No. : A-6-1E

PJ : C^{4}S Research & Development Project

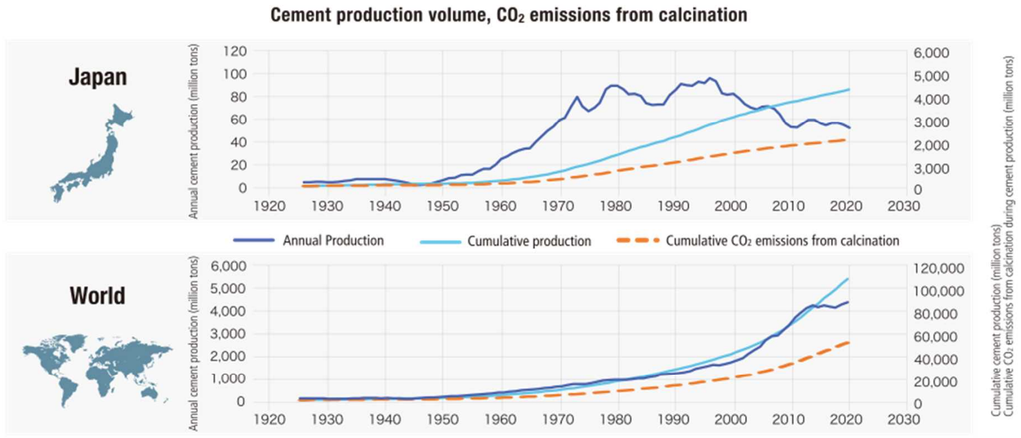
Theme : Save the earth by producing new concrete solely from atmospheric CO_2 and waste concrete!

Organization : The University of Tokyo and Hokkaido University

Contact : Takafumi Noguchi (PM, Professor at the University of Tokyo), noguchi@bme.arch.t.u-tokyo.ac.jp

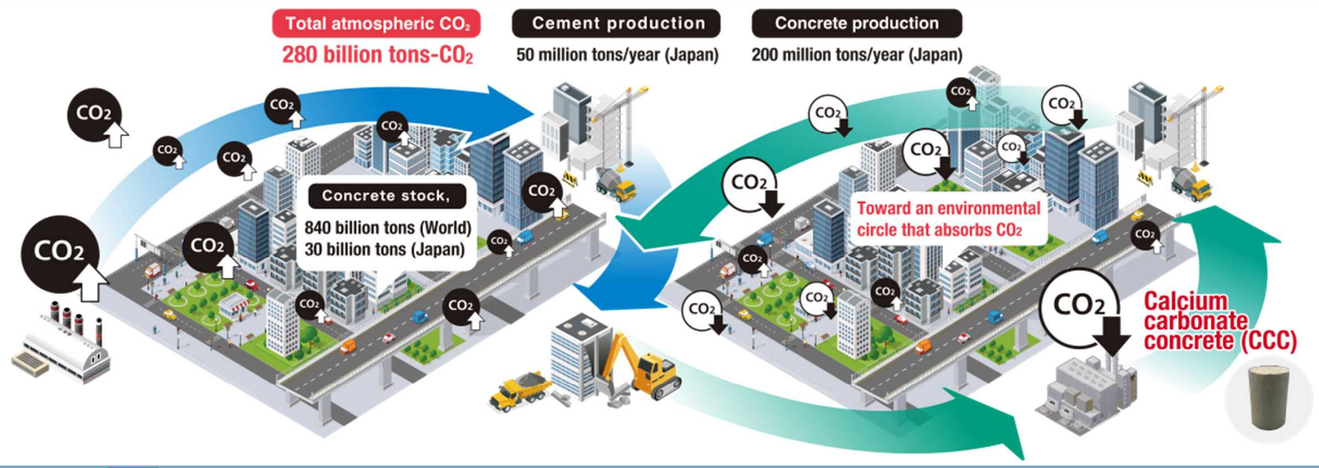
1 How much CO_2 has cement concrete emitted so far?

To date, the calcination of limestone during cement production has emitted a cumulative total of more than 50 billion tons of CO_2 worldwide (more than 80 billion tons cumulatively if calcination energy is included).



2 What are the goals of the project?

Cumulative CO_2 in the atmosphere emitted by the calcination of limestone during cement production will be captured to form calcium carbonate ($CaCO_3$), which will be used as a binder to make calcium carbonate concrete for construction of structures.

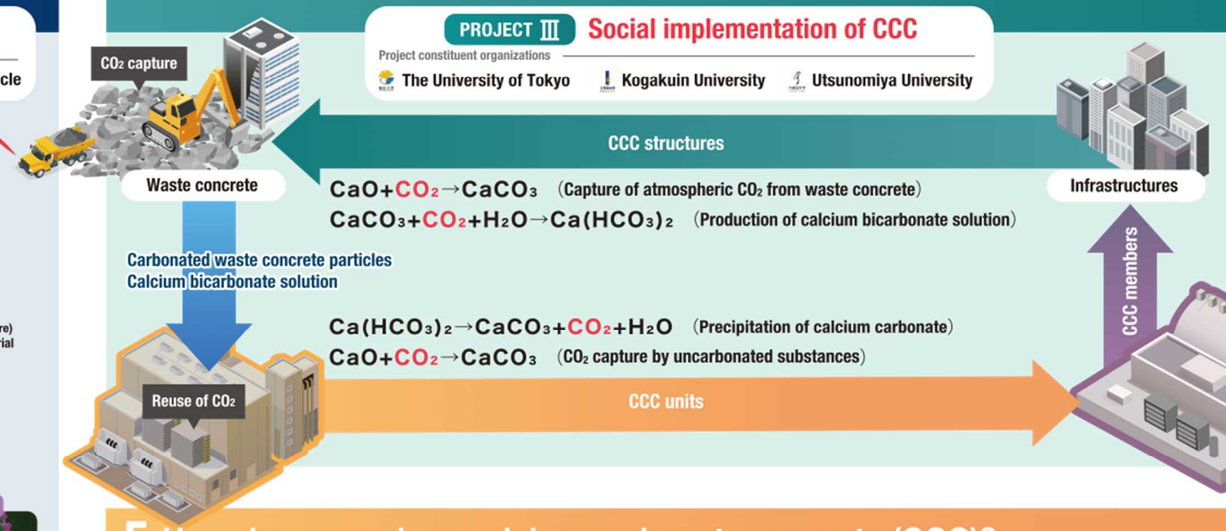


3 How can the project be described in one word?

Calcium carbonate concrete (CCC) is produced using only atmospheric CO_2 and waste concrete, which are ubiquitous raw materials. CCC is then permanently recycled as a construction material.
Proposals will be made to optimize resource circulation and maximize CO_2 capture, which are necessary for social implementation of CCC, as well as to develop the basic criteria and standards for CCC structures.

PROJECT Ⅲ Social implementation of CCC

Project constituent organizations: The University of Tokyo / Kogakuin University / Utsunomiya University

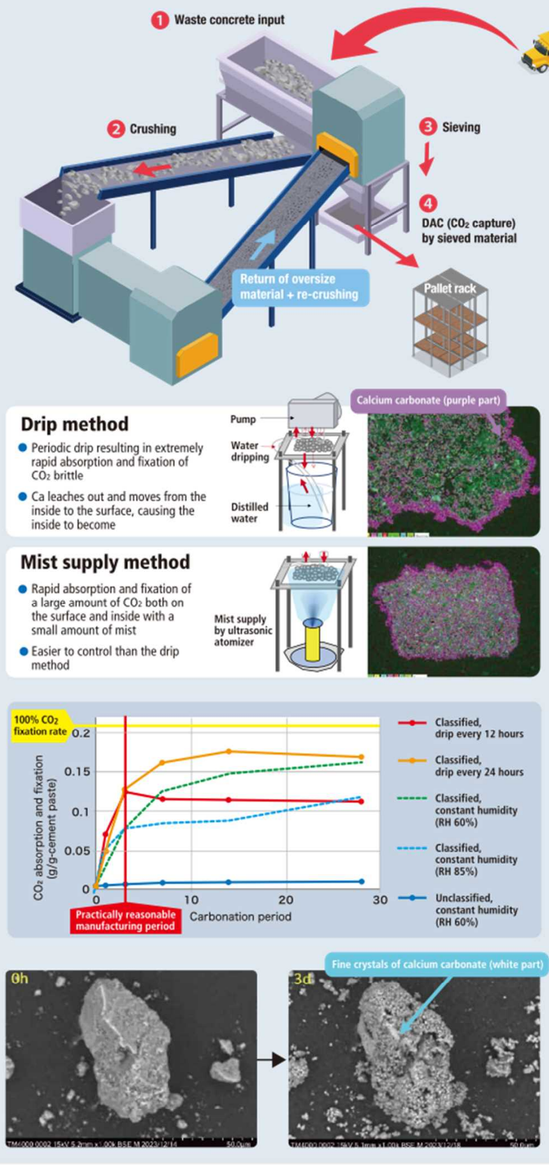


4 How do we capture the CO_2?

By repeatedly providing the fine particles of crushed and graded waste concrete with moderate moisture content, the calcium component (CaO) in the waste concrete reacts with carbon dioxide (CO_2) in the atmosphere quickly and in large quantities, thereby recovering a large amount of CO_2 from the atmosphere.

PROJECT Ⅱ CCC raw material production and DAC (Atmospheric CO_2 capture)

Project constituent organizations: Hokkaido University / Masuo Recycle



Drip method
- Periodic drip resulting in extremely rapid absorption and fixation of CO_2 brittle
- Ca leaches out and moves from the inside to the surface, causing the inside to become

Mist supply method
- Rapid absorption and fixation of a large amount of CO_2 both on the surface and inside with a small amount of mist
- Easier to control than the drip method

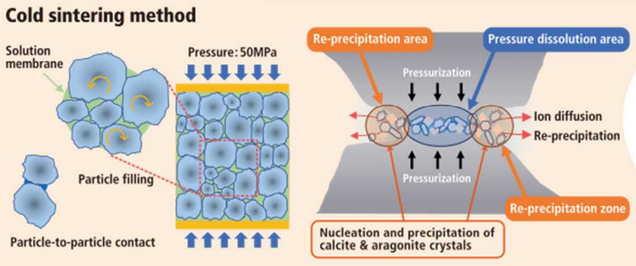
5 How do we produce calcium carbonate concrete (CCC)?

After the carbonated waste concrete particles are mixed with calcium bicarbonate solution, they are packed tightly in a rigid mold and pressurized to cause dissolution of calcium at the contact zone of the particles and re-precipitation of calcium carbonate crystals (calcite, aragonite), followed by several cycles of drying and immersion in calcium bicarbonate solution to produce CCC units.

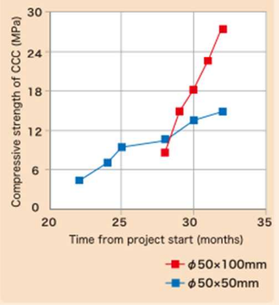
PROJECT Ⅰ Development of reaction control technology for CCC and stabilized production technology for CCC units

Project constituent organizations: The University of Tokyo / Taiheiyo Cement

Cold sintering method



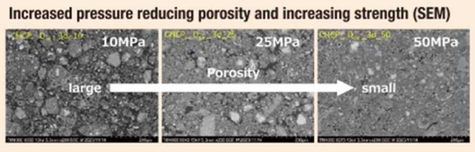
Higher strength of hardened body



Increase in size of hardened body

Optimization of particle size distribution	Reduction of CCC porosity Increase in aggregate-to-aggregate contact area Strengthening of CCC skeleton after pressure molding	Increase of compressive strength
Drying of CCC after pressure compaction	Precipitation of calcium carbonate at the aggregate interface	Densification Bonding of aggregate particles
Immersion in Ca $(HCO_3)_2$ solution and drying (secondary curing)	$Ca(HCO_3)_2 \rightarrow CaCO_3+CO_2+H_2O$ Further precipitation of calcium carbonate Further carbonation of uncarbonated portions by the resulting CO_2	Increase of compressive strength Large energy consumption

Increased pressure reducing porosity and increasing strength (SEM)



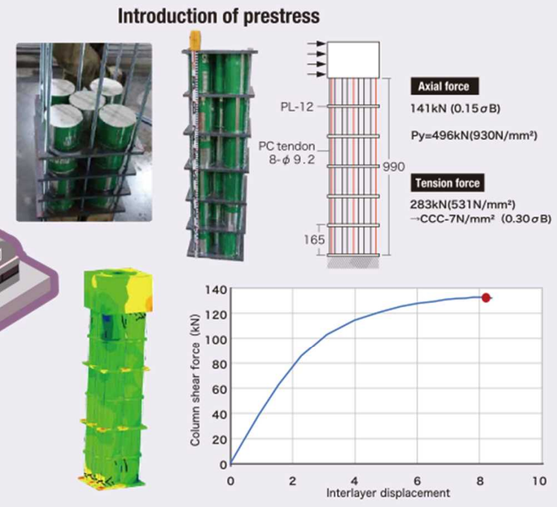
6 How do we build the structure?

Column and wall members are constructed by connecting calcium carbonate concrete (CCC) units and prestressing them into a single unit. The beam and floor members are constructed by compositing them with steel, wood, FRP sheets, etc., or by using an arch, vault, or dome structure in which only compressive forces act. The column, wall, beam, and floor members are then connected to form a CCC structure.

PROJECT Ⅰ Development of manufacturing principles for CCC members
PROJECT Ⅲ Development of structural design and performance evaluation methods for CCC buildings

Project constituent organizations: The University of Tokyo / Tokyo University of Science / Taiheiyo Cement

Introduction of prestress



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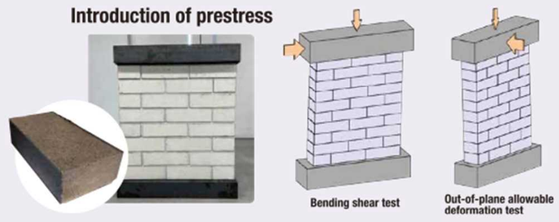
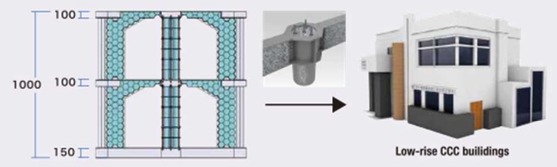


EXPO 2025 Exhibit structure at the Osaka Expo

Exhibit at Future Society Showcase Project
https://www.expo2025.or.jp/en/news/news-20230914-01/
Application for 13m² periodic exhibitions in the Future Life Experience

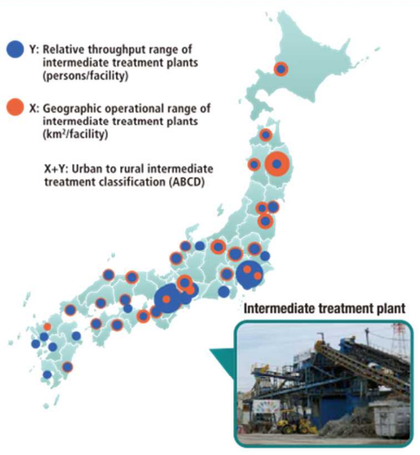
Structure using CCC (shape: to be further elaborated)

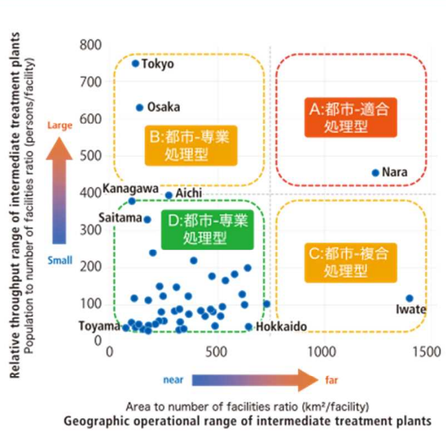
Proposal of CCC structural form considering manufacturing method
- Rigid-frame structure
- Arch, vault or dome structure



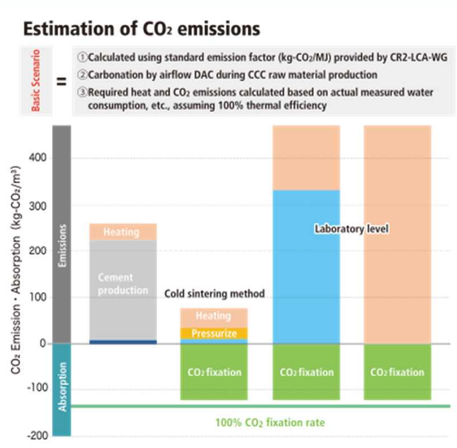
7 How much CCC raw material will be generated and where should it be produced? How much CO_2 will be captured by CCC production?

In the future, structures will be demolished as they reach the end of their service lives, generating approximately 100 million tons or more of waste concrete each year, reaching a cumulative total of approximately 4 billion tons by 2050.For every 1m³ of CCC produced, more than 100 kg of CO_2 (target 124 kg) will be captured from the atmosphere.





Estimation of CO_2 emissions



8 How to implement and disseminate the CCC structure in society?

After confirming that the quality of CCC and the performance of CCC structures satisfy the building code, we aim to construct several CCC buildings in 2030 and half of all concrete structures in 2050 will be CCC structures.

Fiscal year	Development and dissemination of CCC	CCC production volume
2023	Compressive strength of 12 MPa achieved	0 thousand tons
2024	Construction of experimental structures	0.1 thousand tons
2029	Construction of 2-3 low-rise CCC buildings	2 thousand tons
2040	1.725 times increase annually	345 thousand tons
2050	50% of concrete structures are CCC construction.	110,000 thousand tons

Minimum required strength of concrete: 12 MPa
Article 74 of the Building Standard Law Enforcement Ordinance: "The strength of concrete used in reinforced concrete construction shall be as specified below."

Exhibition of experimental structures at Expo 2025 Osaka EXPO 2025

Enactment and revision of laws and standards

①Obtained ministerial approval under Article 20 of the Building Standard Law
②Establishment of the Codes and Standard Specifications of the Architectural Institute of Japan
③Revision of Notification No.1446 (technical standard) of the Ministry of Construction
④Obtained ministerial approval under Article 37, Paragraph 2 of the Building Standard Law
⑤Establishment of Japanese Industrial Standards (JIS)
⑥Revision of Notification No. 1446 (technical standards) of the Ministry of Construction
⑦Compliance with Article 37, Paragraph 1 of the Building Standard Law

CO_2 emission reductions: Japan: ▲26.2 million tons-CO_2/year; World: ▲2.1 billion tons-CO_2/year

9 Concrete to be white carbon!

"White Carbon" following Green Carbon and Blue Carbon reduces global warming.

Concrete can create carbon capture and storage in human ecosystems in addition to continental and marine ecosystems.

Carbon captured in continental ecosystems
Green Carbon
from land green
CO_2 captured **106.4** billion tons/year

Carbon captured in marine ecosystems
Blue Carbon
from ocean blue
CO_2 captured **58.3** billion tons/year

Save the Earth with White Carbon!

Carbon captured in human ecosystems
White Carbon
from human activities
CO_2 captured **10** billion tons/year