CO_2-cured Aerated Concrete – 0.55 g/cm^3 density (*without a need for an autoclave*)

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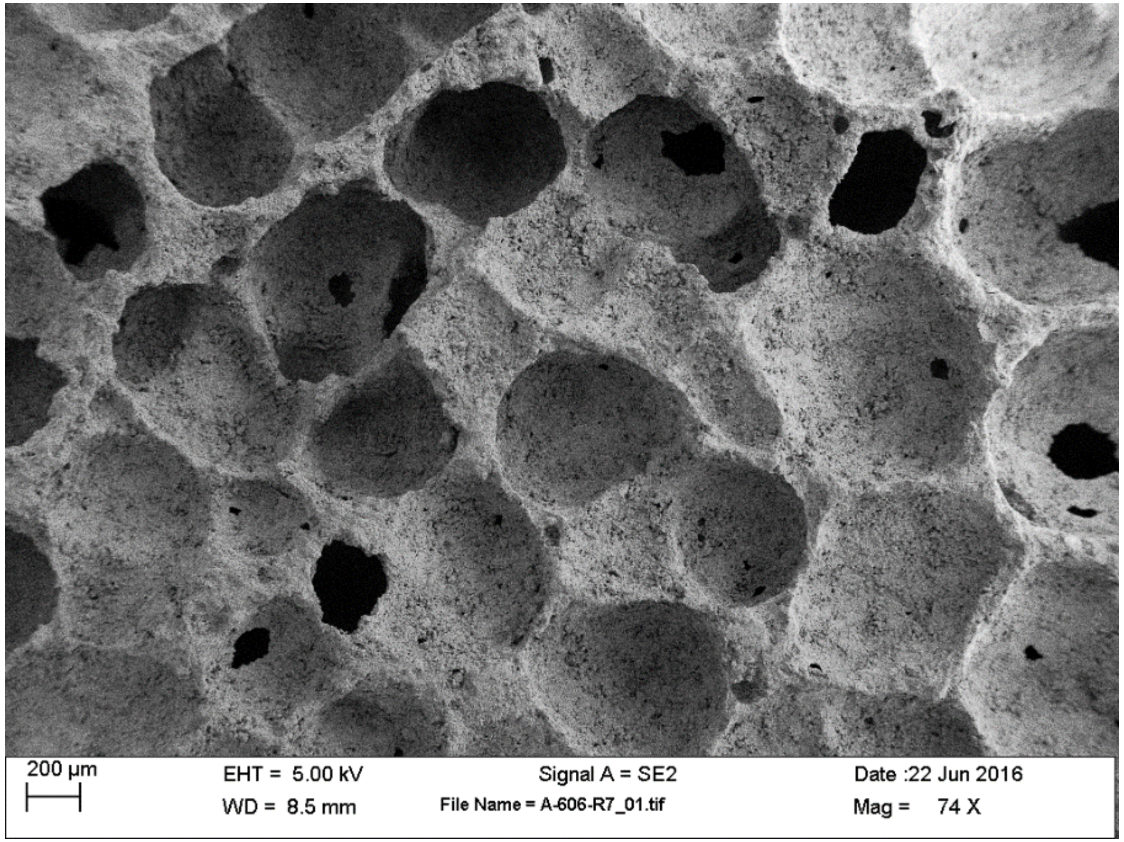
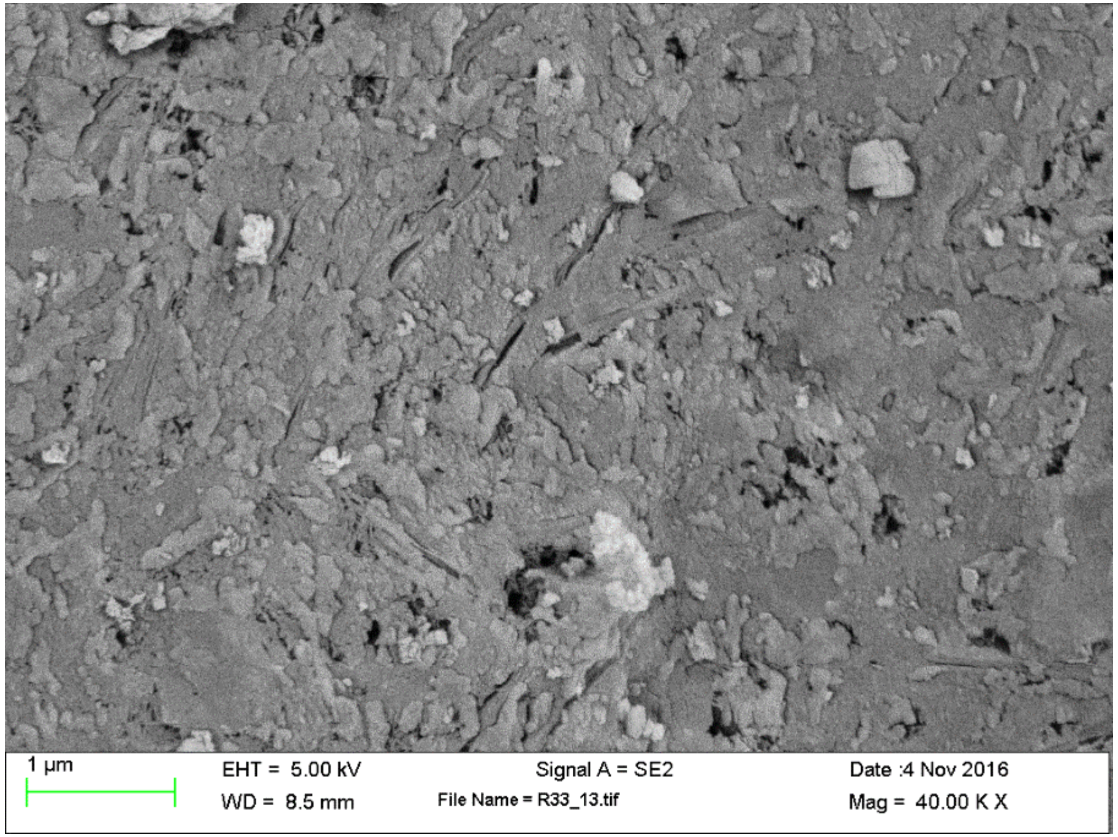
(Principal of the Solidia Technologies-aerated project from July 2015 to Sep 2017)



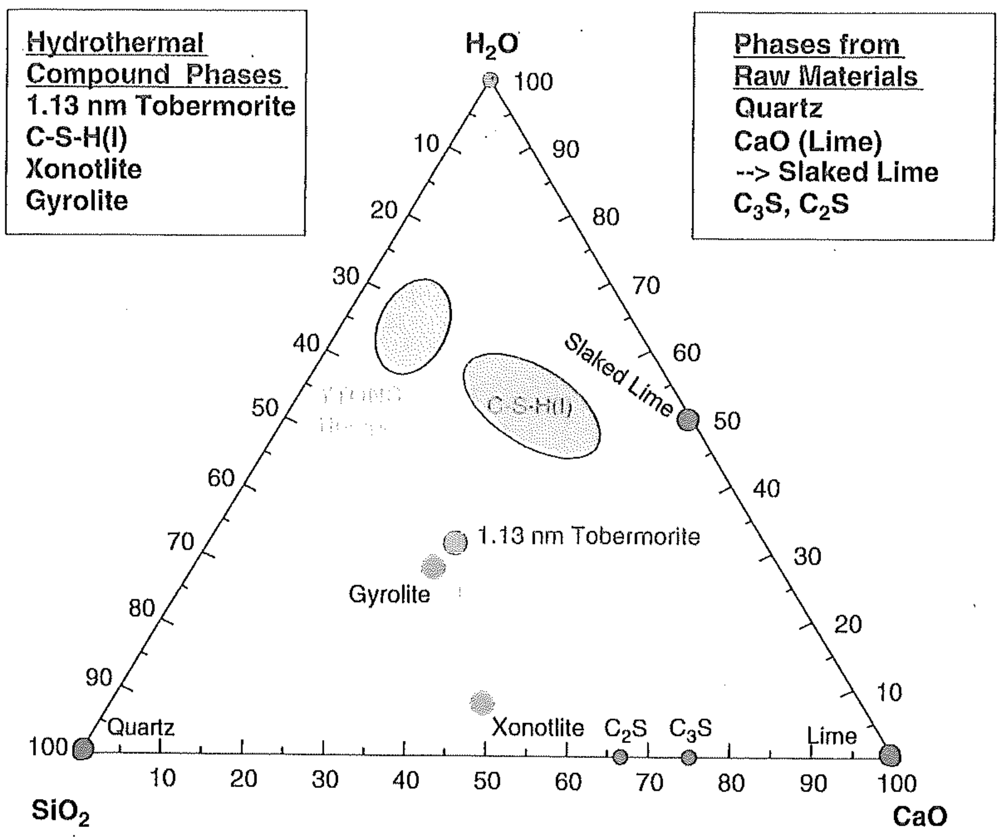
low mag
(macropores)



high mag
(CaCO3)

Differences between AAC and Solidia Aerated Concrete

(conventional) AAC



AAC uses silica (mainly quartz) as a "chemical reactant," and its hydrothermal reactions consume and transform more than 98% of that silica into the crystalline phase of "1.13 nm" **tobermorite**.

Solidia Aerated Concrete

Uses "CaO (quicklime) → slaked lime" reaction and the presence of a small quantity of "MgO + MagCet" as well as about 5 to 6% high reactivity OPC powder to generate green strength in the uncarbonated foam (for the precuring step).

Solidia cement powder does not have the C_3S phase. Solidia cement powder contains the carbonatable crystalline phases of CS, C3S2 and C2S (very small amount).

During the carbonation-curing step with CO_2(g), CS, C2S and C3S2 react to produce
(a) non-crystalline,Ca-deficient silicate, and
(b) crystalline $CaCO_3$ (calcite and aragonite).

The extent of 3D interlocking and intermingling between the non-crystalline silicate, sand and well-crystallized CaCO3 (aragonite whiskers + calcite) is responsible from the strength generation.

Conventional AAC and Solidia Aerated Concrete used the same steps of production

(1) **Milling** of the quartz sand to the desired particle size (Solidia case: mixing of MgO powder with sand at this step)
(2) Selecting and using the suitable **CaO** (with the right slaking (CaO → Ca(OH)2) time) and **Al** powders
(3) Selecting and using the suitable **surfactant** and **superplasticizer**
(4) Preparation of a **slurry** with OPC (or Solidia cement and MagCet), sand, CaO, Al, superplasticizer, surfactant to Reach the targeted **slurry density** and **viscosity** at the proper **temperature** of slurry casting into the 7 m L, 1 m W, 0.70 m H steel (with lubricated inner surfaces) molds (the largest mold Solidia used: 0.95 m L x 0.60 m W x 0.70 m H)
(5) **Foaming** of the cast slurry (in the mold) at the targeted rate (around 45 minutes from the moment of slurry casting); the rise of the foam shall autogenously stop at the top of the mold
(6) **Precuring** (5 to 6 h) at around 40°C in air
(7) **Demolding**
(8) **Wire-cutting** of the monolith into the desired smaller sizes before curing in autoclaves (at 11 atm and 185°C) for 8 to 12 h; in the case of Solidia Aerated after wire-cutting, strengthening is performed in CO2 at 1 atm chamber P
(9) **Shrink-wrapping** of the product on the storage+transportation pallets (to protect them from capturing moisture)

- Industrial AAC production video clips:
  https://www.youtube.com/watch?v=Q4f3lBT4bYw
  https://www.youtube.com/watch?v=kwBuSGdZWpI

- Dimensions of aerated blocks/panels are so determined that every piece can be carried/handled by one masonry worker easily without using any lifting tool/ equipment.

Solidia Aerated Concrete -- optimized SLURRY FORMULATION

1.) Solidia cement powder (x_1% of solids)

2.) CaO (*with a suitable slaking curve*) (x_2%)

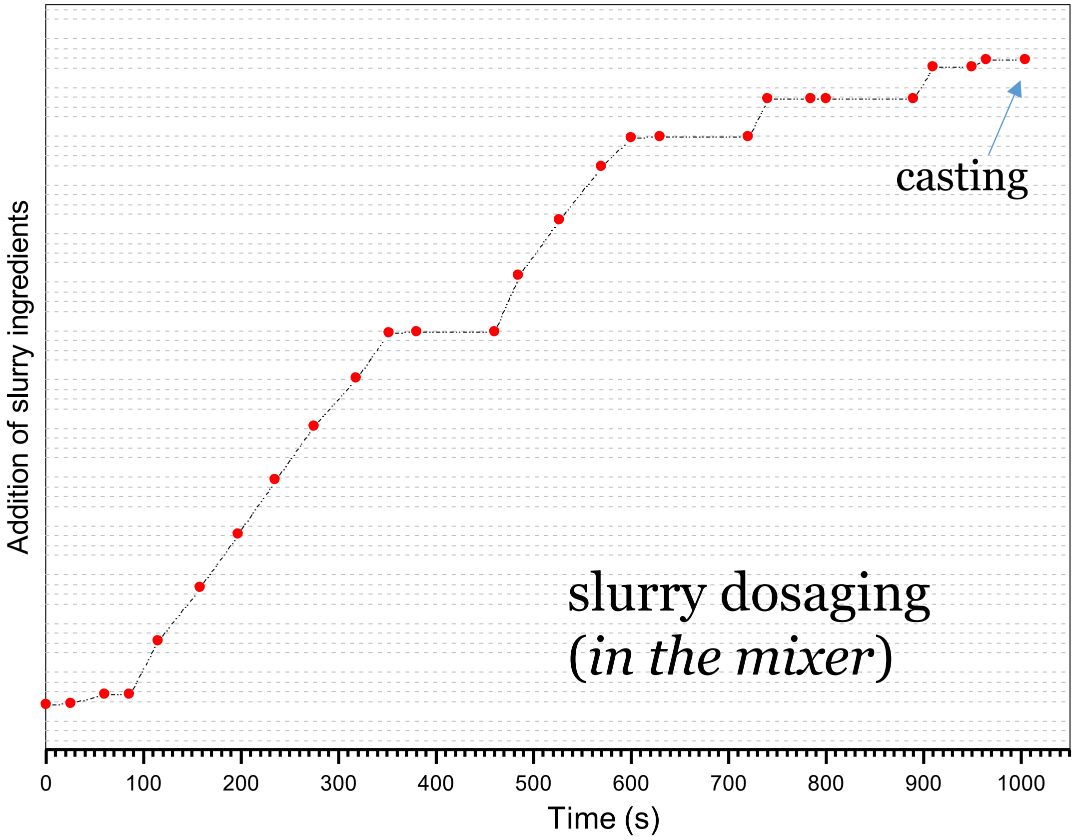
3.) small amount of OPC powder (x_3%)

4.) fine sand (x_4%)

5.) Al powder (<0.1%), added 30 s before cast

6.) MagCet solution (<0.6%)

7.) surfactant



8.) Liquid/solid (L/S) ratio: 0.35 to 0.38, including our own MagCet solution

9.) Water-reducer: 0.4 to 0.5% of solids

10.) max slurry casting T: 35-37°C

- **Porosity** of Solidia aerated concrete: **82 to 85%,** exactly matching that of conventional AAC
- Sand was a **filler**, not a **reactant** in the Solidia aerated concrete.

Spherical pores are formed by the H2 gas generated, according to the reactions below.

CaO (s) + H_2O (l) = $Ca(OH)_2$ $\rightarrow$ Ca^{2+}(aq)

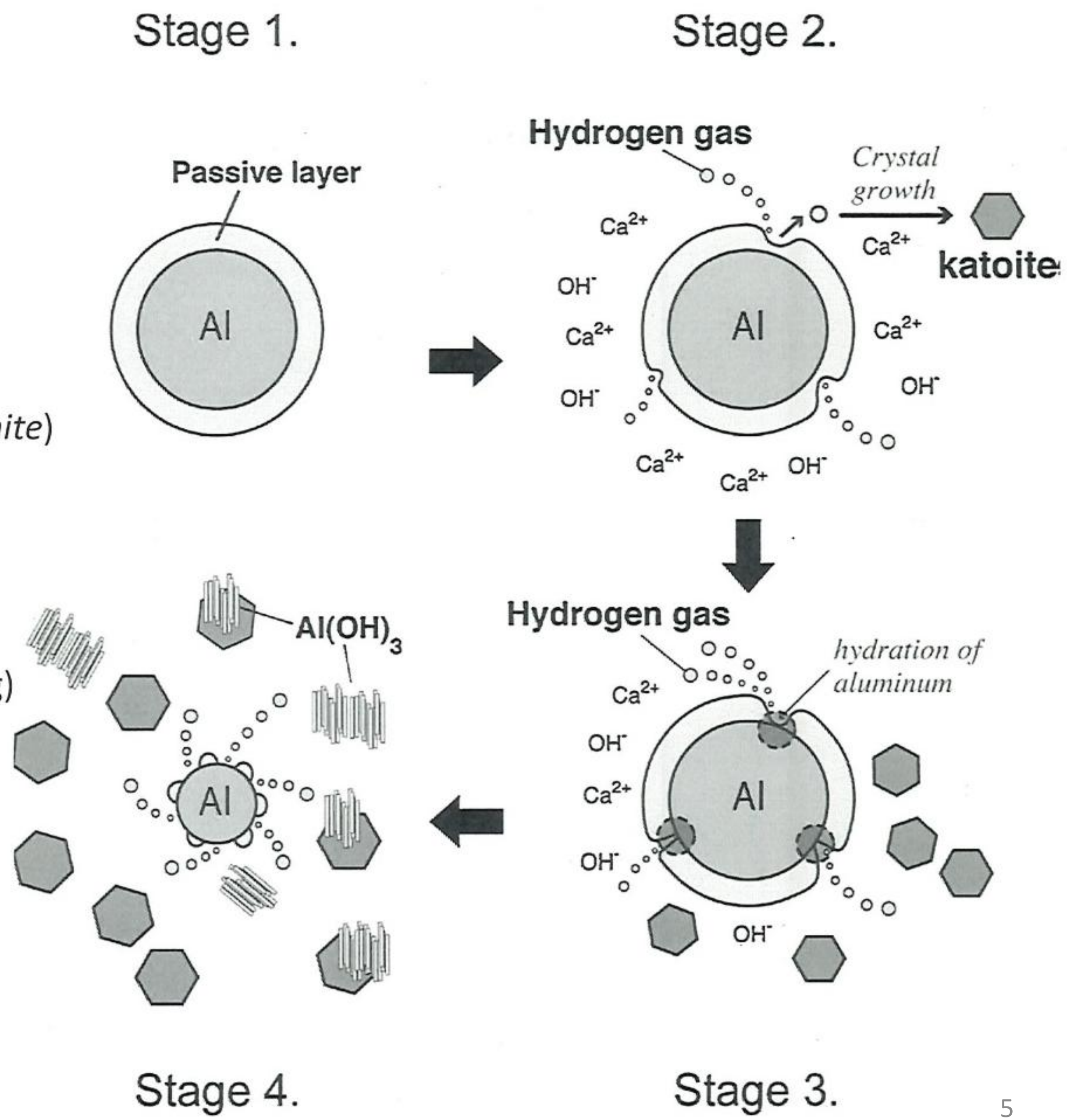
Al particle surfaces are already coated with Al_2O_3.

Al_2O_3 (s) + H_2O (l) $\leftarrow$ *having CaO-Ca(OH)2* = 2AlOOH (s) (*boehmite*)

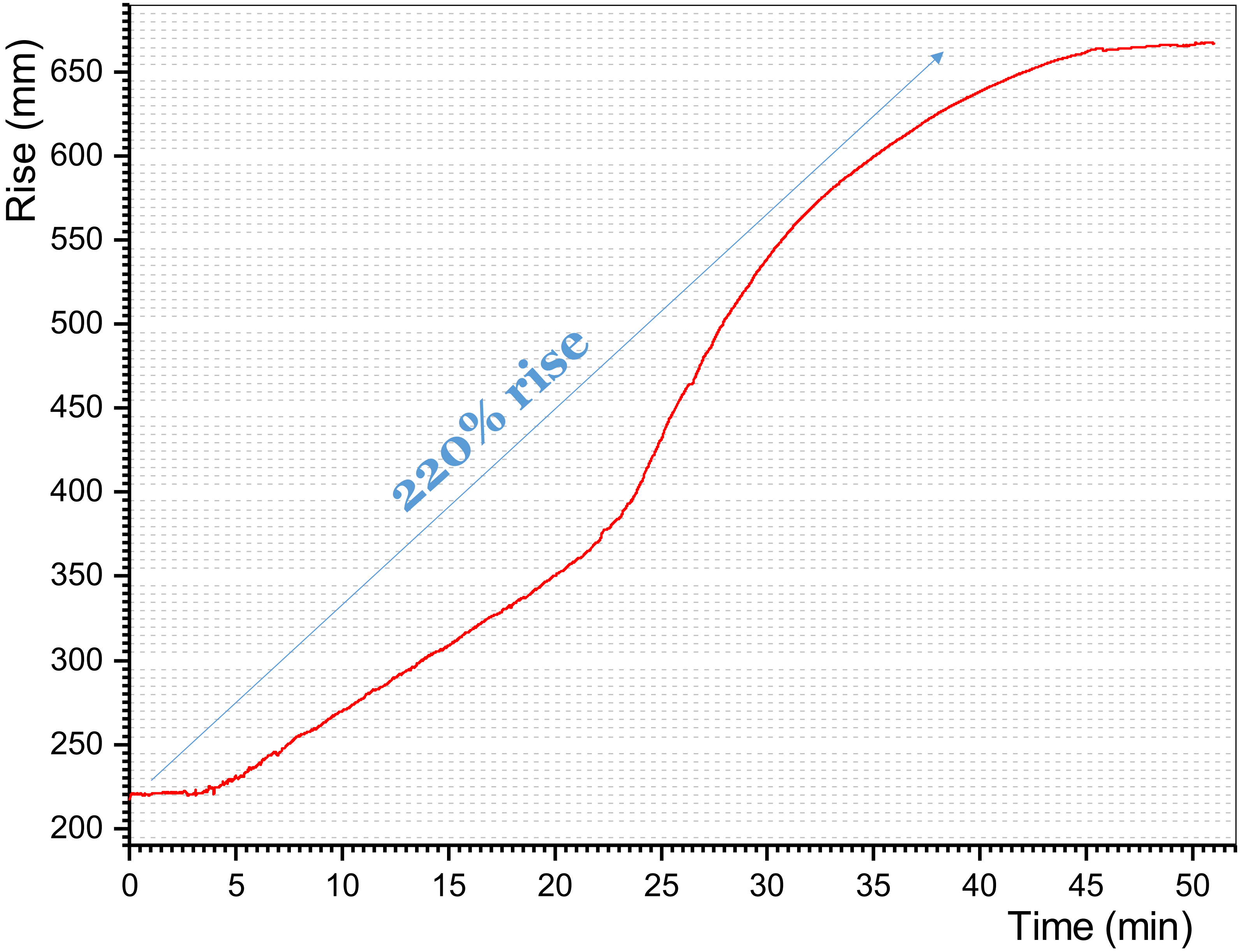
AlOOH (s) + H_2O (l) = $Al(OH)_3$ (*hydrargillite or gibbsite*)

$Al(OH)_3$ (s) + OH^- (aq) = $Al(OH)_4^-$ (aq) *proceeds partially*

$3Ca^{2+}$ (aq) + $2Al(OH)_4^-$ (aq) + $8H_2O$(l) = $Ca_3Al_2(OH)_{12-x}$ + 6$\mathbf{H_2}$ (g)



Solidia Aerated Concrete – SLURRY FOAMING

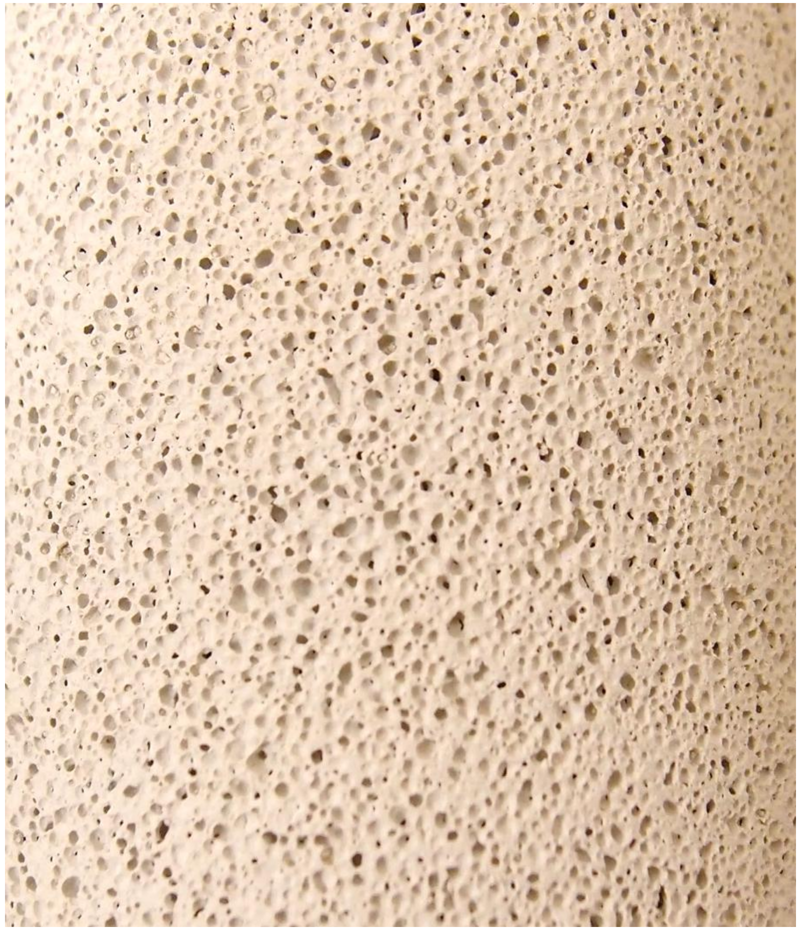


measured
by a laser beam
in real time

Solidia Aerated Concrete -- macro- and microstructure compared with that of conventional AAC

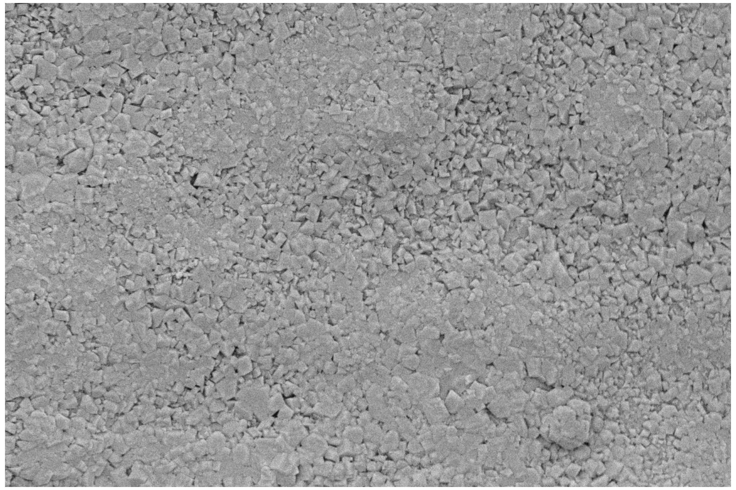
40 mm

Solidia-aerated, 550 kg/m^3, 5.2 MPa



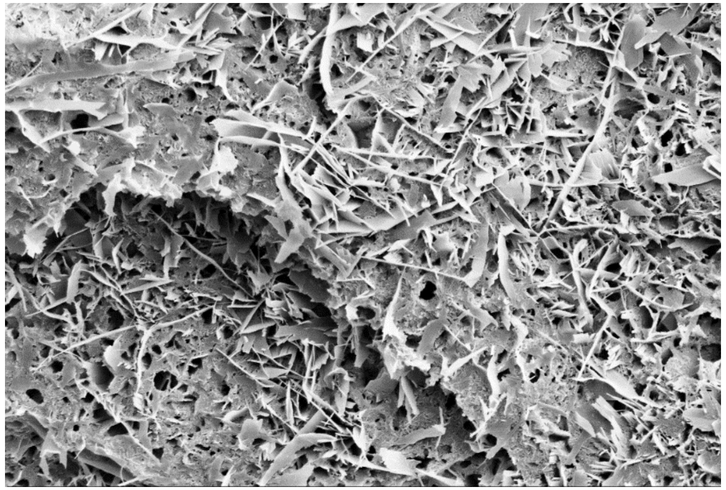
40 mm

Conventional AAC, 540 kg/m^3, 5.3 MPa



27 μm

Solidia aerated, $CaCO_3$ crystals

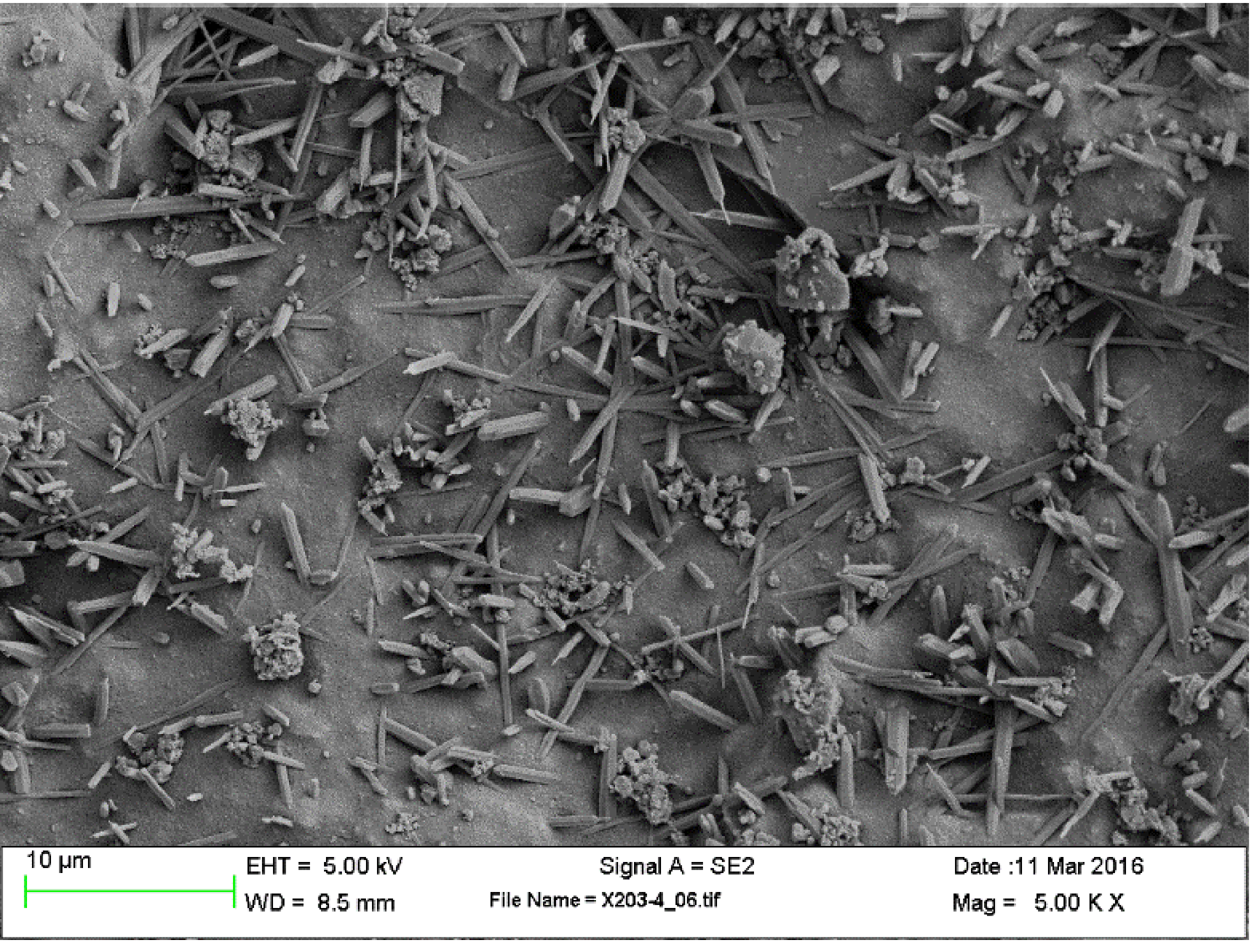


27 μm

Convent. AAC, tobermorite crystals

Yellowish color of the above pics is an artifact generated by the digital camera used; both samples were perfectly white.

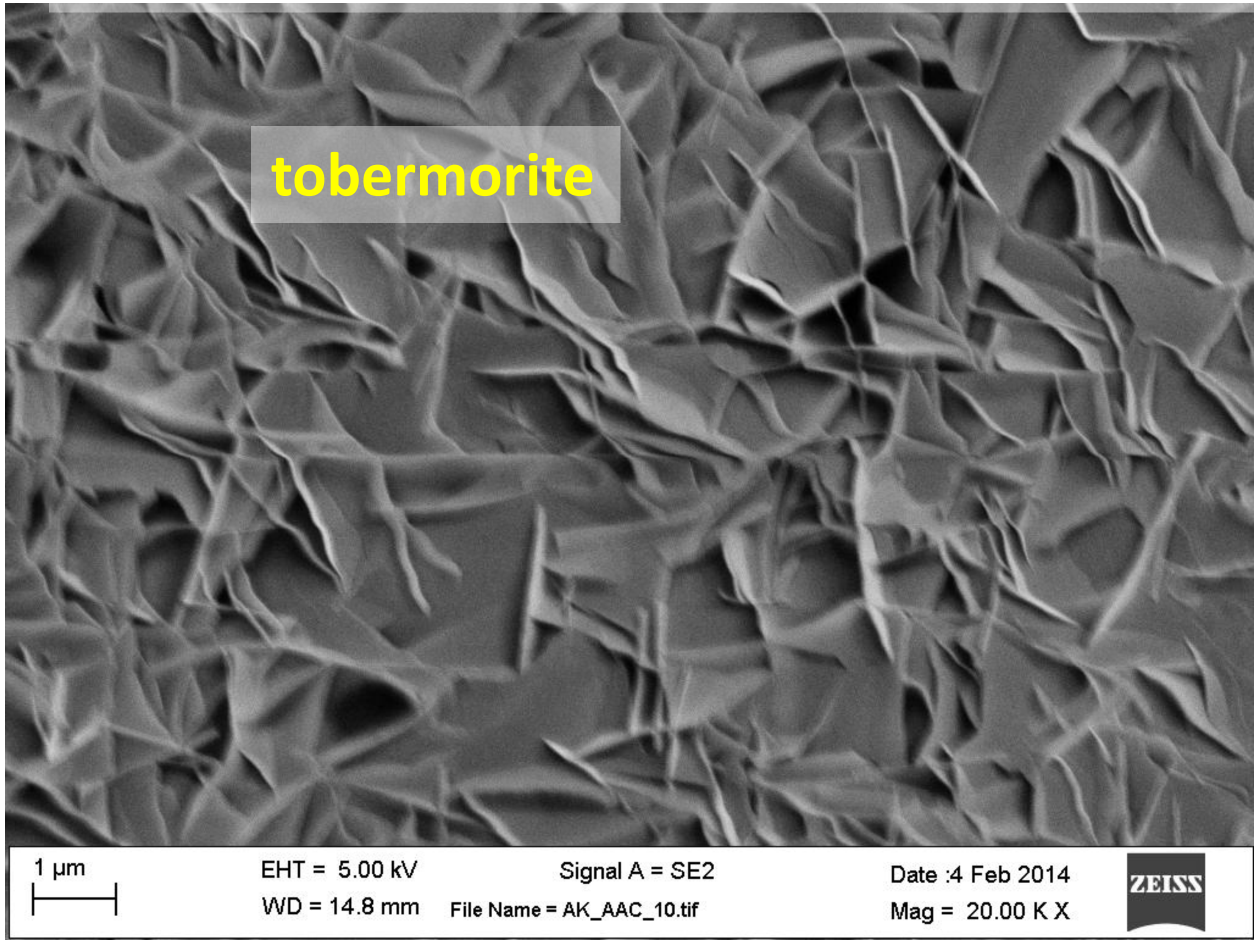
Solidia aerated concrete's strength-generating crystals: $CaCO_3$



Aragonite whiskers visible over a fine calcite matrix

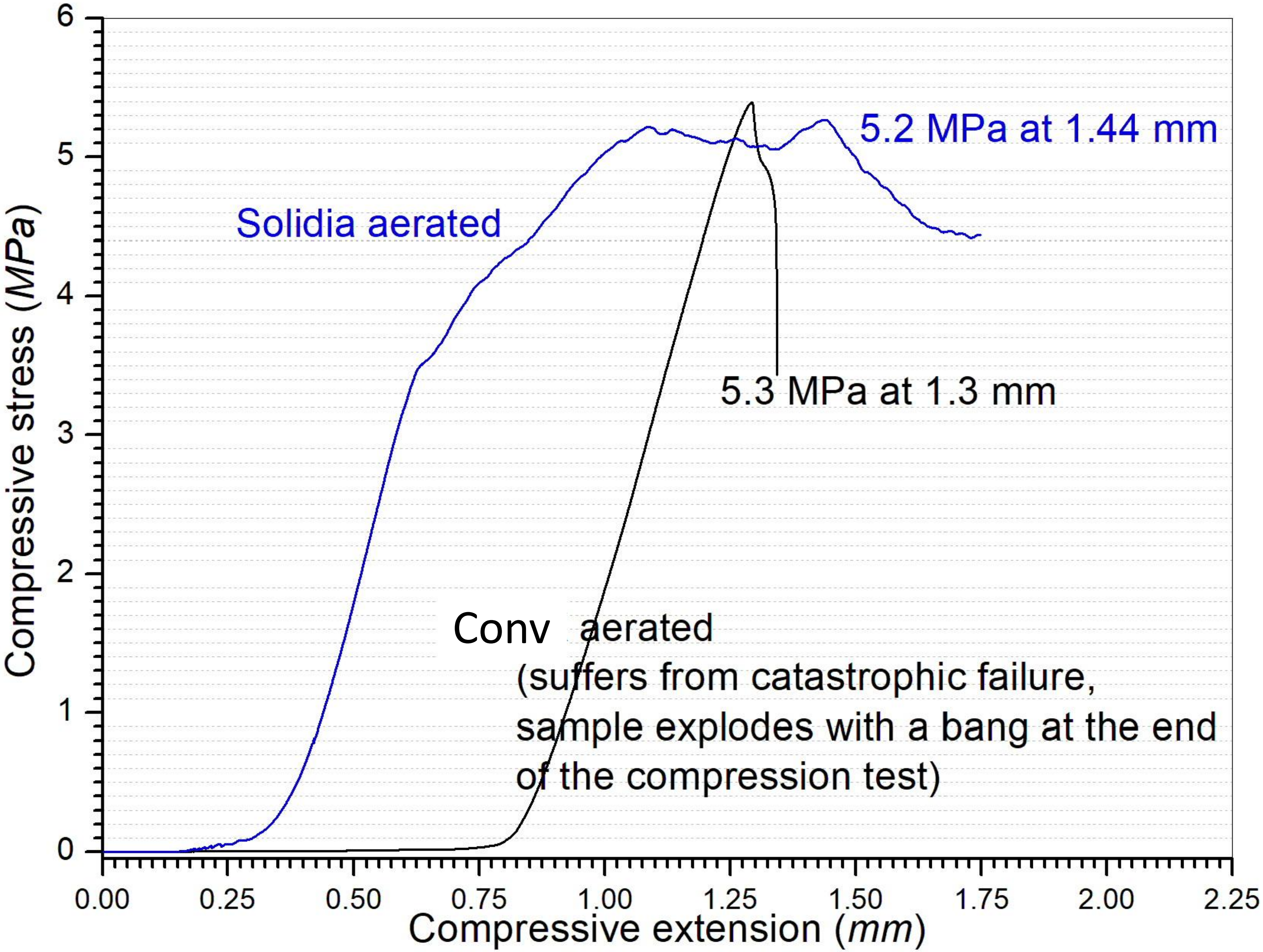
Solidia Aerated Concrete

Conventional AAC's strength-generating crystals: tobermorite

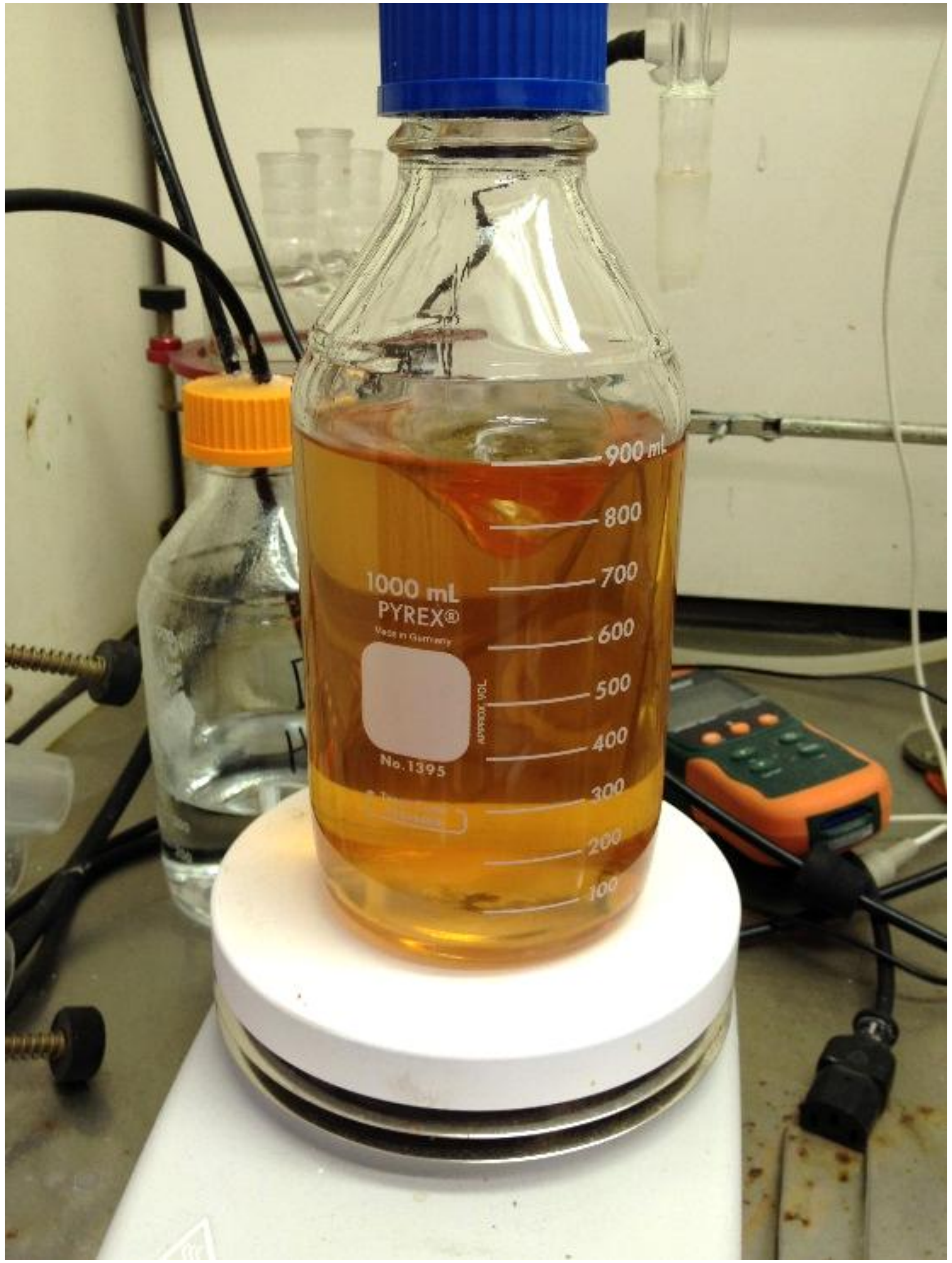


Conventional Autoclaved Aerated Concrete

The most important difference between conventional AAC and Solidia Aerated Concrete



No catastrophic failure in the compressive strength-tested 20 cm tall, 10 cm diameter Solidia aerated sample



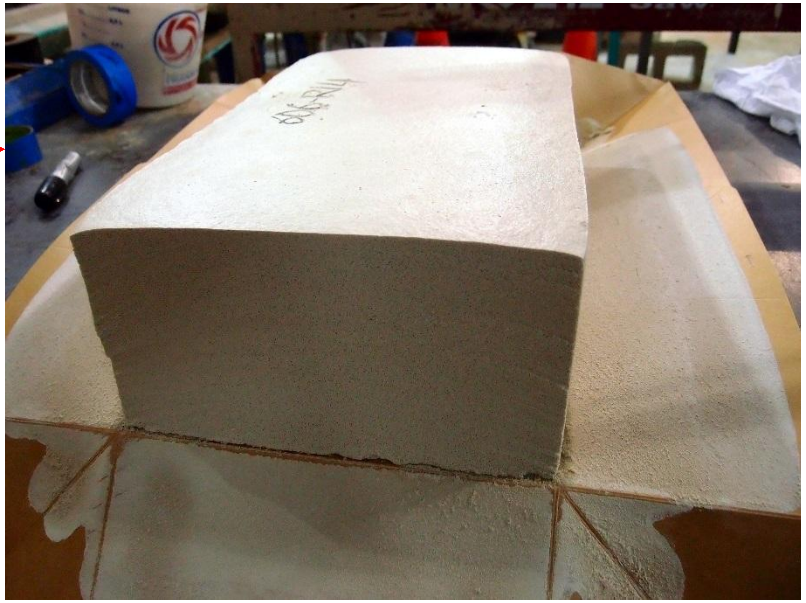
MagCet solution, shown here, as a “curing aid” to add to the slurry waters of Solidia’s aerated concrete is invented by A. C. Tas
(see US patents: 11,767,264 and 11,352,297); proprietary amount of MgO powder dissolved in proprietary amount of acetic acid, no other additive, solution pH = 4.2

Author has also used the same solution as a curing aid in his large-scale (480 of 4x8” pavers simultaneously) paver curing studies (pavers completely removed from their press boards after a brief air-drying at 37°C, and then CO_2-cured in less than 8 h on perforated, mesh substrates at 90 to 105°C) in a special 1 atm chamber he designed and got built; WIPO/PCT Patent Appl.: 2020/046927

Our upscaling steps

250 x 150 x 150 mm
Aug 2015

1



450 x 250 x 150 mm
Apr 2016

2

June-July 2016: 450 x 250 x 300 mm

3

178 mm diameter, 680 mm tall, in a special, 3 piece UHMWPE cylindrical mold I designed, then built in house

Feb 2017

4

700 x 600 x 700 mm, Apr-May 2017

5

1100 x 600 x 700 mm, Aug 2017

End of foaming

700 x 600 x 700 mm, Apr-May 2017

the art of souffle-making

700 (length) x 600 (width) x 700 (height) mm

After demolding and wire-cutting into twelve 100 mm-thick panels (height: 700 mm, width: 600 mm)

imaged just before its transportation, with a forklift, into the specially-designed CO_2-curing chamber

End of foaming

1100 x 600 x 700 mm, Aug 2017

the art of souffle-making

Several hundreds of scale-up and optimization experiments were performed by [Dr. Tas](), with help from few Solidia engineers

This capable mixer, with the properly chosen impeller inside, was able to perfectly mix the Solidia aerated concrete slurries.

Six CO_2-cured aerated concrete blocks shown here (each being 200 mm-thick) came from the same foam (shown here after the steps of precuring in air, wire-cutting, CO_2-curing for 12 h and coring for testing).

Solidia went out of business after deciding not to pursue its very unique and novel CO_2-cured aerated concrete.

T1

T3

M1

Quality checks: cored test cylinders before strength testing

Very good pore size and pore shape distribution achieved in the “**defect-free**,” CO_2-cured test cylinders

B1

B3

B4

- High performance concrete (heavy) buildings kill people, not the earthquakes.

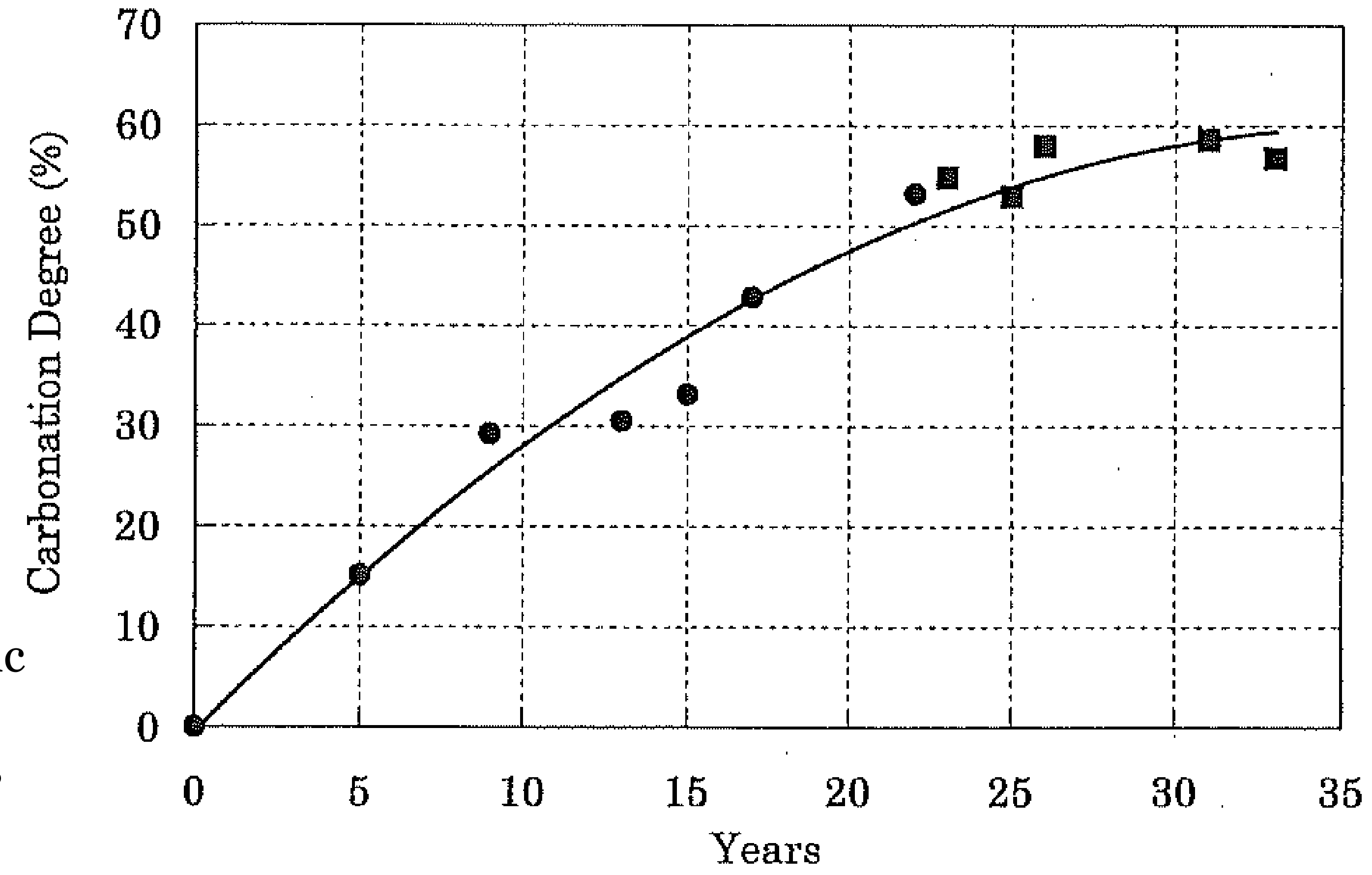
- Lightweight, aerated concrete blocks are excellent thermal insulators, thanks to their 80-85% porosity.

- Lightweight, aerated concrete panels are further strengthened in Japan by using coated reinforcement bars inside.

- Lightweight, aerated concrete blocks provide extraordinary acoustic insulation to the buildings that use them.

Conventional AAC's tobermorite phase will not be stable in increasing CO_2 values of the next decades

Poor service life performance of conventional AAC, measured at the atmospheric CO2 levels of 1999 by the Japanese researchers



Carbonation degree of conventional AAC blocks/panels in service

Cement and Concrete Research 30 (2000) 1741-5

Solidia's Aerated Concrete would not be affected from any increase(s) in the atmospheric CO_2, simply since its crystals were those of calcium carbonate, which cannot be further carbonated.