THE CEMENT MANUFACTURING PROCESS

Prof. Dr Elshafie Ahmed Gad

Faculty of Applied Science

Chemistry Dept.

Portland Cement

Portland cement is made by mixing substances containing $CaCO_3$ with substances containing SiO_2, Al_2O_3, Fe_2O_3 and heating them to a clinker which is subsequently ground to powder and mixed with 2-6 % gypsum

Raw Materials Necessary for Portland Cement Manufacture Must Provide the Following

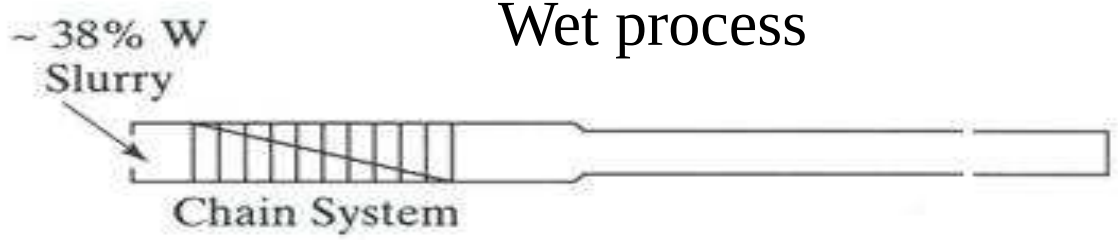
- Calcium
- Silica
- Alumina
- Iron

Calcium	Iron	Silica	Alumina	Sulfate
Alkali waste	Blast-furnace flue dust	Calcium silicate	Aluminum-ore refuse	Anhydrite
Aragonite	Clay	Cement rock	Bauxite	Calcium sulfate
Calcite	Iron ore	Clay	Cement rock	Gypsum
Cement-kiln dust	Mill scale	Fly ash	Clay	
Cement rock	Ore washings	Fuller's earth	Copper slag	
Chalk	Pyrite cinders	Limestone	Fly ash	
Clay	Shale	Loess	Fuller's earth	
Fuller's earth		Marl	Granodiorite	
Limestone		Ore washings	Limestone	
Marble		Quartzite	Loess	
Marl		Rice-hull ash	Ore washings	
Seashells		Sand	Shale	
Shale		Sandstone	Slag	
Slag		Shale	Staurolite	
		Slag		
		Traprock		

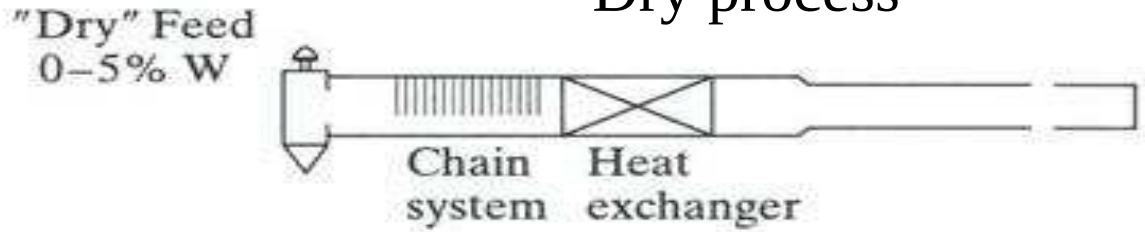
PRODUCTION STEPS

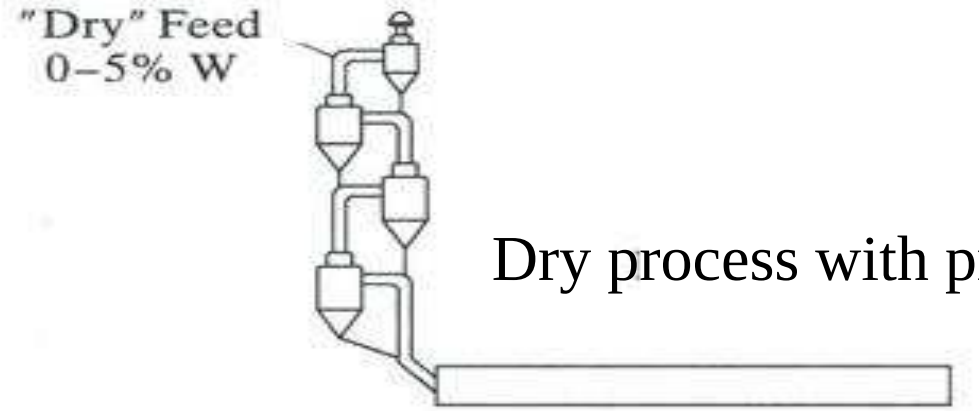
1) Raw materials are crushed, screemed & stockpiled.
2) Raw materials are mixed with definite proportions to obtain “raw mix”. They are mixed either dry (dry mixing) or by water (wet mixing).
3) Prepared raw mix is fed into the rotary kiln.
4) As the materials pass through the kiln their temperature is rised upto 1300-1600 °C. The process of heating is named as “burning”. The output is known as “clinker” which is 0.15-5 cm in diameter.
5) Clinker is cooled & stored.
6) Clinker is ground with gypsum (3-6%) to adjust setting time.
7) Packing & marketting.

Wet process



Dry process



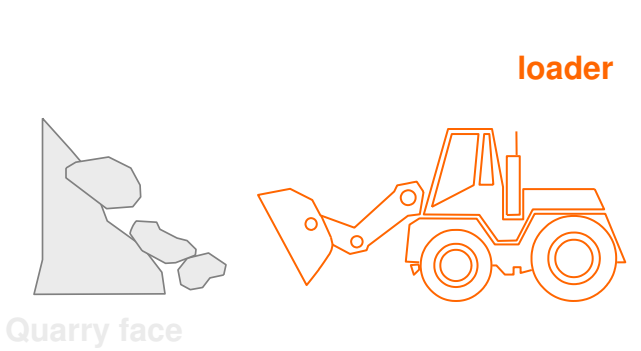


Dry process with preheating tower

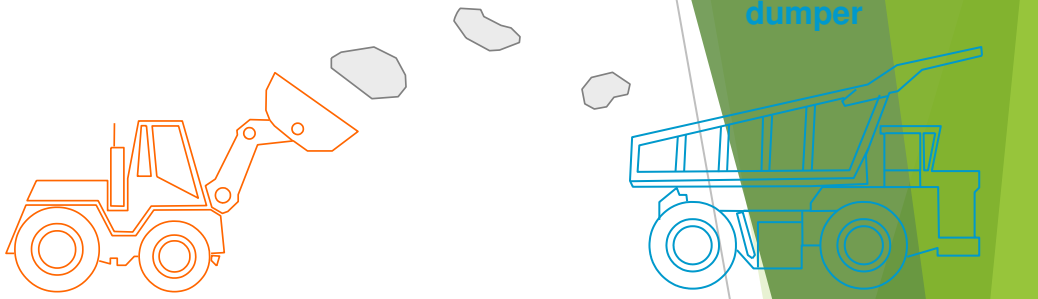
THE CEMENT MANUFACTURING PROCESS

- Quarry
- Grinding
- Burning
- Grinding,
- Storage,
- Packing,
- Dispatch

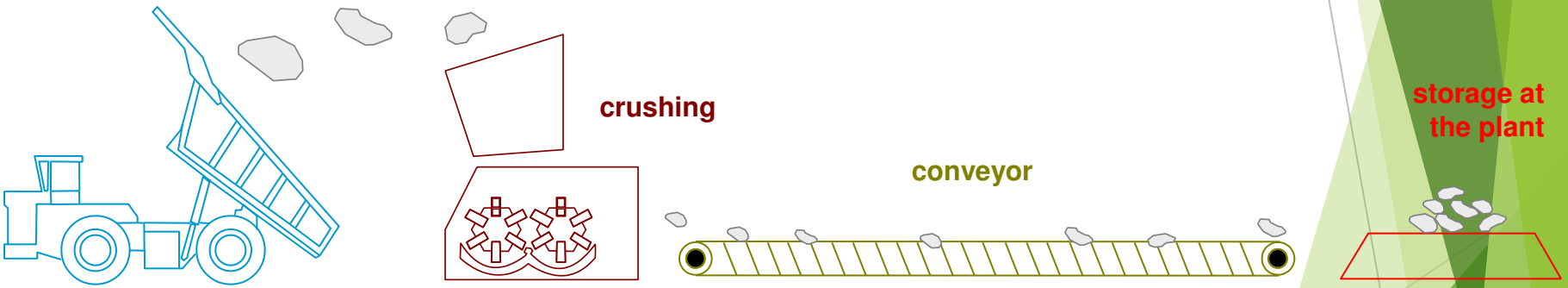
THE CEMENT MANUFACTURING PROCESS



1. BLASTING



2. TRANSPORT



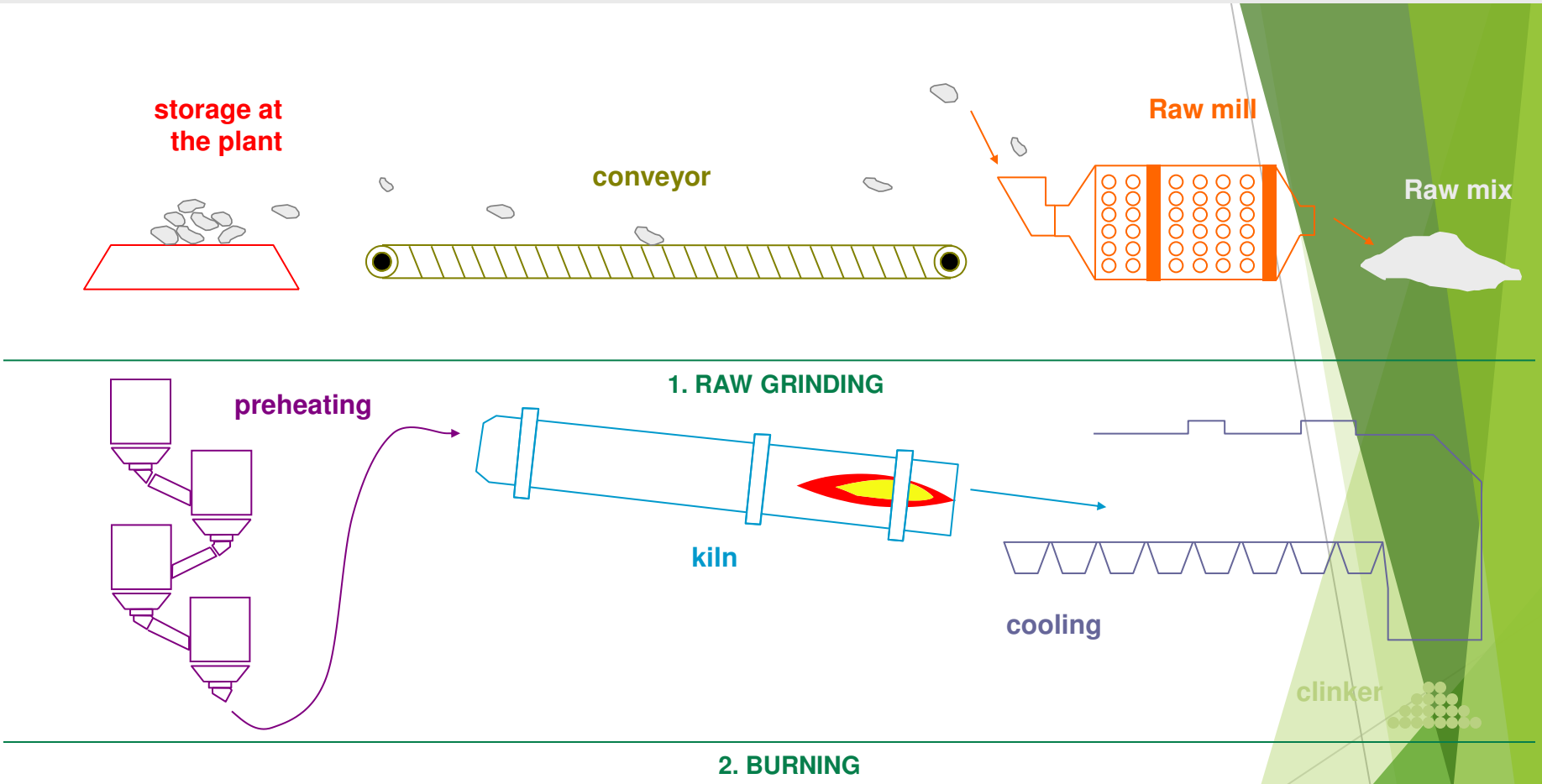
3. CRUSHING & TRANSPORTATION

1. BLASTING : The raw materials that are used to manufacture cement (mainly limestone and clay) are blasted from the quarry.

2. TRANSPORT : The raw materials are loaded into a dumper.

3. CRUSHING AND TRANSPORTATION : The raw materials, after crushing, are transported to the plant by conveyor. The plant stores the materials before they are homogenized.

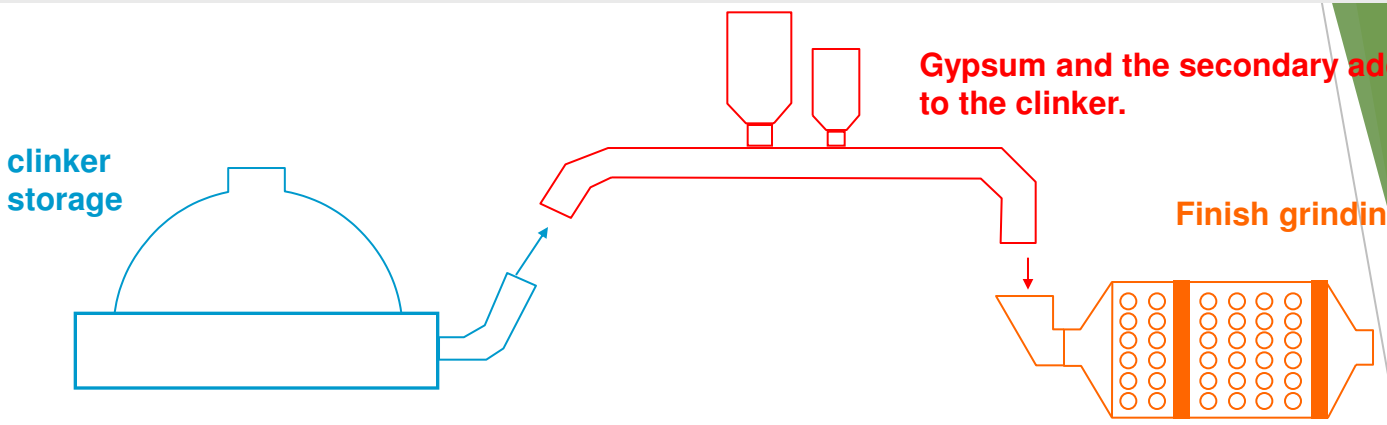
THE CEMENT MANUFACTURING PROCESS



1. RAW GRINDING : The raw materials are very finely ground in order to produce the raw mix.

2. BURNING : The raw mix is preheated before it goes into the kiln, which is heated by a flame that can be as hot as 2000 °C. The raw mix burns at 1500 °C producing clinker which, when it leaves the kiln, is rapidly cooled with air fans. So, the raw mix is burnt to produce clinker : the basic material needed to make cement.

THE CEMENT MANUFACTURING PROCESS



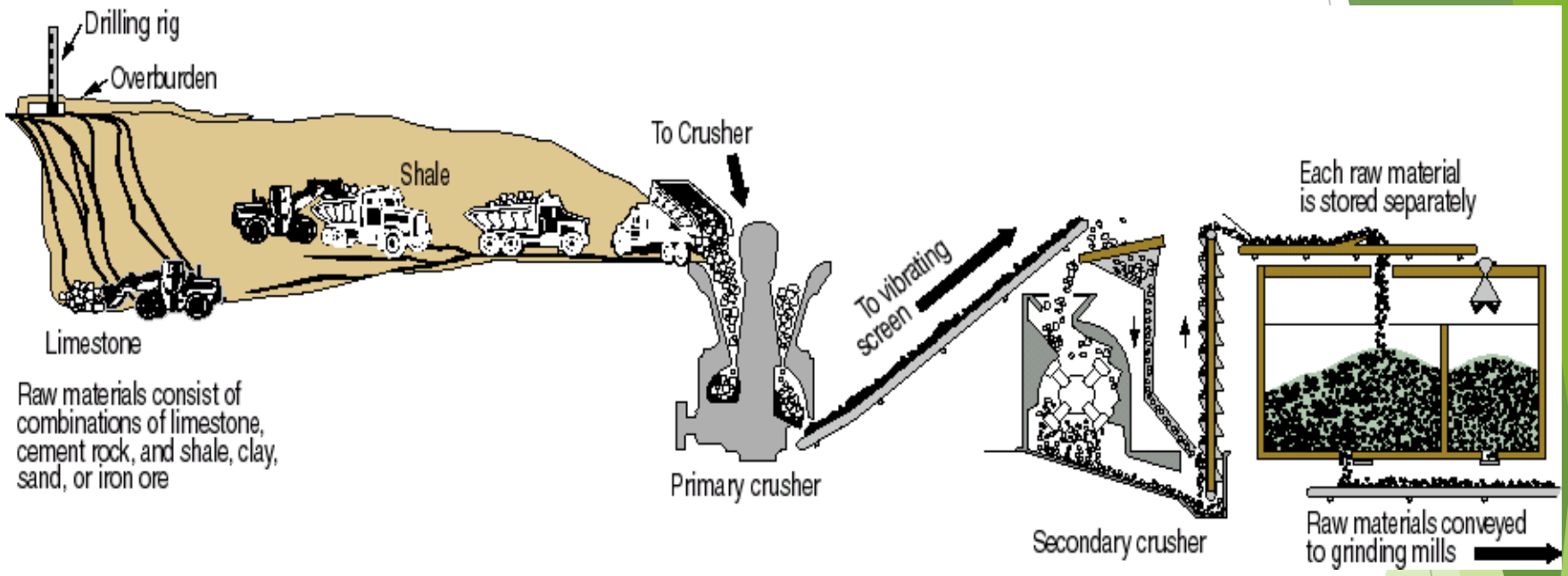
1. GRINDING

2. STORAGE, PACKING, DISPATCH

1.GRINDING : The clinker and the gypsum are very finely ground giving a “pure cement”. Other secondary additives and cementitious materials can also be added to make a blended cement.

2. STORAGE, PACKING, DISPATCH : The cement is stored in silos before being dispatched either in bulk or in bags to its final destination.

Quarry



1. Stone is first reduced to 125 mm (5 in.) size, then to 20 mm (3/4 in.), and stored.

Raw mill

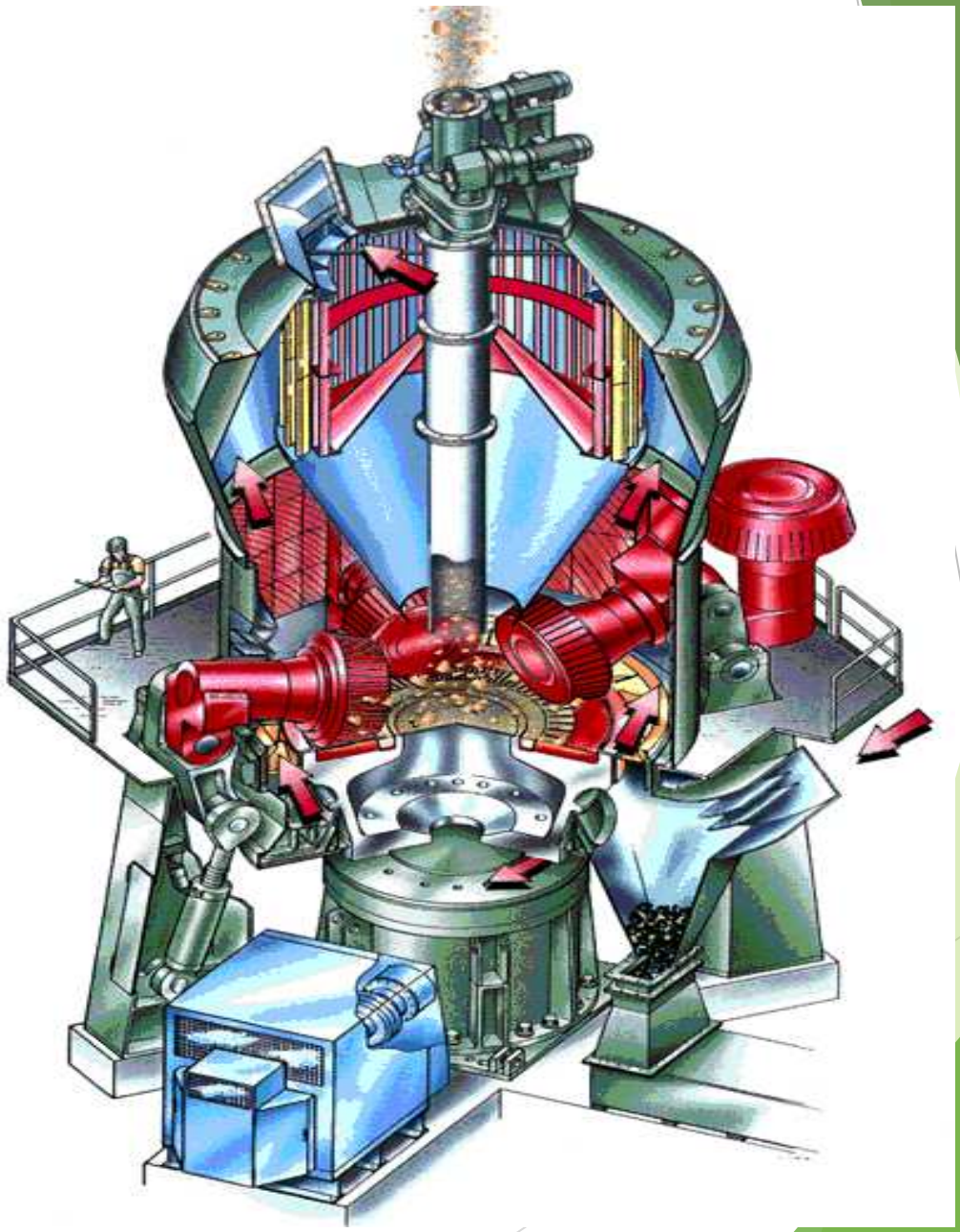
4 materials 225tph

limestone 88%,

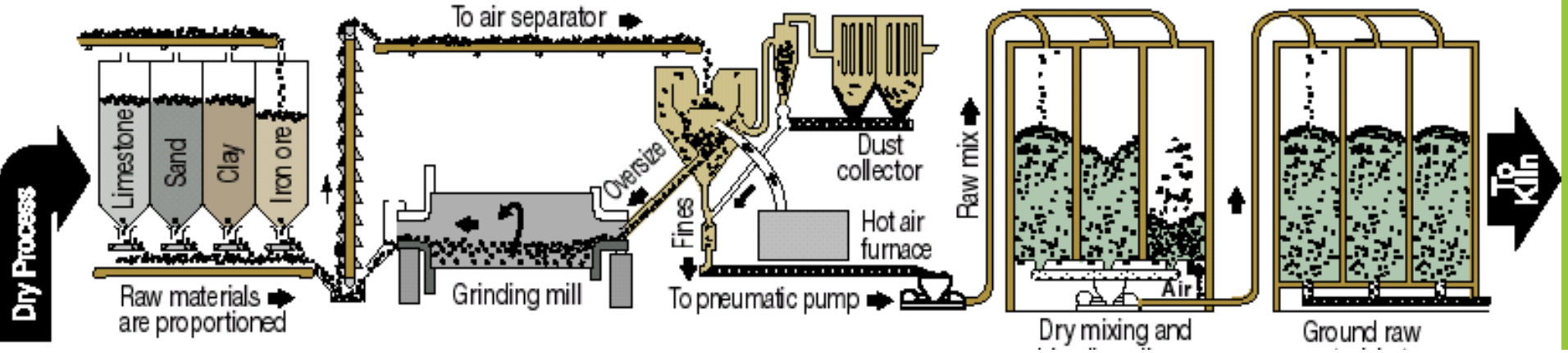
sandstone 5%,

kaolin/clay 5%,

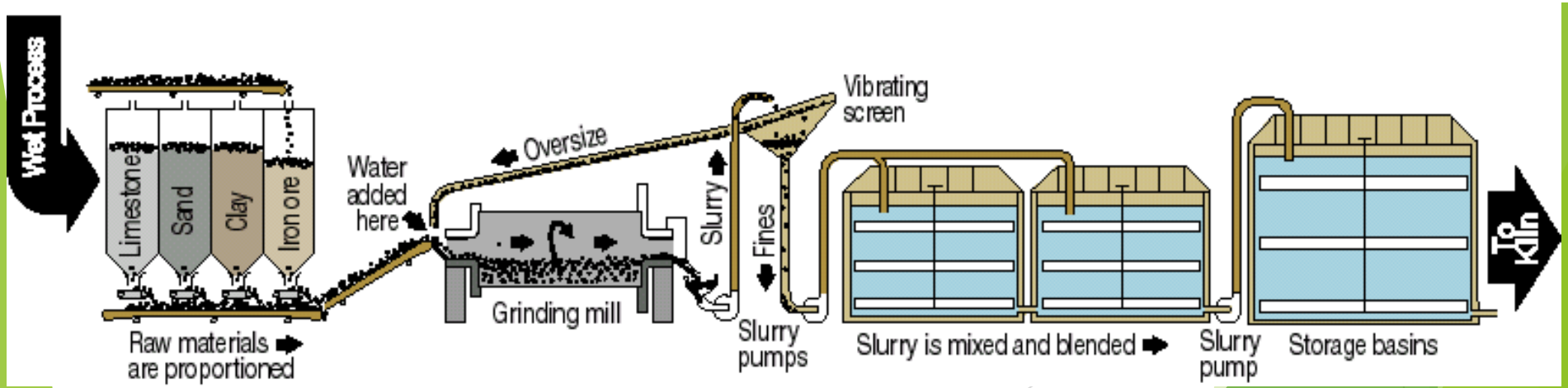
mill scale 2%



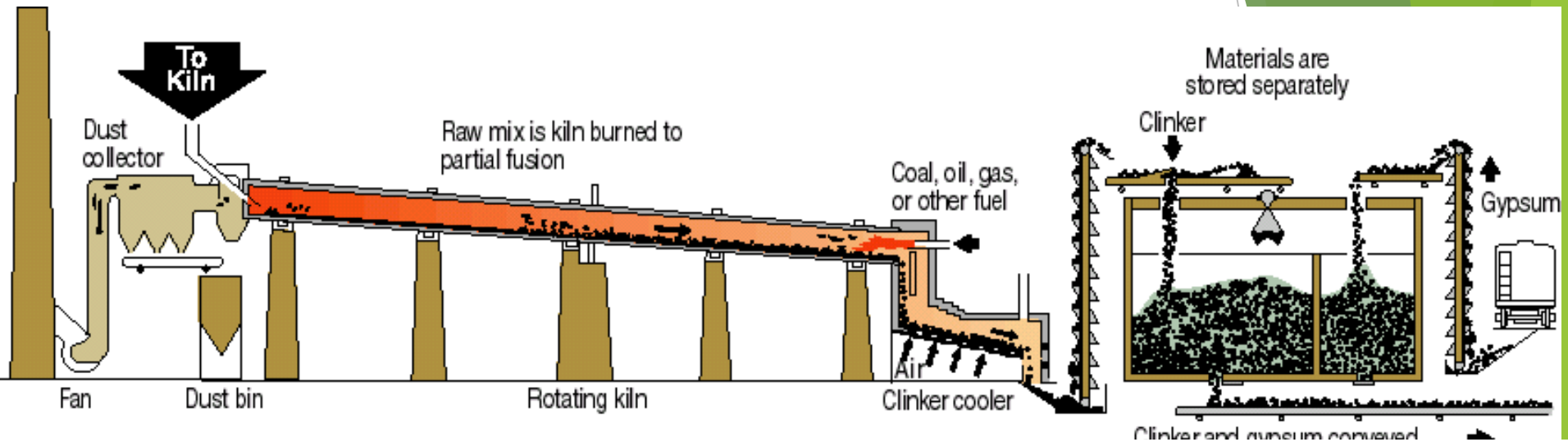
2. Raw materials are ground to powder and blended.



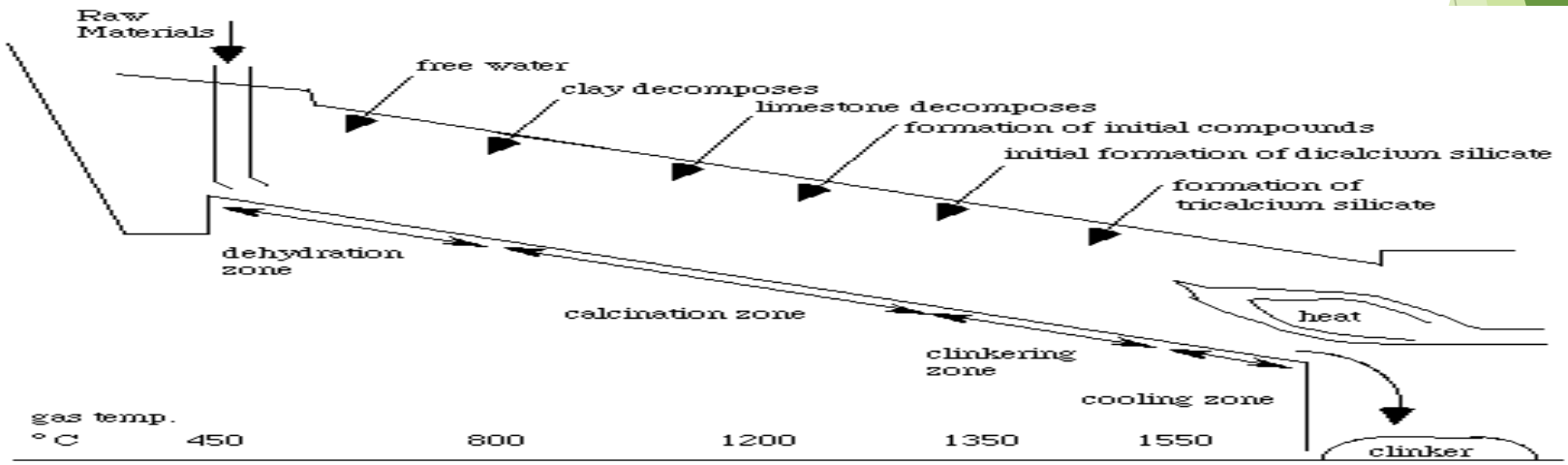
Or 2. Raw materials are ground, mixed with water to form slurry, and blended.



Kiln



3. Burning changes raw mix chemically into cement clinker.

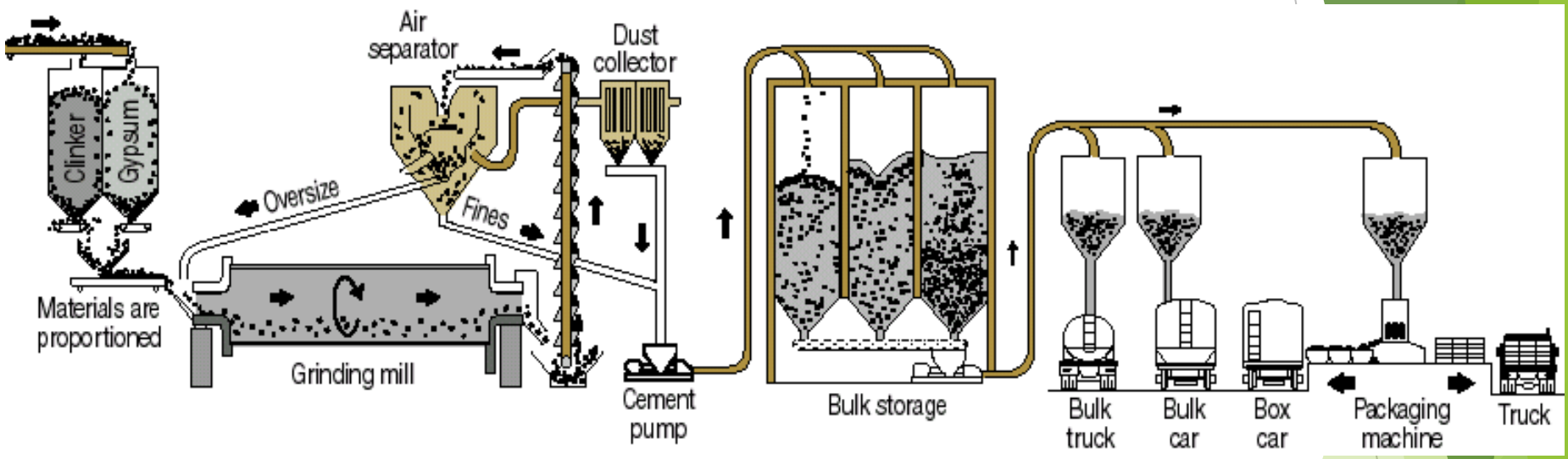


REACTIONS IN THE KILN

- **~100°C→ free water evaporates.**
- **~150-350C°→ loosely bound water is lost from clay.**
- **~350-650°C→decomposition of clay→SiO_2&Al_2O_3**
- **~600°C→decomposition of $MgCO_3$→MgO&CO_2 (evaporates)**
- **~900°C→decomposition of $CaCO_3$→CaO&CO_2 (evaporates)**
- **~1250-1280°C→liquid formation & start of compound formation.**
- **~1280°C→clinkering begins.**
- **~1400-1500°C→clinkering**
- **~100°C→clinker leaves the kiln & falls into a cooler.**

➢ **Sometimes the burning process of raw materials is performed in two stages: preheating upto 900°C & rotary kiln**

4. Clinker is ground with gypsum into portland cement and shipped.



Clinker

Gypsum

Chemical composition of Ordinary Portland cement

Portland cement is composed of four major oxides (CaO, SiO_2, Al_2O_3, Fe_2O_3 ≥90%) & some minor oxides. Minor refers to the quantity not importance.

CHEMICAL COMPOSITION OF OP.C.

Oxide	Common Name	Abbreviation	Approx. Amount (%)
CaO	Lime	C	60-67
SiO_2	Silica	S	17-25
Al_2O_3	Alumina	A	3-8
Fe_2O_3	Iron-oxide	F	0.5-6
MgO	Magnesia	M	0.1-4
Na_2O	Soda	N	0.2-1.3
K_2O	Potassa	K	
SO_3	Sulfuric Anhydride	$\overline{S}$	1-3

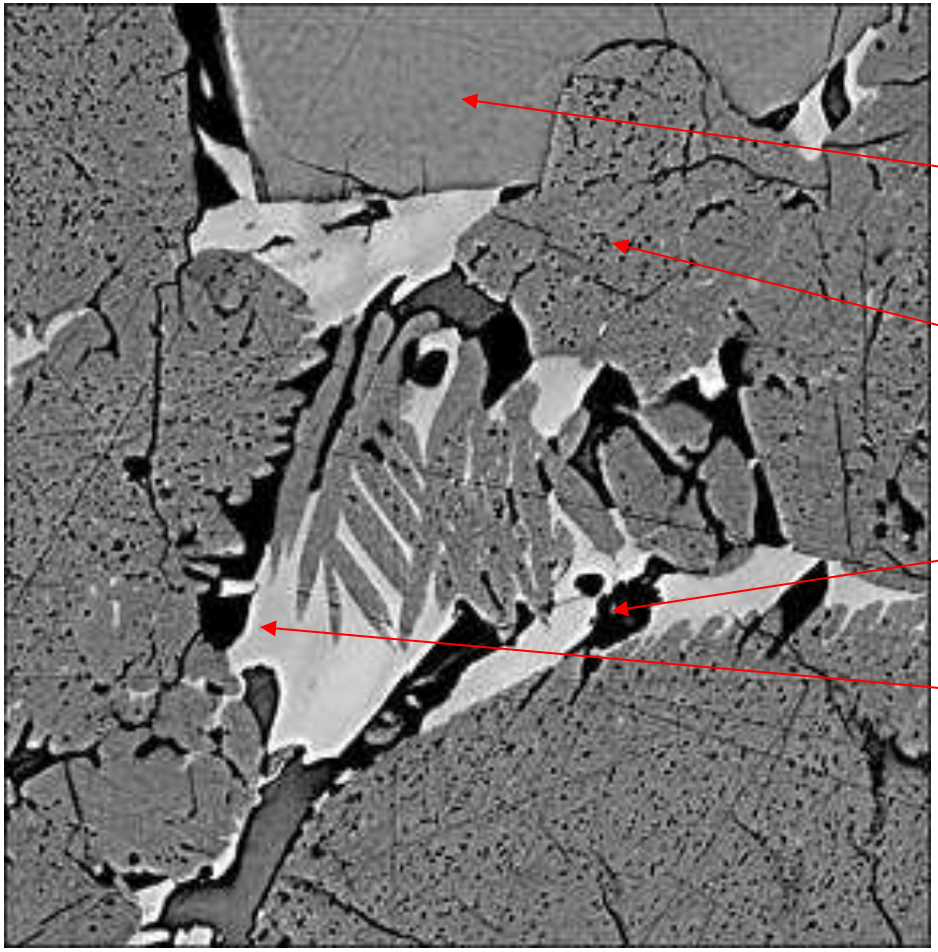
- CaO→limestone
- SiO_2-Al_2O_3→Clay
- Fe_2O_3→Impurity in Clays
- SO_3→from gypsum→not from the clinker

COMPOUND COMPOSITION OF O.P.C. (OR CLINKER)

- Oxides interact with each other in the kiln to form more complex products (compounds). Basically, the major compounds of O. P.C. can be listed as:

Name	Chemical Formula	Abbreviations
Tri Calcium Silicate	$3CaO.SiO_2$	C_3S
Di Calcium Silicate	$2CaO.SiO_2$	C_2S
Tri Calcium Aluminate	$3CaO.Al_2O_3$	C_3A
Tetra Calcium Alumino Ferrite	$4CaO.Al_2O_3.Fe_2O_3$	C_4AF

Microscopic Images of Clinker



Types of Portland Cement

ASTM C 150 (AASHTO M 85)

I	Normal
II	Moderate sulfate resistance
III	High early strength
IV	Low heat of hydration
V	High sulfate resistance

ASTM Type & Name of P.C.	Average Compound Composition				
	C_3S	C_2S	C_3A	C_4AF	
Type I - O.P.C.	49	25	12	8	General Purpose
Type II - Modified	46	29	6	12	For Moderate Heat of Hydration
Type III - High Early Strength	56	15	12	8	C_3S&C_3A increased, C_2S decreased
Type IV - Low Heat P.C.	30	46	5	13	C_2S increased
Type V - Sulfate Resistant P.C.	43	36	4	12	Limit on $C_3A \leq 5\%$, $2C_3A+C_4AF \leq 25\%$