

# **Low Carbon Concrete Production**

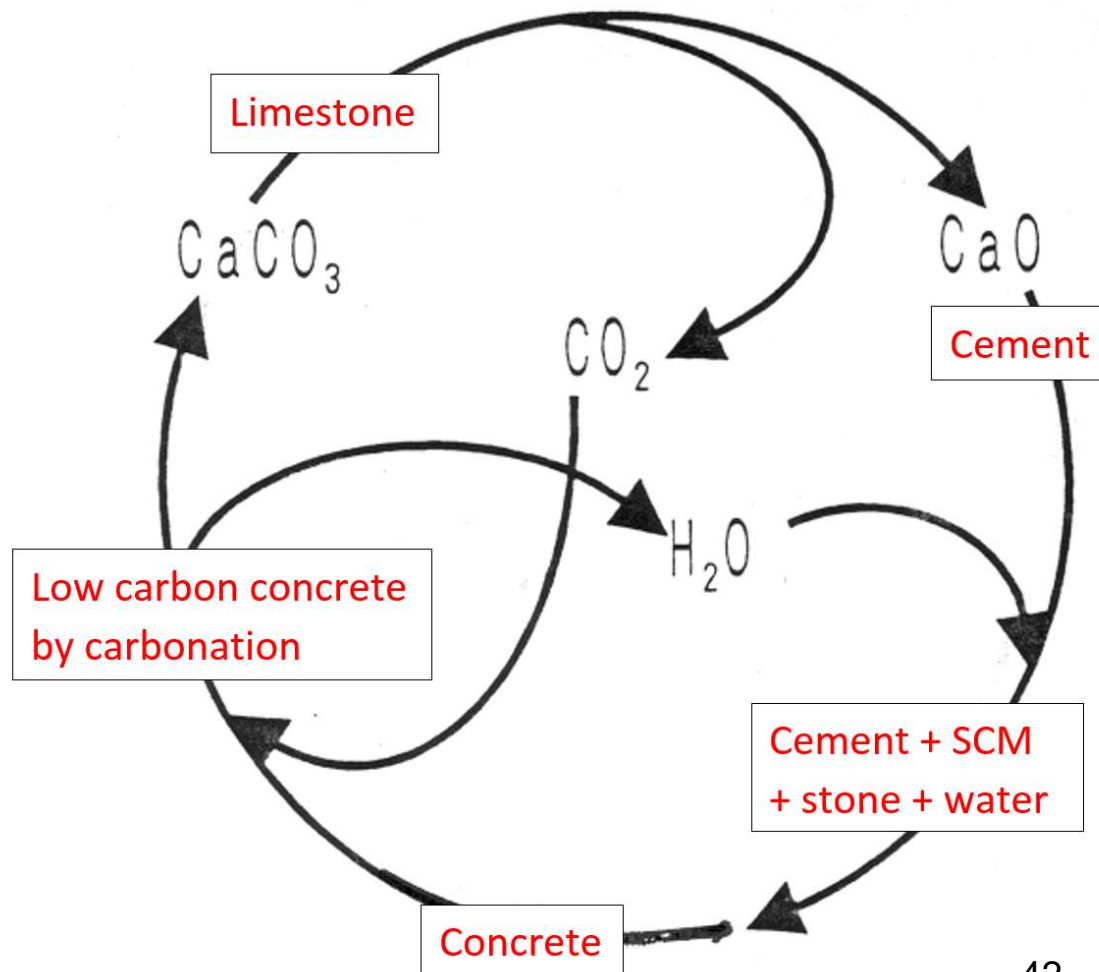
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# Concrete

- **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<sub>2</sub>
  - Canadian cement industry emits 8 Mt CO<sub>2</sub>/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<sub>2</sub> in concrete

# Closed System of Calcium Compound: Low carbon concrete



# Converting CO<sub>2</sub> into CaCO<sub>3</sub> by Carbonation Reaction

- After concrete is formed and CO<sub>2</sub> gas is injected into the concrete during curing:
  - $3\text{CaO} \bullet \text{SiO}_2 + 3\text{CO}_2 + \mu\text{H}_2\text{O} \rightarrow 3\text{CaO} \bullet 2\text{SiO}_2 \bullet 3\text{H}_2\text{O} + 3\text{CaCO}_3$
  - $2\text{CaO} \bullet \text{SiO}_2 + 2\text{CO}_2 + \mu\text{H}_2\text{O} \rightarrow 3\text{CaO} \bullet 2\text{SiO}_2 \bullet 3\text{H}_2\text{O} + 2\text{CaCO}_3$
  - $\text{Ca}(\text{OH})_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$
  - $3\text{CaO} \bullet 2\text{SiO}_2 \bullet 3\text{H}_2\text{O} + 3\text{CO}_2 \rightarrow 3\text{CaCO}_3 + 2\text{SiO}_2 \bullet 3\text{H}_2\text{O}$

# Concrete Products for CO<sub>2</sub> Conversion



Masonry blocks



Fiber-cement panels

Prefabricated  
buildings



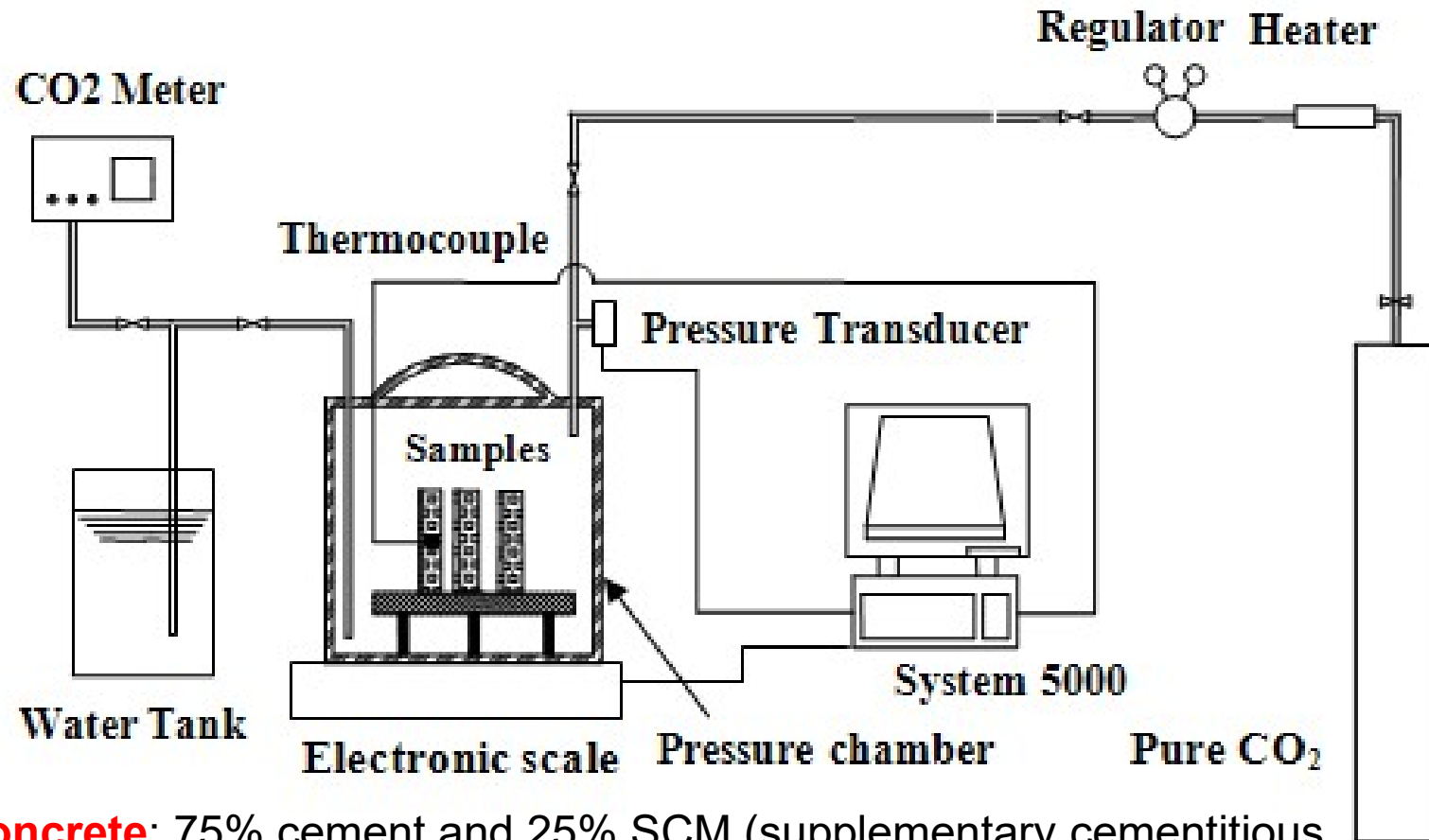
Precast hollowcore

**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

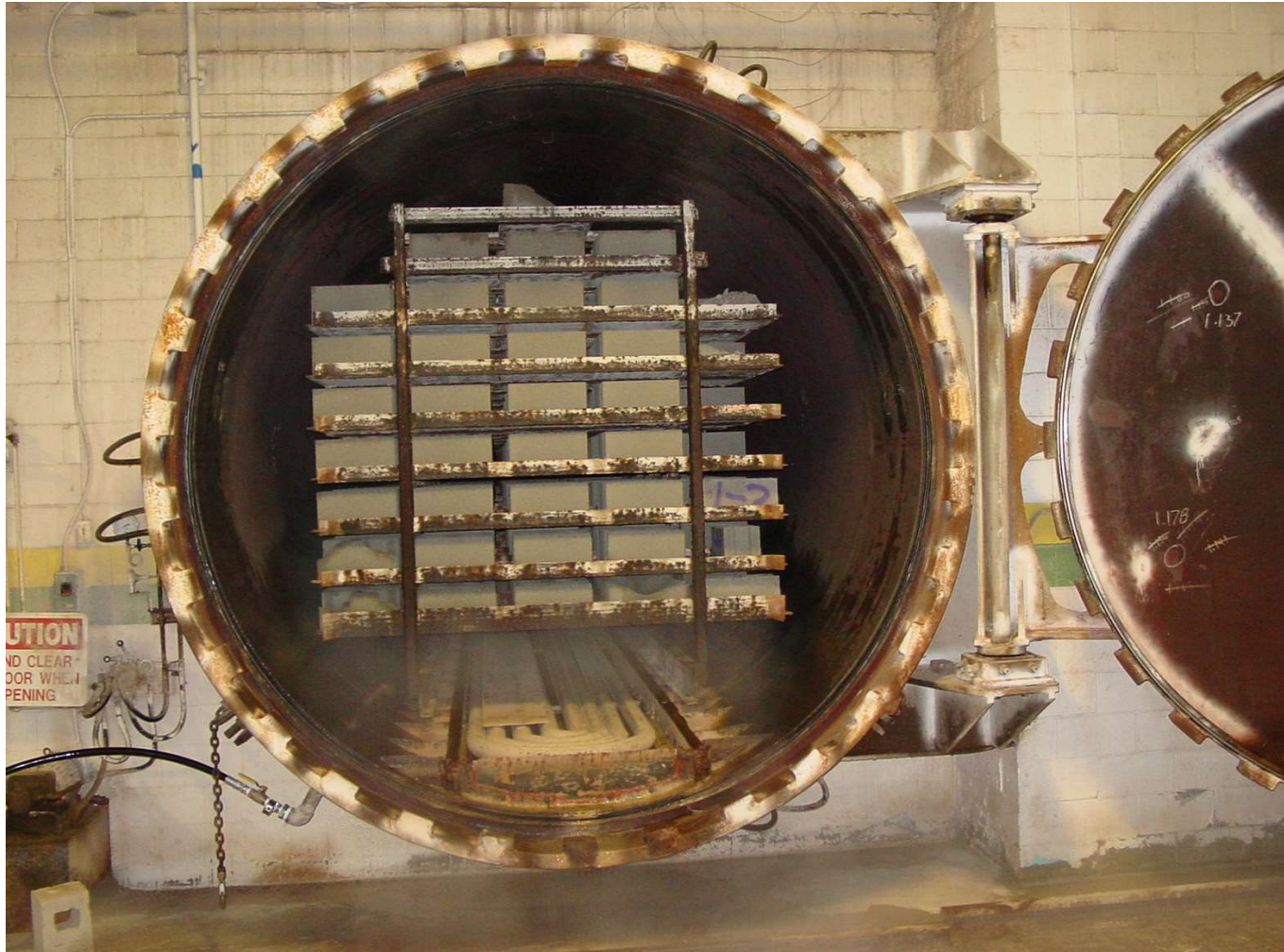


Boehmers Blocks in Ontario with 5 autoclaves

Concrete blocks: normal weight, lightweight, high strength

Autoclave process will be replaced by carbonation process

# Full Scale Production





# CO2 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<sub>3</sub> 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**

# Acknowledgment

- **NSERC Discovery Grants**
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- **FRQNT Team Project Grants**
- **US DOE CO2 Utilization Grants**
- **St Lawrence Cement**
- **Boehmers Blocks**
- **Canadian Concrete Masonry Producers Association (CCMPA)**