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Development and Implementation of Pavement Materials Towards Decarbonized Society

Hiroshi FUJII
Chief Engineer
Professional Engineer
Technical Research Institute
The Nippon Road CO., LTD.

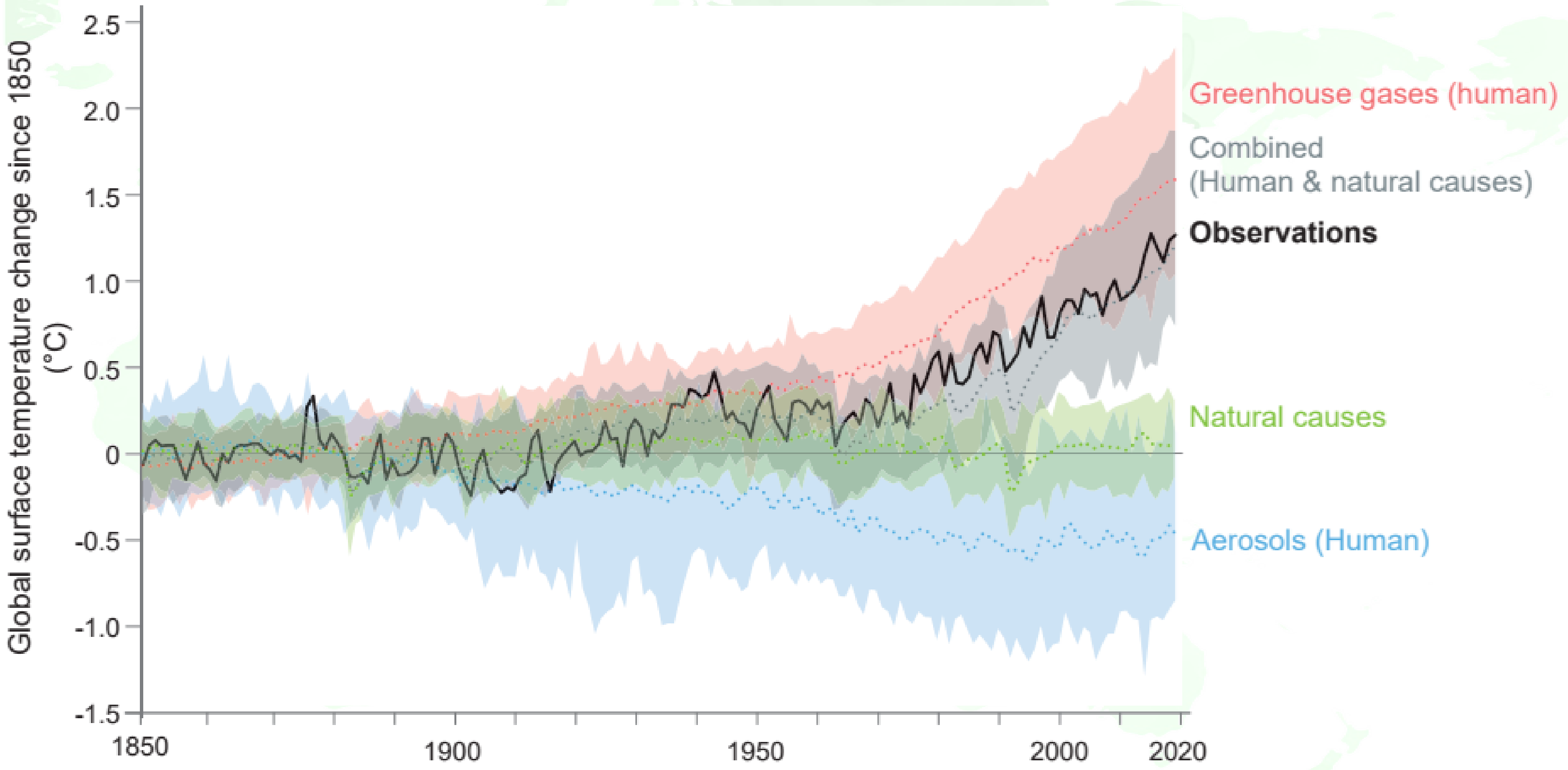
OUT LINE

Subject : Decarbonization technologies of Pavement

1. Background
2. Natural/Plant-Based Binder
3. Carbon Fixed Asphalt Mixture
4. Carbon Capture/Storage Concrete

Background

The Importance of Decarbonize



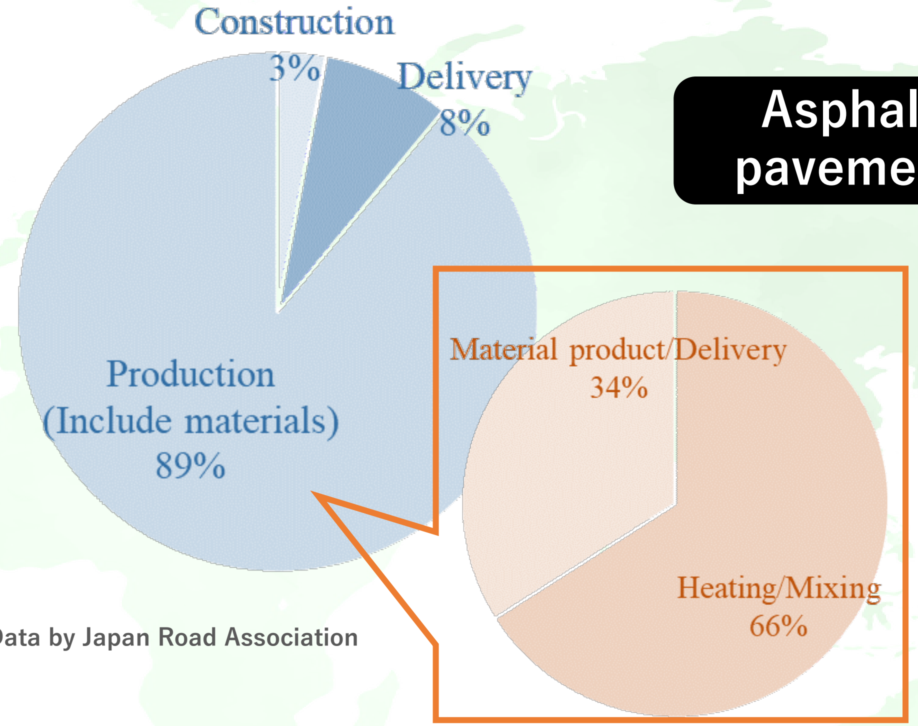
NOTE : IPCC AR6

- GHG emissions and climate change are related
- Climate change has a variety of negative risks

➢ Reducing CO_2 emissions from social activities are important

➢ Variable efforts have been making in the pavement field

CO_2 emission source in the pavement field



NOTE : Data by Japan Road Association

Asphalt pavement

Concrete pavement

1,450℃（calcination） $CaCO_3 \rightarrow CaO + CO_2$

Main factor

- 89% of CO_2 is related to production of HMA*
- Petroleum asphalt requires heating at every process

*HMA : Hot Mix Asphalt

Main factor

- Limestone calcination in clinker production
- Decarbonation of limestone

Our solutions

- Shift to low-carbon alternative materials
- Utilization of carbon-fixed materials
- CO_2 capture and storage in pavements

Botanical Binder

Natural/Plant-Based Binder

Low-carbon alternative material

Raw Material

Botanical binder made from natural/plant-based materials

Petroleum asphalt

Insoluble | Soluble

Asphaltene

Maltene
Resin / Saturate / Aromatic

Alternate →

Botanical binder

Key Points	
	1. Reducing CO_2 emission ・Botanical binder can be transported and stored at ambient temperature 2. Offset some CO_2 emissions with raw materials ・Made from cashew nut shells and other natural material

B2 SQUARE BITUMEN BEYOND OIL

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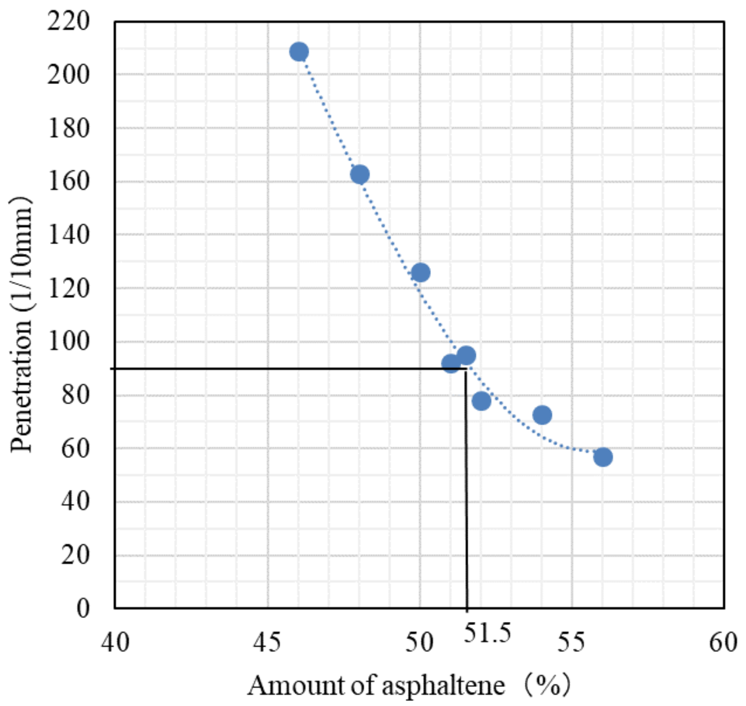
Botanical binder characteristics

Botanical binder can adjust the binder properties with mixing ratio



RHMA* properties of used Botanical Binder or Asphalt

Mixture properties	Binder: Botanical binder	Binder: Petroleum Asphalt	Standards
Add virgin binder (%)	3.1	3.1	N/A
Marshall stability (kN)	8.7	11.3	4.9 or more
Dynamic stability (Pass/mm)	3,940	1,970	N/A
Fatigue resistance (Cycle) (Condition:500 μ , 5℃, 5Hz)	3,940	1,435	N/A

100%

*RHMA : Recycle Hot Mix Asphalt

*Asphalt type : straight-run

Wheel tracking test
Evaluate the Dynamic stability (rutting resistance)

B2 SQUARE BITUMEN BEYOND OIL

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Estimation CO_2 Emissions

Source	CO_2 emissions (kg-CO_2/metric tons of RHMA)	
	Botanical binder	Petroleum Asphalt
Material	-31.8*	8.7*
Delivery	2.3	2.3
Production	30.9	31.5
Total	1.4 ← -97%	42.6

CO_2 emissions intensity (kg-CO_2/kg)
* Botanical binder:-1.2
* Petroleum Asphalt:0.107

Botanical binder reduces the CO_2 emissions about 97% comparing to the petroleum asphalt mixture.

This binder has adopted in several private projects and is under monitoring/evaluation.

B2 SQUARE BITUMEN BEYOND OIL

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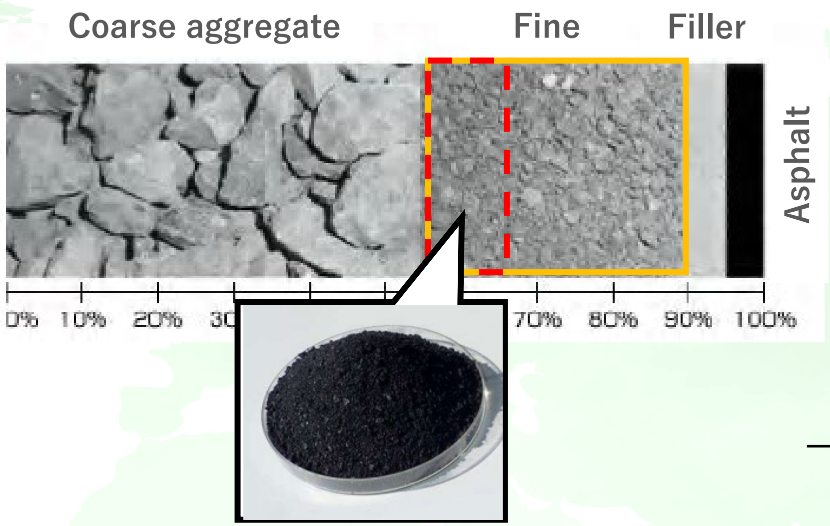
Biochar
Carbon Fixed Asphalt Mixture
Utilization of carbon-fixed material

Raw Material

Biochar is made from woody biomass by pyrolysis method

Key Point	
	1. Made by pyrolysis method not to emit much CO_2
	2. Fixed CO_2 2.3kg-CO_2/kg

Mixture Properties



Mixture Design

- Dense graded mixture
- Replace a part of fine aggregate with Biochar
- Polymer modified asphalt (Use for heavy duty road)

Density (g/cm^3)		1.702
Passing ratio(%)	2.36mm	100
	0.6	70.5
	0.3	50.8
	0.15	27.3
	0.075	17.4

Mixture properties	Biochar content (%)		Standards
	0	3	
Asphalt content (%)	5.4	5.7	N/A
Marshall stability (kN)	12.1	12.0	4.9 or more
Dynamic stability (Pass/mm)	4,630	6,920	N/A
Fatigue resistance (Cycle) (Condition:900 μ, 0℃, 5Hz)	610	605	N/A

Dynamic stability : Rutting resistance evaluated Wheel tracking test

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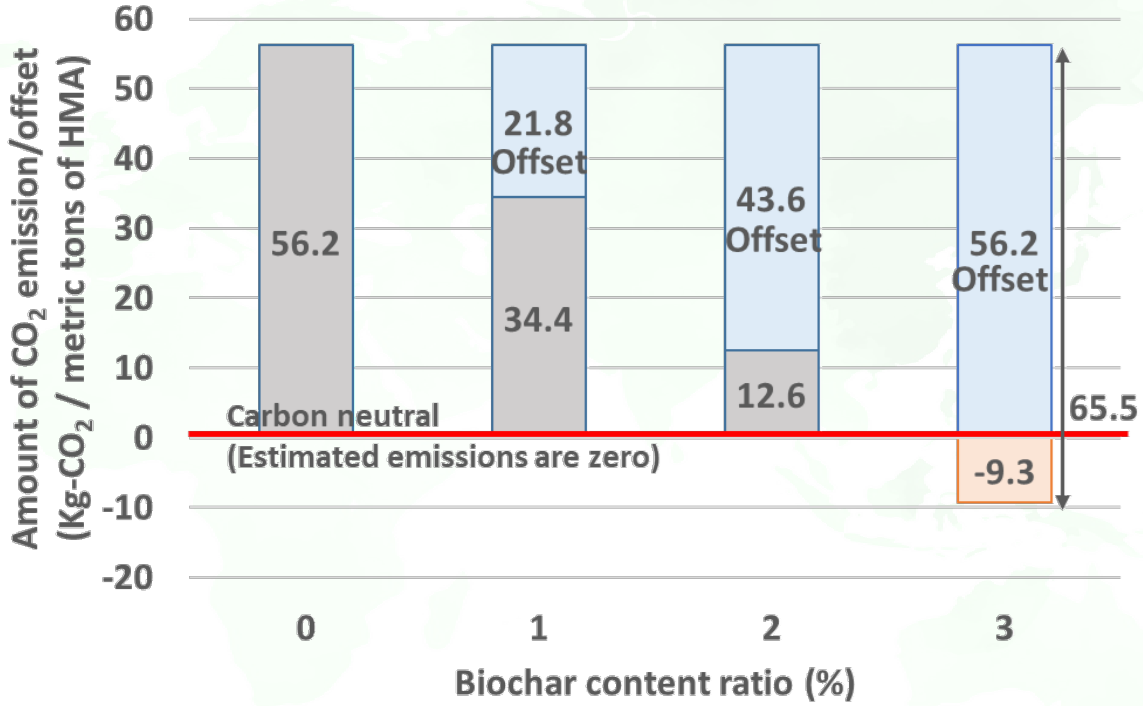
Estimation of CO_2 Emissions

*HMA : Hot Mixed Asphalt



Reduce the CO_2 emissions by replacing for a part of fine aggregate.

Once substitution ratio reaches to 3%, carbon negative can be realized.

Biochar mixture has adopted in both public/private projects and is under monitoring/evaluation.

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CP concrete pavement

Carbon Pool Concrete

CO_2 Capture and Storage in pavement

Based on Green Innovation Fund Project by NEDO
JPNP21023/CARBON POOL CONCRETE CONSORTIUM

NEDO : New Energy and Industrial Technology Development Organization

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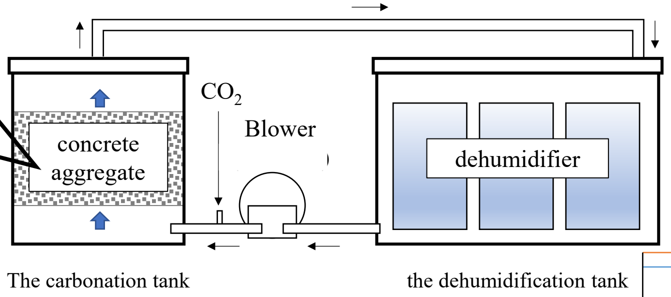
Materials

CO_2 carbonation unit



Granulate leftover/ returned concrete

Sludge

Accelerated carbonation/
Direct air capture

CP aggregate

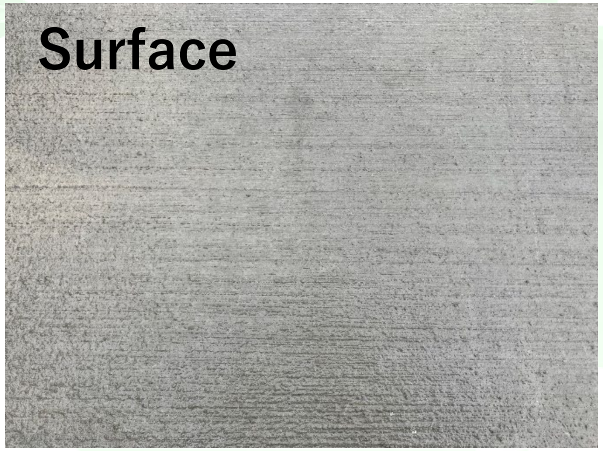
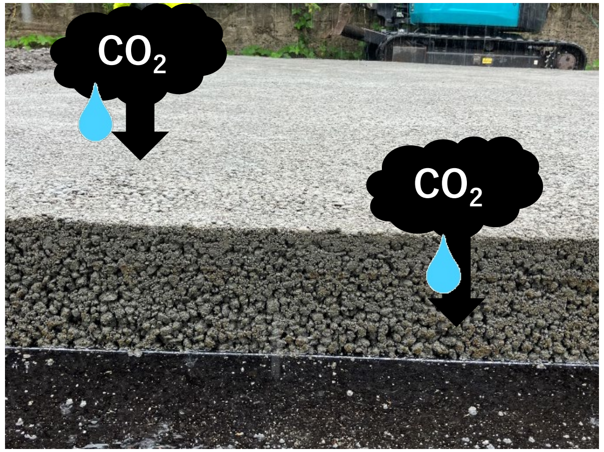
CP additive

Key point

1. CP materials are made by recycling concrete waste from construction sites.
2. Aiming to fix CO_2 emissions from industry/incineration plant, and other sources.

*CP : Carbon Pool

Carbon Pool Concrete Characteristics

Dense type	Pervious type
	
	

Dense type

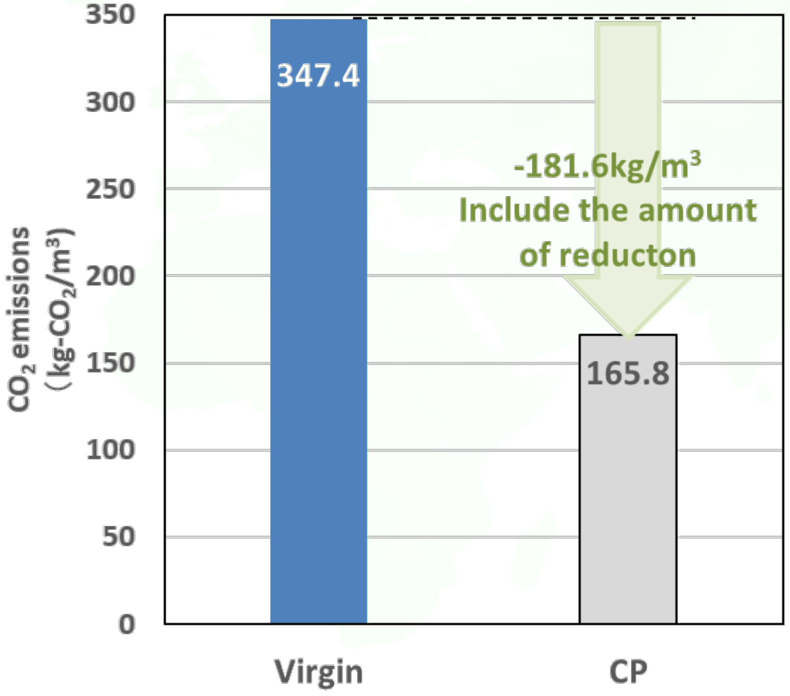
- Large amount of initial CO_2 fixation
- Many CP fine aggregates with high CO_2 fixation are used

Pervious type

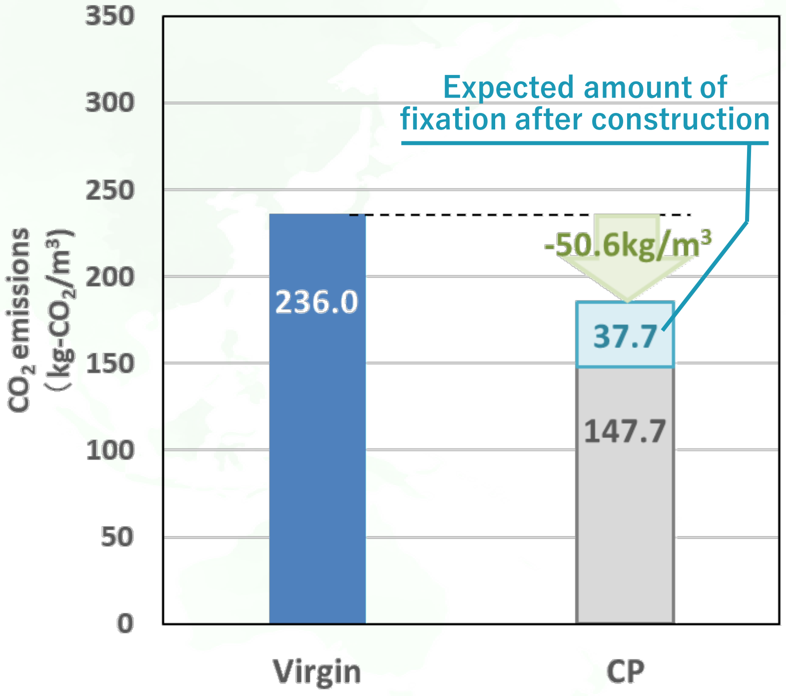
- Absorbs CO_2 even after construction
- Large surface area for carbonation reaction field
- In the pavement structure, repeated hydration caused by rainwater and exposure to CO_2 from vehicle emissions are expected to enable CO_2 fixation.

Estimation CO_2 Emissions

Dense type



Pervious type

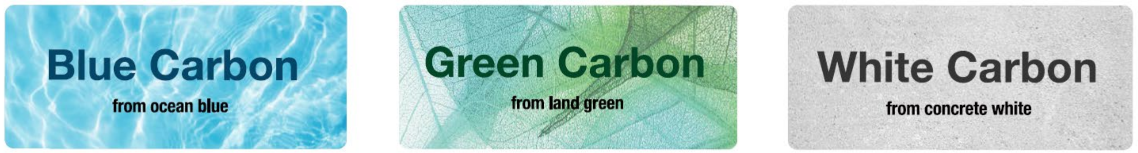


Dense type
52% reduction by utilizing CP aggregates and low-carbon materials

Pervious type
21% reduction by utilizing CP aggregates
37% reduction including expected fixation after construction.

Aim to achieve CO_2 reduction rate of more than 310kg/m^3 of concrete.

CP concrete has adopted in international project and is under monitoring/evaluation.



We call the CO_2 fixed in concrete “White Carbon”

Thank you for your attention
Question?

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