Update on the progress of the work of LC3 TRC in Latin America

Prof. Fernando Martirena
CIDEM
Universidad Central de las Villas
CUBA
Collaboration with Prof. Karen Scrivener

2005-2008
SDC-SNSF Project
Calcined clays for pozzolans

2009-2012
SDC-SNSF Project
Ternary blend cement calcined clay-limestone

2013-2020
SDC-Climate Change
Low Carbon Cement

The pursuit of sustainable alternatives to replace Clinker with Supplementary cementitious Materials
The idea of the collaboration

Based on KFPE’s 11 principles for partnerships between Swiss institutions and institutions in developing countries…
Current situation of cement production in Latin America

• Large availability of suitable clays in vast regions of the continent
• Scarce supply of Supplementary Cementitious Materials
• Cement industry expanding despite economic downturns (especially Central America and the Caribbean)
• Great interest in US for LC3 product (Especially in Florida with Department of Transportation)
• Several countries supporting COP 21’s INDC to mitigating Climate Change
Main obstacles for LC3 dissemination in Latin America

Capital cost. Economic feasibility needs to be demonstrated
Availability of good quality natural pozzolan (volcanic ashes and tuffs) in certain regions
Few economic incentives for innovation at the cement industry level
Scarce knowledge of production of calcined clays (except Brazil)

WHAT’S NEEDED?

• Clear protocols for clay exploration
• Availability of advisory service
• Suitable and affordable equipment for clay calcination
• Clear recognition of the new product in standards
• Economic and fiscal incentives for the industry
Objectives of the TRC Cuba

To **provide advisory service and information** to all parties interested in introducing LC3 as cementitious materials.

To **act as interface between the academia and the industry** for a swift introduction of the new developments in the area of LC3.

To **interact with technology providers** in order to further develop equipment and machinery for the production of LC3.

To **facilitate training** for the industry to assimilate the new technologies for the manufacture of LC3.
Protocol to assist companies introduce LC3

Non-profit company registered in Switzerland, with the goal of providing advisory service to companies in the cement sector
(www.ecosolutions.gl)
Cuban TRC. LC3 Pilot Plant (5 tpd)
S-curve for LC3 Latin America

- Vegetable ashes
- Solid fuel block
- Calcined clay cement
- Exposure site
- Industrial trial Siguaney
- First real demo structure
- Cuban TRC
- Industrial trial Siguaney

Timeline:
- 1995
- 2001
- 2005
- 2009
- 2013
- 2014
- 2015
- 2018
- 2030
Stumbling blocks for industrial applications

- Geologists in cement companies are not used to look for OUR clays (1:1)
- Choice of calcination technology
- People (customers) do not like “red cement”
- Some standards do not include LC3 composition (minimum clinker content, water demand)
- Grinding ternary binders can be complex
- Calcined clays increase water demand in cement & concrete
Which are the suitable clays?

Threshold for good reactivity:
60% Quartz
40% Kaolinite

Suitable clays must comply with

- % Al\(_2\)O\(_3\) = 15,8
- % Al\(_2\)O\(_3\) / % SiO\(_2\) = 0,2
- % OH\(^-\) = 5,6

- % Al\(_2\)O\(_3\) > 18
- % Al\(_2\)O\(_3\) / % 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\(_2\)O\(_3\) < 10,0 (?) (If red color is undesirable, also depending on calcination technology)
Chemical and mineralogical composition

- Clays used in Clinker production have low Al and high Si (contrary to what is needed for LC3)
- High alkalis values indicate not completed weathering process (low kaolinite content)
- Presence of Fe only has implications in color
Two stage process:
1. Removal of absorbed water (calcination tower)
2. Removal of chemically bound water (rotary kiln)

Example: ARGOS plant Rio Claro, Columbia (rotary claciner coupled to a drier tower)

Main parameters:
• 1500 ton calcined clay per day (500 K ton x year)
• Project total cost: 76 millones USD
• OPEX ≤ 20 USD/ton AC
• Thermal consumption: 550 kcal/kg CCL
• Power consumption: 33 kw/ton CCL
Technology for calcination: flash calciner

Two stage process:
1. Removal of absorbed water (calcination tower)
2. Removal of chemically bound water (calcination tower)

Example: Sobute plant. Nanjing (flash calcination tower). China

Main parameters:
- 600 ton calcined clay per day (200 K ton x year)
- Estimated cost project: 30 Mio USD
- Thermal consumption: 620-660 kcal/kg CCL
- Power consumption: 78-89 kw/ton AC

SINOMA, LC3 day, Hong Kong, 08.2018
Technology for calcination: double shaft rotary kiln

Two stage process:
1. Removal of absorbed water (first shaft)
2. Removal of chemically bound water (second shaft)
Example: CEMTECH Ivory Coast (double shaft rotary kiln)

Main parameters:
• 720 ton calcined clay per day (200 K ton x year)
• Cost equipment: 6 millones USD; total: 12 Mio USD
• Thermal consumption: 529 kcal/kg; AC
• Power consumption: 18 kW/ton AC
Diesel combusts and exhaust all oxygen available at ~800ºC. Fuel consumption for color control is less than 1%...

Water spraying cools off the salida upon exiting. Fuel injection and water spraying form a simple system to control color.
Color control. IPIAC technology

Calcination takes place under reducing conditions.
Standards

ASTM C595
Pozzolan content: ≤ 40%
Limestone content: ≤ 15%
Minimum clinker content: 45%

(**) tests carried out by Lafarge (France)
Problems during grinding multi-component cement

- Electrically charged particles coat the steel balls and the walls of the mill and affect clinker grinding
- Excess grinding of soft materials takes place
Impact of grinding aids

CC 1h no GA

CC 1h PCE 1 0.45%

CC 1h Amine 0.13%

CC 1h Glycol 0.12%

Franco Zunino, 2018
Impact of high dosage of SP on early strength

Concreto con LC2. ECM Mariel. 2019

<table>
<thead>
<tr>
<th></th>
<th>P35+LC2</th>
<th>P35 ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement (kg/m3)</td>
<td>266.00</td>
<td>380</td>
</tr>
<tr>
<td>Water (L/m3)</td>
<td>160.00</td>
<td></td>
</tr>
<tr>
<td>LC2 (kg/m3)</td>
<td>114.00</td>
<td>114.00</td>
</tr>
<tr>
<td>SP (L/m3)</td>
<td>6.79</td>
<td>3.5</td>
</tr>
<tr>
<td>Sand 1 (kg/m3)</td>
<td>904.32</td>
<td>904.32</td>
</tr>
<tr>
<td>Sand 2 (kg/m3)</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Gravel 1(kg/m3)</td>
<td>1019.77</td>
<td>1019.77</td>
</tr>
<tr>
<td>Gravel 2 (kg/m3)</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Water/CPO+LC2</td>
<td>0.42</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Water/CPO+LC2: 0.42

0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00
Resistencia compresión Mpa

<table>
<thead>
<tr>
<th></th>
<th>3d</th>
<th>7d</th>
<th>28d</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2 380 kg P35</td>
<td>18.70</td>
<td>21.33</td>
<td>23.77</td>
</tr>
<tr>
<td>H5 380 kg P35</td>
<td>24.20</td>
<td>26.23</td>
<td>34.33</td>
</tr>
<tr>
<td>H7 380 kg P35</td>
<td>33.47</td>
<td>34.93</td>
<td>40.33</td>
</tr>
<tr>
<td>HR lab 266 kg P35+LC2</td>
<td>8.77</td>
<td>33.07</td>
<td>58.05</td>
</tr>
<tr>
<td>HR plant 266 kg P35+LC2</td>
<td>14.77</td>
<td>26.63</td>
<td>46.30</td>
</tr>
</tbody>
</table>
Dissemination activities

• 2011: ICCC Madrid (pre congress courses)
• 2015-06: 1st Int. Conference on Calcined Clays. Switzerland
• 2016-06: LC3 seminar, Cuba
• 2016-10: Habitat 3. Ecuador
• 2017-11: RILEM seminar. Colombia
• 2017-12: 2nd Int. Conference Calcined Clays. Cuba
• 2017-07: Presentation Corvallis. USA
• 2018-01: LC3 day, Cuenca. Ecuador
• 2018-05: LC3 day. Switzerland & Portugal
• 2018-08: LC3 day. Honk Kong
• 2018-09: FICEM conference, Panama
• 2018-11: SIKA seminar. La Habana. Cuba
• 2019-02: LC3 day. Miami. USA
• 2019-09: FICEM, Dom. Repulic
Industrial trial Cuba. December 2018

Calcined clay in nodules

Material left in kiln #3
Industrial trial Guatemala, 11-2018
Sculpture at Biennal Havana 2019 with LC3
Current state. Latin America

**MEXICO**
XX company with interest in technology

**GUATEMALA**
XX industrial trial done. Investment preparation

**BOLIVIA**
XX company with interest in technology

**ARGENTINA**
XX company with interest in technology

**CUBA**
XX company prepares investment 20 miniplants coming up

**GUYANA**
XX company with interest in technology

**COLOMBIA**
XX company started production XX1 company ongoing studies

**ECUADOR**
XX company. Studies finalized. Investment expected

**PERU**
XX company ongoing studies

**GUYANA**
XX company with interest in technology
Forecast of take up of LC3 production in the region

<table>
<thead>
<tr>
<th>Year</th>
<th>Built capacity LC3 Ton/Year</th>
<th>Co₂ Savings Ton/Year *</th>
<th>Co₂ Savings USD/Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>1414286</td>
<td>339429</td>
<td>9062743</td>
</tr>
<tr>
<td>2020</td>
<td>4472286</td>
<td>1073349</td>
<td>28658407</td>
</tr>
<tr>
<td>2021</td>
<td>5264286</td>
<td>1263429</td>
<td>33733543</td>
</tr>
<tr>
<td>2022</td>
<td>12502286</td>
<td>3000549</td>
<td>80114647</td>
</tr>
<tr>
<td></td>
<td><strong>23’653’143</strong></td>
<td><strong>5’676’754</strong></td>
<td><strong>151’569339</strong></td>
</tr>
</tbody>
</table>

Impact on the region between 2019-2022 (4 years)

- Cement production in the region was 120 million tons in 2016 (Increase 10% due to LC3)
- Average Clinker factor around 68-69% (it could be lowered to around 0.60)
- Carbon emissions 70 million tons (reduction of 4% carbon emissions)
Thank you!!

José Fernando Martirena Hernández (Prof. Dr.Sc. Ing.)
Director CIDEM
Faculty of Constructions. Universidad Central de las Villas
e-mail: martirena@uclv.edu.cu/fmartirena@ecosur.org
skype: fmartirena@ecosur.org
Whatsup: +53 5 2637716 or +41 7 9710 2146

Support from SDC is acknowledged