Update of the work of CIDEM

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Core extraction site at coast (12.02.2017)

Taking sample at Artemisa (04.2017)

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Training course Diploma Students (32)

A theoretical and practical course on testing building Materials, with emphasis on cement & concrete

Aggregate optimization

Fine and coarse aggregates were sieved and prepared to comply with Cuban standard NC 251

Preparation of Artemisa material for calcination

PROCESS

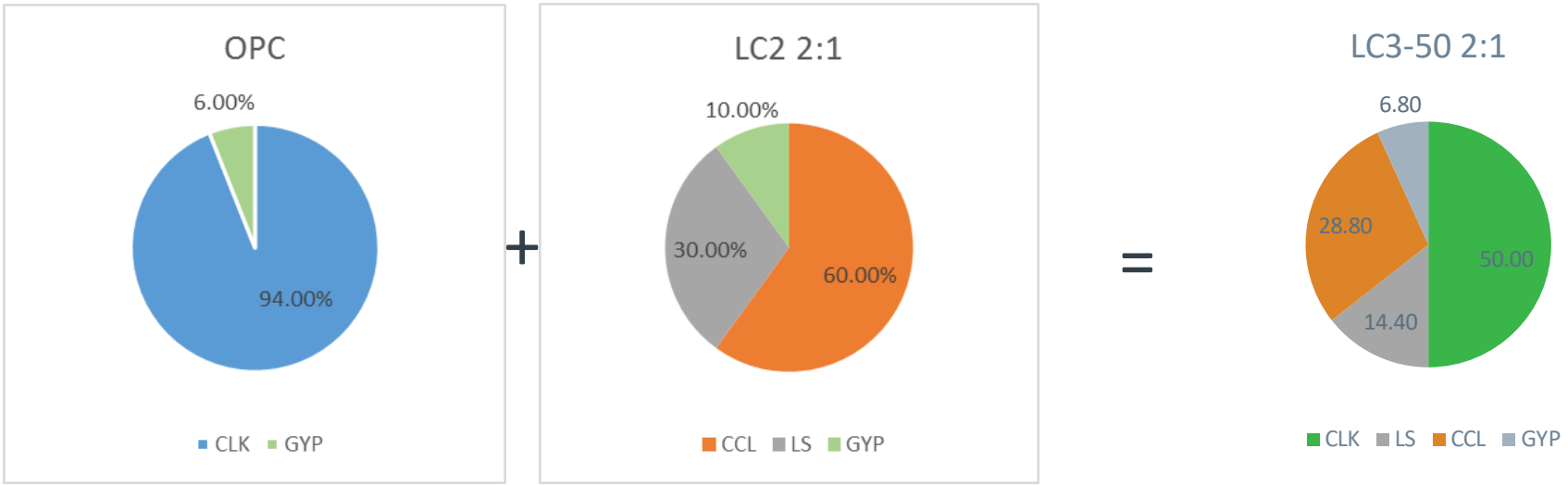
- Dry the material at 105 oC
- Grind the material until retained 90 µm < 10%
- Calcine at 800 oC all fractions
- Mix accordingly all fractions

Testing reactivity of Artemisa clay

- Calcination at 750, 800, 850 oC
- Compressive strength standard mortars PPC30 and LC3-50
- I calo and chemical shrinkage for all temperatures
- R3 for for all temperatures

The best choice in terms of reactivity was 800 oC. In terms of wáter demand 850 oC was slightly better

Producing LC2/LC3 with calcined clay Artemisa



		CLK	CCL	LS	GYP	Total	SO3
Cemento Portland	50.00%	47.00%	0.00%	0.00%	3.00%	50.00%	1.625%
LC2	50.00%	0.00%	30.00%	15.00%	5.00%	50.00%	1.600%
		47.00%	30.00%	15.00%	8.00%	100.00%	3.225%

Formulation of different LC3 cements (Artemisa)

- LC3-50 2:1
- LC3-50 1:1
- LC3-65 2:1
- LC3-65 1:1

Experimental program on cements

- Minicone (rheology)
- Blaine
- Setting time Vicat
- I calo
- Compressive strength standard mortars 1d, 3d, 7d, 28d
- Comparison with previous formulations (Yigre)

Production of concrete with OPC/LC3-50

Muestra	Cemento	Aditivo SIKAPLAST 9100	A/C	Gravilla Purio	Arena Purio	Agua efectiva	Asenta m.	Resistencia a Compresión (MPa)				Porosidad %
	Kg			Kg	kg	Ltros	cm	48h	3d	7d	28d	
H-35	430	0.65%	0.43	877	875	185	20					
H-30	405	0.65%	0.45	877	894	182	20					
H-25	370	0.65%	0.5	877	916	185	20					
H-20	340	0.65%	0.55	877	937	187	20					

Production of concrete with OPC/LC3-50

Tests carried out in concrete

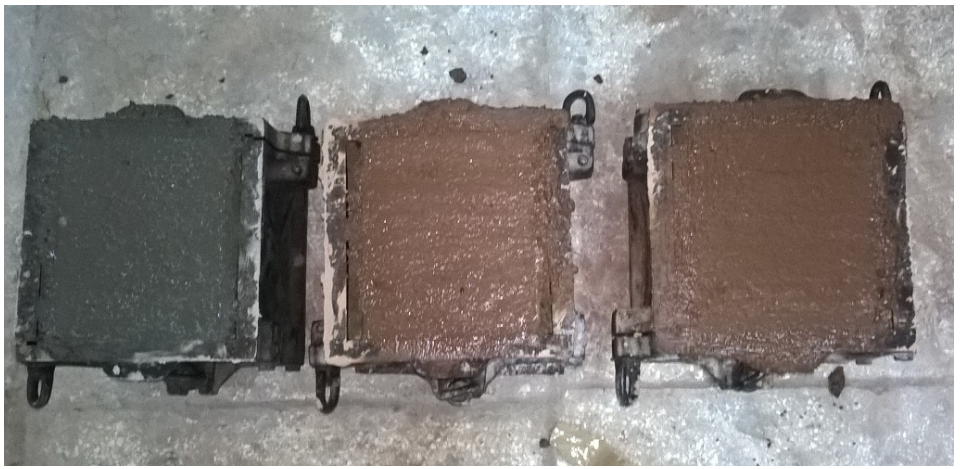
- Ocluded air
- Penetrometer
- Slump
- Compressive strength 24h, 7d, 28d
- Porosity

Use of LC2 as mineral addition to concrete

- LC2 produced with calcined clay from Artemisa and Yigre
- Typical 35 Mpa mix design used (420 kg cement/m3)
- Concrete with minimun cement (350 kg/m3) + 70 kg LC3/m3
- Concrete with minimun cement (350 kg/m3) + 140 kg LC3/m3

Test carried out in concrete

- Ocluded air
- Penetrometer
- Slump
- Compressive strength 24h, 7d, 28d
- Porosity



Use of LC2 as mineral addition to mortar

- LC2 produced with calcined clay from Artemisa and Yigre
- Typical mortar design sand=5, lime=1 and cement=1 (volumen)
- Series : sand=5, lime=1 and cement=0.5, LC2=0.5 (volumen)
- Series 2: sand=5, lime=0 and cement=0.5, LC2=1.5 (volumen)

Test carried out in mortars

- Consistency
- Compressive strength 3d, 7d and 28d
- Porosity
- Bond

Calcining clay at brick kilns

- Clay from Manicaragua used (well known composition)
- Bricks were molded on the workshop and taken raw to CIDEM's lab
- Temperature at the kiln was monitored with thermocouples
- Raw bricks were fired at 700, 800 and 900 oC at a lab oven
- Real bricks were taken as reference
- Bricks were crushed down to poder
- R3 protocol (Icalo, strength)
- Production of LC2
- Cement LC3-50
- Concrete as LC2

I bring some samples of poder for replica at EPFL

Chloride ingress and migration

- Series M381, M25 and M32 laid at coast (< 500 m)
- Series M2, M8, M11 and P laid at coast (< 500 m)
- Same series exposed at second exposure site (500m < d < 2 km)

Test carried out in concrete

- STADIUM
- Porosity

Carbonation

- Series M381, M25 and M32 laid at coast (< 500 m)
- Series M2, M8, M11 and P laid at coast (< 500 m)
- Same series exposed at second exposure site (500m < d < 2 km)
- Series at CIDC (SGR) with 3 different curing time

Tests carried out

- Carbonation depth
- Porosity of both layers
- Sorptivity of both layers

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Air permeability

- Series M381, M25 and M32 laid at coast (< 500 m)
- Series M2, M8, M11 and P laid at coast (< 500 m)
- Same series exposed at second exposure site (500m < d < 2 km)
- Series at CIDC (SGR) with 3 different curing time

Tests carried out

- Air permeability
- Resistivity

Database for concrete standards

» Concrete series H1, H2, H3 and H4, both with OPC and LC3, designed according to prescritions for each exposure class

Muestra	Cemento	Aditivo SIKAPLAST 9100	A/C	Gravilla Purio	Arena Purio	Agua efectiva	Asentam.
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Tests to be carried out:

» Air permeability
» Resistivity
» Carbonation
» Chloride profiles (AgNi)
» Cl profiles (µXRF)
» Porosity
» Sorptivity
» ASTM 1202

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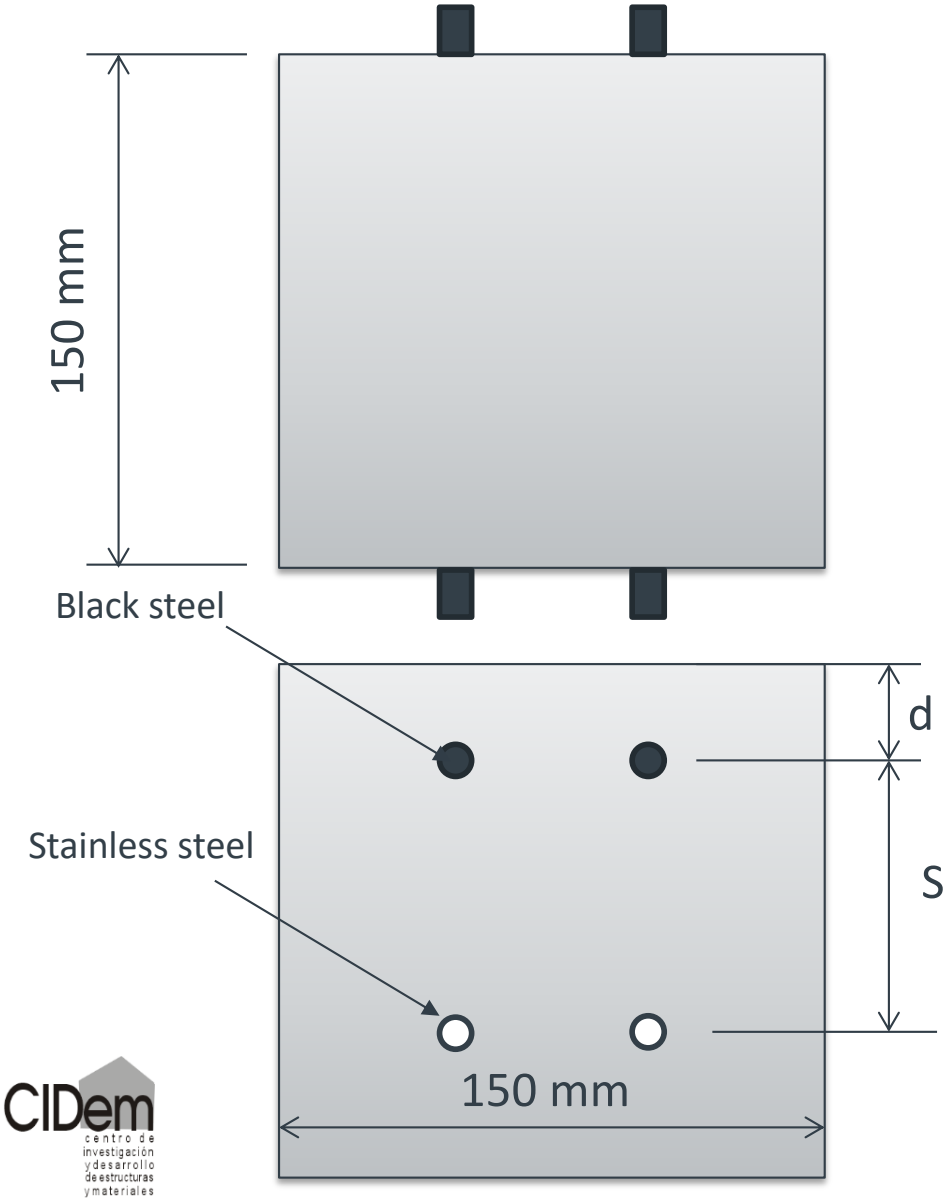
Macro cells corrosion



Conditions:

- d= 15, 30 mm
- S= 7 cm
- 2 replica for every d
- Concrete H1 with P35 and LC3-50
- Concrete block fully carbonated (4% CO_2 until full carbonation). Reference under natural carbonation
- Blocks placed on shelf indoor (RH around 70%)
- Measurement of steel potential and linear polarization resistance (2 measurements per day minimum)
- Measuring time: minimum 2 months

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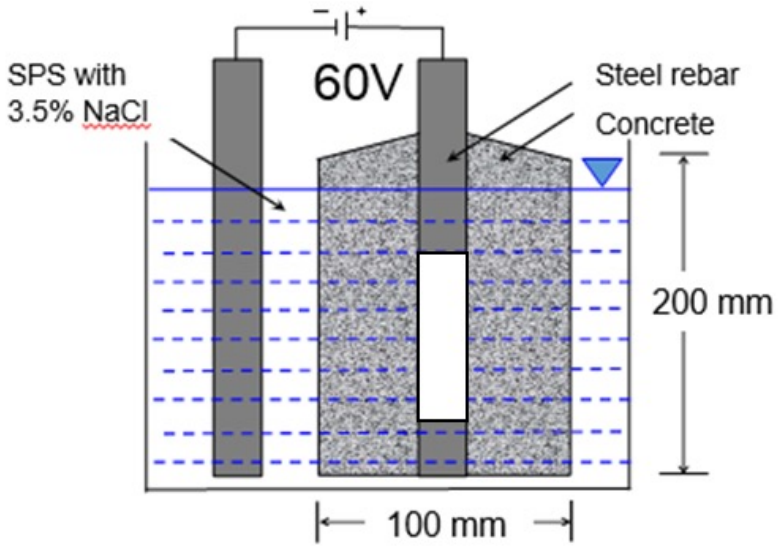
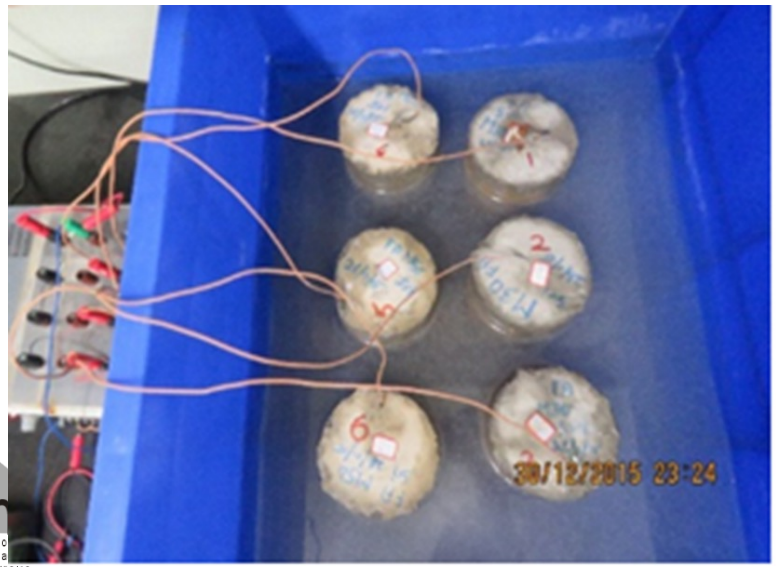
Macro cells corrosion

Impressed current measurement





Conditions:

- To have a preliminary assessment of corrosion induced crack resistance in cementitious systems
- Use of 3 kinds of cements (LC3-50, PP35, P35)
- Mix proportioning for concrete H1 (430 kg/m3 cement)
- 160 mm black Steel
- Applied voltage 60 V

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Limestone Calcined Clay Cement LC3

LOW CARBON LOW COST LOW CAPITAL

Thank you