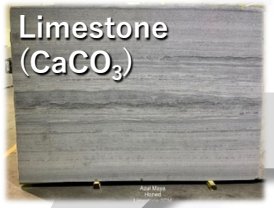
# C⁴S* Research & Development Project

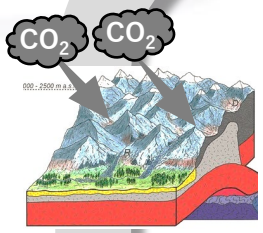
* Calcium Carbonate Circulation System for Construction

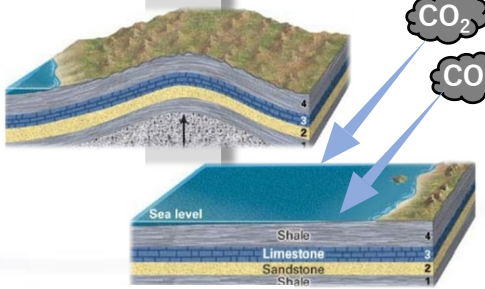
MOONSHOT RESEARCH & DEVELOPMENT PROGRAM

NEDO








Formation of limestone by biological and inorganic processes

■ Total $CO_2$ in the atmosphere
2,800 billion tons

■ **$CO_2$ emissions due to calcination during clinker production**

- **Cumulative amount**
  - World 55,000 million tons
  - Japan 2,000 million tons
- **Annual**
  - World 2,100 million tons
  - Japan 26 million tons


Production of CCC (Calcium Carbonate Concrete, $CaCO_3$)

CCC products

Utilization of $CO_2$

Utilization of $CO_2$

**Circulation of CCC**

**C**alcium **C**arbonate **C**oncrete

Recycled concrete aggregate

Calcium bicarbonate solution

Production of CCC raw materials

$Ca(HCO_3)_2aq. \rightarrow CaCO_3+CO_2+aq.$





$CaCO_3+CO_2+aq. \rightarrow Ca(HCO_3)_2aq.$

Coarse particles

Fine powders

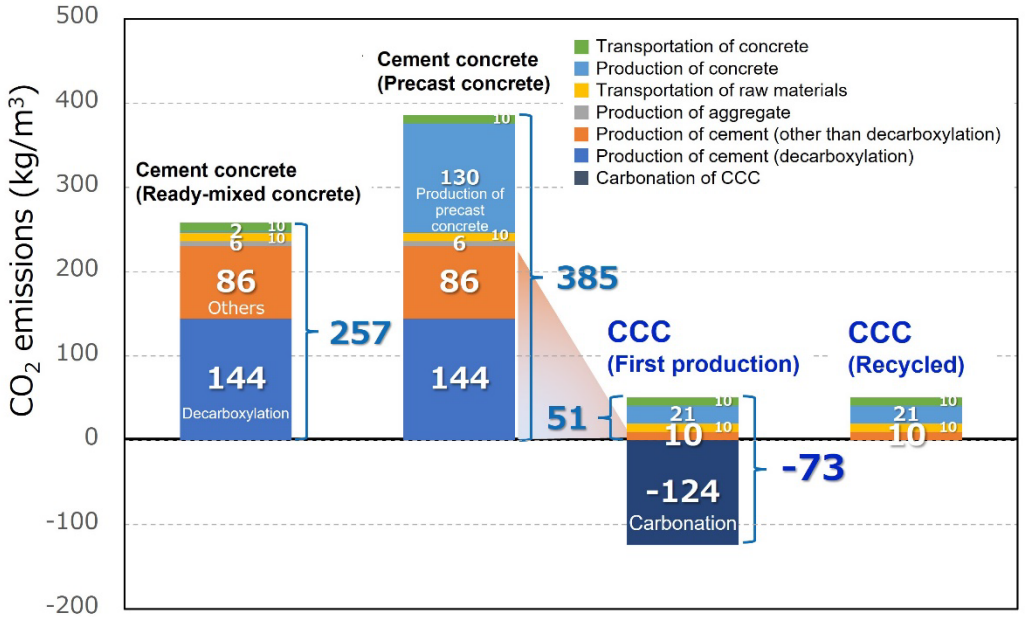

$Ca(OH)_2+CO_2 \rightarrow CaCO_3+H_2O$

$(CaO)_x(SiO_2)(H_2O)+{}_xCO_2 \rightarrow {}_xCaCO_3+SiO_2(gel)+H_2O$

**5th October 2022**

**Takafumi Noguchi, Professor at the University of Tokyo**

# C⁴S Research & Development Project




- **Carbon negative or neutral**
  - ➡ CCUS equivalent to $CO_2$ emitted by cement concrete
- **Local production for local utilization**
  - ➡ $CO_2$ and concrete structures that are ubiquitous
- **Completely recyclable**
  - ➡ Recyclable as many times as you like with negligible $CO_2$ emission

## White Carbon

**$CO_2$ sink: 1.0 billion tons/year**

- ➢ 1/5 of Blue Carbon
- ➢ 1/10 of Green Carbon

| Year | Development and dissemination | Establishment & revision of laws and standards |
|---|---|---|
| 2023 | Compressive strength with 12 MPa | ①Revision of Building Standard Law of Japan<br>②Development of Japanese Industrial Standards for CCC<br>③Institutional technical guidelines for design and construction of CCC<br>④International standards for CCC |
| 2025 | Construction of mock-up structure | |
| 2030 | Construction of several low-rise CCC buildings | |
| | *1.725 times increase every year* | |
| 2050 | 50% of concrete structures made of CCC | |

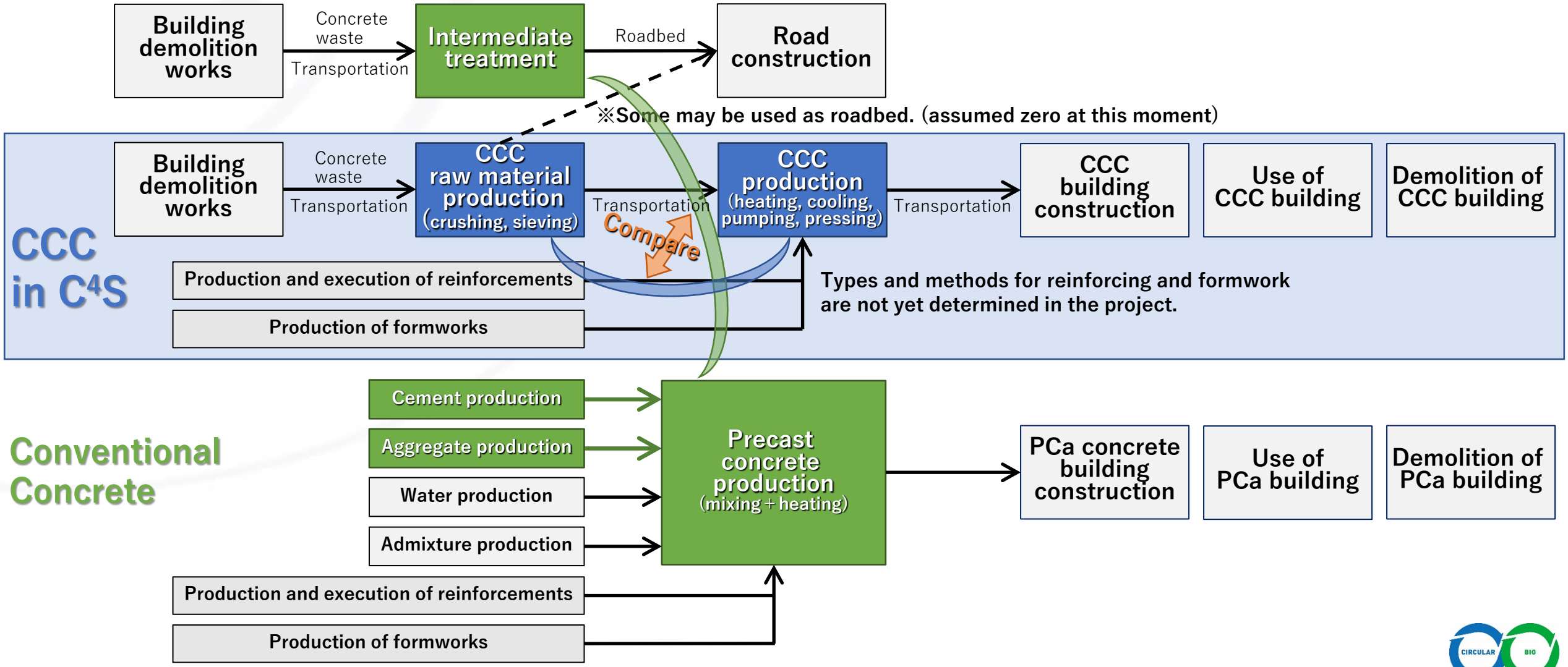
**In 2050, $CO_2$ to be captured, utilized & stored as CCC**

World 1,000 million tons/year
Japan 12 million tons/year

**After 2050**

Concrete will become carbon neutral like wood.

# C⁴S Research & Development Project



# C⁴S Research & Development Project

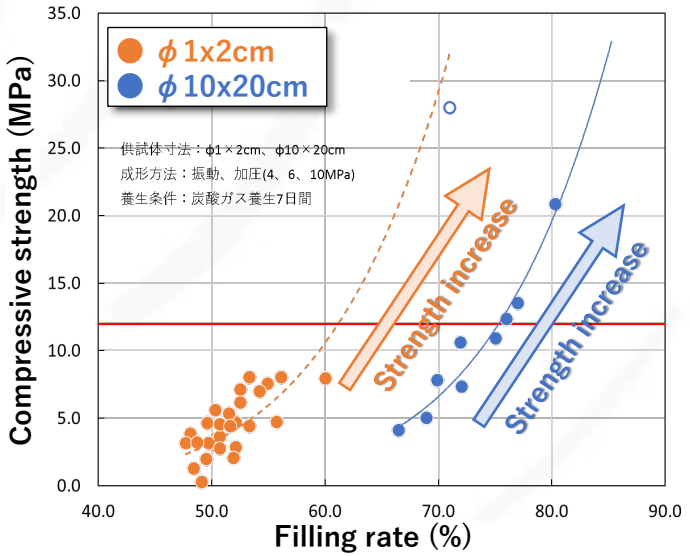
The higher the filling rate before curing, the higher the compressive strength.

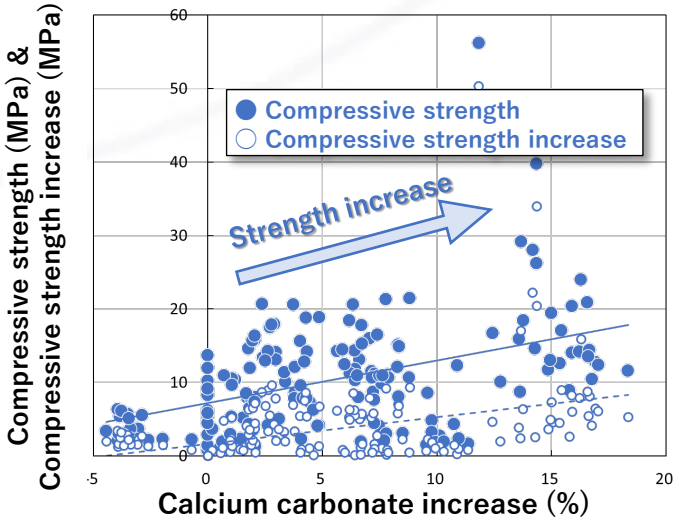
**Pressure molding**

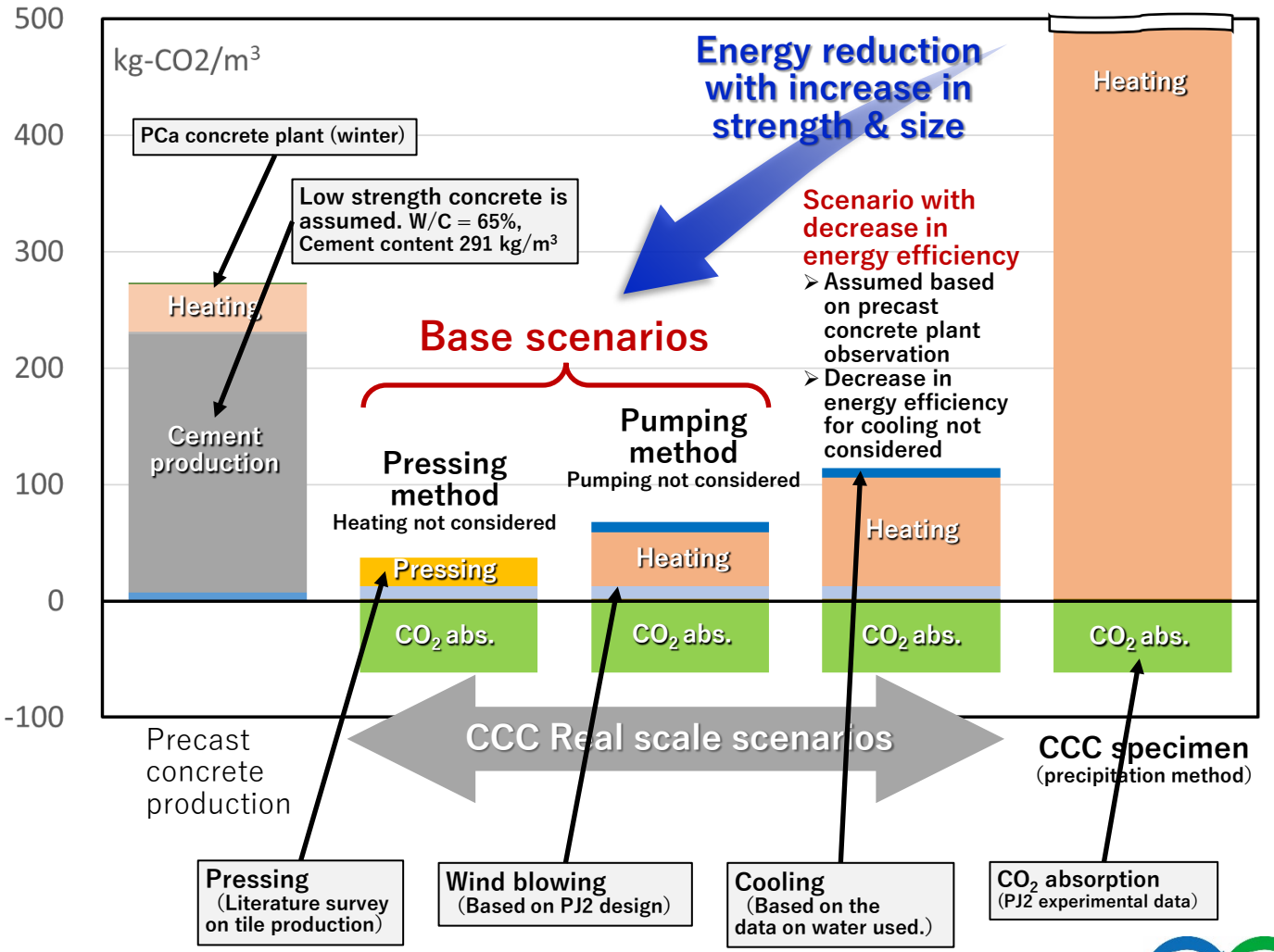
**Strength increase with size increase**

**$CO_2$ curing**

The greater the increase in calcium carbonate precipitation, the greater the increase in compressive strength.



# $CO_2$ Calculation Assumptions

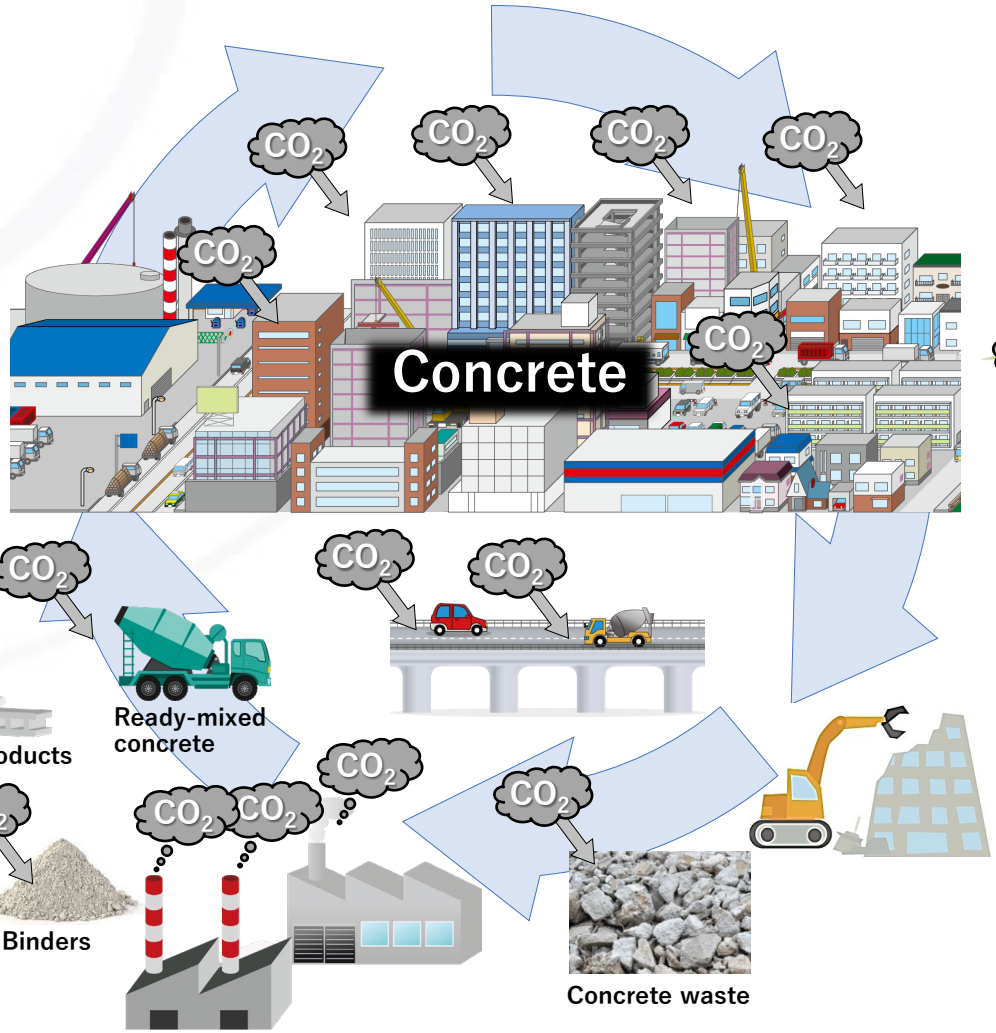
- **Heating and cooling energy for CCC production is calculated based on the amount of water** used for CCC specimen production. 100% energy efficiency is assumed for this process. Water amount is obtained from CCC experimental data for small specimen.
- **Energy efficiency decrease in heating is calculated based on the precast concrete plant observation**. However, energy efficiency decrease in cooling is not considered.
- **Heated water (70℃) in CCC production is cooled down to 20℃** in outdoor exposure without any energy consumption.
- **Pressing energy is calculated based on ceramic tile plants data** ($MJ/m^2$), and 200 times pressing is assumed for $1m^3$ CCC production.
- **Crushing energy for CCC raw material production is assumed as the same for roadbed materials from demolished concrete**. The energy may increase depending on the particle size distribution necessary for CCC production.
- **Wind blowing energy during CCC raw material production is calculated based on the machinery inventory data**. The machine operation condition is set based on the laboratory data and the semi on-site data.
- **$CO_2$ absorption of CCC is calculated based on experimental and semi on-site data**.
- **Pumping energy is not considered** due to the lack of data in full scale scenario.
- **Water spray energy is not considered** due to the lack of data in full scale scenario.
- Strength of precast concrete is assumed as low to keep consistency with CCC in strength.
- Heating energy for precast concrete is calculated based on the on-site plant observation.

# CCUS with Concrete “White Carbon”

## White Carbon

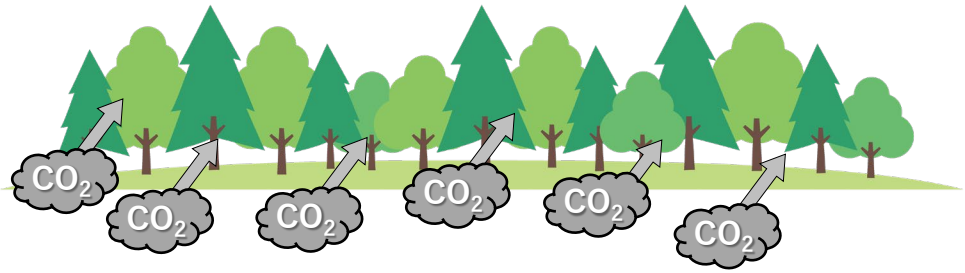
**$CO_2$ sink:**
**1.0 billion tons/year**

- 1/5 of Blue Carbon
- 1/10 of Green Carbon



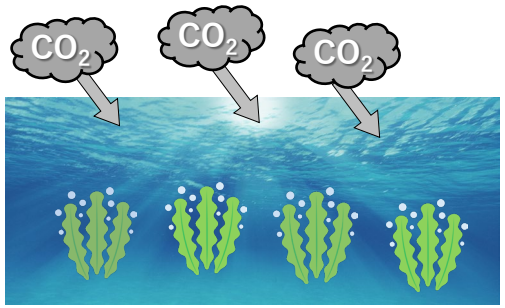

## Green Carbon

**$CO_2$ sink:**
**10.64 billion tons/year**




## Blue Carbon

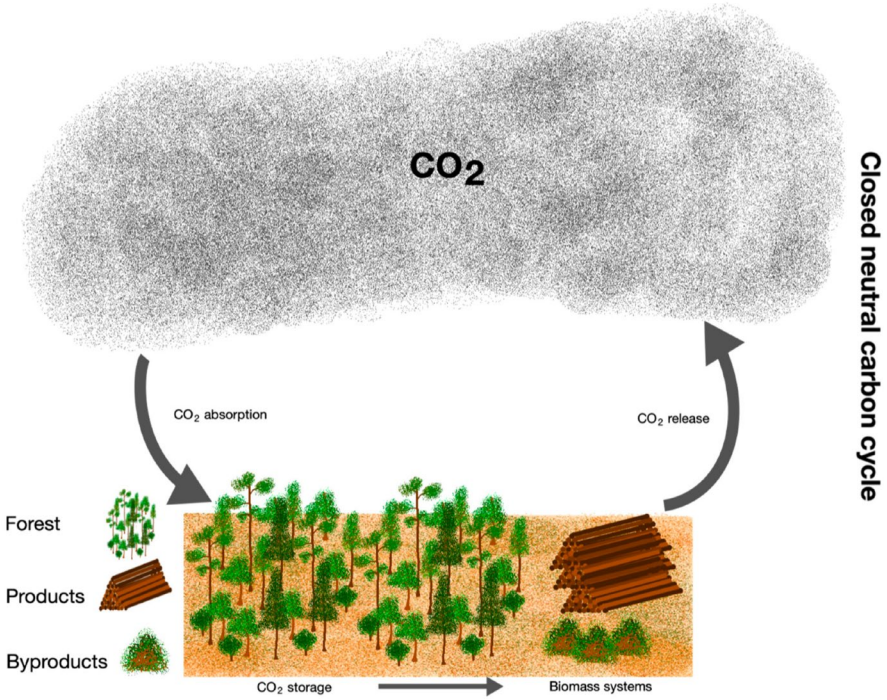
**$CO_2$ sink:**
**5.83 billion tons/year**



# Carbon Neutral Concrete toward Ideal CCUS

- Concrete is essential for construction.
- Concrete shall be sustainable like **wood**.
  - **Sufficient resources**
  - **Well-balanced between raw materials (Ca, Mg, $CO_2$) and products (cement, concrete)**
  - **Closed completely recyclable**
  - **Locally produced for locally utilized**
  - **Economic**

**CCC (Calcium Carbonate Concrete)**
promising candidate




Nunes LJR, Meireles CIR, Pinto Gomes CJ, Almeida Ribeiro NMC. Forest Contribution to Climate Change Mitigation: Management Oriented to Carbon Capture and Storage. *Climate*. 2020; 8(2):21. https://doi.org/10.3390/cli8020021