Elucidating the Hardening Mechanism of Sustain-Crete® (Zero-cement Type)
- Collaborative Research Results with the University of Sheffield (UK) **-**

April 24, 2025

We are pleased to announce that we have elucidated the hardening (strength development) mechanism of Sustain-Crete® (※1) , which does not contain Portland cement, through collaborative research between our company and the University of Sheffield (UK). Sustain-Crete, developed by our company, has high fluidity under extremely low water-binder ratio conditions, and achieves high strength without using Portland cement. This research paper has been published in the international journal "CEMENT".

（※1） Sustain-Crete website
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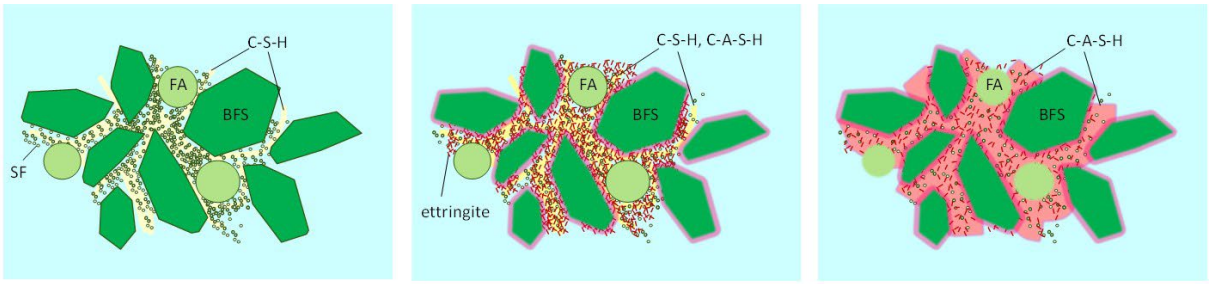
■Hardening mechanism

In this study, we investigated the role of each of the materials used in the formulation of Sustain-Crete (zero cement type) through chemical analysis, from immediately after mixing to the long-term. In the Sustain-Crete (zero cement type) system, each material reacts in sequence from the early to long-term stages to fulfill its respective role. As a result, it not only exhibits high fluidity despite an extremely low water-to-binder ratio but also achieves high strength without using Portland cement. Furthermore, it was confirmed that the reaction products produced under the hardening process of Sustain-Crete (zero cement type) are similar to the hydrates produced in conventional concrete in which part of the Portland cement has been replaced with Supplementary Cementitious Materials (SCMs).

The hardening process without using Portland cement is as follows:

① Silica fume (SF), which has a large specific surface area, reacts with expansive additive (EX) to produce the hydrate C-S-H (※2) .
② The C-S-H produced fills the gaps between the SCMs, such as ground granulated blast furnace slag (BFS) and fly ash (FA).
③ The alkaline stimulation by EX causes BFS to react, producing C-A-S-H (※3) and ettringite (※4) .
④ FA also reacts to produce C-A-S-H later.
⑤ The later generated C-A-S-H and ettringite are intricately linked to the first generated C-S-H, forming a very dense hardened body.

（※2） C-S-H: Calcium silicate hydrates (C-S-H) are the main binding phases in all Portland cement-based systems.
（※3） C-A-S-H: A hydrate in which Al is incorporated in C-S-H. Al is supplied from SCMs such as BFS and FA.
（※4） Ettringite: One of the cement hydrates, its chemical formula is $3CaO{\cdot}Al_2O_3{\cdot}3CaSO_4{\cdot}32H_2O$.



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【Image of the hardening process without using Portland cement】

■Paper Information

Title：Multi-year cementitious hydrate product formation in non-Portland high performance concretes

Authors：Daniel A. Geddes, Brant Walkley, Taku Matsuda, John L. Provis

Journal：CEMENT

URL：https://doi.org/10.1016/j.cement.2024.100111

（Refs.）The mechanism by which Sustain - Crete exhibits high fluidity with a small amount of water is mentioned in the following paper.

Reversible Adsorption of Polycarboxylates on Silica Fume in High pH, High Ionic Strength Environments for Control of Concrete Fluidity | Langmuir

■Contact

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