



**Energy**  
National Research Programmes 70 and 71

# Project

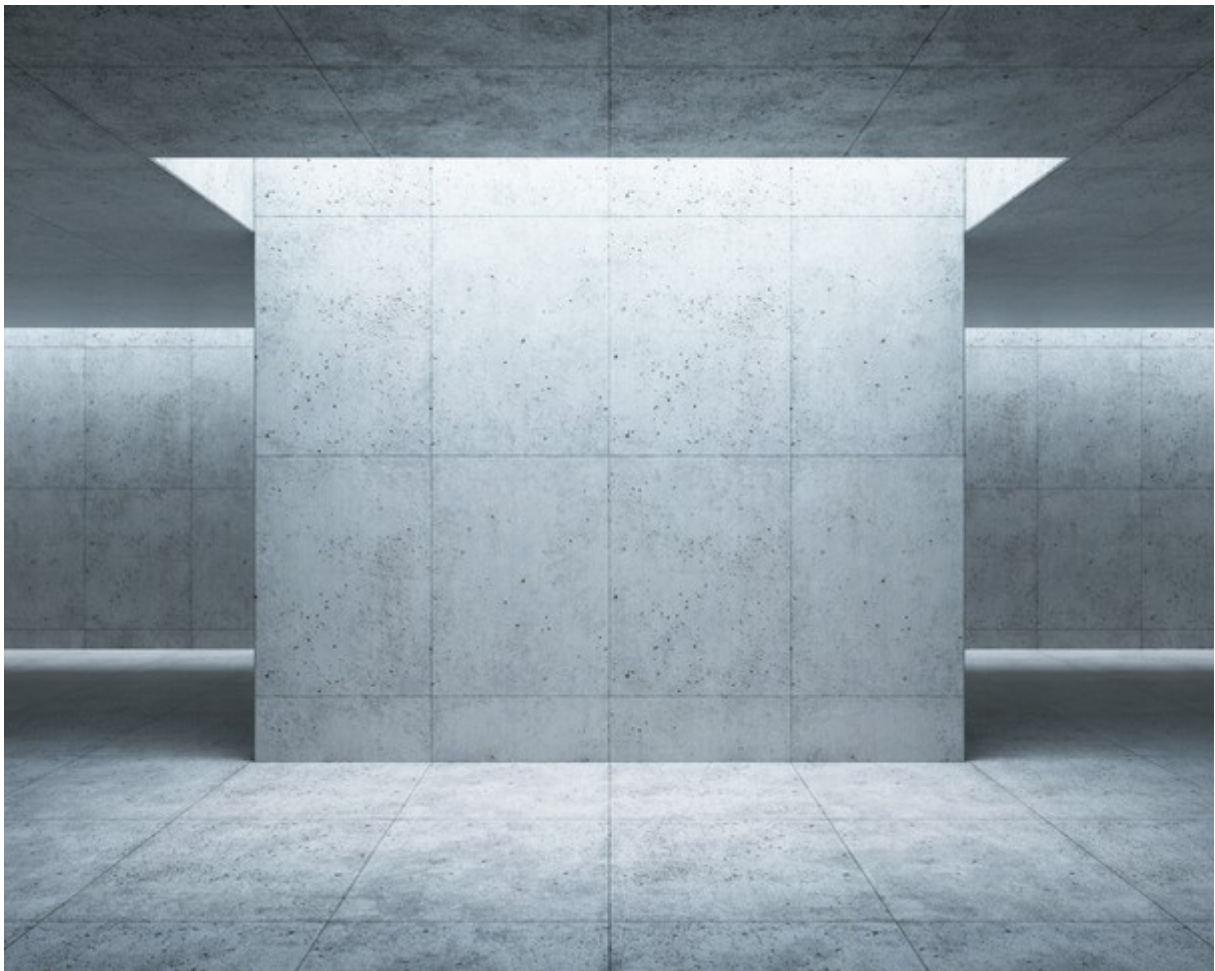
Low energy concrete





## Concrete Solutions

Concrete is the most commonly used building material in Switzerland. However, the production of concrete is energy-intensive and causes CO<sub>2</sub> emissions. This could soon change – a new mix could make concrete more environmentally friendly.



The production of concrete is energy-intensive and causes CO<sub>2</sub> – this could soon change. *Source: iStock*





## At a glance

- The energy that is used for the production of building materials and the construction of buildings is in future likely to account for the lion's share of the energy consumption of buildings.
- The use of concrete without steel with only a small cement content could make buildings more environmentally friendly.
- Hybrid constructions with materials such as wood and plastic fibres could make low-energy concrete more stable.

When it comes to energy, buildings are expensive: they are responsible for 40 % of global energy consumption. At present, building expenses primarily stem from their operation. However, using energy-efficient construction methods, as envisaged under Energy Strategy 2050, it will be possible to considerably reduce this energy consumption. As a result, so-called "grey energy" that is used for the production of materials and the construction process is increasingly coming under the spotlight. In future, it will account for up to 100 % of the total energy consumption of new buildings. This is because the production of cement and steel is extremely energy-intensive and causes high emissions. As part of the joint project "Low energy concrete", Guillaume Habert, a professor for sustainable construction at ETH Zurich, and his team have therefore investigated to what extent new materials can make concrete structures more environmentally friendly.

Result: building structures constructed without steel and with low-energy concrete could together reduce grey energy by 50 % and reduce CO<sub>2</sub> emissions by up to 80 %.



## A new concrete mix

Concrete comprises cement, sand and gravel. The energy- and emission-intensive ingredient is the cement. Cement is produced by heating the raw materials of limestone, clay and marl to around 1,500 degrees Celsius and burning them into an intermediate product. This is referred to as clinker. The clinker is ground and mixed – together with other ingredients such as fly ash – in order to form cement. During burning, each tonne of clinker produces half a tonne of CO<sub>2</sub>. The researchers have therefore developed a new concrete mix that contains less clinker and instead comprises substitute products such as limestone and burnt oil shale. Fly ash and oil shale are waste products from other sectors such as the coal and steel industries and up to 30 % of the content of concrete is already accounted for by them. The researchers have increased this share – to 50 %. The challenge lay in increasing this share without adversely affecting the mechanical strength of the concrete. This was to remain at 30 megapascal.

## New building structure without steel

However, the low-energy concrete developed in this way has a disadvantage: the steel integrated in the concrete becomes more susceptible to rust. Tests have shown that under humid environmental conditions signs of deterioration emerge more quickly in this concrete.

In three other sub-projects, scientists from ETH Zurich, the Swiss Federal Laboratories for Materials Testing and Research (Empa) and the Swiss Federal Institute of Technology Lausanne (EPF Lausanne) have therefore developed new, non-metal based support materials and tested their resilience. Wood-concrete structures represent an alternative to steel-based reinforcements. In a sub-project, it was therefore tested how materials could be layered and adhesive could be used in order to hold the concrete and wood together. Alternatives such as carbon-fibre polymers and plastic fibres for ultra-high-strength concrete were also examined.

The fifth sub-project tested the techniques and their resilience at existing Swiss bridges.



## The potential is great

In the joint project “Low energy concrete”, the researchers finally quantified the environmental costs of each technology over the entire life cycle of the structures. Here, opportunities for the recycling of the used concrete and the substitute materials for cement were also investigated.

The analysis shows that low-energy concrete and support structures without steel can make an important contribution to the energy turnaround. The newly developed concrete could reduce carbon emissions by half and would require up to 50 % less energy. There are also additional savings in connection with the alternative support materials: for example, CO<sub>2</sub> emissions could be reduced by up to 80 % here.

The researchers emphasise that the new concrete mix could be processed at the same plants as the currently popular mixes. The switch to low-energy concrete could therefore take place soon. While levels of acceptance among construction firms for the new concrete are high, acceptance still needs to be established for new support materials such as wood-concrete, carbon fibres and plastic fibres. This should be achieved through the performance of additional tests.

The projects conclude that concrete will also play a key role over the coming decades. Demand for building space will increase by 230 million square metres by 2050. Until this time, new buildings will thus be built continuously. Only after this time are building activities likely to stagnate owing to a stabilisation in the population size. Overall, however, the analysis of the joint project shows that low-energy concrete can make a contribution to the energy turnaround immediately.



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## Produkte aus diesem Projekt

- Eine Bauwelt ohne Zement  
Date of publication: 27.09.15
- Environmental assessment of radical innovation in concrete structures  
Date of publication: 29.05.17



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## Connected projects

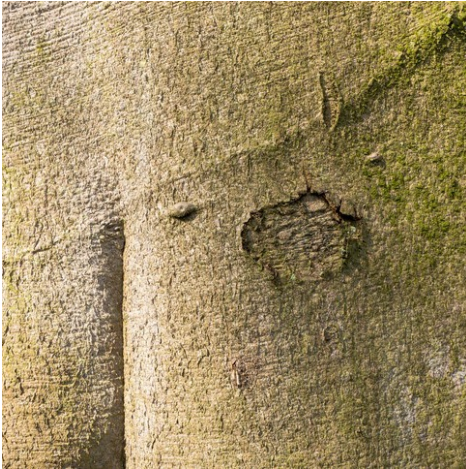


Low-clinker cements

Concrete with less cement –  
environmentally friendly and cost-efficient

High-performance concrete

Ultra-high performance fibre reinforced  
concrete: malleable like steel, castable like  
concrete



Hybrid load-bearing structures

Beech – a miracle wood: how concrete can also be made stable without steel



Pre-stressed carbon-fibre concrete

Prestressed concrete with carbon fibres and little cement: an environmentally friendly variant



Monitoring of concrete constructions

How healthy is a building or a bridge?

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