From downcycling to recycling: Using lighting to separate cement particles from stone

October 1 2012

Researchers have developed a method of breaking down concrete into its constituent parts. Credit: Fraunhofer IBP

Every year several millions of tons of building rubble are produced. An

efficient way of recycling concrete – the building material of the 20th and 21st century – does not yet exist. Researchers are working on new recycling methods, and with the aid of lightning bolts, they can break down the mixture of cement and aggregate into its components.

Whether the Pantheon in Rome or the German concrete canoe regatta, whether ultra-light or decorative: concrete is unbelievably versatile and is the world's most widely used material – next to water. It is made of cement, water and aggregate, a mixture of stone particles such as gravel or limestone grit in various sizes. However, the CO_2 emissions, which are mainly the result of cement production, are problematic: the production of one ton of burned cement clinker of limestone and clay releases 650 to 700 kilograms of carbon dioxide. This means that every year 8 to 15 percent of global CO_2 production is attributable to concrete manufacturing. And when it comes to recycling waste concrete, there is no ideal solution for closing the materials loop. In Germany alone the quantity of construction waste amounted to almost 130 million tons in 2010.

"This is an enormous material flow, but at the moment there is no effective recycling method for concrete rubble" explains Volker Thome from the Fraunhofer Institute for Building Physics IBP from the Concrete Technology Group in Holzkirchen. The current method is to shred the concrete, which produces huge amounts of dust. At best, the stone fragments end up as sub-base for roads. "This is downcycling," explains Thome, in other words, simply the reutilization of raw materials, the quality of which deteriorates from process to process. On the other hand, if it were possible to separate the stone particles from the cement stone, the gravel could easily be reused as an aggregate in new cement – a first decisive step in the direction of recycling waste concrete. "The recovery of valuable aggregate from waste concrete would multiply the recycling rate by a factor of around ten and thereby increase it to 80 percent," says Thome. If it were also possible to obtain a

cement substitute from waste concrete, the cement industry's CO2 emissions would be considerably reduced. To achieve these goals Thome revived a method that Russian scientists already developed in the 1940s then put on ice: electrodynamic fragmentation. This method allows the concrete to be broken down into its individual components – aggregate and cement stone.

Recycling valuable components

Using this approach, the researchers in Holzkirchen are unleashing a veritable storm of lightning bolts. "Normally, lightening prefers to travel through air or water, not through solids," says Thomas. To ensure the bolt strikes and penetrates the concrete, the expert uses the Russian scientists' expertise. More than 70 years ago they discovered that the dieletric strength, i.e. the resistance of every fluid or solid to an electrical impulse, is not a physical constant, but changes with the duration of the lightning. "With an extremely short flash of lightning – less than 500 nanoseconds – water suddenly attains a greater dielectric strength than most solids," explains Thome. In simple terms, this means that if the concrete is under water and researchers generate a 150 nanosecond bolt of lightning the discharge runs preferably through the solid and not through the water." That is the essence of the method," says Thome. In the concrete the lightning then runs along the path of least resistance which is the boundaries between the components, i.e. between the gravel and the cement stone. The initially generated impulses, the pre-discharges, first weaken the material mechanically. "The pre-discharge which reaches the counter-electrode in our fragmentation plant at first, then causes an electrical breakdown," explains Thome. At this instant a plasma channel is formed in the concrete which grows within a thousandth of a second, like a pressure wave from the inside outwards.

"The force of this pressure wave is comparable with a small explosion," says Thome. The concrete is torn apart and broken down into its basic

components. With the laboratory fragmentation plant the researchers can currently process one ton of concrete waste per hour. "To work efficiently, our goal is a throughput rate of at least 20 tons per hour," says Thome. In as little as two years' time, an appropriate installation could be ready for market-launch.

Provided by Fraunhofer-Gesellschaft