Limestone Calcined Clay Cement

- Experiences in India and Africa

LC3 Information Day
University of Cape Town
19th. November 2019, Cape Town, South Africa

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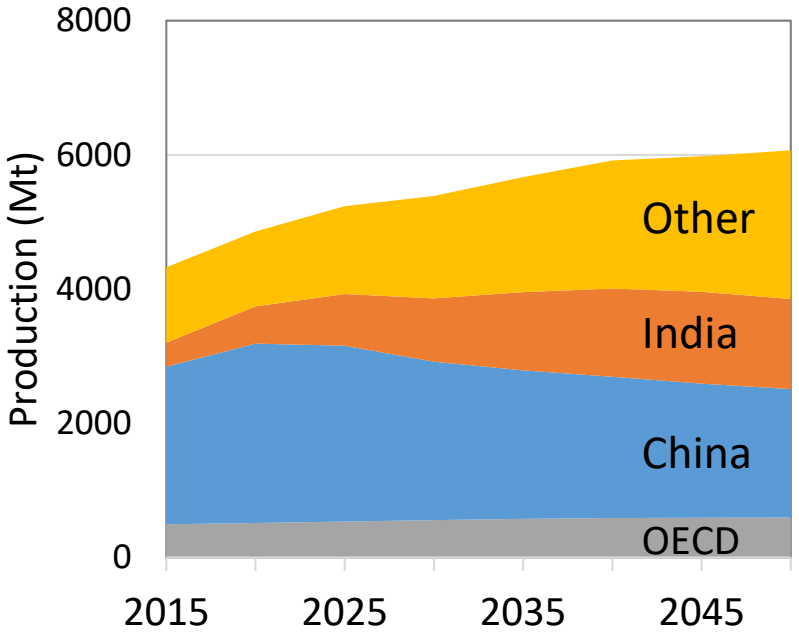
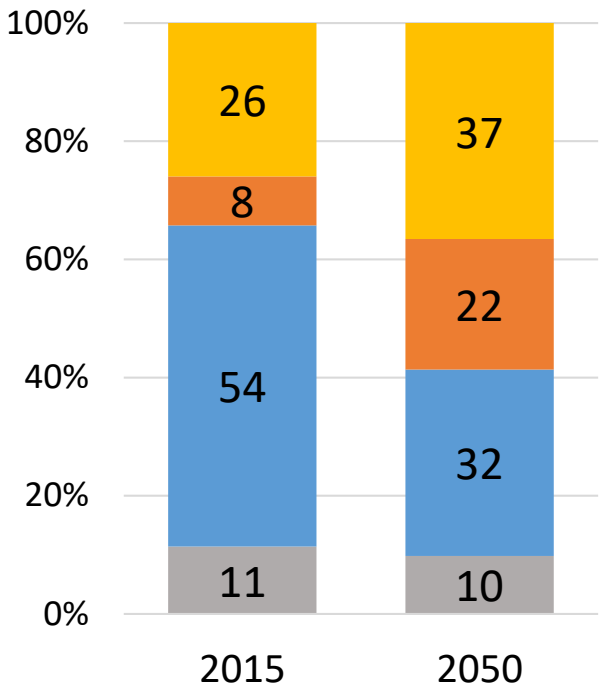
Growth forecast for the cement industry





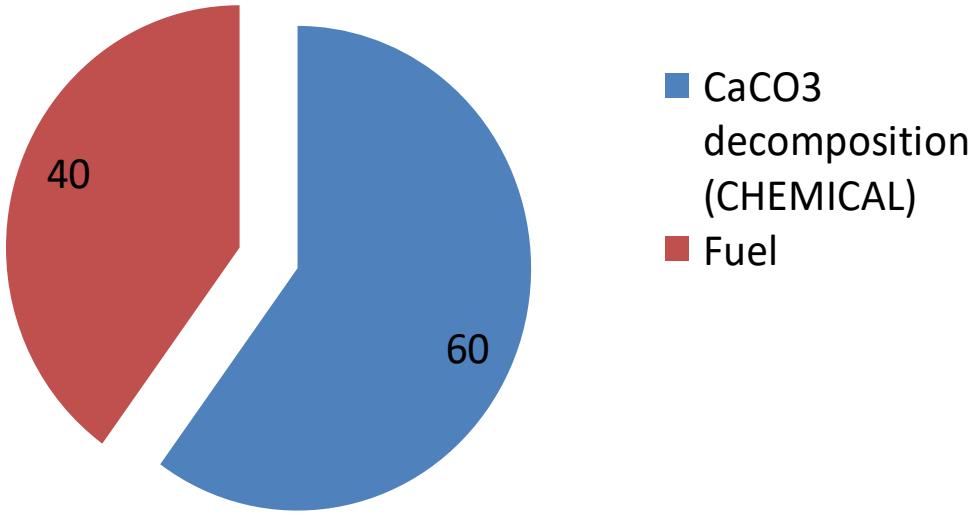
We need **profitable** solutions for developing countries

Origins of CO_2 production in the cement industry

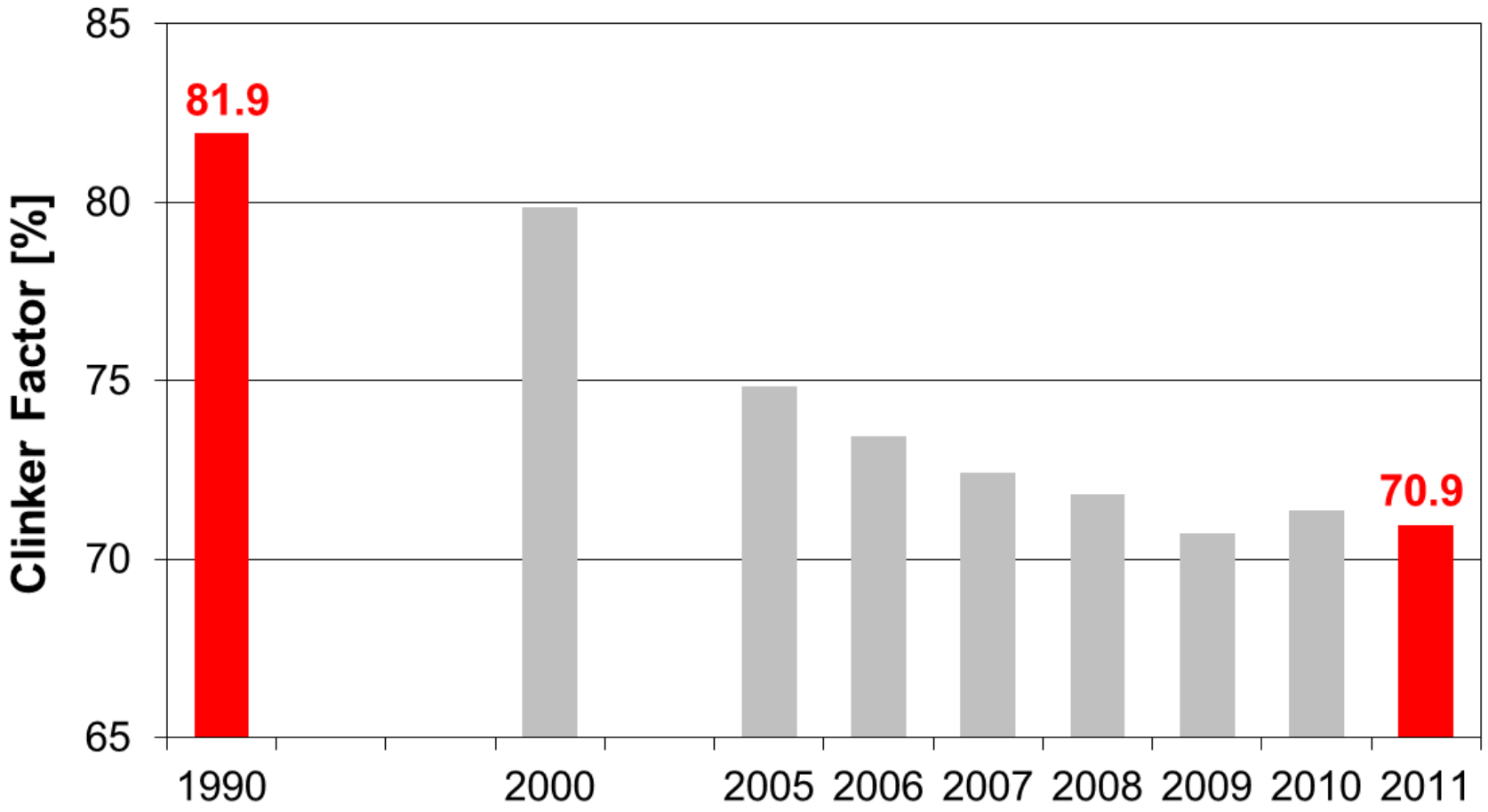
1 tonne of cement leads to the emission of 650 – 900 kg CO_2

The production process is highly optimised
Around 80% of thermodynamic limit.
it is estimated that **< 2%** further savings can be made here

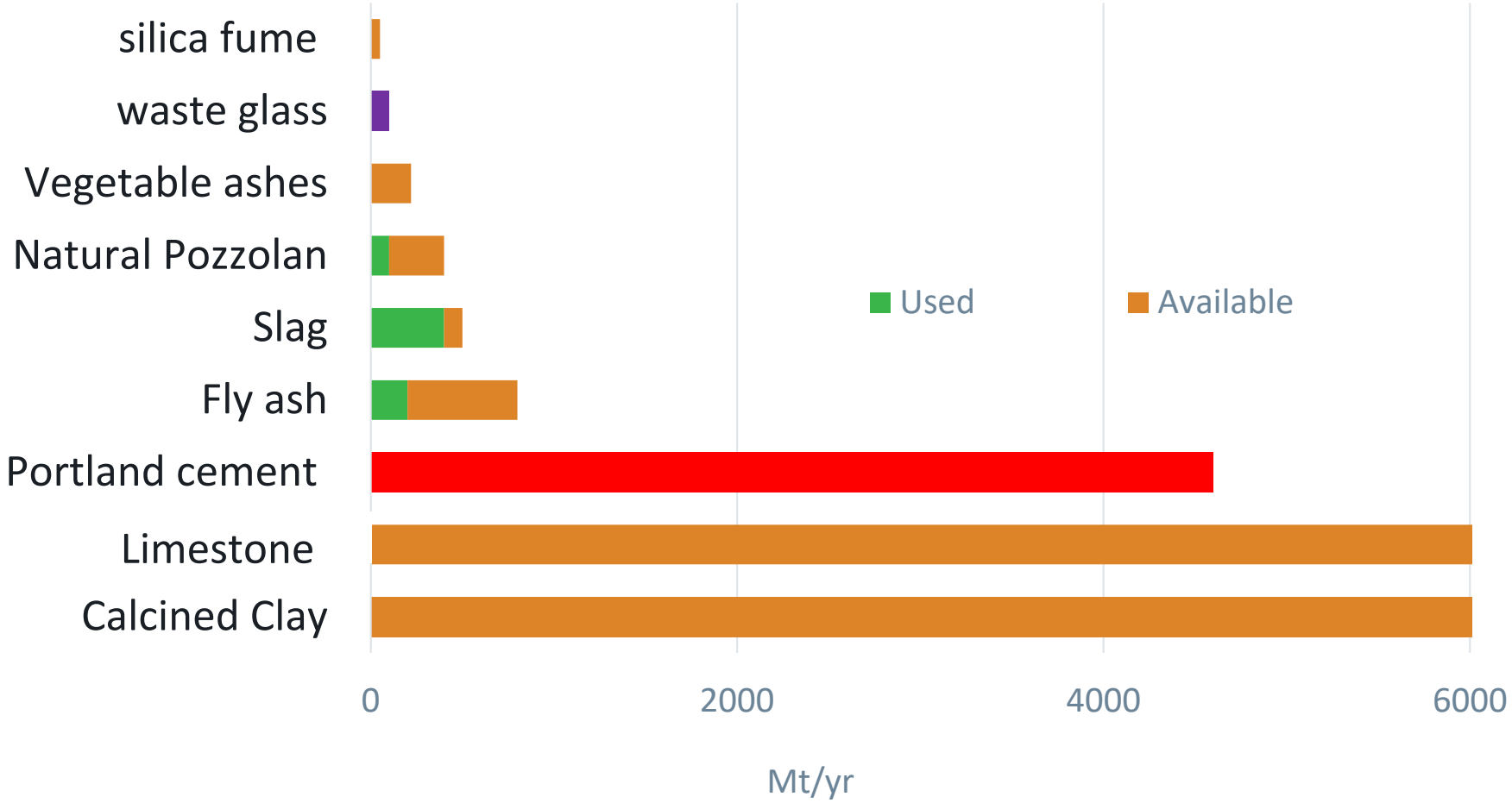
Use of waste fuels, which can be **> 80%** reduces the demand for fossil fuels



Evolution of clinker substitution



Alternate materials availability

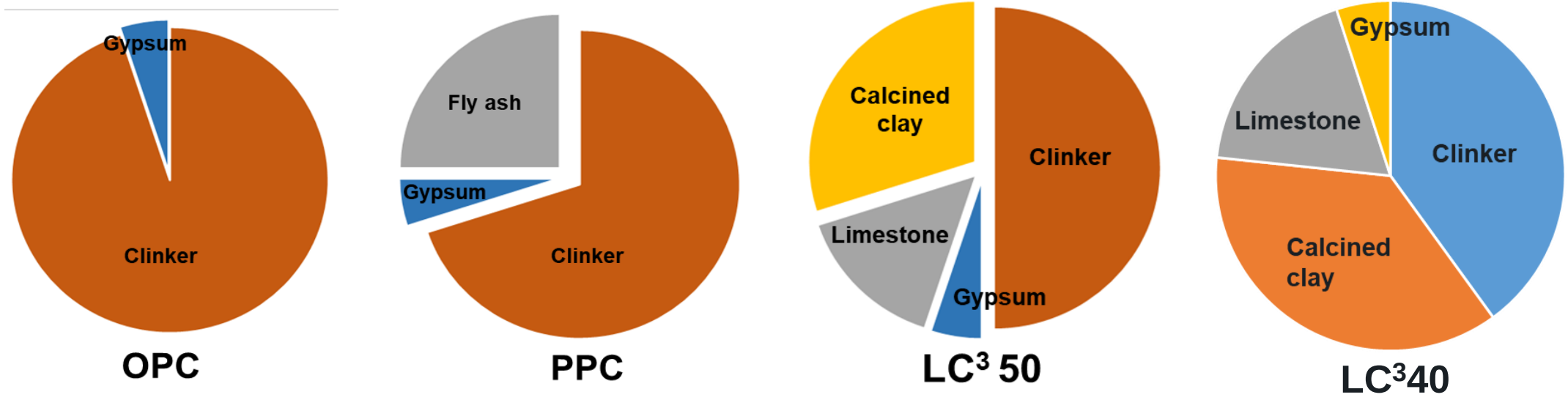


Portland based cements will continue to dominate

Blended cements are the most realistic option to reduce CO_2 and extend resources

LC^3 – promises to be a transformative innovation for the future

The Limestone Calcined Clay Cement blend – LC³



LC³: Advantages

- Clinker factor reduced to 50%
- Use of moderate quality clays and low grade limestone resources
- Low temperature calcination of kaolinitic clays (800^{0}C)
- Saving of around 30% CO_2 emissions compared to Portland Cement

The Journey so far …….. from lab to companies

Proof of Concept

Clay mapping, testing and feasibility

Intensified research and application

Pilot production, applied research, short and long term performance and reliability tests

Dissemination

TRC and dissemination of knowledge across continents

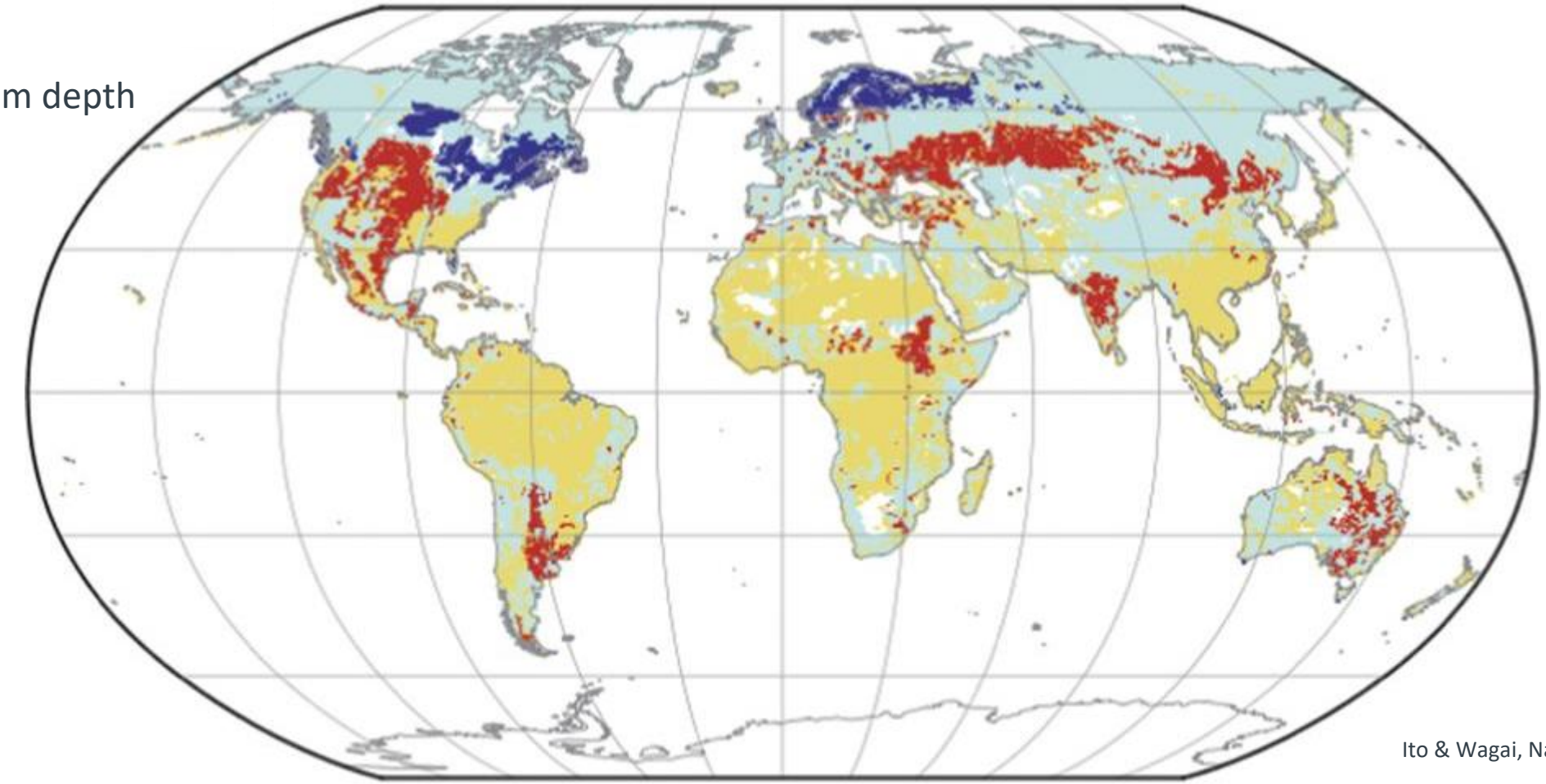
2013	2014	2015	2016	2017	2018	2019
• Survey for required clay • First trial calcination • Lab scale blend	• First trial production (Project) • Demonstration structures	• Second trial production by Project in association with Ultratech Cements • Performance evaluation	• First pilot production by JK Lakshmi Cements • Applied research	• Lab scale testing of clays in Malawi with LHM • Trial calcination by Dalmia Cements • Setting up LC3TRC's	• Third pilot trial by Lafarge Holcim Malawi • Feasibility studies of clays in India, Asia and African countries	• Second pilot production by Ultratech Cements • Feasibility studies in India

KEY QUESTIONS ASKED

- Do we have enough china clay and where?
- What are the various qualities of raw material we need?
- Is **LC^3** comparable with normal cements available in the market?
- Do you need a high capital investment?
- Is it profitable to produce **LC^3** ?

Do we have enough china clay and where?

Subsoil
- below 0.3 m depth

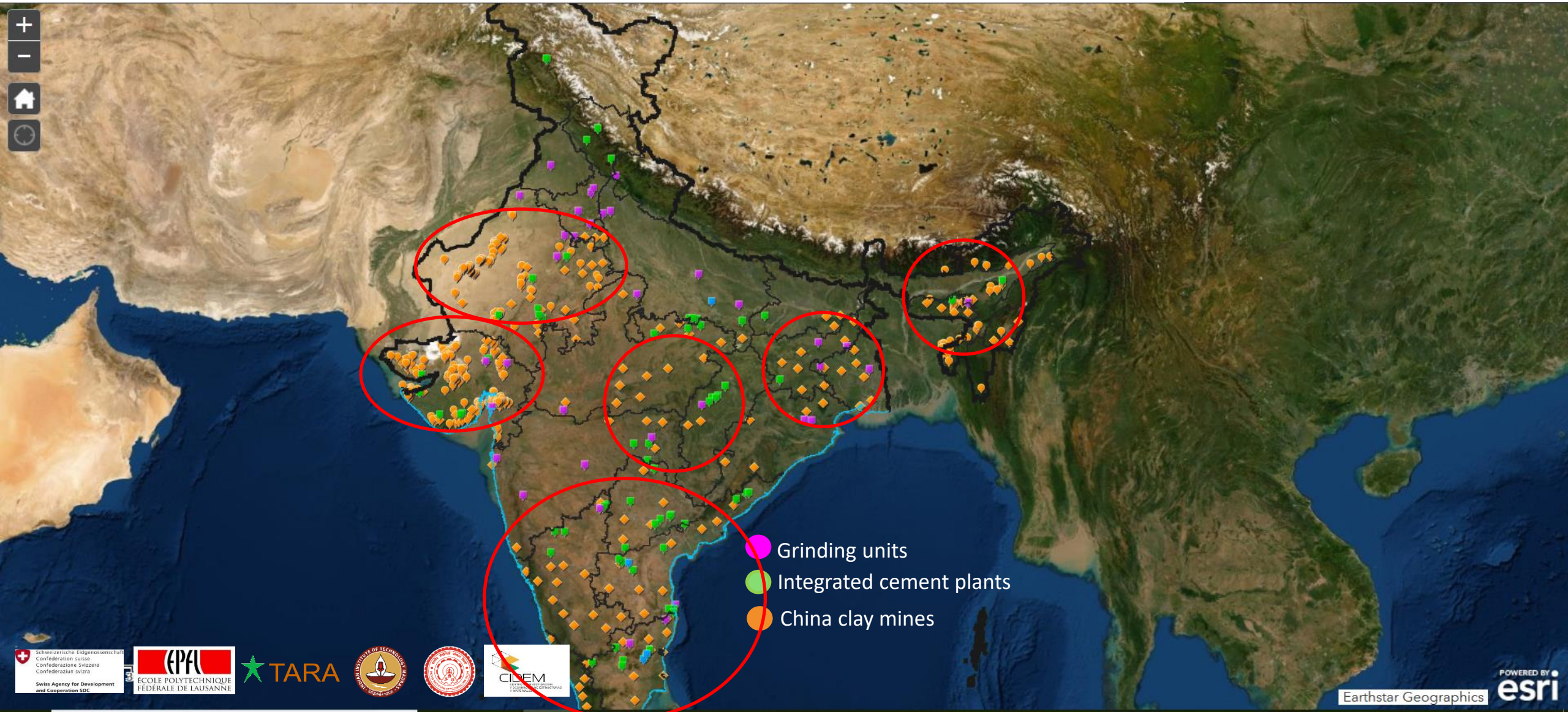


Ito & Wagai, Nature Research, 2017

Limestone Calcined Clay Cement LC3

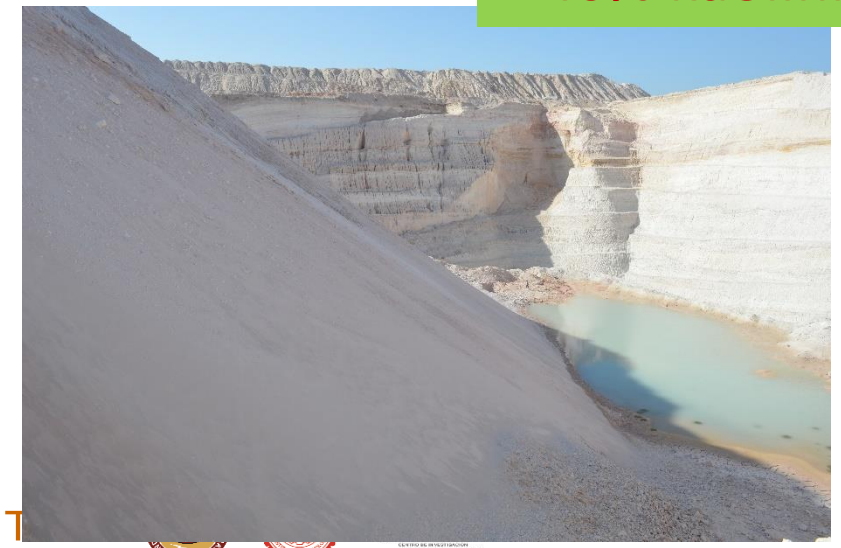
LOW CARBON LOW COST LOW CAPITAL

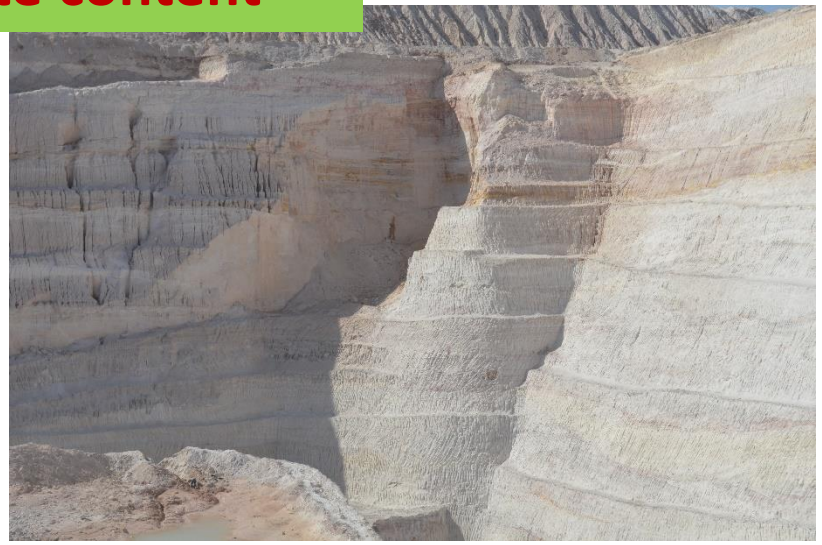
Do we have enough china clay and where?



Qualities of raw materials required?

> 40% kaolinite content





Qualities of raw materials required – China clay

Threshold for good reactivity:
60% Quartz
40% Kaolinite

→

- % Al_2O_3 = 15.8
- % Al_2O_3 / % SiO_2 = 0.2
- % OH^- = 5.6

Suitable clays must comply with

→

- % Al_2O_3 > 18
- % Al_2O_3 / % SiO_2 > 0.3
- % LOI > 7.0

↓

- % CaO < 3.0 (Low contents of calcite/gypsum)
- % SO_3 < 2.0 (Low contents of pyrite/alunite/gypsum)
- % Fe_2O_3 < 10.0 (If red color is undesirable, can be changed depending on calcination technology)

Courtesy: Prof. Fernando Martirena, UCLV

Qualities of raw materials required?

> 35% CaO content

Production of LC³ - Calcination

Production of LC³ - Calcination

- Easy to use and maintain
- Familiar technology
- Low specific energy consumption
- Redundant rotary kilns can be used
- Clay with high moisture content can be used
- No elaborate clay processing technology

Production of LC³ – Calcination colour control

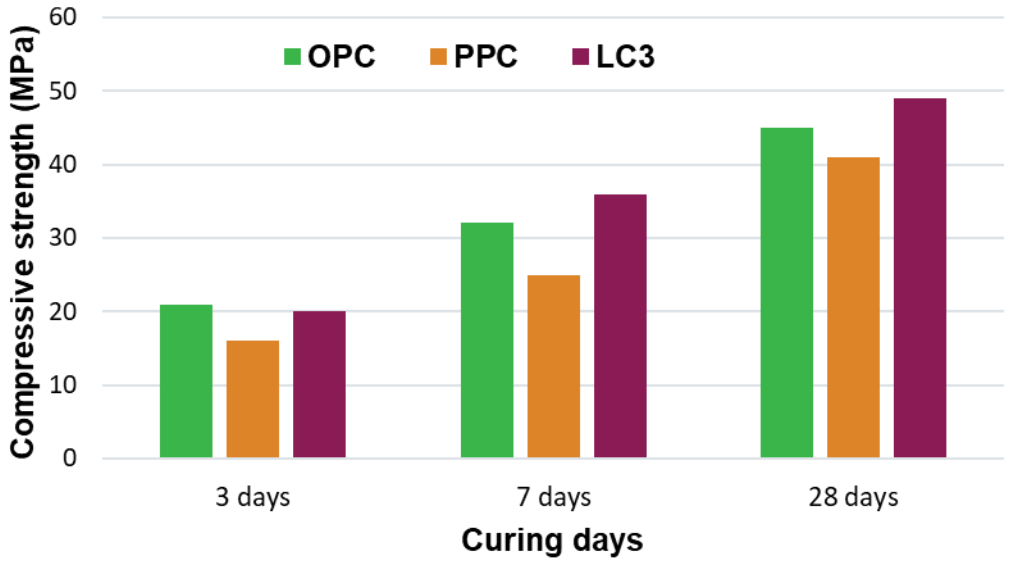
Calcination under reducing conditions

Production scale diversity

Robust system

- Similar quality at any scale of production

Quality and durability



Results:

- Significant refinement of porosity even at 3 days
- Better chloride resistance
- ASR resistant
- Good flowability with addition of superplasticizers

Production of LC^3 – Feedback from companies

- Mill efficiency/productivity of LC^3 is higher than OPC due to higher grindability of LC components.
- For same level of productivity LC^3 demands lower capital investment and lower cost of operation compared to OPC.
- Productivity of calcined clay operated at 750^{o}C-850^{o}C (average range) is nearly double compared to 1450^{o}C-1500^{o}C with same rotary kiln and infrastructure as evident from pilot calcination.
- Relatively higher fineness is required for LC^3 in order to have comparable reactivity.

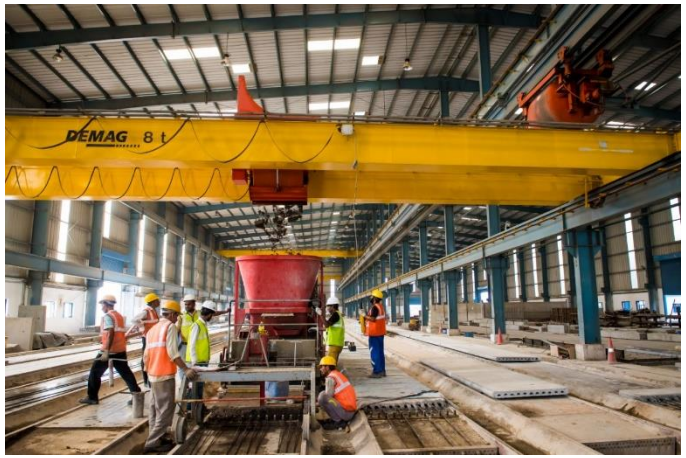
Application of LC3

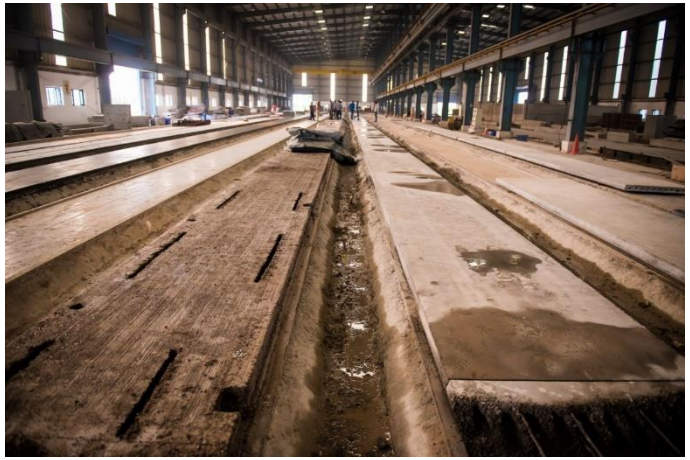
Field performance

- Building materials
- Houses and office buildings
- Pavements and walkways
- Roads

Product and production diversity

Application of LC³ – Large scale





LC³ based pre-stressed hollow core slab

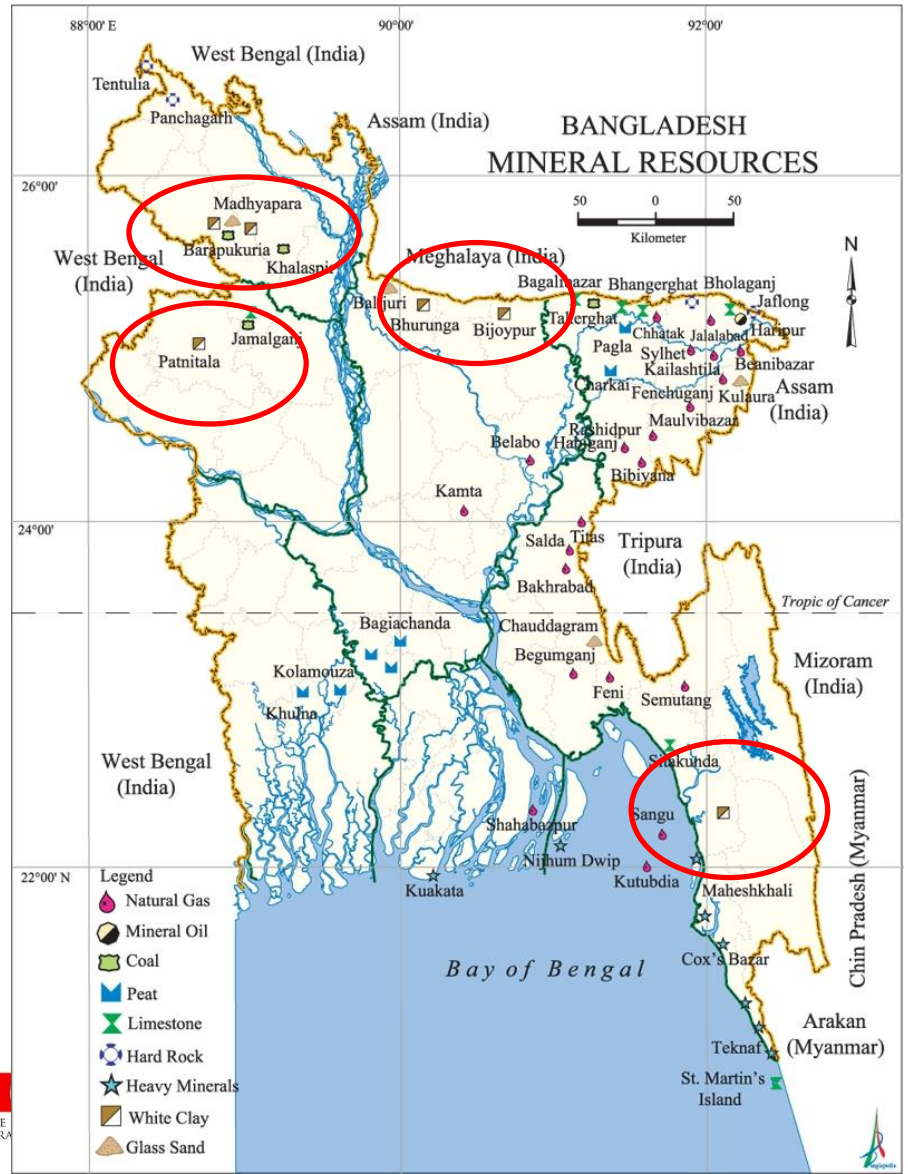
- 0 slump
- No admixtures
- 22 hours strength at 22 MPa
- 28 days strength at 52 MPa

Application diversity

Application diversity

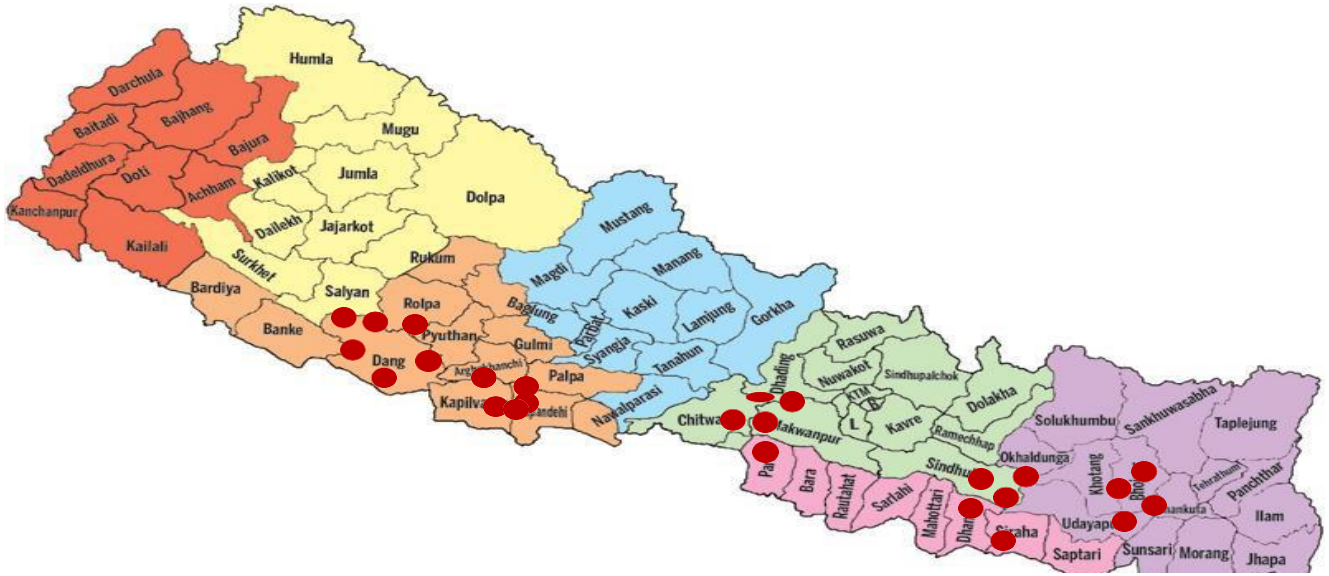
Applicability in Asia

Asia - Bangladesh



- Installed capacity 68 Mn tons
- Total plants around 100, operational only around 37
- Only 2 integrated plants, rest all grinding units
- No availability of quality limestone
- Imports clinker from all countries and fly ash from India
- Average growth in cement – around 12% from last 10 years
- High cost due to high transportation cost
- High competition from large companies

Asia - Nepal



Occurances of kaolinitic clays all across the Terai and Sub-Himalayan region

- Installed capacity 15 Mn tons
- Total plants 61
  - Integrated plants – 21
  - Grinding units – 40
- Capacity 1000 tpd to 6000 tpd
- Imports pozzolana from India
- Average growth in cement – around 10% from last three years
- Price of cement – highest in Asia i.e. USD 120-130 per MT for OPC

Applicability in Africa

Limestone Calcined Clay Cement LC3

LOW CARBON LOW COST LOW CAPITAL

Do we have enough china clay and where?

M12 Mzimba

S125

M1

Linthipe Linthipe

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Google Earth

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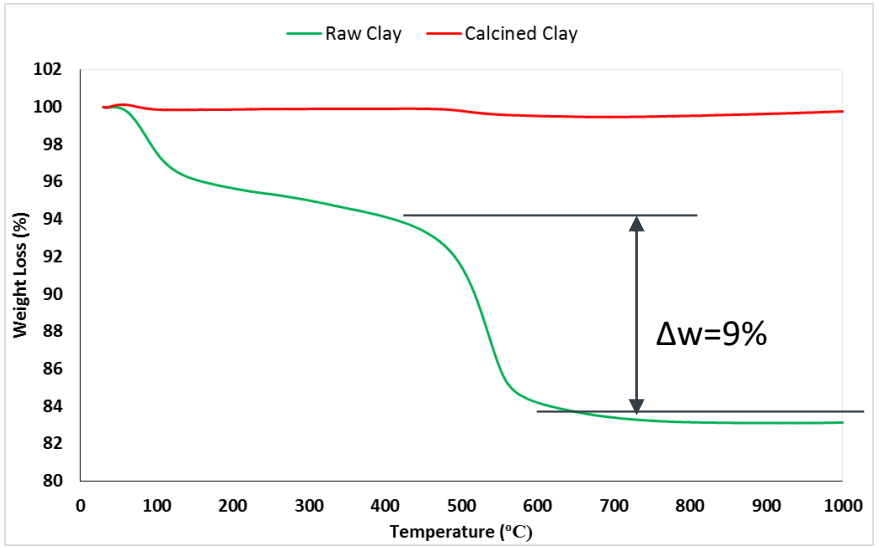

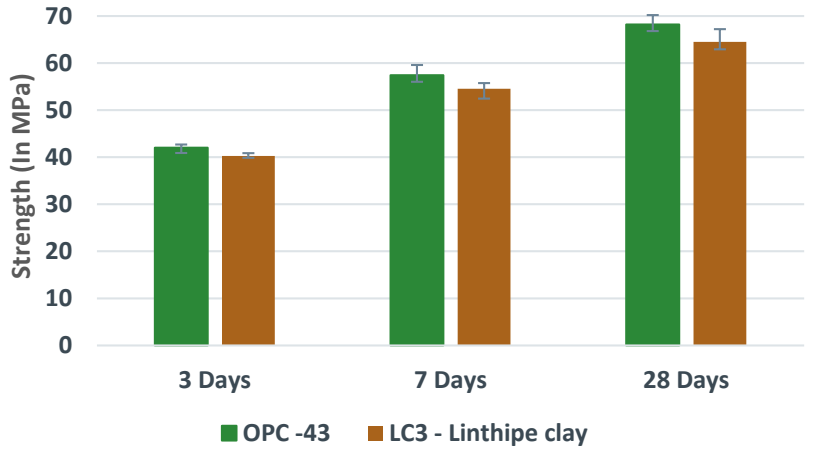

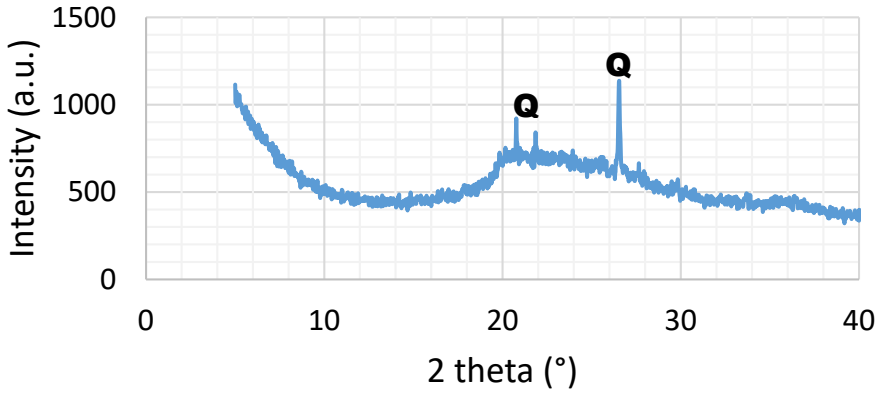

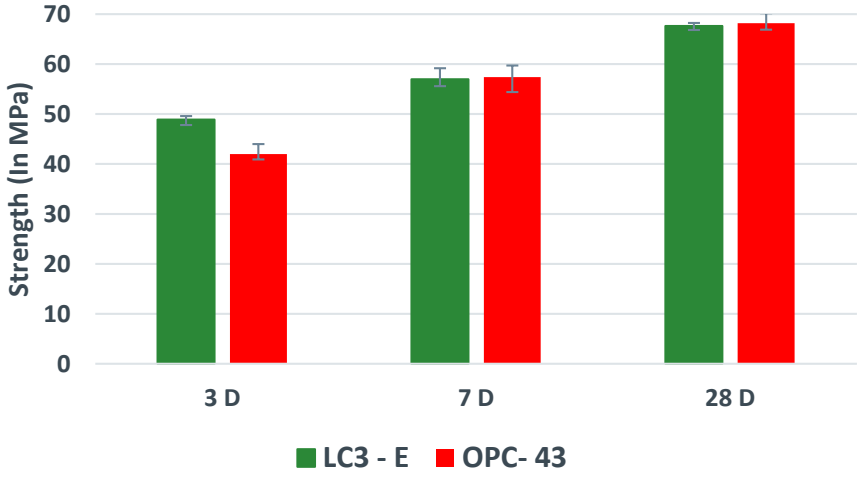

Africa - Uganda

	Clay 1	Clay 2	Clay 3	Clay 4
Al_2O_3	28.89	28.71	14.66	19.80
SiO_2	46.68	44.07	57.31	66.21
Fe_2O_3	8.73	11.82	8.45	3.61
CaO	0.56	0.74	4.58	0.63
MgO	0.26	0.39	1.29	0.43
K_2O	3.71	4.87	2.63	1.72
Na_2O	0.49	0.54	1.13	0.01
P_2O_5	0.06	0.06	0.36	0.01
TiO_2	1.08	1.11	-	0.01
SO_3	0.01	0.03	-	0.03
LOI	7.83	6.95	8.53	6.66

Africa – Rwanda, Tanzania, Ethiopia, Kenya, Sierra Leone, Senegal, Egypt

- Large substantial deposits of clay
- Kaolinite content in some cases as high as 70%
- Presently small quantities being used for ceramic purposes
- In some clays – complicated
- Within a short distance from existing companies

- High compressive strength (Mortar) equivalent to 52.5 grade
- Clinker content can be further reduced for 32.5 grade

CONCLUSIONS

- Extremely versatile in nature
- LC^3 performs better than ordinary cement in all types of applications
- No process or production system change is required
- Suitable for use in all scale of operations

LC3 Technology Resource Centre

Pioneering Green Technology Solutions For the Cement and Concrete Industry

The LC^3 Technology Resource Centre is an outcome of a decade of international collaborative research on development of Limestone Calcined Clay Cement (LC^3). The collaborating partners for India include

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INDIAN INSTITUTE OF TECHNOLOGY DELHI

INDIAN INSTITUTE OF TECHNOLOGY MADRAS

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- ✓ Feasibility of china clays for use in LC^3
- ✓ Advisory support for pilot calcination of china clay
- ✓ Training of personnel in all aspects of LC^3
- ✓ Life Cycle Assessment of LC^3 pilot production
- ✓ Standard and certified raw materials e.g. calcined china clay, LC^2 or LC^3.

Limestone Calcined Clay Cement LC3

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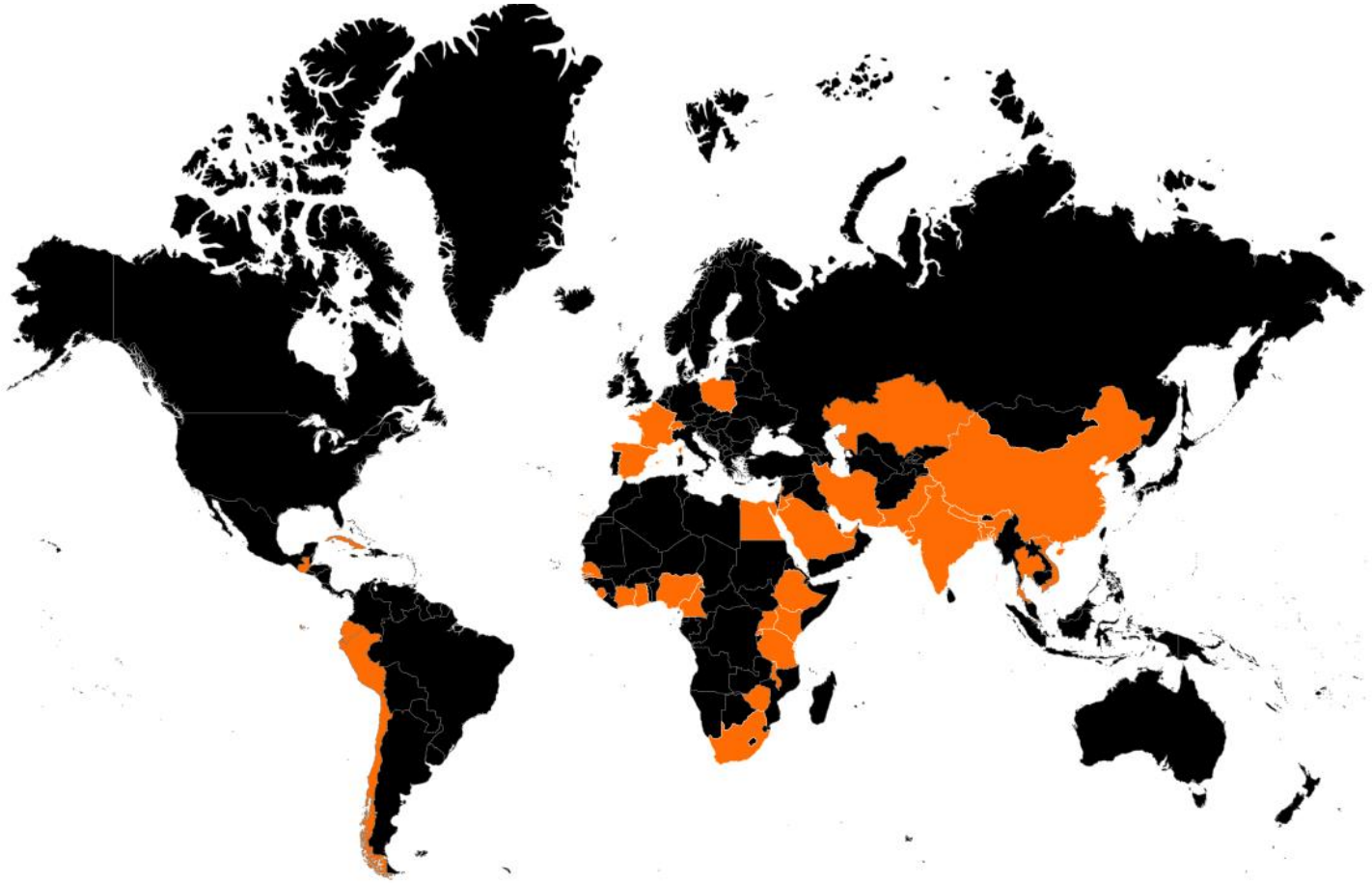

Asia

India
Nepal
China
Bangladesh
Thailand
Vietnam
Kazakhstan
Iran

South America

Cuba
Ecuador
Chile
Peru
Guatemala

Europe

Switzerland
Portugal
Poland

Middle east

UAE
Lebanon
Jordan

Africa

South Africa
Malawi
Kenya
Ethiopia
Egypt
Uganda
Rwanda
Senegal
Sierra Leone
Cameroon
Ghana
Ivory Coast
Zimbabwe
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Thank you

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