PRESS RELEASE

Construction materials for the future

Sustainable and Versatile: Fraunhofer IBP Is Driving the Development of Climate-Friendly Construction Materials

Cutting carbon emissions by more than two-thirds with consistently high quality: Specialists from the Fraunhofer Institute for Building Physics IBP are working on future ways to manufacture the popular construction material with as little climate impact as possible. They will be showcasing their solutions at the BAU trade show in Munich from January 13 to 17, 2025.

What would perfect concrete be like? The researchers at Fraunhofer IBP are tackling this question. It should be versatile and sustainable, ideally made from local resources, recyclable and earthquake-resilient, and produced with low carbon emissions. With these standards in mind, the team is working on multifaceted solutions with the potential to radically reshape the construction industry.

The quest for the perfect concrete

One key aspect the experts are working on is replacing various components of the concrete with pyrochar, which is made by heating up plant residue or other organic substances, such as methane, in an oxygen-free atmosphere. Up to 40% of the carbon present in the plants is stored as solids in the form of pyrochar in the process. Incorporating it into concrete yields a product with negative emissions, as the process binds more carbon dioxide in the concrete in absolute terms than is emitted during production.

The researchers modify the pyrochar so it can be incorporated precisely to meet requirements, but that is not all. They have also developed a method of granulating the chars. The aggregates resulting from this are smaller than two millimeters and used as a substitute for sand in the concrete. This lowers the concrete's climate impact while also making it much lighter in weight, which additionally cuts the cost of transportation.
"Using one part pyrochar can reduce about three parts carbon dioxide in the overall product. This puts us very close to climate-neutral concrete, with no downside in comparison to the conventional version in terms of quality," explains Dr. Volker Thome, head of the Inorganic Materials and Recycling department at Fraunhofer IBP. To further improve the concrete's carbon footprint and conserve natural resources, the experts

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also use what is known as biogenic lime. Producing it also draws carbon dioxide out of the atmosphere and binds it as a solid inside the calcite.

Clay as an environmentally friendly clinker alternative

Another point where the researchers are working to reduce CO_2 emissions involves lowering the clinker content of the cement. Since the supply of established cement substitutes and concrete additives such as blast furnace slag and fly ash from coal power plants is declining sharply, the specialists at Fraunhofer IBP are exploring suitable alternative materials that are locally available in the volumes needed: clays. There are various types of clay in Germany. Activated either thermally or mechanochemically, they can be added to the cement as supplementary cementitious materials (SCM).

In the LOCALAY project, a group of researchers from Fraunhofer IBP are studying formulas based on different types of clay for low-carbon binders with reduced cement clinker or no cement at all. The ultimate aim is to use the new formulas in mass-produced construction materials. To achieve this, the team is identifying and analyzing clay deposits. They have also developed a reactivity test they use to quickly clarify how specific types of clay need to be activated, depending on the purpose for which they are used, and are testing aspects such as ease of processing and durability.

The primary source of clay in Germany is excavated soil. At 125 million metric tons a year, the soil represents the country's biggest source of mineralic waste materials. To tap into this potential, the Fraunhofer researchers are growing their skills in soil analysis accordingly, from processing of excavated soil to separation of the clay fraction and utilization of the finest types of clay found in filter cakes such as those produced during rinsing of vegetables.

Ancient technology brought forward to the present day

When looking to the future of concrete, it is worthwhile to consider the past as well. Indeed, Roman concretes used in antiquity meet all the criteria that apply to sustainable modern construction materials: They are free of cement, made from locally available resources such as volcanic ash, and both durable and earthquake-resilient. Sadly, though, the formulas used to make these kinds of concrete have been lost to time. In the RICIMER (Roman Inspired Cement Innovation by Multi-Analytical Enhanced Research) project, experts from Fraunhofer IBP have teamed up with colleagues from the Max Planck Institute for Solid State Research in Stuttgart to study these ancient formulas. Their objective is to detect the original compositions, including additives, and then translate that knowledge to modern construction materials.

Thome believes they are on the cusp of a breakthrough: "We're on the verge of solving the puzzle of the cement-free formulas used in antiquity. Now, the task will be to use

our findings to create new formulas that follow the sustainable Roman model and use ash from waste incineration and industry instead of the volcanic ash used back then."

Geopolymers — tapping into ancient knowledge for the future

Even artificial additives that make structures more durable are not solely a modern phenomenon. Wonders of the world such as the Egyptian pyramids are said to have been constructed using these substances. Hieroglyphs and stone inscriptions attest to fluid, artificial forms of sandstone that cannot be destroyed by either water or fire.

Depending on their composition, these kinds of geopolymers, also known as alkali-activated binders, are corrosion-resistant, high in strength, and non-flammable. This makes them ideal for use in areas with bio-corrosion, such as in the coatings of sewage pipes. Thanks to their strength, they are already in use in runways and buildings in Australia.

While production of conventional construction materials depends on primary deposits of raw materials, the experts at Fraunhofer IBP are using municipal residue or industrial byproducts such as fly ash and slag to produce these binders. "We have a lot of experience by now, so we can produce demand-driven geopolymers," Thome explains.

The team of specialists will be presenting their solutions at BAU, the world's leading trade show for architecture, materials and systems, in Munich from January 13 to 17. The items on display will include climate-neutral pyrochar concrete, Roman concrete and a selection of geopolymers.

Fig. 1 Concrete with and without pyrochar: One partpyrochar can reduce three parts CO_2 in the final product.

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Fig. 2 Roman concrete is impressive for its extreme durability. Experts at Fraunhofer IBP are transferring its properties to new construction materials.

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