

CEMENT – An Ingenious Building Material

प्रो. अचिन्त्य

PROF. ACHINTYA

Ph.D.(Engg.), FIE (India)

PRINCIPAL, DCE, DARBHANGA & BCE, BHAGALPUR

FORMER PRINCIPAL, M I T, MUZAFFARPUR

FORMER PRINCIPAL, S I T, SITAMARHI

FORMER DEAN OF ENGG., A K U, PATNA

drachintya@rediffmail.com

www.drachintya.com

CEMENT

IS USED AS A BINDING MATERIAL IN
MAKING THE CONCRETE



CONCRETE =

- **Cement** + Fine Aggregate (Sand) + Coarse Aggregate (Stone Chips) + Water + Some Admixture [if any]
- **HENCE CALLED CEMENT CONCRETE**

Types of Cement

3

Ordinary Portland Cement (O.P.C.)

IS 269: 2015

is a single Indian Standard code for OPC and all the requirements of previously existing codes such as

33 Grade OPC (**IS 269**),

43 Grade OPC (**IS 8112**) and

53 Grade OPC (**IS 12269**)

have been merged into this standard.

PORTLAND POZZOLANA CEMENT (P.P.C.)

- ✖ **IS: 1489 – 1991**

- ✖ Portland Pozzolana Cement has been made by blending of OPC Clinker with 15 – 35 per cent of pozzolanic material which is primarily be silicious or aluminious material such as fly ash, calcined clay, etc.

- ✖ **IS: 455 – 1989**

- ✖ Portland slag cement where blast furnace slag of steel industries are mixed with OPC Clinker.

- ✖ **IS: 16415 – 2015**

- ✖ Composite cement in which both fly ash and slag undergo intergrinding with OPC Clinker. Nowadays, the composite cement is on boom for the construction purpose of structures. Trade names are Ultratech Premium, ACC F2R, etc.

- ✖ **These are known as Blended Cement**

What Makes **BLENDED CEMENT** such as **POZZOLANA PORTLAND CEMENT** different from others like **ORDINARY PORTLAND CEMENT** in Quality ?

- Richest source of lime stone with high Total Economic Cost of Production (TC) factor.
- Better manufacturing process.
- Superior raw material selection.
- Accurate Quality monitoring.

Market Scenario – OPC vs BLENDED CEMENT

6

- OPC - Decreasing production worldwide.
- High strength blended cement available now.
- Good quality supplementary cementitious material (SCM) like flyash, silica fume, slag, etc.

WHY BLENDED CEMENT ??

BLENDED CEMENT (FLY ASH BASED) – ECO FRIENDLY CEMENT.

Lime stone – depleting resource

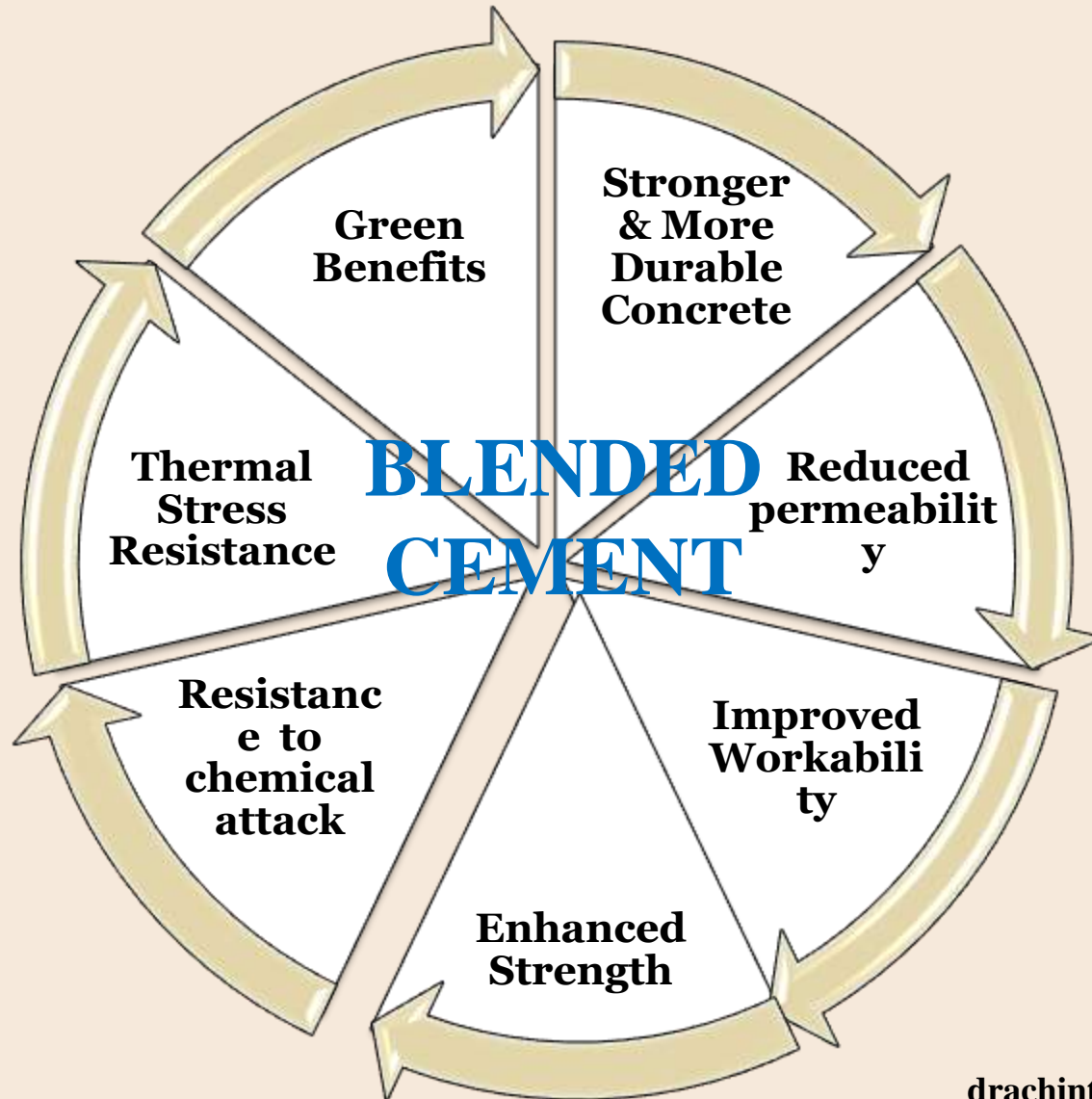
Fly Ash – a major pollutant.

It is estimated that, 100 million tones of fly ash is generated per year, out of which only 15% is used at present

Easy availability of good quality dry fly ash.

High quality consistency fly ash will give Extra fineness to blended cement

Performance of Blended Cement



OUTPUT OF BLENDED CEMENT

- **MINIMUM STRENGTH from 43 Mpa to 53 MPa IN 28 DAYS.**
- **STRONG SHIELD AGAINST ACIDIC AND SALT ATTACK.**
- **SUPERFINE CEMENT.**
- **AN IDEAL CEMENT FOR ALL APPLICATIONS.**

drachintya@rediffmail.com

CEMENT PLANT & ITS SALIENT FEATURES



10 • **PRESENT PRODUCTION CAPACITY- 7.0 MILLION TONNES PER ANNUM.**

• **PROGRESSING TOWARDS 25 MILLION TONNES PER ANNUM IN NEXT TWO YEARS.**

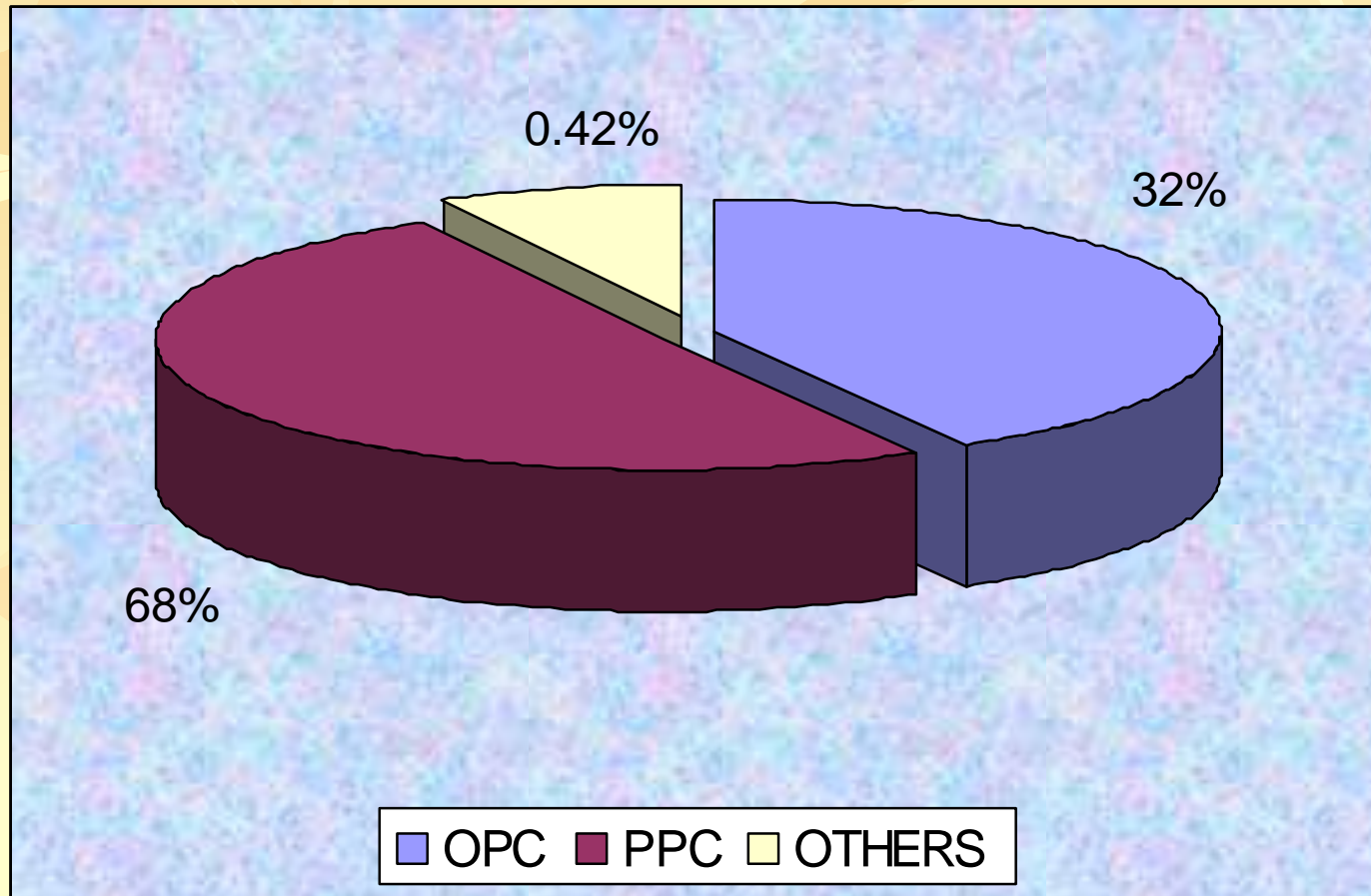
• **SINGLE LARGEST CEMENT PRODUCTION COMPLEX AT ONE LOCATION IN INDIA.**

• **THREE MODERN CEMENT PLANTS**

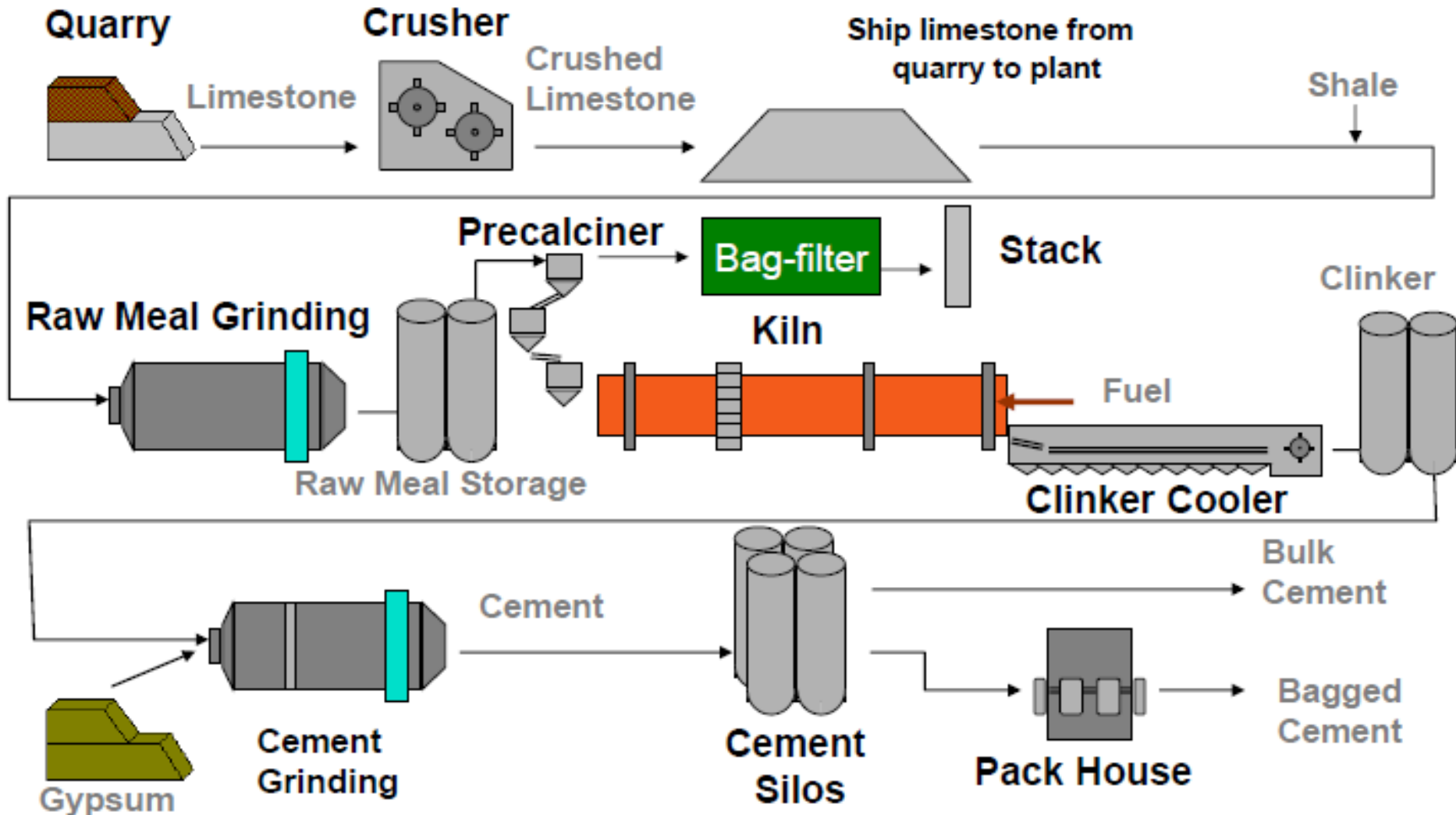
• **STATE OF ART EQUIPMENTS INCLUDE:**

COMPUTER AIDED DEPOSIT EVALUATION (CADE), QUARRY SCHEDULING AND OPTIMISATION PACKAGE (QSO) AS WELL AS COMPUTERISED ON-LINE BULK MATERIAL ANALYSER (GAMMA MATRICES) ETC. STACKER/RECLAIMER FOR LIME STONE & COAL, DYNAMIC & HIGH EFFICIENCY SEPARATORS FOR RAW & FINISH GRINDING.

GRADE WISE PRODUCTION



Flow Chart – Cement Manufacturing Process

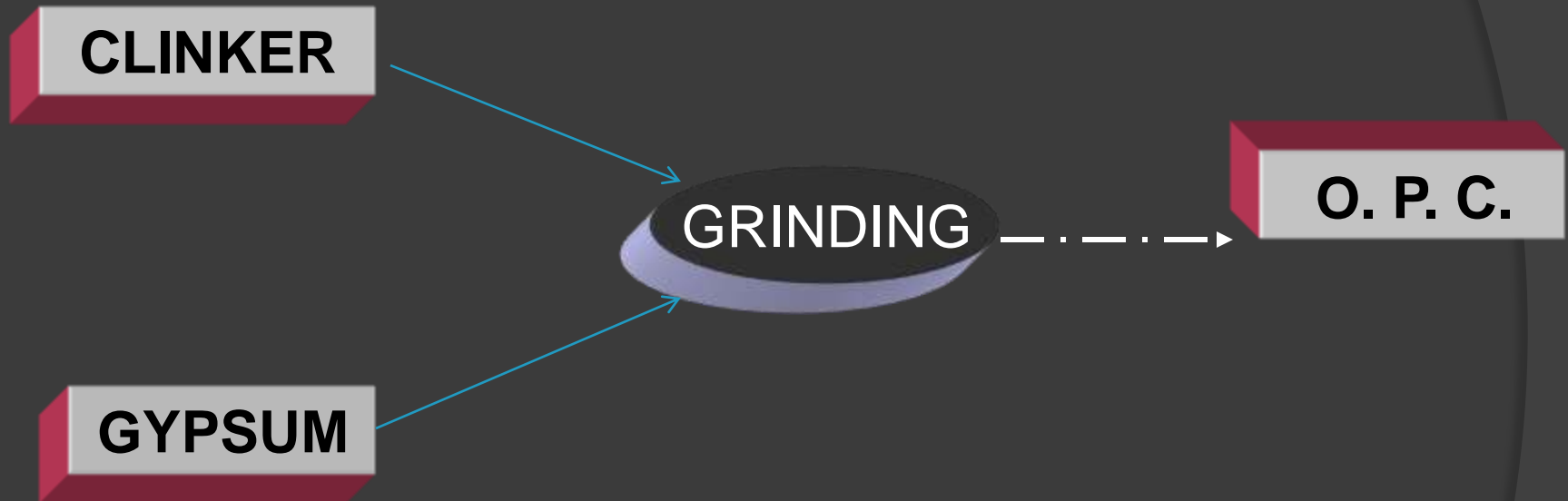


Clinker & Cement



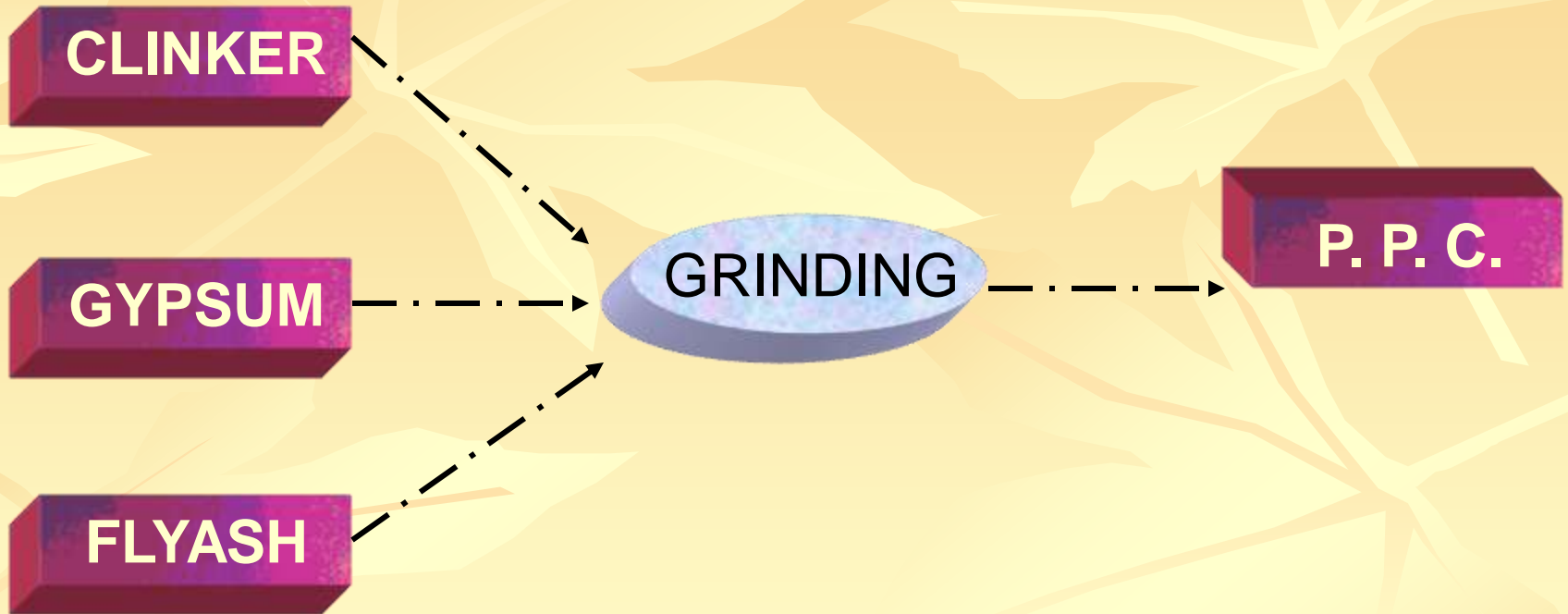
drachintya@rediffmail.com

WHAT MAKES Ordinary Portland Cement (O.P.C.) ?



cement conforming to IS: 269 – 2015

WHAT MAKES Portland Pozzolana Cement (PPC) ?



Quality of flyash conforming to IS – 3812
cement conforming to IS: 1489 – 1991

Main Compounds of Cement

- A. TRICALCIUM SILICATE (C_3S)**
 - EARLY STRENGTH
 - HIGH LIBERATION OF HEAT
- B. DICALCIUM SILICATE (C_2S)**
 - LATER STRENGTH
 - LOW LIBERATION OF HEAT
- C. TRICALCIUM ALUMINATE (C_3A)**
 - AFFECTS SETTING BEHAVIOUR – FLASH SET
 - HIGH LIBERATION OF HEAT
- D. TETRA CALCIUM ALUMINO FERRITE (C_4AF)**
 - NO CONTRIBUTION TOWARDS STRENGTH

MINEROLOGICAL COMPOSITION OF CEMENT & HEAT OF HYDRATION

17

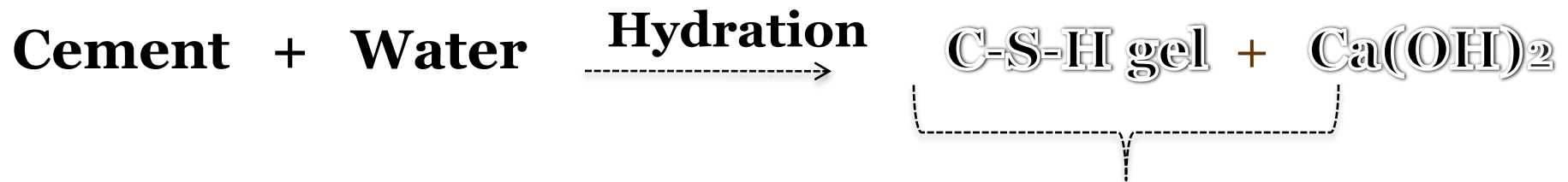
SL. NO	COMPOUND	CHEMICAL FORMULA	COMPOSITION (%)	HEAT OF HYDRATION (CAL/GM)
1	C ₃ S	3 CaO.SiO ₂	45 – 50%	100 – 110
2	C ₂ S	2 CaO.SiO ₂	25 – 30%	50 – 60
3	C ₃ A	3 CaO.Al ₂ O ₃	7 – 9%	200 – 210
4	C ₄ AF	4 CaO. Al ₂ O ₃ .Fe ₂ O ₃	10 – 11%	150 – 175
5	FREE LIME	Ca(OH) ₂	1 – 1.5%	--

drachintya@rediffmail.com

Oxide Composition of Ordinary Portland Cement (OPC)

Sl. No.	Name of Oxide	Chemical Formula	Per cent Content
1.	Calcium oxide	CaO	60 – 67
2.	Silicon dioxide	SiO ₂	17 – 25
3.	Aluminum oxide	Al ₂ O ₃	3.0 – 8.0
4.	Ferric oxide	Fe ₂ O ₃	0.5 - 6.0
5.	Magnesium oxide	MgO	0.1 – 4.0
6.	Alkalies	K ₂ O, Na ₂ O	0.4 – 1.3
7.	Sulphur trioxide	SO ₃	1.3 – 3.0

HYDRATION OF CEMENT

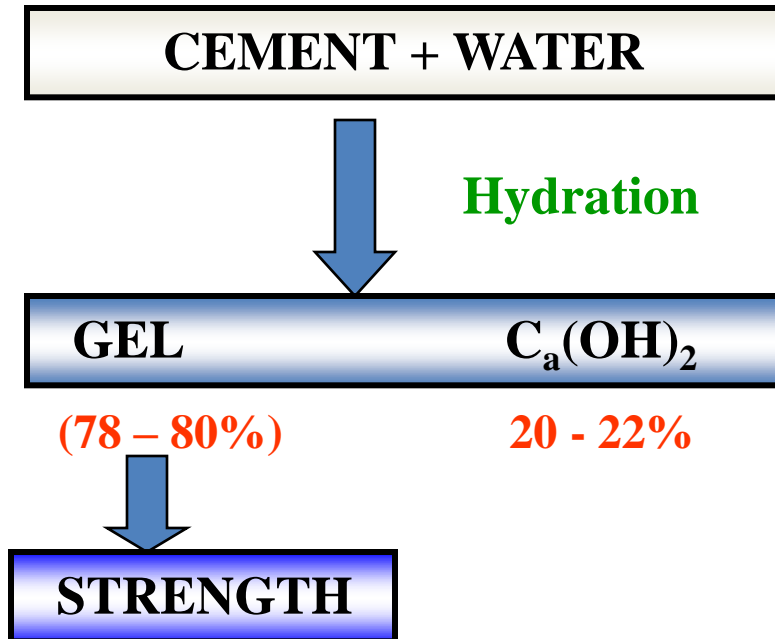


Hydration products

Formation of hydration products over time leads to:

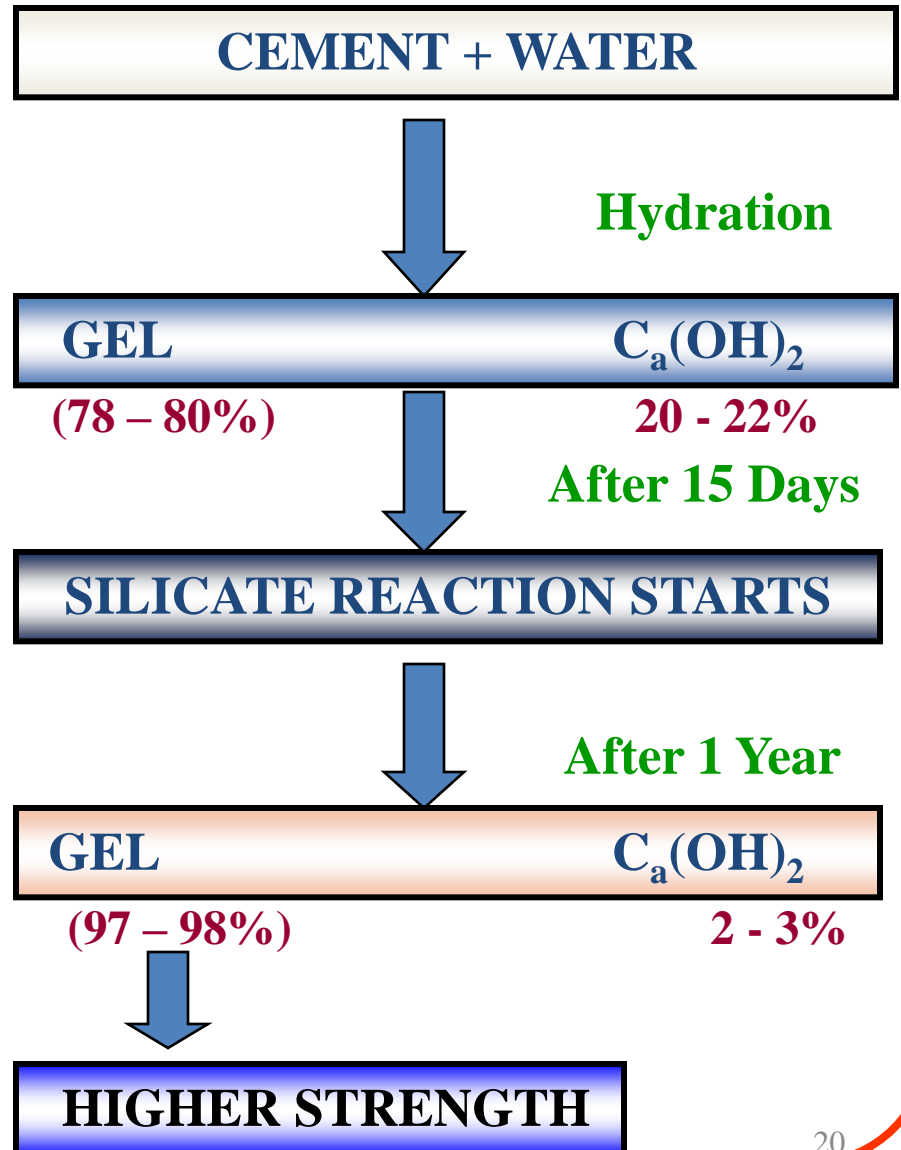
- Stiffening (loss of workability)
- Setting (solidification)
- Hardening (strength gain)

In O.P.C.

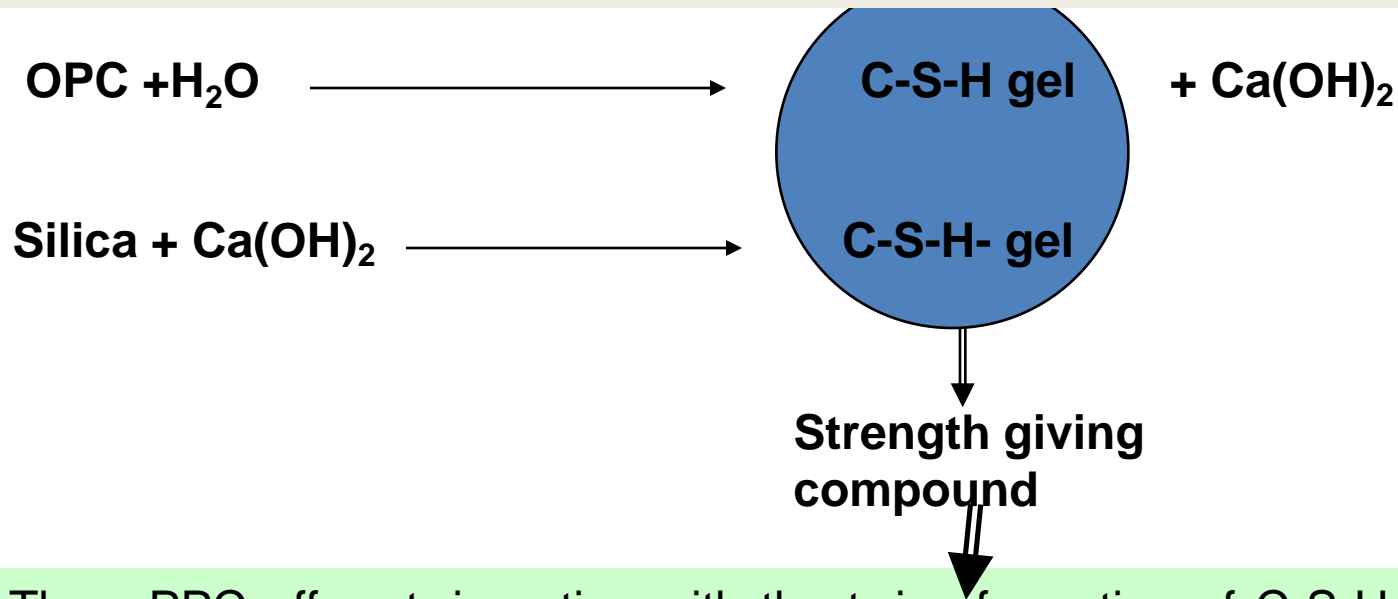


drachintya@rediffmail.com

IN BLENDED CEMENT (P.P.C.)



REACTION MECHANISIM OF POZZOLANA PORTLAND CEMENT

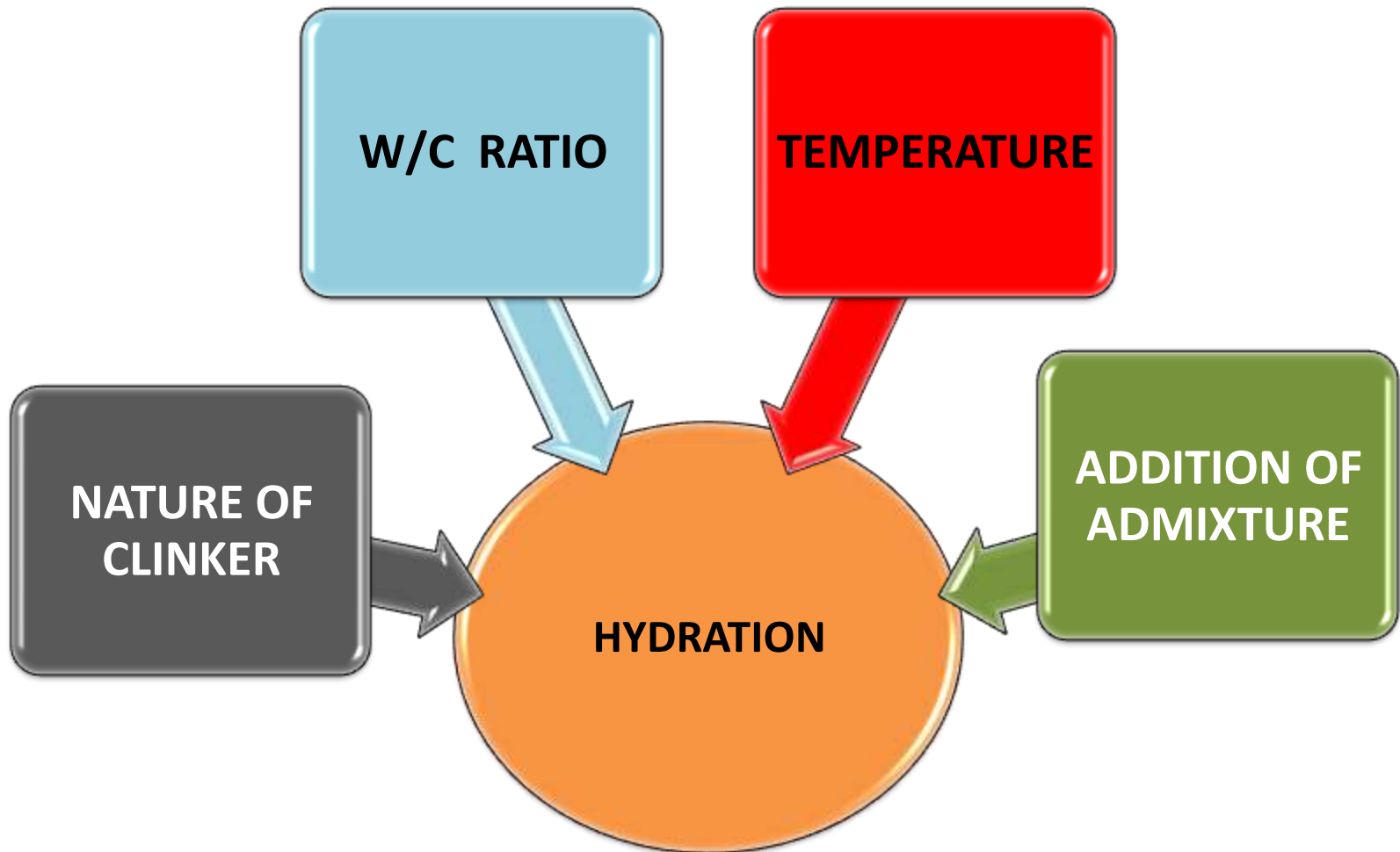


Thus, PPC offers twin action with the twice formation of C-S-H gel. The twin action means **strength with durability**.

RATE OF COMPRESSIVE STRENGTH DEVELOPMENT

MIXTURE	1 DAY	7 DAYS	56 DAYS	1 YEAR
CONVENTIONAL OPC	30-40%	60-90%	100-120%	~130%
30% FA	20-30%	50-70%	110-130%	~140%
50% FA	10-15%	40-60%	115-135%	~170%

FACTORS INFLUENCING HYDRATION OF CEMENT ON CONCRETE



FUNCTIONS OF CEMENT PASTE

- Lubricates coarse aggregates, leading to good compaction of fresh concrete.
- Imparts binding and fills the small voids of fine aggregates, coats the coarse aggregates and imparts binding.
- Provides a plastic mass
- Provides strength and water tightness to concrete in hardened state.

Physical Parameters of P P C

As per the Bureau of Indian Standards (BIS)

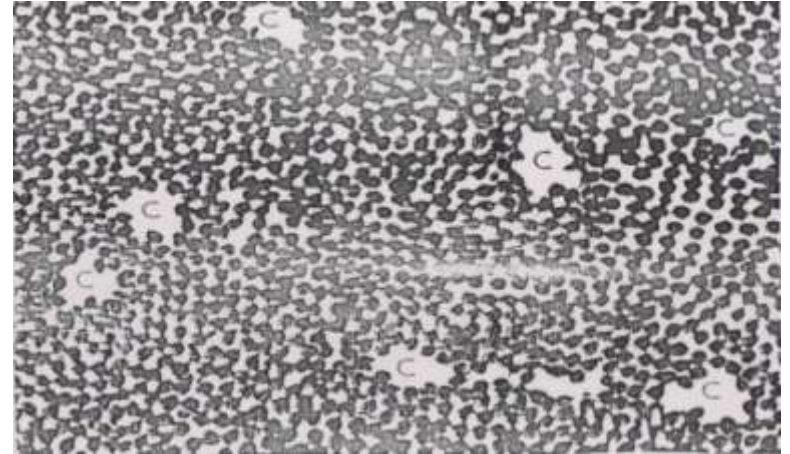
Particulars	IS:1489 Part-I (1991)
Blaine (cm ² /gm)	3000
Setting Time (Minutes) - Initial - Final	30 min. 600 max.
Compressive Strength (MPa) 3 Days 7 Days 28 Days	16 22 33
Soundness - Autoclave (%) - Le. Chatelier (MM)	0.8 max 10 max.

CEMENT PASTE STRUCTURE

AFTER 28 DAYS



AFTER 6 MONTH

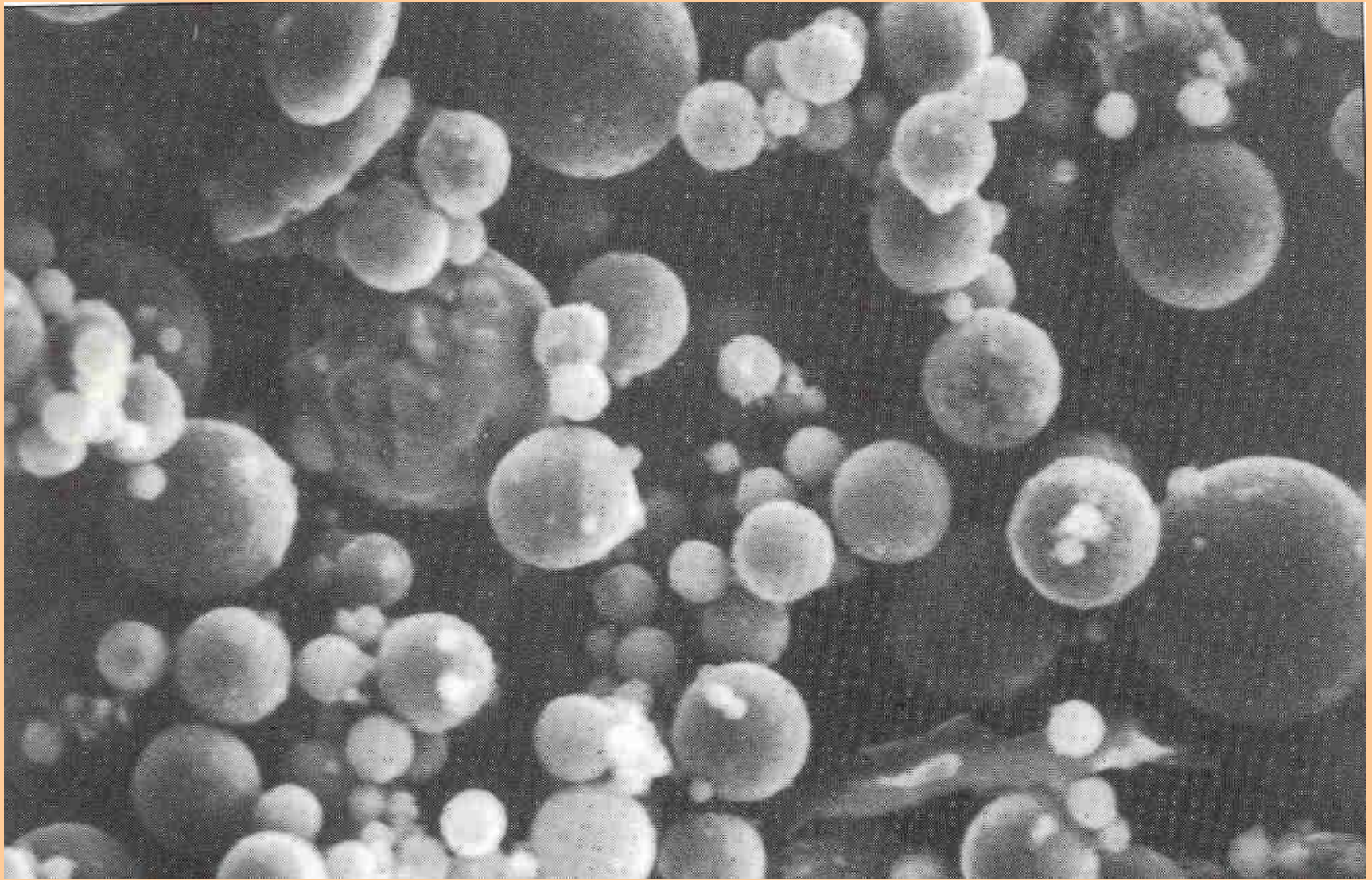


AFTER 1 YEAR

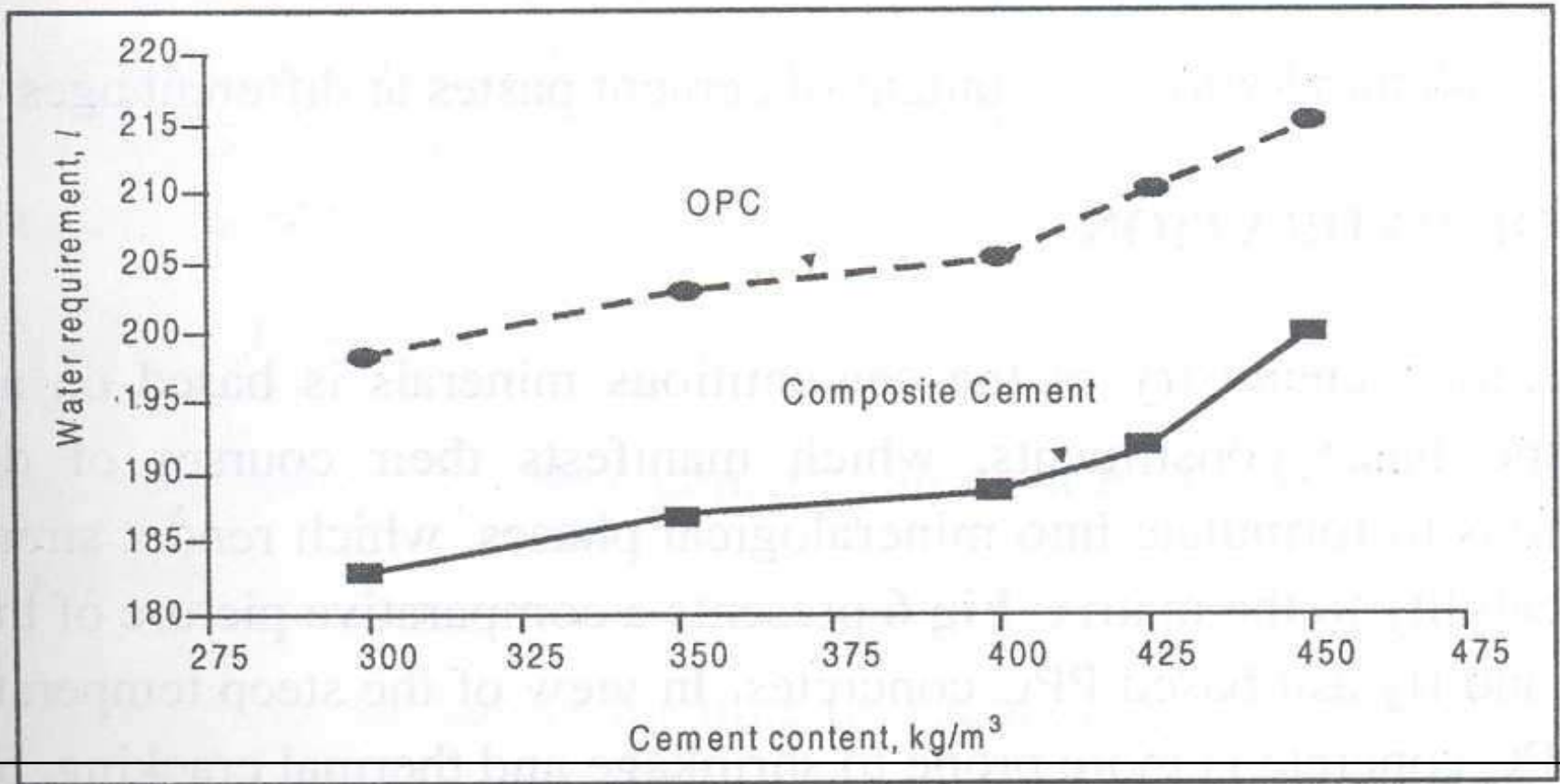


A.M. Neville

FLYASH PARTICLES AS SEEN THROUGH A MICROSCOPE

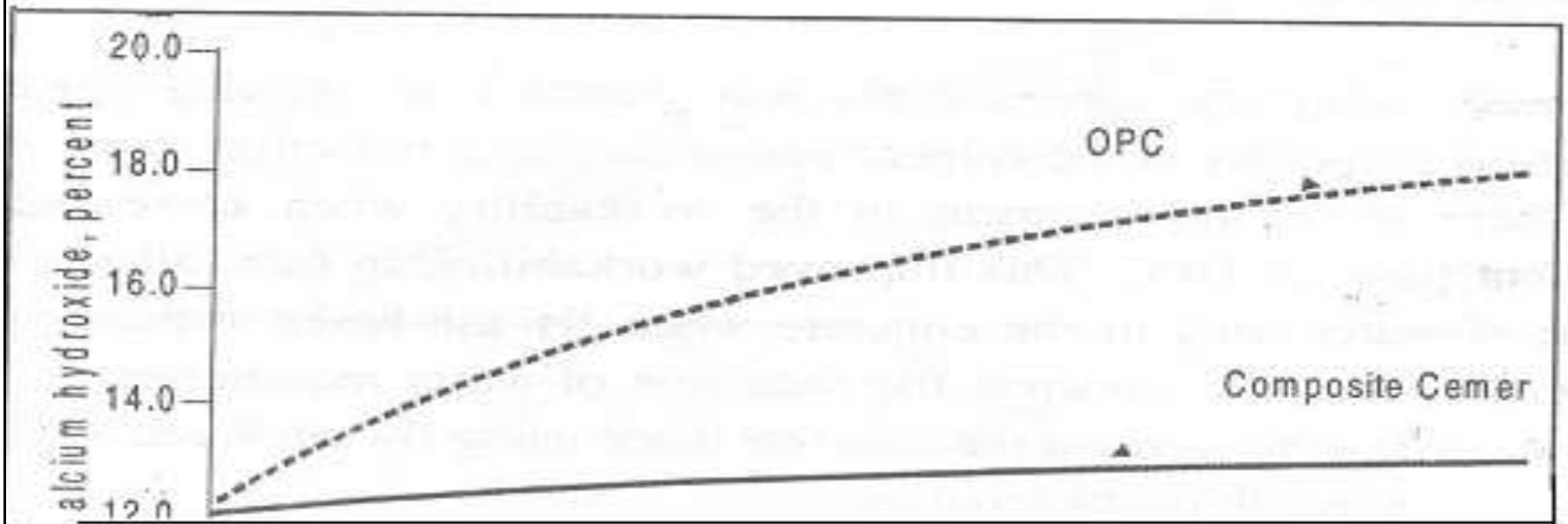


Workability



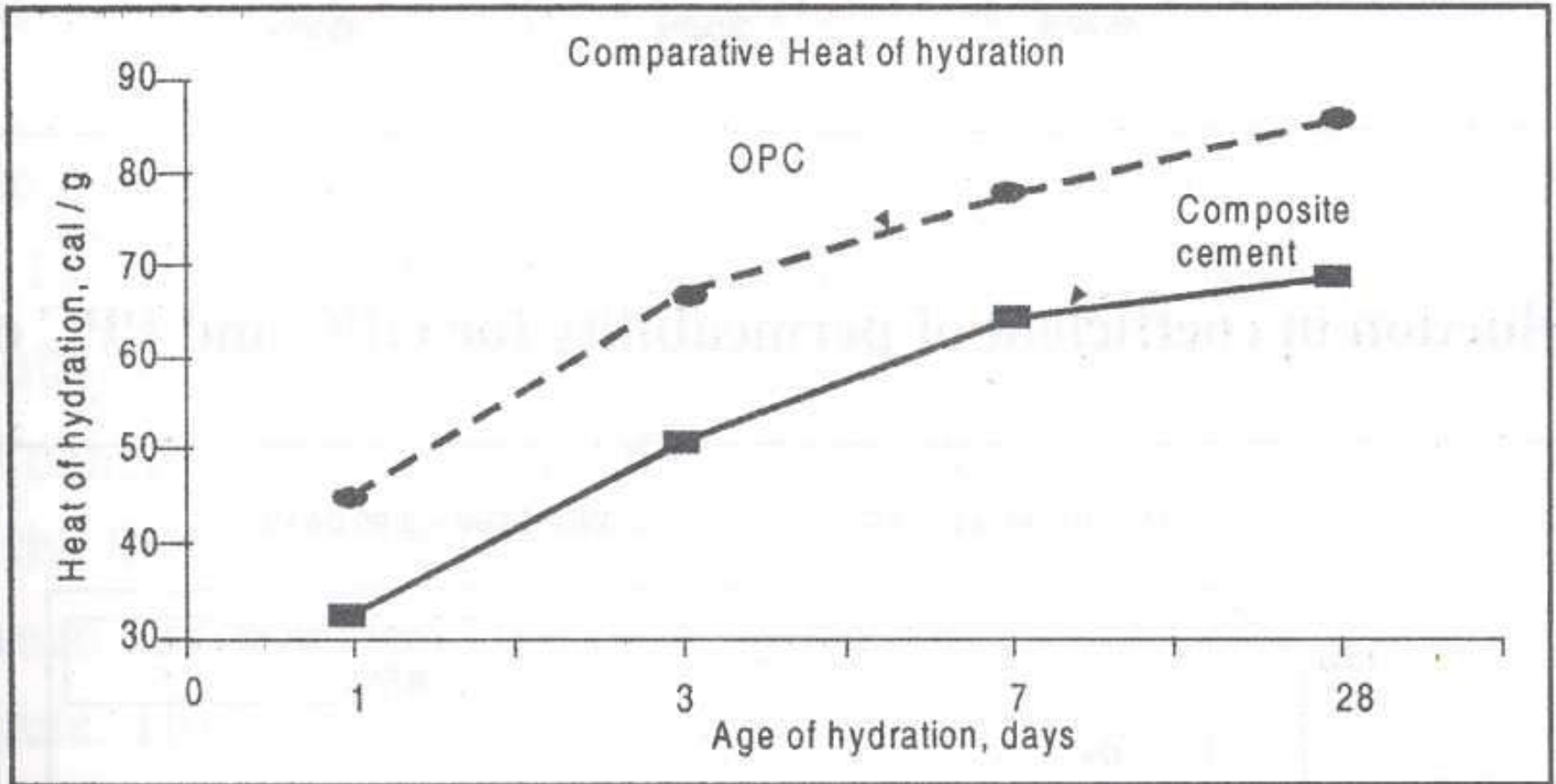
OPC for equal workability in concrete

Note: The spherical shape of the Pozzolana Cement particles and their extreme fineness has beneficial effect on workability.



Note: In Pozzolana Portland Cement, lime Ca(OH)_2 liberated during initial hydration is consumed by reactive silica and form insoluble cementitious product instead of leaching on concrete surface. This helps to reduce void spaces and block capillary formation.

HEAT OF HYDRATION



Note: The hydration process is slow process resulting in slow heat generation and lower internal stresses in concrete.

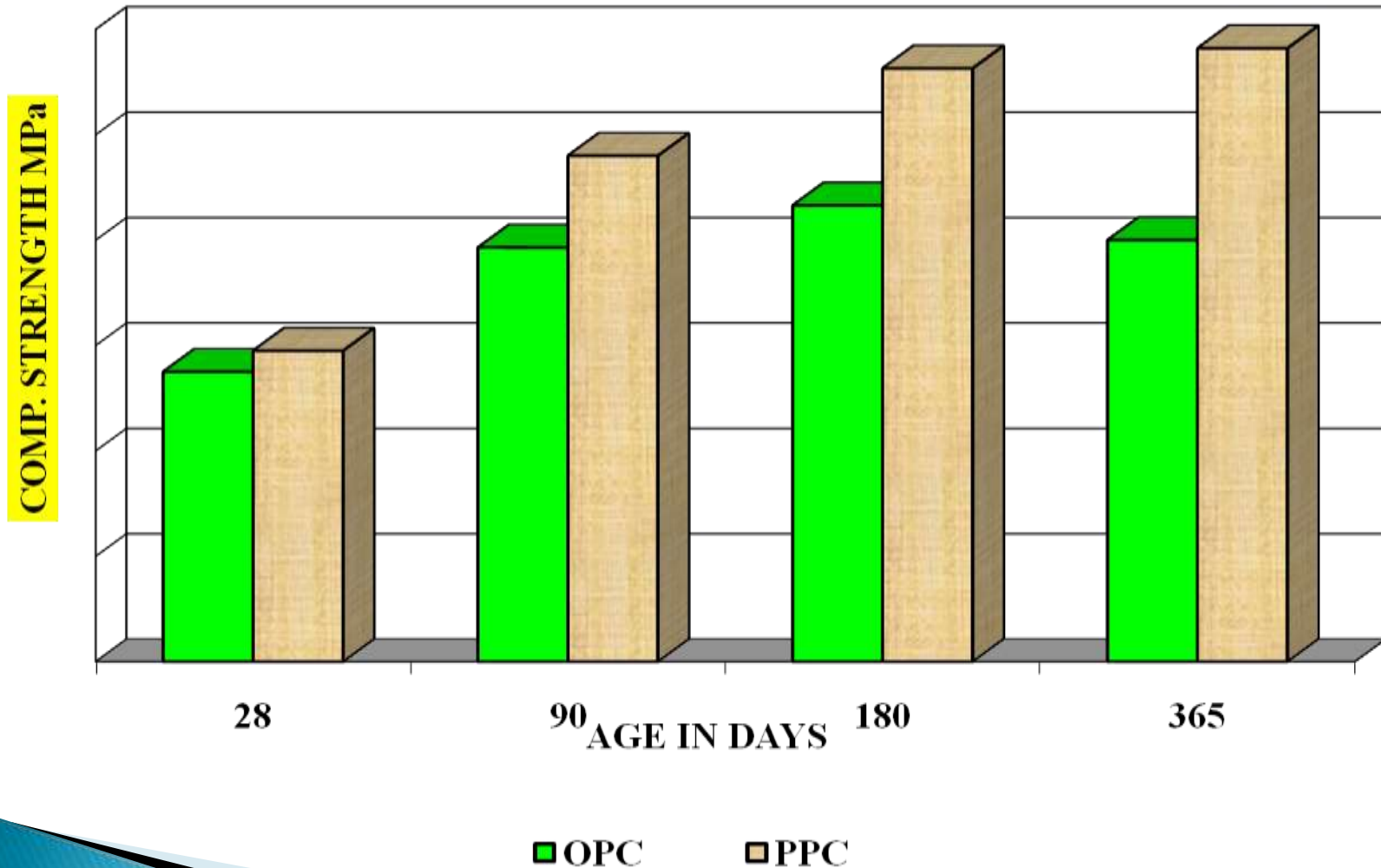
- Portland Pozzolana Cement(PPC) derives its strength advantage from the pozzolanic reaction.
- The active silica present in Fly Ash etc, admixed in OPC during manufacture of PPC, reacts with free lime in pozzolanic reaction.
- Full free lime is generated in about 14 days time in portland cement matrix from mixing concrete / mortar. Hence requirement of enhanced wet curing in case of PPCs.

Technical Advantage of using Pozzolana Portland Cement

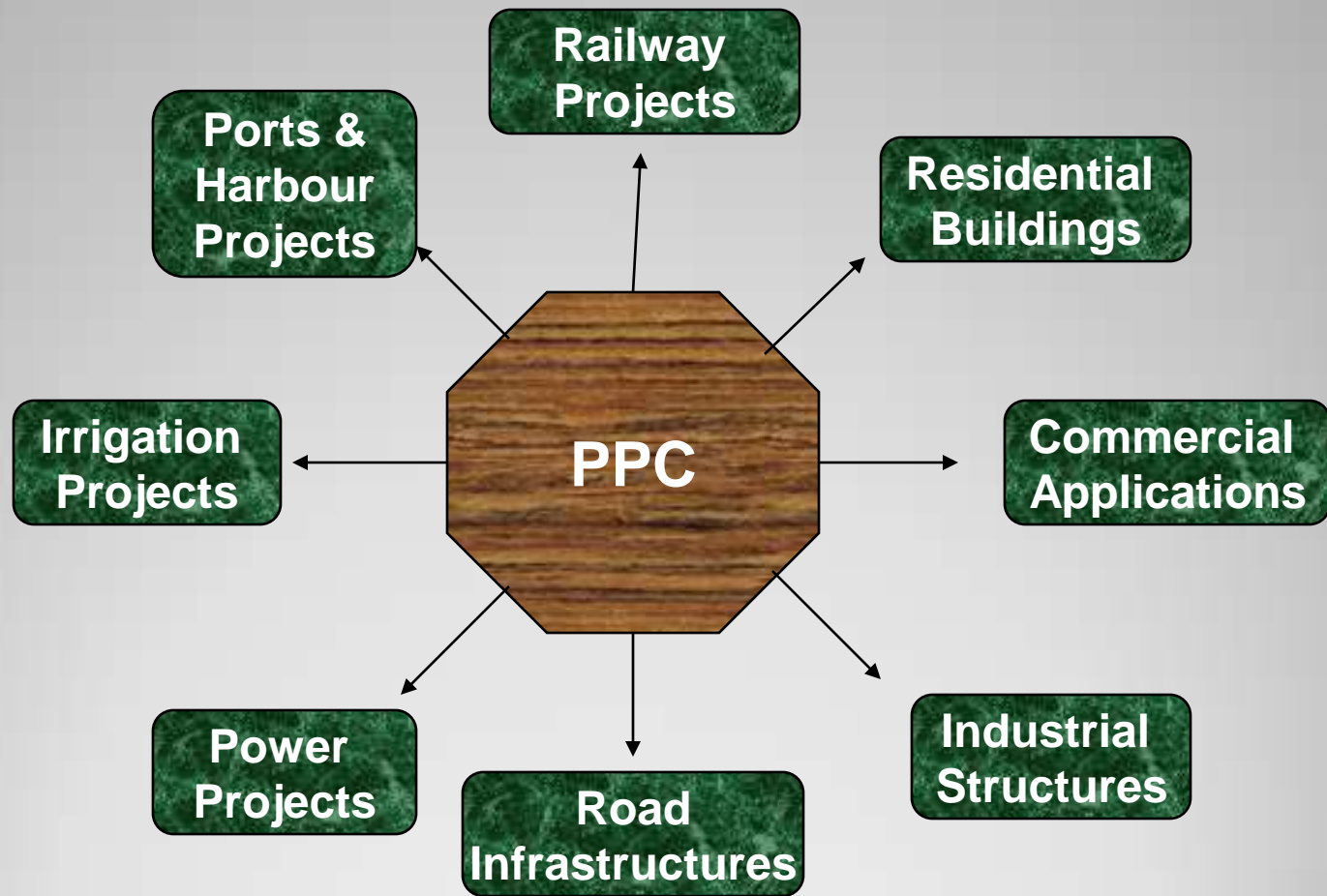


- Minimum strength of 53/43 MPa in 28 days.
- Continuous growing Strength with passage of time.
- Particle size distribution of 5 micron to 30 micron gives mixes more cohesive and workable.
- Reduces permeability, more dense & leak proof.
- Reduced thermal cracking (low internal stresses developed).
- Better resistance against alkali aggregate reaction.
- Better resistance against sulphate & chloride attack.

TREND OF COMPRESSIVE STRENGTH



WIDE SPECTRUM OF APPLICATIONS



FEW PRESTIGIOUS PROJECT WHERE POZZOLANA PORTLAND CEMENT IS USED

- SARDAR SAROVAR DAM**
- OMKAREAHWAR , INDIRA SAGAR DAM.**
- DULHASTI, BAGLIHAR (J&K), KARCHAM WANGTOO (H.P.), VISHNU PRAYAG DAM (UTTRANCHAL)**
- NHPC PROJECT.**
- VARIOUS PROJECTS OF N.T.P.C., L&T, N.H. ROAD PROJECTS, IRCON, GAMMON INDIA.**
- HCC, SOMDUTT, SIMPLEX INFRASTRUCTURE, ORIENTAL STRU.**

drachintya@rediffmail.com



INDIAN CEMENT INDUSTRY SCENARIO

Cement Companies (Nos)	44
Cement Plant (Nos.)	132
Installed Capacity (Mln.T)	166
Cement Production (Mln.T)	155
Per Capita Consumption (Kg)	125

- Second largest in the world after China.
- Lowest per capita cement consumption.

सुनहरे सपने.
सनहरा कल.



THANK

YOU