nanocem THE INDUSTRIAL-ACADEMIC NANOSCIENCE RESEARCH NETWORK FOR SUSTAINABLE CEMENT AND CONCRETE

Concrete Solutions

Research & Carbon Reduction Options

The world population is estimated to reach 9 billion by 2050 with 70% of all people living in cities. As countries develop, there will be an ever increasing demand for building materials, especially concrete. Cement production is thus set to increase to 5 billion tonnes per year.

Concrete is the ideal material to meet many of the challenges the world will face in the coming decades: It is low-carbon made from abundant resources, capable of integrating large quantities of waste and by-products and is extremely durable.

Using alternative construction materials would, in many cases, not be a sustainable solution. Forest growth would not be able to compensate a dramatic increase in the use of wood and increasing steel production for construction would lead to higher emissions. Furthermore, concrete is the only viable material for many applications such as foundations, high rise structures, or dams.

Nevertheless we should explore all possible options to reduce the emissions linked to cement and concrete production and save resources.

Emissions in cement production are threefold:

- From the production of the electrical energy used to grind the raw materials and clinker;
- From the fuel burned to heat the raw materials in a kiln to 1450°C to form clinker, which is later crushed and blended with gypsum to make cement;
- Process emissions: as the limestone is heated, it changes into lime and CO_2. These emissions represent 60 to 65% of total emissions linked to cement production.

Since process emissions, caused by the use of limestone, are responsible for most of the emissions, it would make sense to think that we simply have to use another raw material. However, there is a catch. Limestone is widely available close to almost all places where cement is used, and no viable substitute has yet been found despite many decades of intense research. It is possible to envisage niche products using alternative materials, but the bulk cement will still be Portland cement using limestone as a main raw material.

This is why our research does not focus on finding a revolutionary type of new cement, but rather on making concrete even better.

We study cement and concrete at a microscopic level to help understand the scope of physical and chemical reactions that occur when using different cement types or materials in the concrete mix. Furthermore, we look at how the concrete is likely to perform in the future.

Fundamental research is needed to study these complex materials and their interaction with the environment that surrounds them.

Using advanced techniques like atomic force microscopy, X-ray diffraction and transmission electron microscopy we get a better understanding on what goes on inside concrete. Gaining this knowledge will help develop solutions that will lower the carbon impact of concrete.

Our research supports several parallel pathways of reducing concrete's carbon impact:

- Improved prediction of performance of new types of cement and concrete. Because safety comes first, there has been a tendency to use a concrete that is stronger than actually needed. Increasing our understanding of how each concrete will perform for the next 50 to 100 years will increase the use of cement and concrete types with lower emissions per tonne.

- Research into the performance of different mixtures could lead to concrete types that use less cement whilst ensuring equal structural integrity over time.

- Increase understanding how concrete deteriorates and ensure new materials will be durable.

- In Europe, more than 20% of clinker is replaced by waste materials or industrial by-products like blast furnace slag or fly ash. Decreasing the amount of clinker reduces both process emissions (originating from the decomposition of limestone) and thermal emissions. Our research looks into the performance that different cement types with alternative materials have today and might have over time.

- Our research actively explores possibilities for new replacement materials such as calcinated clays or pozzolans or optimising the use of the replacement materials used today.

- We investigate the impact of chemical admixtures on concrete performance. Admixtures can help improve the properties of concrete, making it more durable and sustainable.