Project

Low-clinker cements

Concrete with less cement – environmentally friendly and cost-efficient

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Worldwide, no material is produced as much as concrete. This is an energy-intensive process and causes CO_2. A new type of concrete with less cement is more environmentally friendly.

Texture from ready-mix concrete cement mortar. *Source:* iStock

At a glance

- The production of concrete is energy-intensive and causes CO_2.
- Researchers from ETH Zurich and the Swiss Federal Institute of Technology Lausanne (EPF Lausanne) have therefore developed a low-energy concrete.
- While the low-energy concrete carbonises quicker than conventional concrete, experiments show that this does not result in the greater corrosion of the steel components embedded in the concrete under normal environmental conditions.

Concrete is the most-produced material in the world. It comprises, sand, gravel and cement. The latter is produced as part of an enormously energy-intensive process: between 2 % and 3 % of global energy requirements can be attributed to cement production. Pollutants are also released during its manufacture and 5 % to 8 % of man-made CO_2 originates from the cement industry. By 2050, this share could even increase to 25 %.

One measure for implementing Energy Strategy 2050 could therefore be to reduce the cement content of concrete.

The new recipe

In cooperation with LafargeHolcim, researchers from ETH Zurich have developed a new concrete mix that only contains half as much cement as traditional mixes. In its place, locally available substitute products such as burnt oil shale or limestone are added to the mix. The production of this new concrete is less energy-intensive. With the new mix, between one and two million tonnes of CO_2 could be saved each year in Switzerland. This equates to 2 % of our country's annual carbon emissions.

The challenge for this new recipe was that low-cement concrete has lower mechanical strength – especially in the hours and days immediately after it is poured. In order to improve its strength, the researchers added additives to the concrete. This increased its compressive strength by up to 120 % in the first 90 days.

The new recipe was tested with industrial partners in the Austrian town of Bludenz. The researchers produced the concrete wall of a garage using the new material.

Measuring carbonation

The new concrete is thus environmentally friendly. However, it also needs to be stable. To test this, the team from the EPF Lausanne investigated the carbonation of the new concrete. In the construction sector, this term denotes a chemical reaction that takes place in the concrete in the presence of carbon dioxide and moisture. This changes the pH value of the concrete and, for reasons of statics, the steel elements embedded in it become susceptible to rust.

In order to measure the carbonation, the scientists developed methods that artificially bring about the chemical process in the concrete without changing the process itself. They thus simulated natural carbonation. The simulation revealed the factors that influence the process. In addition to moisture, these include the porosity of the concrete and its composition. Here, it was shown that the burnt oil shale and limestone, which partially replaced the traditional cement, had a positive impact. They inhibited the carbonation process.

Generally speaking, the results suggest that the effect of carbonation on the structure of the concrete is smaller than had been assumed until now – its structure obviously also changes when it dries up.

Corrosion depends on moisture

Once the concrete is carbonated, the reinforcement steel embedded within it becomes susceptible to corrosion. But under which conditions does rust actually form? And how quickly does the disintegration of the steel progress? In order to find out, the researchers from ETH Zurich tested the corrosion rates under different environmental conditions as part of an experiment. Surprisingly, the results did not confirm the existing mechanisms for the formation of corrosion. On this basis, the researchers conclude that conventional methods for monitoring concrete such as cathode controls and the measurement of electrical resistance are not sufficiently reliable. Instead, they were able to establish a direct link between the moisture and porosity in the concrete and the corrosion rate. Based on these findings, the researchers developed a new method for calculating the speed of corrosion. In this method, the porosity of the concrete and the presence of moisture in the environment are the key factors.

The researchers thus concluded that the new, low-cement concrete is not more susceptible to corrosion under normal environmental conditions – even if it carbonates quicker than conventional concrete.

Cost-efficient and precise

Both the newly developed concrete and the new carbonation and corrosion measurement methods are cost-efficient and easy to implement. The researchers write that the new control method is more reliable than the old one and reflects the condition of the concrete more precisely. They also state that it is now down to the market leaders to adjust the cement production process step by step. The lower production costs could accelerate this process.

Produkte aus diesem Projekt

- Electrochemistry and capillary condensation theory reveal the mechanism of corrosion in dense porous media
  Date of publication: 01.01.18
- The kinetic competition between transport and oxidation of ferrous ions governs precipitation of corrosion products in carbonated concrete
  Date of publication: 01.01.18
- Changes of microstructure and diffusivity in blended cement pastes exposed to natural carbonation
  Date of publication: 01.01.18
- Development of compatible superplasticizers for low clinker cementitious materials
  Date of publication: 01.01.18
- Increased reactivity of burnt oil shale in new activated blended cements
  Date of publication: 01.01.18
- Compatible superplasticizers with low clinker cements
  Date of publication: 01.01.18
- Eco-friendly concrete
  Date of publication: 01.01.18
- Innovative sample design for corrosion rate measurements in carbonated blended cements
  Date of publication: 01.01.18
- Merging electrochemistry and water capillary condensation to understand the corrosion mechanism of steel in carbonated concrete
  Date of publication: 01.01.18
- A new setup for rapid durability screening of new blended cements
  Date of publication: 01.01.18
- Relative importance of corrosion rate and exposure condition on the practical use of new environmentally friendly binders
  Date of publication: 01.01.18
- Corrosion rates in carbonated low clinker cements: Are the new binders really sustainable?
  Date of publication: 01.01.18
- Evolution of microstructure and phase assemblage in Portland cement and blended cement pastes exposed to natural carbonation
  Date of publication: 01.01.18
- Changes of microstructure and diffusivity in blended cement pastes exposed to natural carbonation
  Date of publication: 01.01.18
- Microstructural and phase assemblage changes in naturally carbonated cement paste with supplementary cementitious materials (SCMs)
  Date of publication: 01.01.18
- Carbonation of low carbon binders
  Date of publication: 01.01.18

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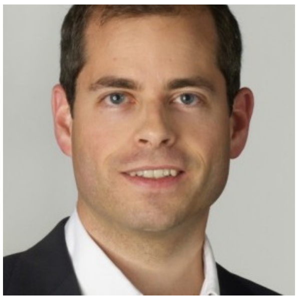

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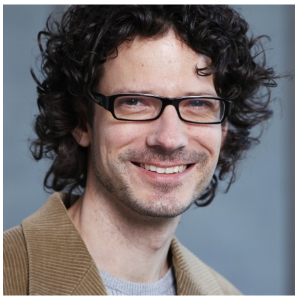

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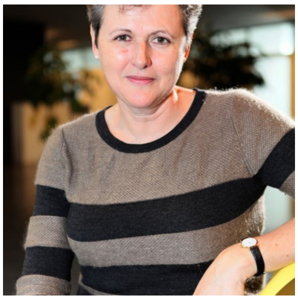
Project direction



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All information provided on these pages corresponds to the status of knowledge as of 17.12.2018.