Capturing carbon with concrete

Professor Peter Claisse of Coventry University looks at the potential for storing carbon dioxide in concrete.

The potential for capturing carbon by concrete is estimated very roughly at 266 million tonnes worldwide each year - and that is the problem, the very significant margin for error in these kinds of figures.

A lack of research and a basis for accurate measurement means we don't know how concrete can be used most effectively for sequestration. As a result, businesses are still missing out on an important new opportunity for carbon trading and hard evidence for environmental reporting.

With pressure from Government and its own tough carbon reduction targets, it's imperative there is a standard measurement for carbon capture by concrete and a new culture of recognition of its role and value.

The process

Carbon capture is the process by which concrete, and some other materials, react with carbon dioxide in the air and so reduce atmospheric concentrations. Known as 'carbonation', this is a slow and continual process working from the outer surface of the concrete inward, slowing down as it reaches deeper within a structure.

On the one hand carbonation increases the strength of concrete, but at the same time also increases the potential for reinforcement steel to corrode. Business needs to think about how it can maximise the opportunity, the nature of its current and planned property stock, and how they can be best adapted or constructed.

In order to do this, far more needs to be known across types of concrete mixes, buildings and other structures in order to develop the high-potential materials and achieve the greatest benefits.

The potential

The potential for optimising carbon capture is huge. Assuming an average cement content of 350kg and a total potential sequestration (if the concrete is fully carbonated) of 19%, the potential total is 65kg per m3 of concrete. Typical current values are estimated to be around 3% during the initial life of a structure, i.e. 10kg.

Given the corrosion risk, there are obviously some structures - such as road bridges - where it would be very bad practice to try to increase the degree of carbonation, so it may be that only around 50% of the potential total would be suitable for sequestration.

A good example of where it could be done would be a warehouse floor, which will remain dry so the reinforcement will not corrode. If 750 m3 of concrete was placed in the floor and it was made to carbonate to 50% of its potential total, this would sequester 20 tonnes of CO2. The strength and hardness of the floor would also be improved by the process.

On a general level, actively using and monitoring carbon capture for concrete, just at current levels, will lead to expected reporting of savings of more than 150,000 tonnes of CO2 each year in the UK (again, only a rough figure currently, with a margin for error of up to 50%).

For the concrete industry under scrutiny and pressure due to the high carbon footprint of cement production, here is an opportunity to offset this figure by developing and recording the value from carbon absorbing concrete. For construction firms there is a revenue opportunity with clients who are prepared to pay an additional cost to demonstrate they are achieving carbon saving targets through BREAM or CEEQUAL.

Landlords with large-scale property stocks involving concrete will be able to make assessments of their contribution to carbon capture. Across industries there is the potential for including the role of concrete in environmental reporting.

Case study - demolition

One example of a specific area is the potential of the demolition process - an area that needs to be exploited by industries under pressure to demonstrate creative thinking on environmental issues.

As mentioned, carbon capture has to be limited in all reinforced concrete structures due to the need to protect steel reinforcement against corrosion. That means the sequestration is limited to the outer layer, typically a 40mm depth. However, when concrete is crushed for re-use as a foundation material for roads or an aggregate to make more concrete, the internal surface is exposed and leads to far more rapid sequestration and much higher levels of capture than at any other part of the life-cycle of the structure.

The carbonation reaction needs water - so it may be that wetting the crushed material could be an easy way to increase sequestration. It also may well be the case that substantial potential capacity may be lost on some occasions when crushed material is encapsulated into concrete as recycled aggregate without being given the opportunity to carbonate.

This can be done by recording the amount of CO2 removed from the atmosphere through lab-scale tests, with samples placed in chambers in which the CO2 concentration is maintained at atmospheric levels by introducing gas to make up for losses. The amount that is introduced will be accurately measured to give direct data for sequestration.

Different concrete mixes also sequestrate to different extents. This particularly applies to mixes where cement replacements are used. Pulverised Fuels Ash (PFA) and Ground Granulated Blastfurnace Slag (GGBS) are the most common replacements and are often considered as similar alternatives. However a GGBS mix will have a far higher sequestration capacity than one with PFA because of differences in the chemical reactions in them (although no precise figures are available).

Similarly some mixes are far more permeable and will permit far more carbon dioxide to enter and gain access to their reactive components. The permeable mixes will tend to be those with lower strengths so mixes with unnecessarily high strengths should be avoided.

Conclusion

Given the strict targets in the UK for reducing carbon emissions, the pressure on all forms of industry - leading to potential penalties and charges - will be increasingly intense in the coming years. Here is a clear opportunity for new and significant forms of carbon capture, and action is needed now to gather the all-important basis for measurement.

More information

Professor Peter Claisse, Low Impact Buildings Centre, Coventry University.

The aim of the Low Impact Buildings Centre (LIBC) is to help create a low carbon, sustainable built environment.

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