$)

- **The main steps of cement production:**
- The main steps of cement production are:
  - Crushing and grinding of raw materials (mixing the raw materials)
  - Strong heating or burning (formation of clinker)
  - Cooling clinker and mixing additives
  - Final grinding

→ **Crushing:** Raw materials are extracted from quarries by blasting, drilling, or ripping using heavy machinery, Wheel loaders and dumper trucks transport the raw materials to the crushing installations. Limestone's produced are then crushed with the help of crushers installed at the mine site and crushed limestone is transported to plant stack pile with the help of Belt conveyor/Ropeway.

→ **Grinding and blending the materials in the correct proportions:** Crushed quarried limestone is further grinded to provide a fine material for the blending step. Thus obtained grinded material is blended with corrective ingredients like clay/shale, silica, and iron ore in required proportion and mix homogeneously to produce clinker of the desired composition. The raw materials "cement rock", obtained from a mine may contain appropriate proportions of all the required minerals or may need to add corrective ingredients to adjust SiO_2, Al_2O_3 and Fe_2O_3 levels.

Strong heating (pyro processing):

The blended raw materials are stored in silos before being fed into the kiln for pyro-processing operation. The blended material is then heated at the hearth of the pyro processing system at high temperatures up to 1300- 1500°C in a rotary kiln to produce a clinker. The kiln is heated with the help of powdered coal or oil or hot gases from the lower end of the kiln so that the long hot flames are produced.

Reactions in kiln:

i. Evaporation of free water.
ii. Evolution of combined water in the argillaceous components.
iii. Evaporation of volatile constituents (e. g., sodium, potassium, chlorides, and sulfates).

iv. Calcination of the calcium carbonate ($CaCO_3$) to calcium oxide (CaO). $CaCO_3 \rightarrow CaO + CO_2$.
v. Reaction of CaO with silica to form dicalcium silicate and with excess, CaO gives tricalcium silicate.
$2CaO + SiO_2 \rightarrow 2CaO.SiO_2$ (Dicalcium silicate
$3CaO + SiO_2 \rightarrow 3CaO.SiO_2$, (Tricalcium silicate

vi. Reaction of CaO with the aluminum and iron-bearing constituents to form the liquid phase.
$3CaO + Al_2O_3 \rightarrow 3CaO.Al_2O_3$ (Tricalcium aluminate)
$4CaO + Al_2O_3 + Fe_2O_3 \rightarrow 4CaO.Al_2O_3.Fe_2O_3$ (Tetracalcium aluminoferrite)
vii. Formation of the clinker nodules.

→ Cooling clinker and mixing additives

The clinker coming from the burning zone is very hot and is admitted in a counter-current direction at the base of the rotary kiln. This cooled clinkers are collated in small trolleys.

Generally following types of additives are mixed. They are

a. Retarder: To prevent quick setting of cement plaster, retarders like gypsum or plaster of pairs (2.5%-3%.) are used.

b. Dispersing agent: Small quantity of dispersing agent like sodium salt or naphthalene or sulphuric acid is added to cement to prevent formation of lumps and cakes in cement.

c. To stop freezing and thawing, improve durability of concrete, additives like vinyl resins or darex are added. These agent have property of imparting air in to cement paste.

→ Final Grinding:

The clinkers are pulverized to fine grains in tube mill. During grinding additives are added. The grinded powder is packed in to bags through automatic packaging machine.

Types of cement

Cement is classified on the basis of constituents. They are

1. Portland cement (OPC)
2. High alumina cement
3. Hydraulic cement
4. Pozzolana Portland cement (PPC)

Composition of Cement:

	Types of cement	Code	Chemical formula	Types	%
i.	Portland	C_2S	$2CaO.SiO_2$	Silicate	Major
	(OPC)	C_3S	$3CaO.SiO_2$	Silicate	Major
		C_3A	$3CaO.Al_2O_3.Fe_2O_3$	Aluminate	Major
		C_4AF	$4CaO.Al_2O_3.Fe_2O_3$	Aluminate	Minor
			MgO		Minor
			CaO		Minor
ii.	High alumina	C_3A	$3CaO.Al_2O_3$	Aluminate	Major
		C_2AS	$2CaO.Al_2O_3.SiO_2$	Mixed	Minor
iii.	Hydraulic hydrated lime	–	$Ca(OH)_2$	Hydroxide	Major
		C_2S	$2CaO.SiO_2$	Silicate	Minor
		C_3A	$3CaO.Al_2O_3$	Aluminate	Minor
iv.	Pozzolana Portland cement (PPC)		2.4 Parts hydrated lime + mixture of volcanic ash, burnt clay or shale		

Difference between OPC and PPC Cement

OPC	PPC
1. It has higher strength than PPC in the initial stage.	1. The strength of PPC is good than OPC in long terms.
2. It has high heat of hydration making it unfavorable for mass concreting.	2. The hydration process is slower than OPC resulting low heat of hydration. Therefore, it is suitable for mass concreting.
3. The presence of sulphates, alkalies, chlorides, etc. is higher and less resistant than PPC.	3. It has low percentage of sulphate alkalis, chlorides, magnesia and free lime in its composition, which makes the concrete durable.
4. OPC is not favorable in aggressive weather.	4. Show greater resistance to aggressive weather.
5. OPC cement are available in three grades, such as 33 Grade, 43 Grade, 53 Grade	5. PPC is available in any specific grades.
6. It is slightly costlier than PPC.	6. Cheaper than OPC.

Characteristic of Good Cement

1. Provides strength to masonry.
2. Stiffens or hardens early.
3. Possesses good plasticity.
4. An excellent building material.
5. Easily workable.
6. Good moisture-resistant.

Manufacture of Portland cement with flow sheet diagram

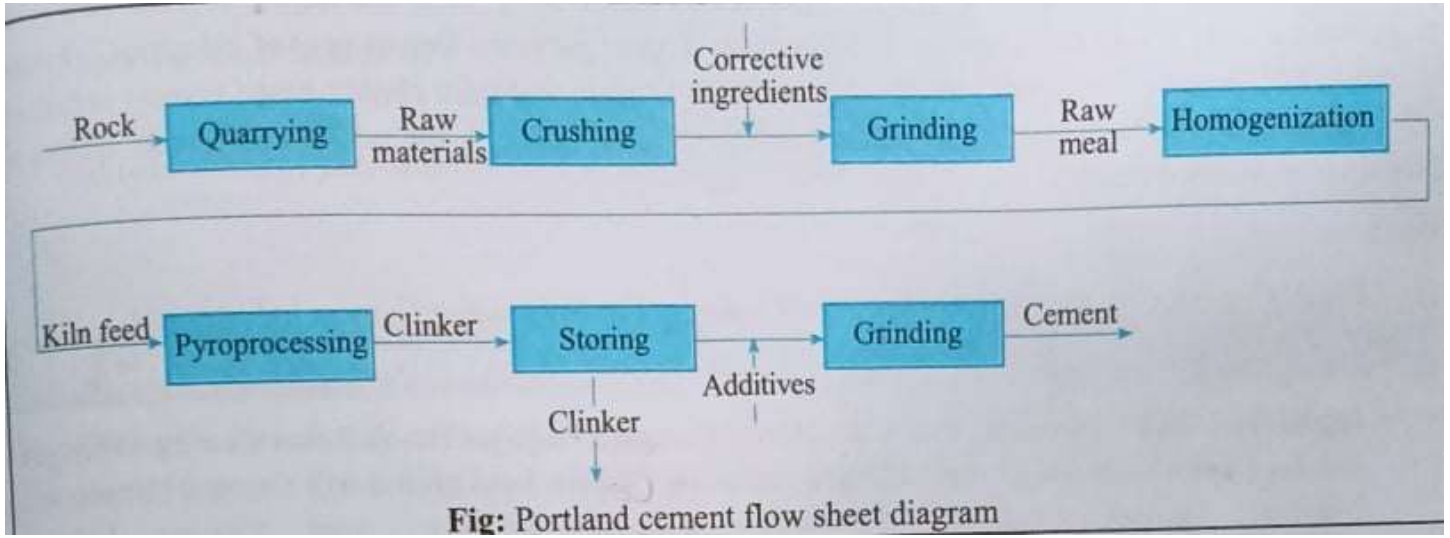

Fig: Portland cement flow sheet diagram

Flow Chart of Manufacturing OPC

Raw materials:

Calcarious → Lime stone or Chalk

Argilaceous → Clay or Shale

Two processes of mfg. of cement

WET PROCESS

Raw Maerial

↓

Crushers

↓

Grinders

↓

Wash mill

↓

Raw Material + 35% To 50% of water

↓

Slurry of Raw materials is mixed in storage tank/silos

↓

Kiln (Calcination)

↓

Clinkers

↓

(Addition of Gyspum) Grinders + Ball mill

↓

Cement (Packed in Bags of 50 kg)

DRY PROCESS

Raw Maerial

↓

Crushers

↓

Grinders

↓

Compressed Air Blenders

↓

Raw Material + 15% of water

↓

Flakes of Material

↓

Kiln (Calcination)

↓

Clinkers

↓

(Addition of Gyspum) Grinders + Ball mill

↓

Cement (Packed in Bags of 50 kg)

Cement Industry in Nepal

Status of Cement Industries in Nepal

→The use of cement in Nepal begins from 1950's but supply of cement was diversified in 1965. The cement was started to import in commercial scale only in 1970 from China, South Korea, Burma, North Korea, Indonesia, Thailand, Japan, Hong Kong and other countries.

→ In 1975, the first cement plant, Himal Cement Company a state owned company started manufacturing cement 160 tons per day was production capacity. Then Hetauda Cement Industry and Udayapur Cement Industry limited were established. Himal Cement Company was dissolved in 2002 due to environment cause.

→ Department of industries shows 27 mini, medium and large scale cement industries, 17 mini and mini clinker based industries are registered and factories are still growing.

→ Public sector: Himal cement company Ltd.

→ Private sector: Shivum cement, Maruti cement, Kepy cement etc.

→ Clinker based cement industries: Ambe cement Pvt. Ltd. Etc.

Cement Industry in Nepal

i. **Jagdamba Cement:** It is the best cement in Nepal and has remained the market leader in cement manufacturing business.

ii. **Udaypur Cement:** It is the largest cement factory in Nepal. The plant is located in Jaljale, Udaypur district, province no. 1, eastern Nepal. They use the modern plant and produces high quality cement.

iii. **Hetauda Cement:** It is located in Hetauda, Nepal and is one of the best-selling cement brand in Nepal.

iv. **Arghakhachi Cement:** It is one of the foremost cement manufacturers **Shivam Cement:** It is onwhich produces high quality OPC cement.

v. **Shivam Cement:** It is one of the top cement companies in Nepal. It process OPC cement of grade 43 and 53.

vi. **Sona Cement:** This is the largest cement company in western Nepal which produces both PPC and OPC cement.

vii. **CG Cement:** It is one of the leading and best selling cement companies which uses modern technology to control the process. Bishal Cement, Agni Cement, Unitech Cement, Kaveri Cement etc.