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Carbon negative concrete “CO_2-SUICOM”

Takeshi Torichigai (Kajima corporation)

Current status of CO_2 emissions in Japan and the world

According to a report by the Japan Center for Climate Change Actions (JCCCA), Japan emitted 1.24 billion tons of CO_2 in 2018, or 3.2%, of the world's total of 33.5 billion tons. This makes Japan one of the world's largest emitters of CO_2, ranking fifth behind China, the United States, India, and Russia. In the Paris Agreement adopted at the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) held in 2015, Japan set a goal of reducing its greenhouse gas emissions by 80% by 2050. Five years later, in October 2020, then Prime Minister Kan declared in a policy speech that Japan would go further and achieve a carbon-neutral society by 2050. Incoming Prime Minister Suga declared in his October 2020 policy speech that Japan would achieve a carbon-neutral society by 2050, and efforts to reduce CO_2 emissions are rapidly accelerating.

CO_2 emissions reduction and environmental load reduction in the concrete industry

The Japan Society of Civil Engineers (JSCE) compiled "Environmental Performance Verification Guidelines for Concrete Structures (Draft)" in 2005. These draft guidelines mention the effective use of industrial by-products to form blended cements and the active use of recycled aggregates as major methodologies for reducing CO_2 emissions when constructing with concrete. Recent activity has focused particularly on the development of technologies to minimize the use of cement, the production of which is highly CO_2 intensive. One example of this is ECM (energy-CO_2 minimal) cement using a large amount of blast furnace slag fine powder and geopolymer in place of cement.

Although the production of cement emits a large amount of CO_2, the cement industry also plays a major role in the treatment and disposal of industrial waste, taking in about 29 million tons of industrial waste annually in Japan as raw materials for cement and fuel substitutes. A rapid fall in cement consumption could give rise to the new problem of pressure on the disposal of industrial by-products. Against this background, the author has focused on the "carbonation curing" of concrete as a new method for the reduction of CO_2 intensity.

Carbonation of Concrete and CO_2-SUICOM

A phenomenon known as ‘neutralization’ occurs in normal concrete structures when the pH of the concrete approaches neutral due to the carbonation reaction between CO_2 in the atmosphere and calcium hydroxide in the concrete. Neutralization is considered poisonous for concrete because it promotes corrosion of the steel reinforcement. However, the carbonation curing technology we have been developing has the purpose of quickly carbonating concrete to the core, because we believe that neutralization is not problematic in unreinforced concrete or in concrete with corrosion-resistant reinforcement. The carbonation curing process fixes a large amount of CO_2 within the concrete at the time of product manufacture, which greatly reduces the CO_2 emissions balance. Using

this technology, we have developed a new environmentally friendly concrete, "CO_2-SUICOM" (Fig.1), that can achieve virtually zero or even negative CO_2 emissions in the manufacture of concrete products. We combine the use of special admixtures and other industrial by-products exhibiting CO_2-absorbing and hardening properties (as substitutes for cement) with forced carbonation using CO_2 from exhaust gas.

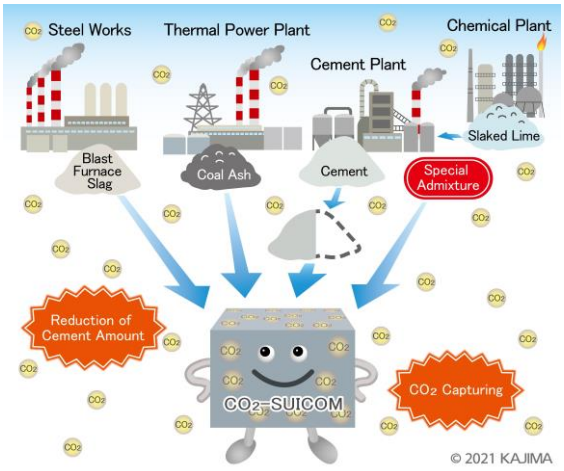

Figure 1 Overview of CO_2-SUICOM

CO_2 reduction potential of CO_2-SUICOM

The reduction in CO_2 emissions obtained by replacing conventional concrete with CO_2-SUICOM concrete is approximately 324kg per m^3 of concrete, as illustrated in Fig. 2. According to the 2008 annual report on production statistics published by the Ministry of Economy, Trade and Industry (Statistics on Resources, Ceramics, and Building Materials), about 3.5 million m^3 of standardized secondary concrete products, such as components for roads, are produced per year. If all of these were to be replaced by CO_2-SUICOM concrete, the reduction in CO_2 emissions would be about 1 million tons. Under the J-credit system, by which the government certifies reductions in greenhouse gas emissions as credits, the total reduction in emissions over the past four years from the 644 projects registered so far is 2.51 million tons, which clearly shows the potential of the new concrete.

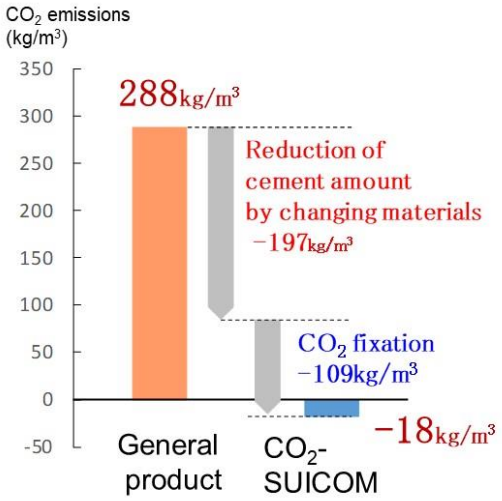

Figure 2: Comparison of CO_2 emissions

According to the Roadmap presented at the ICEF (Innovation for Cool Earth Forum), an international conference for solving climate change problems hosted by Japan, CO_2 absorption in concrete is expected to be the effective way to reduce CO_2 emissions in the near future. Then, the CO_2-SUICOM technology may be widely expanded internationally in the future.

Photo 1: Examples of CO_2-SUICOM application

In addition to contributing to the reduction of CO_2 emissions, CO_2-SUICOM has the following advantages:

1) The resulting concrete is neutral, making it friendlier to nearby vegetation and encouraging growth.
2) The resulting concrete is denser and has improved

abrasion resistance.

3) The efflorescence phenomenon is suppressed and so aesthetic appearance at the time of manufacture is maintained.

As an addition to the work described above, we have recently been studying the application of embedded formwork reinforced with glass fiber for the purpose of improving productivity in manufacturing work.

Toward a low-carbon society

The use of CO_2-SUICOM has so far been restricted to relatively small unreinforced precast products. This is because it was generally believed that the use of steel rebars as reinforcement in concrete that becomes neutral through the carbonation reaction would result in premature corrosion. The unreinforced precast concrete market is rather small, so it would limit CO_2 reductions to a few hundred thousand tons per year. Work is now in progress to expand the field of CO_2-SUICOM application by utilizing the expertise we have gained through the study of carbonation curing over more than 15 years under commission from NEDO. If we could absorb CO_2 by using CO_2-SUICOM for all cast-in-place concrete and reinforced concrete, which emits several tens of millions of tons of CO_2 per year in Japan, we believe it will be a great toward a carbon-neutral society.