

Pumpable High Powder Content Carbon-Negative Concrete: Cast-in-Place Construction Made Possible

Toda Corporation (Head Office: Chuo-ku, Tokyo, President: Otani Seisuke) and Nishimatsu Construction Co., Ltd. (headquarters: Minato-ku, Tokyo; President: Hosokawa Masakazu) have been collaborating on the joint development of environmentally friendly, low-carbon concrete since 2010. High powder content carbon-negative concrete is made with calcium carbonate, which absorbs and fixes CO₂ as a constituent material of the concrete, thereby reducing material-derived CO₂ emissions^{*1} to zero or less on a calculation basis. We have used concrete pump trucks to run demonstration tests confirming that cast-in-place construction is possible with this kind of concrete.



Fig. 1 Degree of CO₂ reduction^{*2} in carbon-negative concrete / Concrete

- *1 Material-derived CO₂ emissions are the CO₂ emissions as calculated by using the CO₂ emissions intensity of the materials used in the production of concrete. The amount of CO2 absorbed and fixed increases, depending on the amount of Carbon Capture and Utilization (CCU) materials added, resulting in calculated CO₂ emissions of zero or less.
- *2 The "ordinary concrete" shown in Figure 1 refers to concrete mixtures with a strength grade equivalent to that of carbon-negative concrete. Carbon-negative concrete mixtures 1 and 2 differ only in the method by which the calcium carbonate they use was produced (substrate and method of absorbing and fixing CO₂).

1. Background to the Development

Concrete is widely used as a key material in the construction industry, with total shipments within Japan amounting to roughly 70 million cubic meters annually (figures from 2023).*3 The generally held view is that the production of one cubic meter of concrete emits approximately 270 kg of CO2. Total annual emissions would accordingly be calculated at roughly 19 million tons of CO₂ — an astronomical figure. It is therefore an urgent matter to reduce CO₂ emissions associated with the production of concrete, if we are to achieve carbon neutrality.

Toda Corporation has previously collaborated with Nishimatsu Construction on the joint development of Slagrete[®],*4 which can reduce the material-derived CO₂ emissions of concrete by up to 85%. Building on this technology, we have now been engaged in the development of carbon-negative concrete. In this demonstration test, we followed up on the precast product manufacture verification conducted in previous years*5 and confirmed pumpability.

*3 Trends in Nationwide Shipment Volumes, 2023, published by the National Federation Ready-Mixed Concrete Industrial Associations and National Federation Ready-Mixed Concrete Cooperative Associations (Japanese only) https://www.zennama.or.jp/3-toukei/nenji/index.html

*4 Toda Corporation news release "The Development of Low-Carbon Concrete 'Slagrete®" (Japanese only) https://www.toda.co.jp/assets/pdf/20160208.pdf

*5 Toda Corporation news release "Commencement of Joint Development on Carbon-Negative Concrete" (Japanese only) https://www.toda.co.jp/news/2023/20231205 003291.html

2. Overview of the New Material

This new carbon-negative concrete is based on Slagrete®, a low-carbon concrete that replaces up to 90% of the cement used in concrete mixtures with ground granulated blast-furnace slag, an industrial by-product. The carbon-negative concrete currently being developed takes the Slagrete® compound as its base and adds calcium carbonate, which absorbs and fixes CO₂. Depending on the amount of calcium carbonate added, the CO₂ emissions from this new concrete material can be calculated as zero or less.

Generally speaking, concrete with a high powder content, such as this one, tends to be highly viscous and hardens quickly. Unless the fluidity is improved, such concretes are often unsuitable for pumping with a concrete pump truck. The new material preserves the fluidity of the concrete by using a specially developed admixture during the concrete mixing process.

3. Demonstration Tests

Toda Corporation and Nishimatsu Construction carried out demonstration tests of this new material by using calcium carbonates produced according to differing methods to prepare two different carbon-negative concrete mixtures. We confirmed the following points by pumping and casting the mixtures through a concrete pump truck.

- Using the specially developed admixture makes it possible to produce carbon-negative concrete that can be pumped through a concrete pump truck, even with calcium carbonates of varying properties.
- The compressive strength is similar to that of ordinary concrete, and comparable strength can be achieved.
- The coloration can vary depending on the production method of the calcium carbonate, but it is whiter than ordinary concrete.
- The surface quality is equivalent to or superior to ordinary concrete.



Photo 1: Carbon-negative concrete being discharged



(1) Surface air permeability test



Photo 2: Carbon-negative concrete test specimens



(2) Surface water absorption test

Photo 3: Confirming the surface quality

4. Future Developments

Toda Corporation and Nishimatsu Construction will continue work on developing this material with the aim of achieving its broad application in the fields of civil engineering and construction industries on the way to building a carbon-neutral, decarbonized society by 2050.

The Company will strive to optimize its business portfolio by promoting strategic investments in priority management businesses and intangible assets that will drive future growth, and to achieve its medium-to long-term goal of 8% ROE, as well as to further enhance corporate value.



