Project AETHER

Testing the durability of a lower-CO_2 alternative to Portland cement

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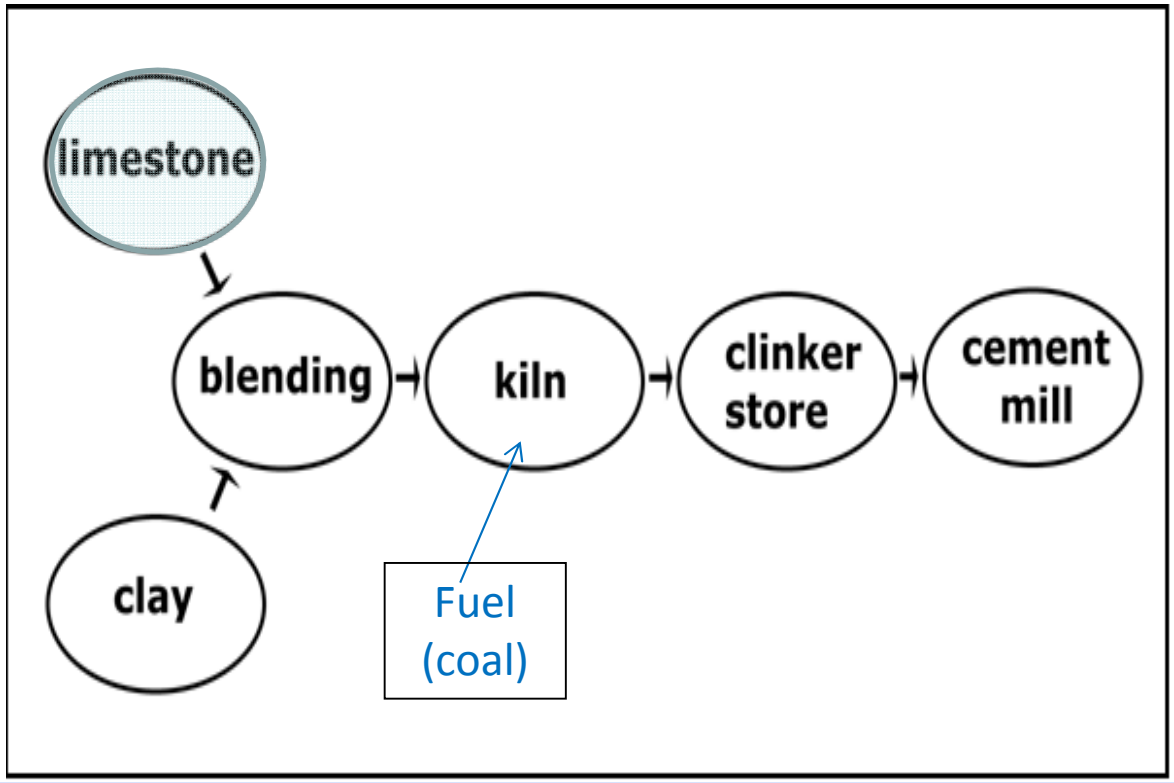
Aether® is a new low-CO_2 cement based on:

- Belite: C_2S
- Calcium sulfoaluminate (ye'elimite): $C_4A_3\$$ or 4 $CaO.Al_2O_3.SO_3$
- Ferrite: $C_4(A,F)$

This new clinker and its mineralogical composition is patented : (***Gartner, E., and Li, G., 2006. World Patent Application WO2006/018569 A2***)

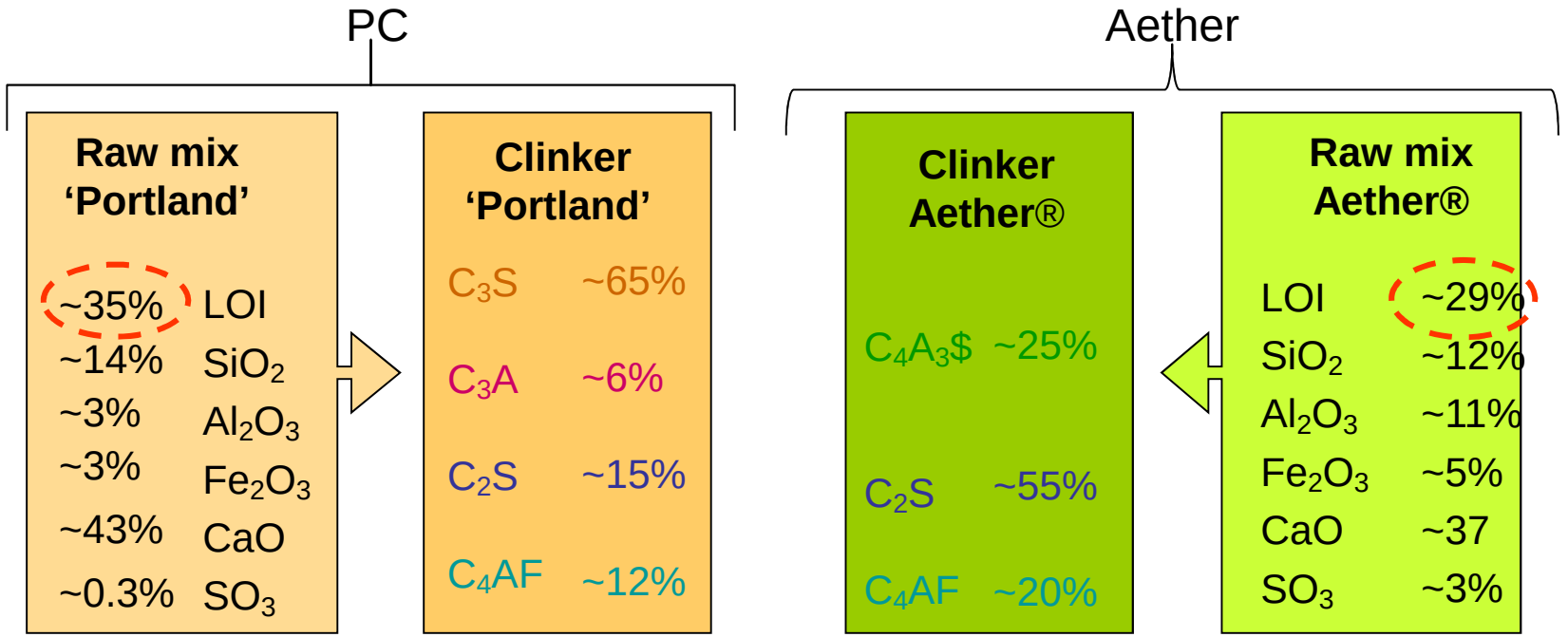
- Belite: 40 – 75%
- Ye'elimite: 15 - 35 %
- Ferrite: 5 – 25%
- Minor phase: 0.1 – 10%

Cement manufacture



Aether® – Concept

- The C_3S+C_3A phases responsible for Portland cement properties (but also CO_2 emissions), are replaced by a new strongly reactive phase = $C_4A_3\$$
- Raw mix => less limestone, more Al_2O_3 and more SO_3 = lower CO_2 emissions
- New generation of clinker...



Project Aether®

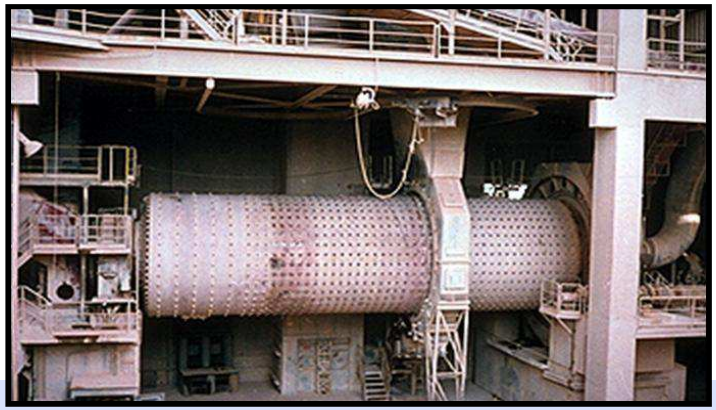
- Consortium
  - Lafarge (France, Lyon) – co-ordinator
  - BRE (UK) - partner
    - Building Research Establishment, private sector centre with expertise in building materials, specialists in research, assessment, testing and certification of cements and concretes, 600 staff
    - Role in the project: Durability testing // Normative aspects // CO_2 assessment
  - RCBM (Poland, Cracovie) - partner
    - Institute Construction and Building Materials, private institute specialised in the production of special binders, involved in the certification process, 250 staff
    - Role in the project: Pilot trials with two small cement kilns // Evaluation of mechanical properties

Pilot production trials

Aether® clinkers can be successfully produced :

- in kilns designed for making Portland cement clinker (semi-dry or dry process),
- using similar process parameters and fuels,
- with conventional raw materials,
- at lower temperatures (1250 -1300°C) than for Portland cement clinker (1400 – 1500°C),
- with significantly lower energy that Portland cement clinker,
- Aether® cement grinding energy is also lower than for PC.

Assessments during the trials confirm that Aether® generates 20 to 30% less CO_2 per tonne of cement than pure Portland cement (CEM (I) type)



Concrete performance data

- Three Aether mix designs + PC control
- Strength development (water at 20°C, 38°C, 5°C), and air at 20°C at 65% RH)
- Sulfate and acid resistance
- Delayed ettringite formation (DEF)
- Alkali silica reaction (ASR)

2-year data were collected in summer 2014

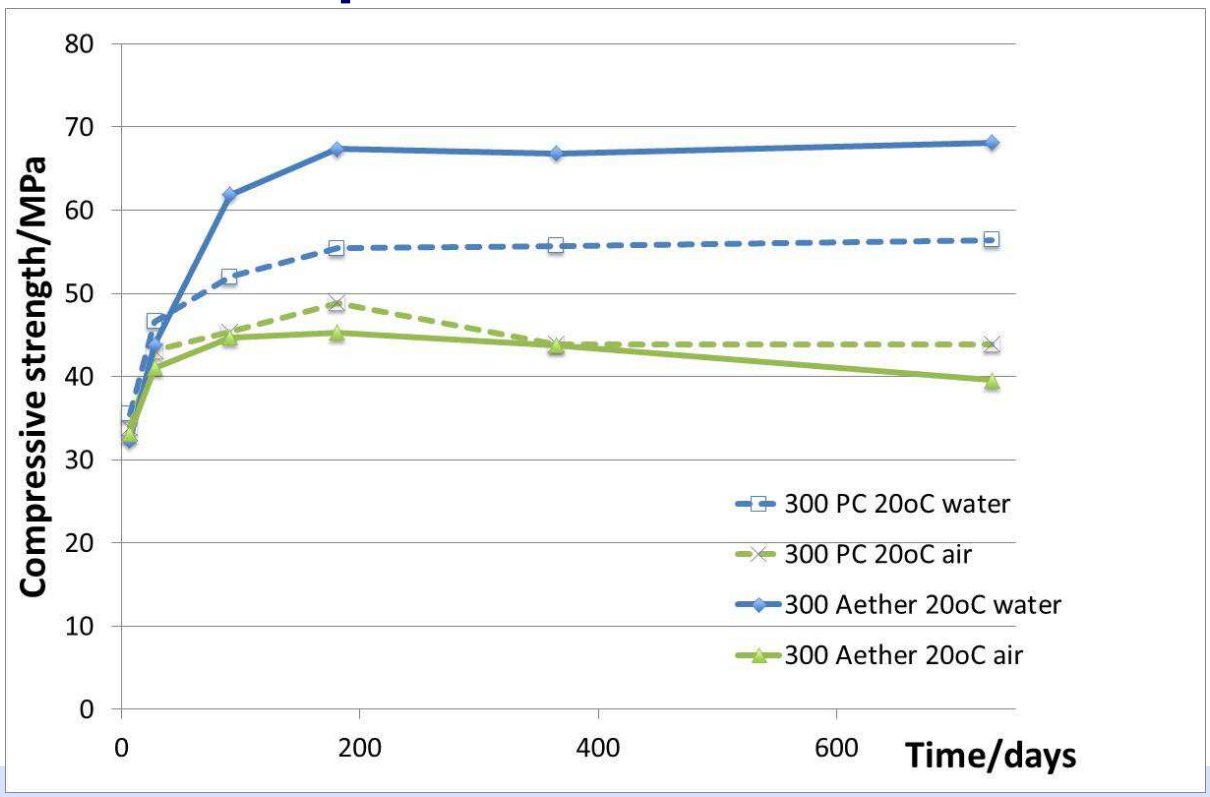
Concrete mixes studied in BRE durability programme

- Concrete mix designs (x 4):
  - A. Aether = 240 kg/m^3; free w/c = 0.65
  - B. Aether = 300 kg/m^3; free w/c = 0.50
  - C. Aether = 360 kg/m^3; free w/c = 0.42
  - D. Portland cement= 300 kg/m^3; free w/c = 0.50

  - + specific ASR mixes (440 kg/m^3)


CAPCO

Compressive strength development in water and air



Aether and PC concretes 300 kg/m^3 and free w/c 0.50):

Chemical resistance

Specimens exposed to:

- Class 5 sulfate at 5°C
  (6,000 mg/lit SO_4^{2-}. Mg & Na sulfates)
- 3% citric acid at 20°C

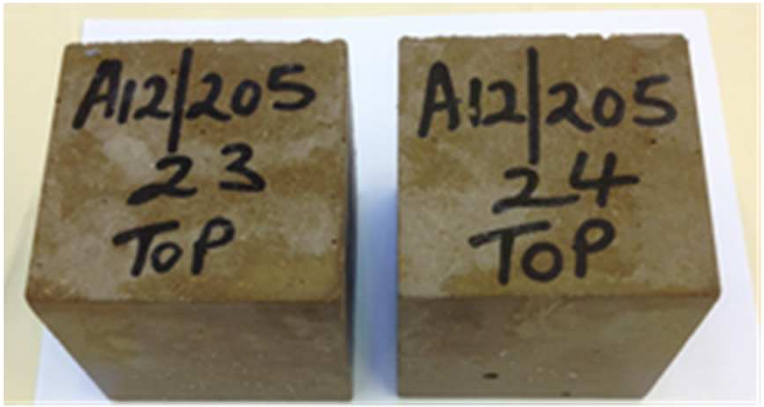
Assessment:

- Visual inspection
- Weight change

Solutions replaced every 3 months

Chemical resistance

Specimens exposed to Class 5 sulfate at 5°C

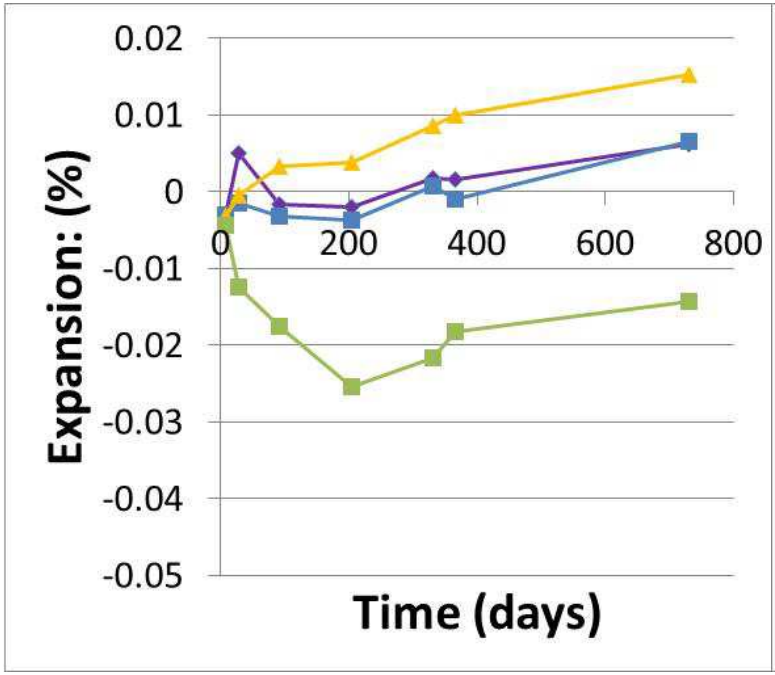


Aether concrete 300 kg/m^3 and free w/c 0.50) after 2 years

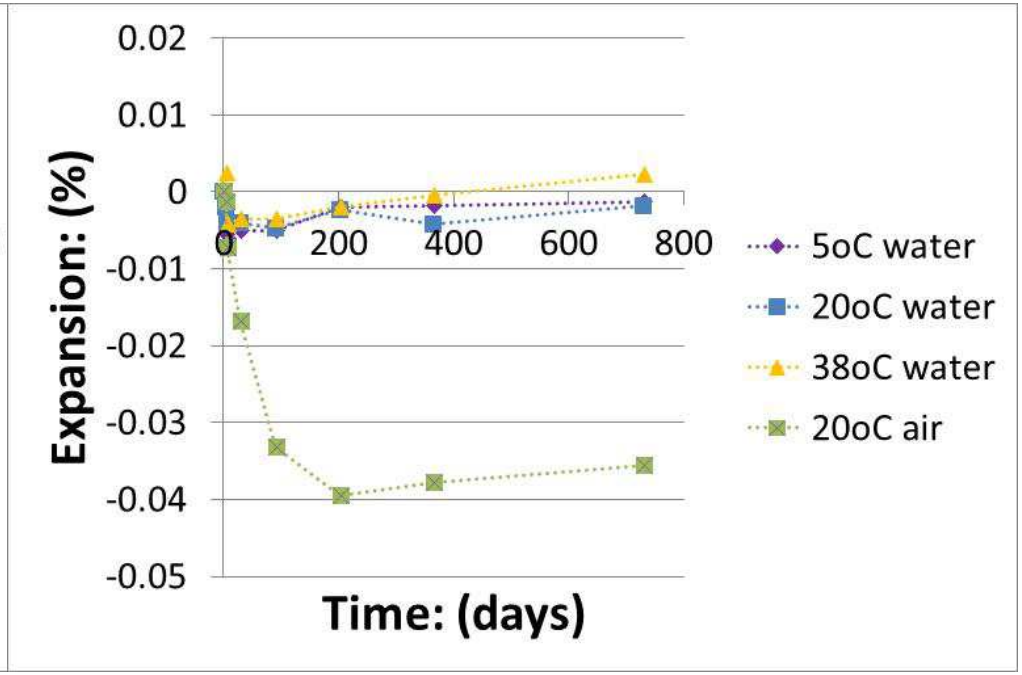
PC concrete 300 kg/m^3 and free w/c 0.50 after 2 years

Dimensional stability, DEF & ASR

Dimensional stability & drying shrinkage



Aether concrete 300 kg/m^3 + free w/c 0.50) after 2 years

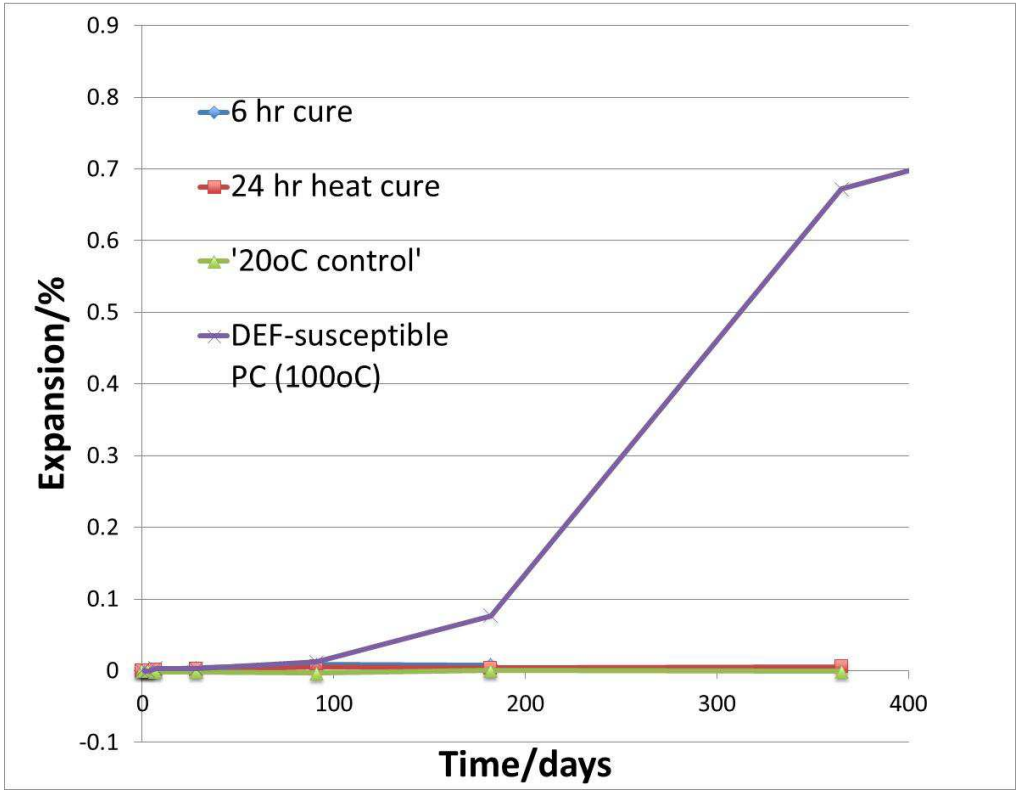


PC concrete 300 kg/m^3 + free w/c 0.50) after 2 years

Delayed ettringite formation (DEF)

- Aether concrete specimens subjected to early heat cure cycle (90° C to 6 hrs or to 24 hrs), cooled and then stored in water to 1 year
- No evidence of any expansion in Aether concrete

Delayed ettringite formation (DEF)



Aether:360 kg/m^3 and free w/c 0.42

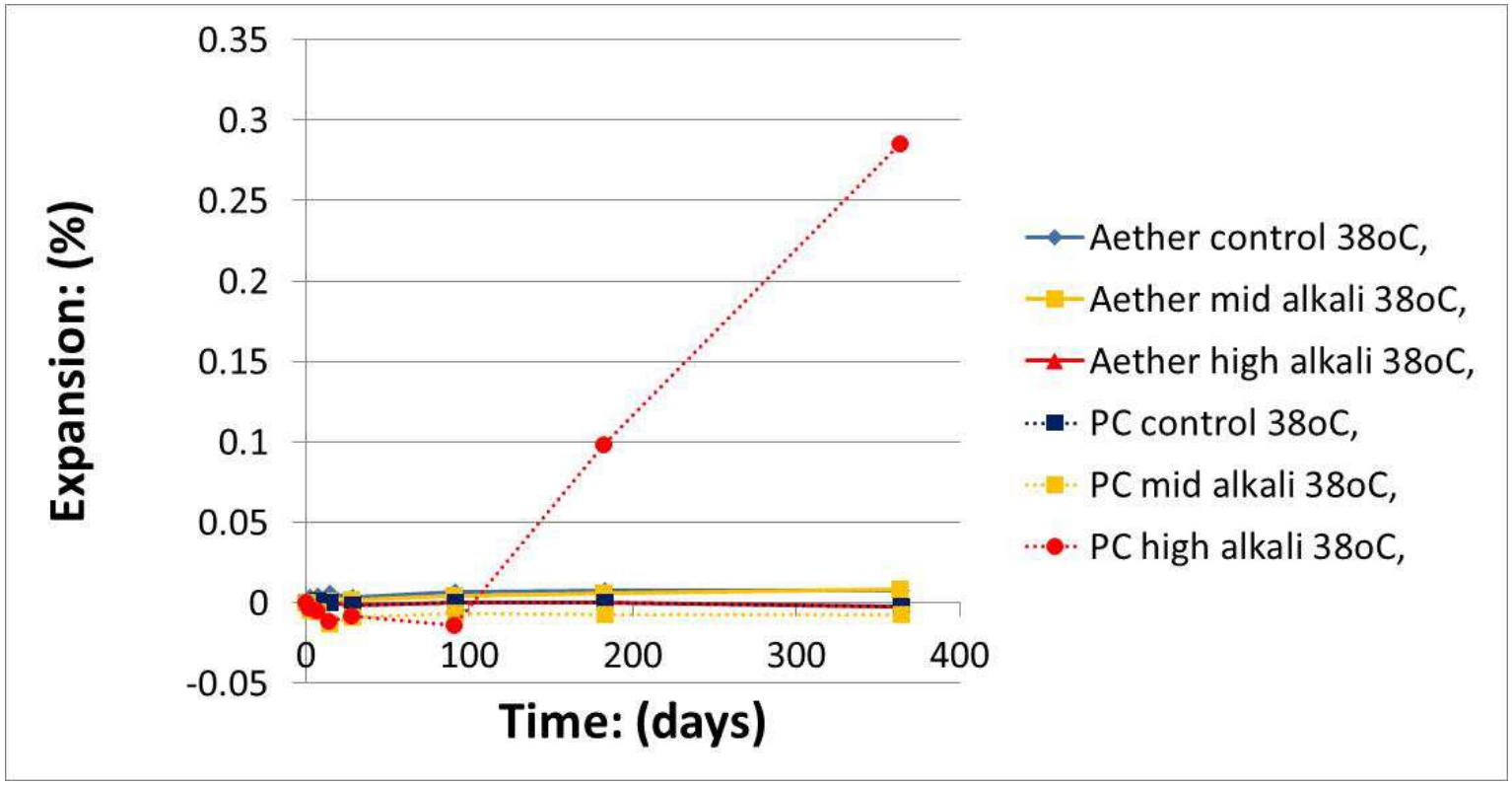
PC:

Alkali silica reaction (ASR)

- Aether* concrete specimens (440 kg/m^3 binder and up to 6.0 kg Na_2O eq. per m^3) stored at high humidity and 38˚ C for 1 year
- Limestone coarse aggregate and reactive Thames Valley (siliceous) sand
- No evidence of any expansion to date in Aether concretes

*Aether cement 0.5% alkalies (Na_2O equiv)

Alkali silica reaction (ASR)



Conclusions

- Good quality, cohesive concretes can be prepared using Aether cement.
- Compressive strengths of Aether concrete at least matches that of otherwise equivalent PC concrete at test ages of up to 2 years.
- The Aether concretes are also dimensional stable and have shown durability comparable to or better than a PC control concrete.