Limestone Calcined Clay Cement

- Experiences in India and Africa

LC³ Information Day
University of Cape Town
19th. November 2019, Cape Town, South Africa
Growth forecast for the cement industry

We need **profitable** solutions for developing countries
Origins of CO₂ production in the cement industry

1 tonne of cement leads to the emission of 650 – 900 kg CO₂

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

- **1990**: 81.9%
- **2000**: 70.9%
- **2011**: Current value (70.9%)

Clinker Factor [%]
Alternate materials availability

- Silica fume
- Waste glass
- Vegetable ashes
- Natural Pozzolan
- Slag
- Fly ash
- Portland cement
- Limestone
- Calcined Clay

Mt/yr

0 2000 4000 6000

Used
Available
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°C)
- Saving of around 30% CO₂ 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

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<tbody>
<tr>
<td>2013</td>
<td>• Survey for required clay</td>
<td>• First trial production (Project)</td>
<td>• Second trial production by Project in association with Ultratech Cements</td>
<td>• First pilot production by JK Lakshmi Cements</td>
<td>• Lab scale testing of clays in Malawi with LHM</td>
<td>• Third pilot trial by Lafarge Holcim Malawi</td>
<td>• Second pilot production by Ultratech Cements</td>
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<td></td>
<td>• First trial calcination</td>
<td>• Demonstration structures</td>
<td>• Performance evaluation</td>
<td>• Applied research</td>
<td>• Trial calcination by Dalmia Cements</td>
<td>• Feasibility studies of clays in India, Asia and African countries</td>
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<td>• Lab scale testing of clays in Malawi with LHM</td>
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KEY QUESTIONS ASKED

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

Subsoil
- below 0.3 m depth

Ito & Wagai, Nature Research, 2017
Do we have enough china clay and where?

Grinding units
- Integrated cement plants
- China clay mines
Qualities of raw materials required?

> 40% kaolinite content
Qualities of raw materials required – China clay

Threshold for good reactivity:
60% Quartz
40% Kaolinite

Suitable clays must comply with

• % CaO < 3.0 (Low contents of calcite/gypsum)
• % SO₃ < 2.0 (Low contents of pyrite/alunite/gypsum)
• % Fe₂O₃ < 10.0 (If red color is undesirable, can be changed depending on calcination technology)

• % Al₂O₃ = 15.8
• % Al₂O₃ / % SiO₂ = 0.2
• % OH⁻ = 5.6

• % Al₂O₃ > 18
• % Al₂O₃ / % SiO₂ > 0.3
• % LOI > 7.0

Courtesy: Prof. Fernando Martirena, UCLV
Qualities of raw materials required?

> 35% CaO content
Production of LC³ - Calcination
Production of LC$^3$ - 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
Results:

- Significant refinement of porosity even at 3 days
- Better chloride resistance
- ASR resistant
- Good flowability with addition of superplasticizers
Production of LC³ – Feedback from companies

- Mill efficiency/productivity of LC³ is higher than OPC due to higher grindability of LC components.
- For same level of productivity LC³ demands lower capital investment and lower cost of operation compared to OPC.
- Productivity of calcined clay operated at 750°C-850°C (average range) is nearly double compared to 1450°C-1500°C with same rotary kiln and infrastructure as evident from pilot calcination.
- Relatively higher fineness is required for LC³ in order to have comparable reactivity.
Application of LC$^3$

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

• 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

Occurances of kaolinitic clays all across the Terai and Sub-Himalayan region
Applicability in Africa
Do we have enough china clay and where?
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Do we have enough china clay and where?

Δw=9%
## Africa - Uganda

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<tr>
<th></th>
<th>Clay 1</th>
<th>Clay 2</th>
<th>Clay 3</th>
<th>Clay 4</th>
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<tr>
<td>Al₂O₃</td>
<td>28.89</td>
<td>28.71</td>
<td>14.66</td>
<td>19.80</td>
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<tr>
<td>SiO₂</td>
<td>46.68</td>
<td>44.07</td>
<td>57.31</td>
<td>66.21</td>
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<td>Fe₂O₃</td>
<td>8.73</td>
<td>11.82</td>
<td>8.45</td>
<td>3.61</td>
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<td>CaO</td>
<td>0.56</td>
<td>0.74</td>
<td>4.58</td>
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<td>MgO</td>
<td>0.26</td>
<td>0.39</td>
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<td>K₂O</td>
<td>3.71</td>
<td>4.87</td>
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<td>Na₂O</td>
<td>0.49</td>
<td>0.54</td>
<td>1.13</td>
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<td>P₂O₅</td>
<td>0.06</td>
<td>0.06</td>
<td>0.36</td>
<td>0.01</td>
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<tr>
<td>TiO₂</td>
<td>1.08</td>
<td>1.11</td>
<td>-</td>
<td>0.01</td>
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<tr>
<td>SO₃</td>
<td>0.01</td>
<td>0.03</td>
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<td>0.03</td>
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<tr>
<td>LOI</td>
<td>7.83</td>
<td>6.95</td>
<td>8.53</td>
<td>6.66</td>
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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
• \( \text{LC}^3 \) 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
Pioneering Green Technology Solutions For the Cement and Concrete Industry
The LC³ Technology Resource Centre is an outcome of a decade of international collaborative research on development of Limestone Calcined Clay Cement (LC³). The collaborating partners for India include
✓ Feasibility of china clays for use in LC³
✓ Advisory support for pilot calcination of china clay
✓ Training of personnel in all aspects of LC³
✓ Life Cycle Assessment of LC³ pilot production
✓ Standard and certified raw materials e.g. calcined china clay, LC² or LC³.
Asia
India
Nepal
China
Bangladesh
Thailand
Vietnam
Kazakhstan
Iran

Middle east
UAE
Lebanon
Jordan

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

South America
Cuba
Ecuador
Chile
Peru
Guatemala

Europe
Switzerland
Portugal
Poland
Thank you

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www.lc3trcindia.com

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