Carbonaide

transforms CO_2 into a rock-solid concrete

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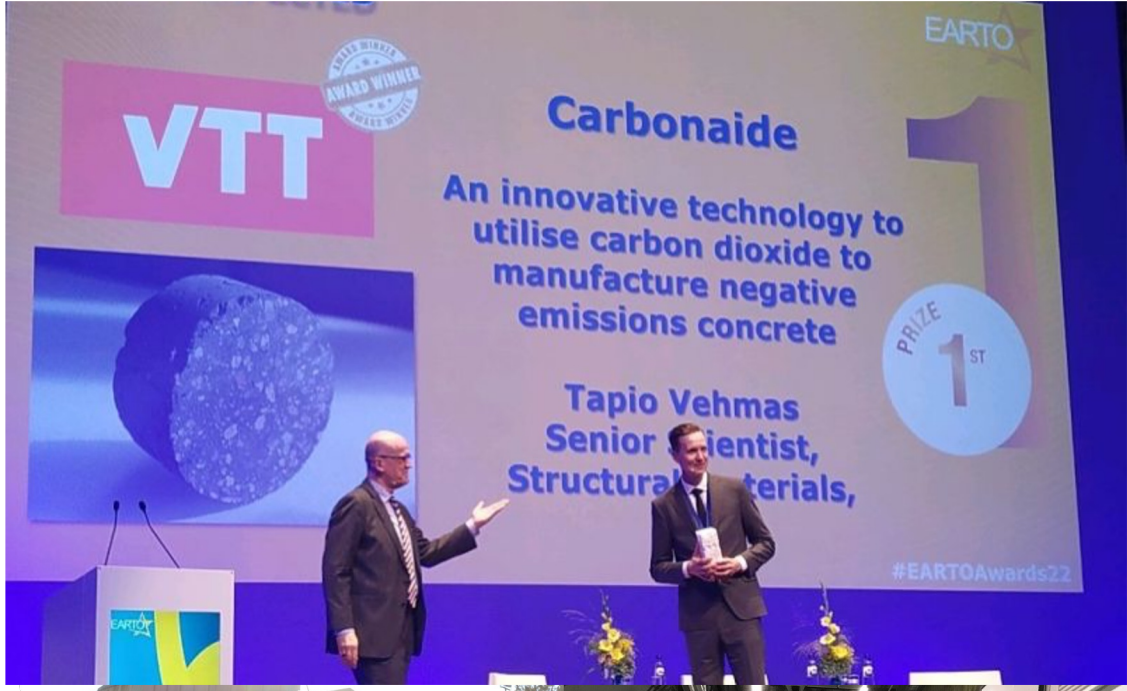
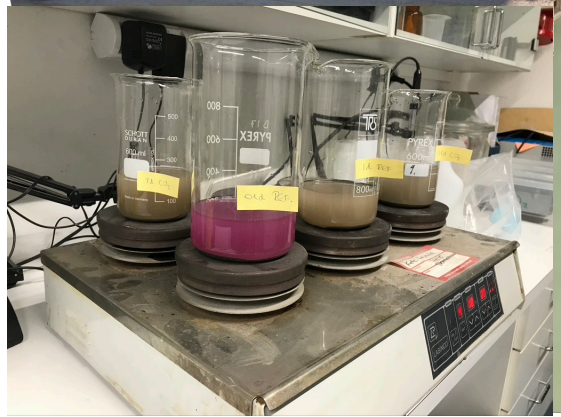
Introduction Carbon Curing

- Carbon curing is a process where concrete is exposed to carbon dioxide (CO_2) during hardening process.
- Hardening concrete reacts with CO_2 and forms various carbonates.
- Carbonates are minerals where CO2 is permanently stored.
- Formation of carbonate minerals is also very beneficial for concrete.
- The process combines Carbon dioxide reuse and storage (CCUS).

Introduction Carbonaide

- Technical Research Centre of Finland (VTT) has developed an effective carbon curing technology for precast concrete industry.
- Technology is further commercialized by VTT spin-off Carbonaide Oy.





Carbonaide Factory Unit

- First industrial scale Carbonaide unit is retrofitted in Finnish concrete production line in Hollola Finland.
- Two curing units have total production pallet capacity 430.
- Maximum CO2 consumption is up to 5 tons per day.

Carbonaide mission

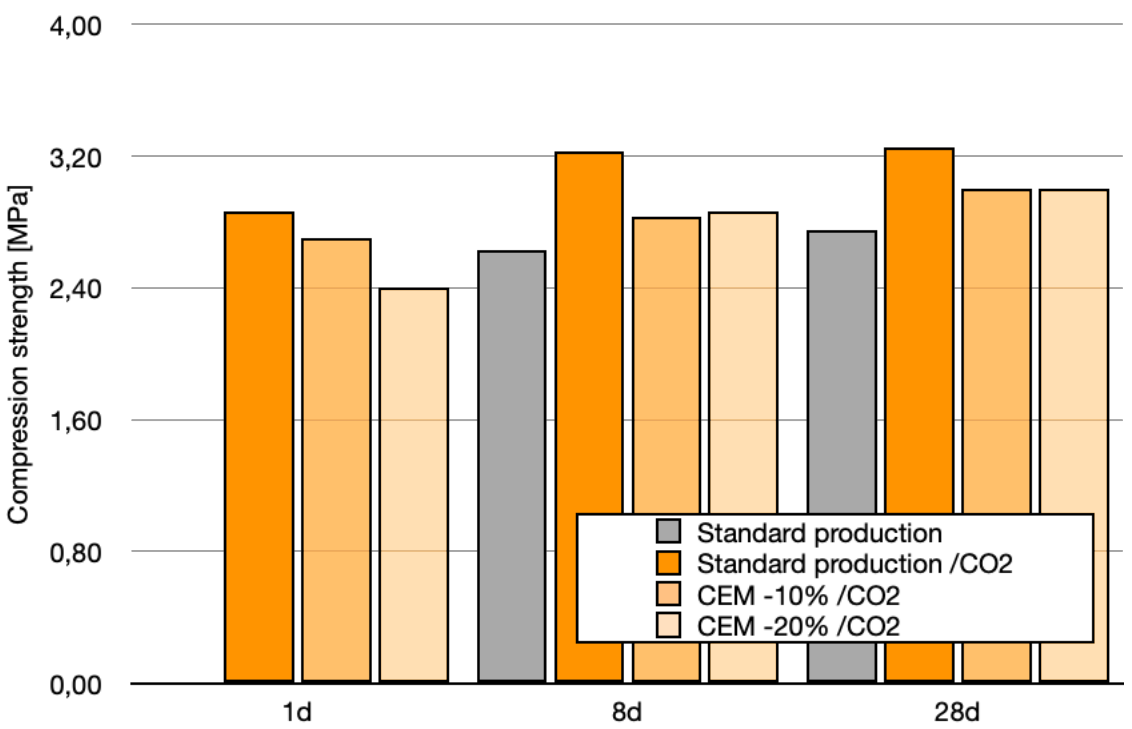
- Carbonaide’s mission is to enable carbon curing in pre-cast concrete production.
- Carbonaide will take care of the issues that are not directly related to concrete manufacturing.
  - Plant can operate normally without extra workload.
- Carbonaide’s duties
  - CO_2 sourcing and valorization.
  - Safety related aspects.
  - Life cycle analysis and verifications.
  - SCM and alternative binder availability


Technical observations

Replace Portland cement with CO_2

- Carbon dioxide replaces cement in matured concrete.
- Carbon cured concrete has higher compression strength in 28 days.
- Strength increase enables cement reduction >20%, depending on the application.
- Carbonaide's method densifies microstructure via
  - Formation of reactive calcium carbonate and carboaluminates.
  - Increased pozzolanity and activation of Belite.
- The ultimate strength increase is sensitive on selected carbon curing method.

Experimental results



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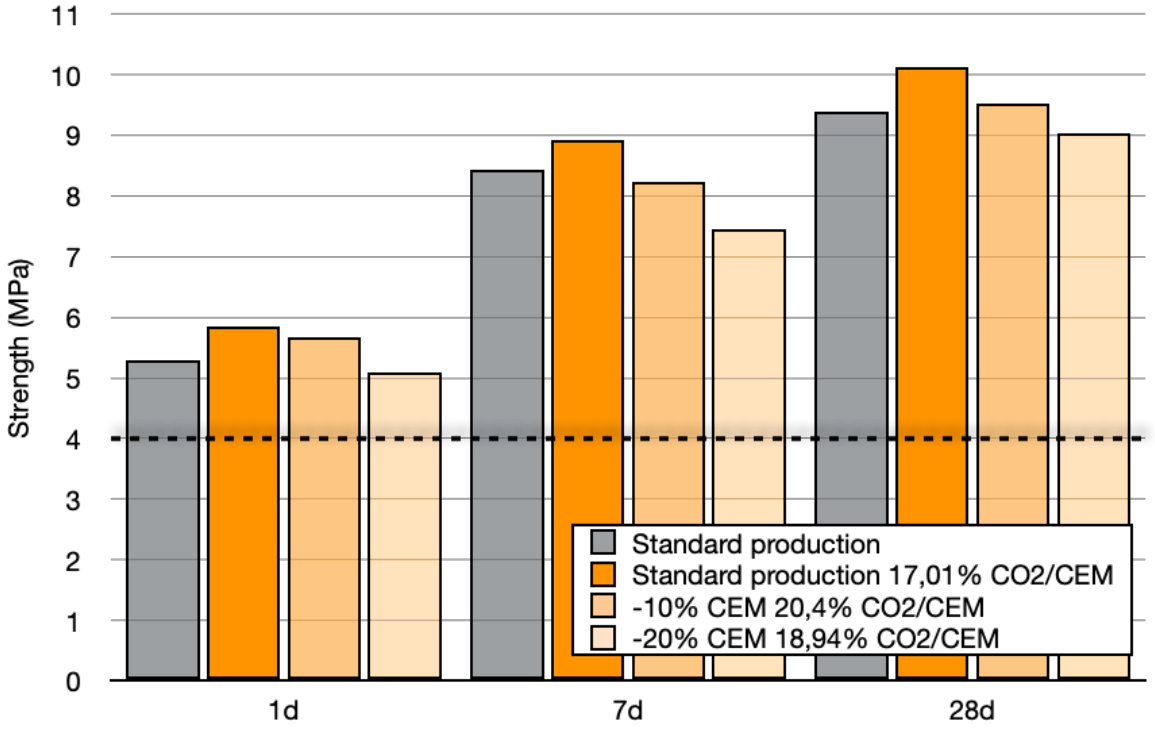
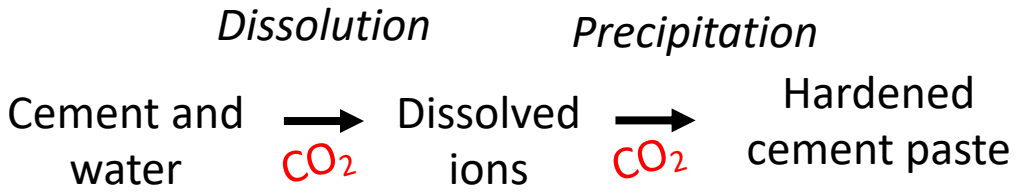


Pavements

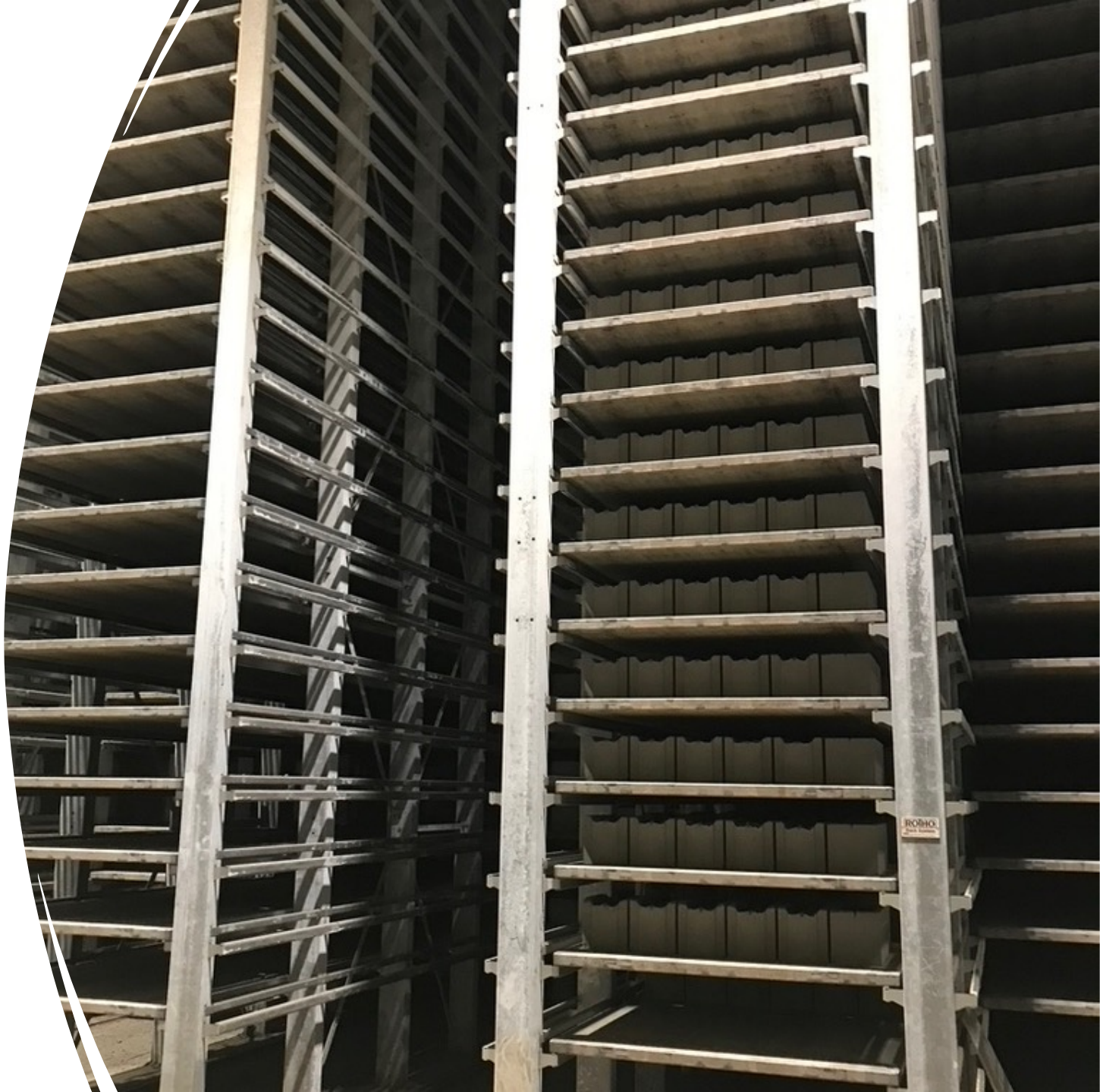
Accelerated strength development

- CO_2 is a powerful accelerator for concrete.
- CO_2 reacts with Ca^{2+} forming nanosized calcium carbonates that acts as nucleation sites for further process.
- CO_2 activates dissolution of cement phases.



Reduced effloresence

- Carbonation bounds free lime into concrete products that eliminates calcium-based efflorescence. (hard efflorescence)



New SCM's and binders

- Carbon curing enable use of supplementary cementitious materials that are based on carbonization.
  - Calcium-rich ashes (CaO) e.g. biobased ashes etc..
- Slags that are non-reactive in traditional concrete technology.
  - Stainless steel slags, etc...
  - Belite slags
- **Carbon negative concrete.**

Technical CO2 storage

- Carbon curing forms “Technical carbon storage”.
- Carbon storage has been formed in cement manufacturing.
- The storage is not currently used.
- The storage is possible to commercialize.
  - Receiving CO2 from EU-ETS regulated emission sources.
  - Buying biogenic CO2 and generation of CDR for third parties.

FAQ: Durability

Table 1. Effect of carbonation curing on the durability of concrete.

Carbonation Time (h)	Durability Index	Improvement	References
2	Frost resistance	+55%	[27]
12	Surface resistivity	+608%	[76]
	Resistance to chloride ion attack	+34%	
6	Water absorption rate	−66.5%	[29]
	Resistance to chloride ion attack	+42.7%	
12	Porosity	−2%	[75]
	Surface resistivity	+734%	
	Resistance to chloride ion attack	+53.8%	

FAQ: Steam vs. Carbon curing

Table 2. Comparison of the effects of carbonation curing and steam curing [27].

Methods	Compressive Strength (MPa)		Electric Flux (C)		Surface Resistivity (kΩ cm)	Mass Loss Rate of Freeze–Thaw Cycles (%)		Permeability (s)
	20h	28d	2d	28d		10%	20%	
Steam Curing	26.5	36.8	9861	6028	13.4	16.4	67.7	61
Carbonation Curing	23.3	38.9	2898	965	42.7	0.3	8.6	391
Standard Curing	17.0	22.1	4386	1321	41.3	6.5	19.2	155

Thank you!

"We are the first generation to feel the impact of climate change and the last to be able to do anything about it."

-Barack Obama-

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