Low Carbon Concrete Production

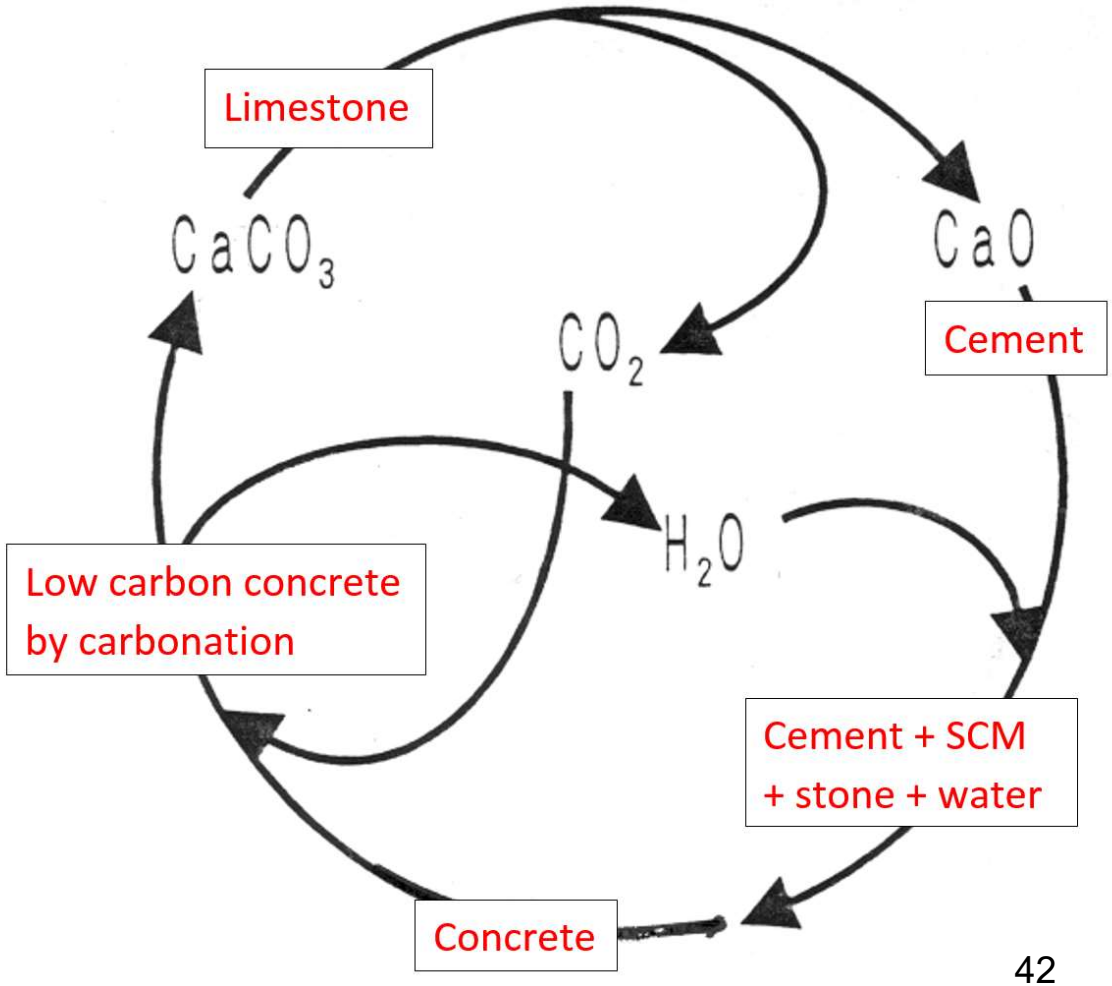
Yixin Shao, Zaid Ghouleh and Subhasis Ghoshal

Department of Civil Engineering
McGill University
Montreal, Canada

Concrete

- **The most used construction material:**
  - Annual production of cement in Canada: 10Mt
  - Annual production of concrete in Canada: 60Mt
- **The carbon emission-intensive material:**
  - One ton cement emits 0.8 ton CO_2
  - Canadian cement industry emits 8 Mt CO_2/year
- **Low carbon concrete strategy:**
  - Use supplementary cementitious materials (SCM such as Fly ash and slag) to partially replace cement
  - Use carbon dioxide to activate early strength, at the same time sequester CO_2 in concrete

Closed System of Calcium Compound: Low carbon concrete



Converting CO_2 into $CaCO_3$ by Carbonation Reaction

- **After concrete is formed and CO_2 gas is injected into the concrete during curing:**
  - $3CaO \bullet SiO_2 + 3CO_2 + \mu H_2O \rightarrow 3CaO \bullet 2SiO_2 \bullet 3H_2O + 3CaCO_3$
  - $2CaO \bullet SiO_2 + 2CO_2 + \mu H_2O \rightarrow 3CaO \bullet 2SiO_2 \bullet 3H_2O + 2CaCO_3$
  - $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$
  - $3CaO \bullet 2SiO_2 \bullet 3H_2O + 3CO_2 \rightarrow 3CaCO_3 + 2SiO_2 \bullet 3H_2O$

Concrete Products for CO_2 Conversion

Masonry blocks

Fiber-cement panels

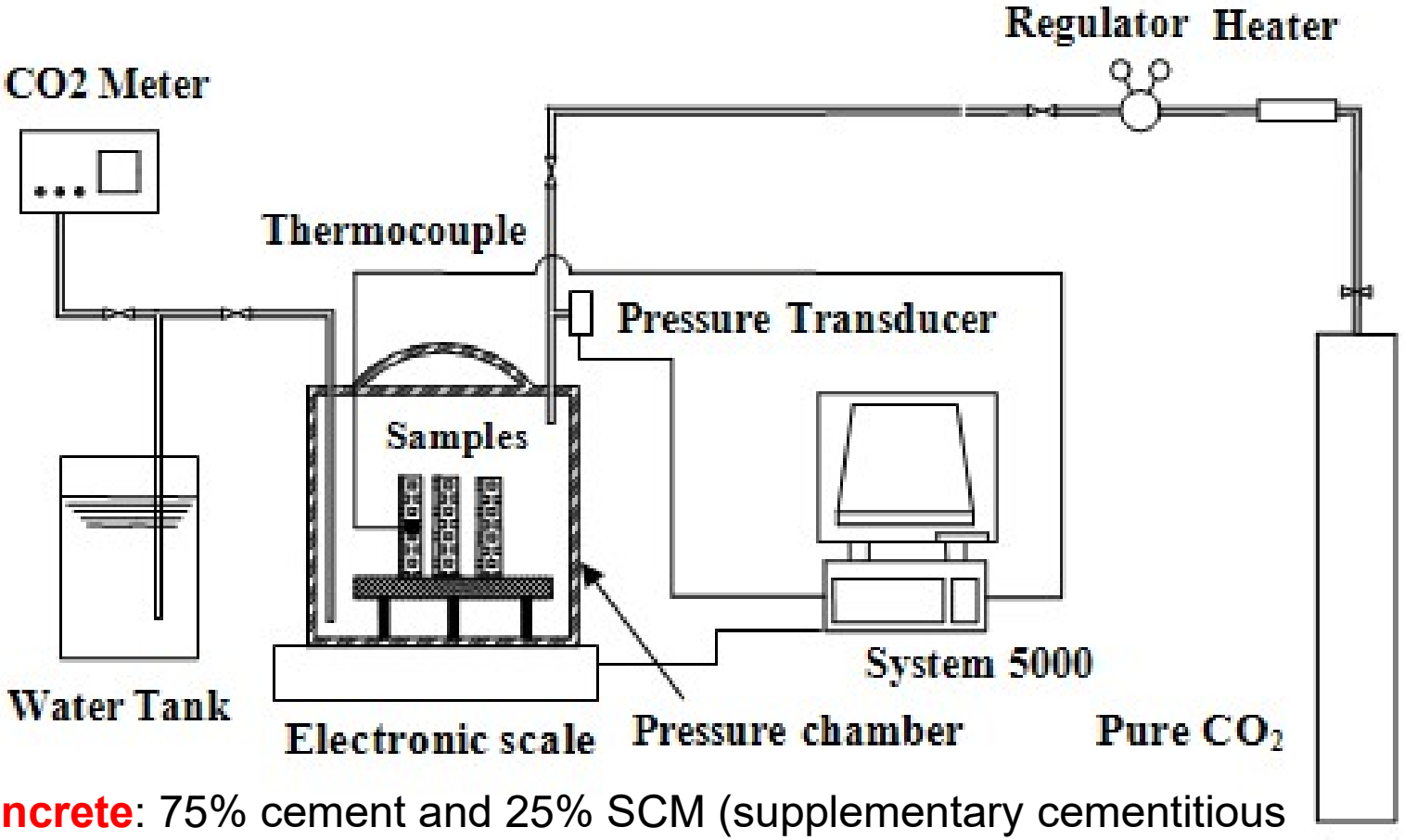
Prefabricated buildings

Precast hollowcore

Hollow-core slab

Concrete pipes

Carbonation Curing Process



Concrete: 75% cement and 25% SCM (supplementary cementitious materials)

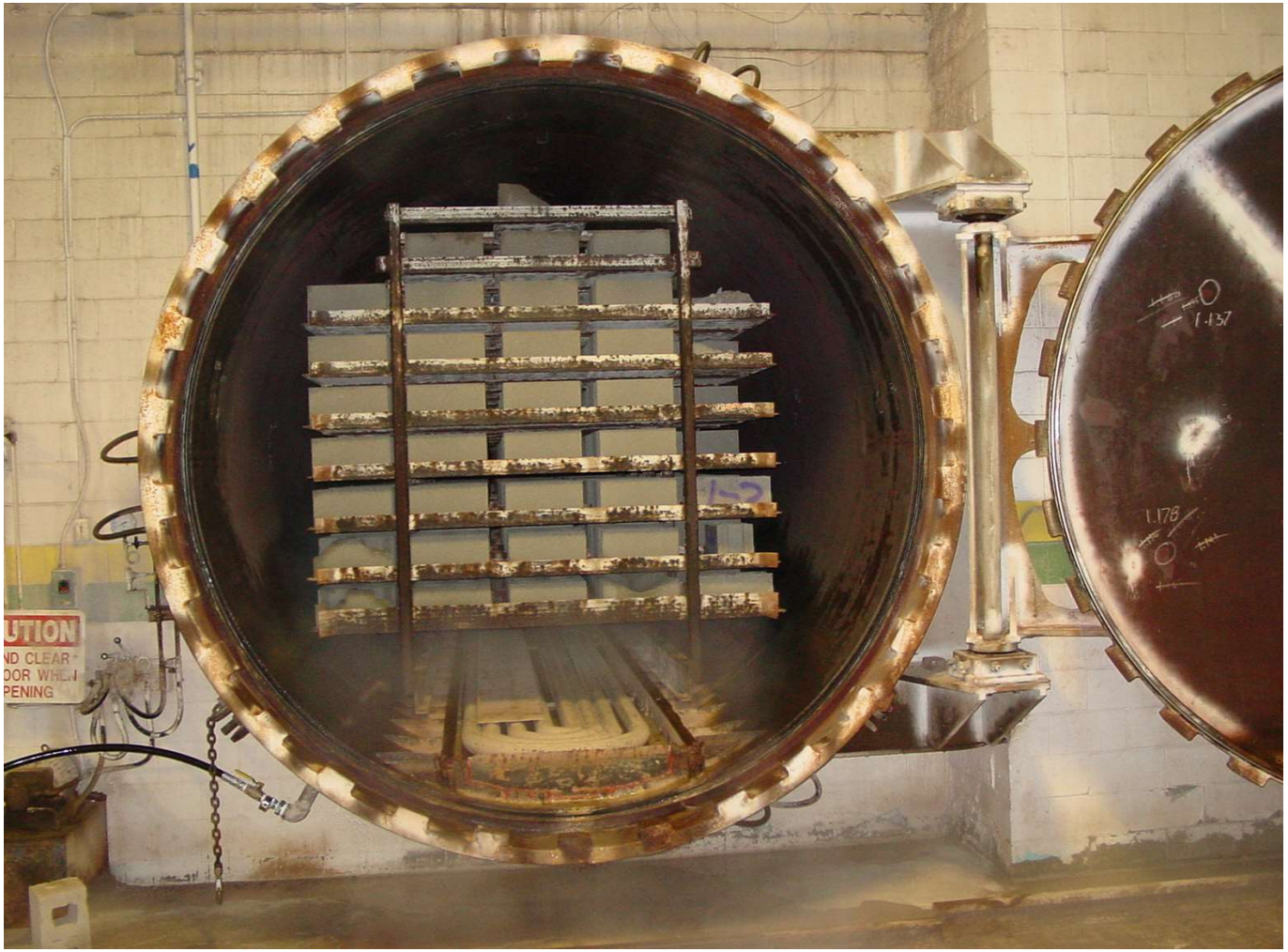
Carbonation process: pressure=0.5 bar, time=2-4 h

Carbon dioxide uptake by concrete: 20% of cementitious binder mass

Full Scale Production of Concrete Blocks

Boehmers Blocks in Ontario with 5 autoclaves
Concrete blocks: normal weight, lightweight, high strength
Autoclave process will be replaced by carbonation process

Full Scale Production



CO_2 Gas: By-Product of Ethanol Production

Carbonated and Autoclaved Blocks

Low Carbon Concrete Blocks

	Conventional block	Low carbon block
Cement (kg)	2.3	1.73
SCM (kg)	0	0.57
Stone (kg)	14.5	14.5
Water (kg)	1.1	1.1
Total mass (kg)	17.9	17.9
CO2 emission due to cement (kg)	1.84	1.38
CO2 reduction due to SCM (kg)	0	-0.46
CO2 reduction due to uptake (kg)	0	-0.46
Net CO2 emission per block (kg)	1.84	0.46
Percent CO2 reduction	0	75%
Strength (MPa)	25	33

Benefits of Low Carbon Concrete

- **Environmental:**
  - Carbon emission reduction up to 75% in comparison to conventional products
- **Technical:**
  - Accelerated early strength
  - Improved durability due to the formation of nano-$CaCO_3$ crystals
- **Economical:**
  - Low cement and low embodied energy
  - Steam can be replaced by carbon dioxide

An Emerging Industry for Low Carbon Concrete

- **Carboclave Technology, (a spin-off from Boehmers Blocks), Ontario, Canada.**
- **CarbonCure Technology, Halifax, Canada**
- **Carbicrete Technology, Montreal, Canada**
- **Solidia Technology, NJ, USA**

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