Carbon sequestration by mixing biochar into concrete

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Construction projects in ASEAN countries by Shimizu

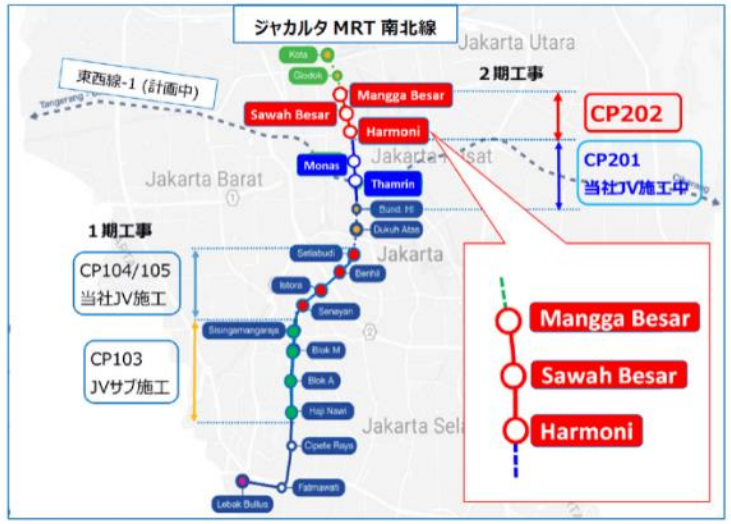
Hotel in Singapore

https://www.shimz.co.jp/works/sg_com_202303_panpaci.html

Bridge in Vietnam

https://www.shimz.co.jp/shimizusan/civil/

MRT in Jakarta



https://www.shimz.co.jp/company/about/news-release/2022/2022035.html

Subway in Philippines

https://www.shimz.co.jp/company/about/news-release/2023/2022062.html

Contents

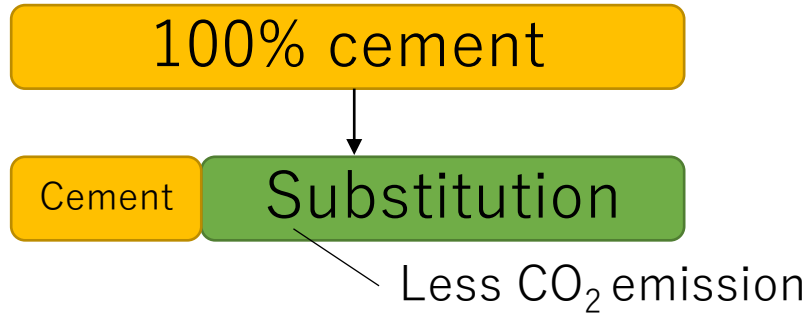
Outline of concrete mixed with biochar

Eco-friendly concrete to reduce CO_2

■ Using Low carbon cement

△Workability

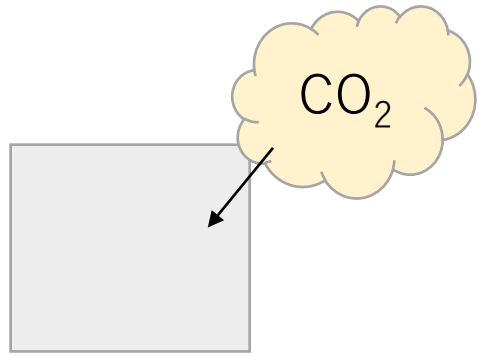
×Carbon neutral



■ Artificially carbonated concrete

△ Cost

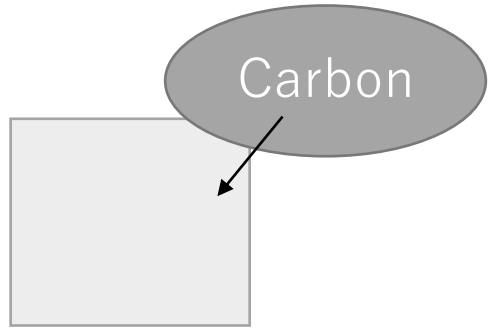
Available only for precast products



■ Storing carbon into concrete

Concrete mixed with biochar

Concrete mixed with calcium carbonate



Feature of biochar concrete

■ Easy to use

- □ Manufacturable at **any plants** and castable **on construction sites**
- □ Performance can be made **equal** to general concretes

■ Efficient carbon removal

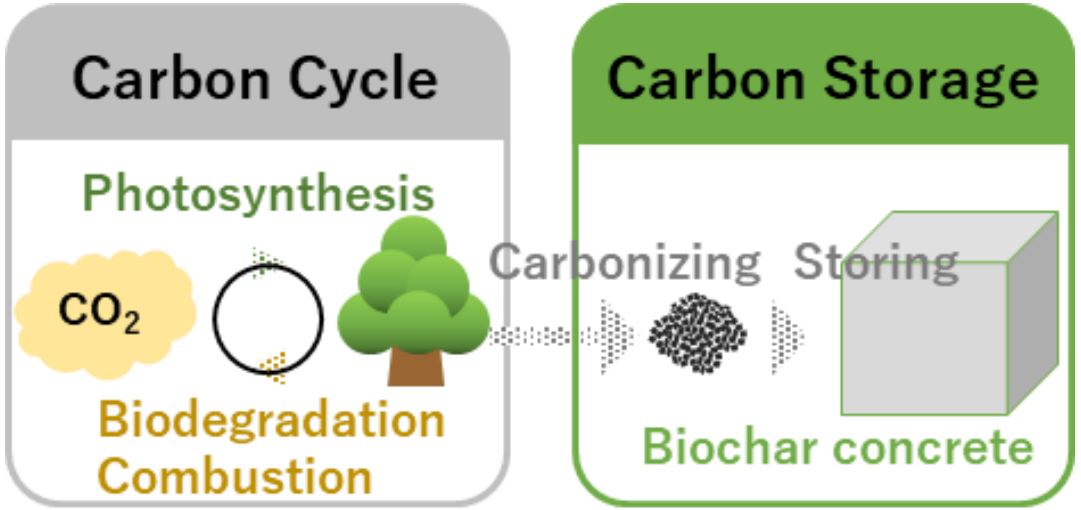
- □ Effective carbon dioxide fixation rate
  - ➢ Biochar：**2.29**kg-CO_2/kg, Calcium carbonate：0.44kg-CO_2/kg
    (under consideration)

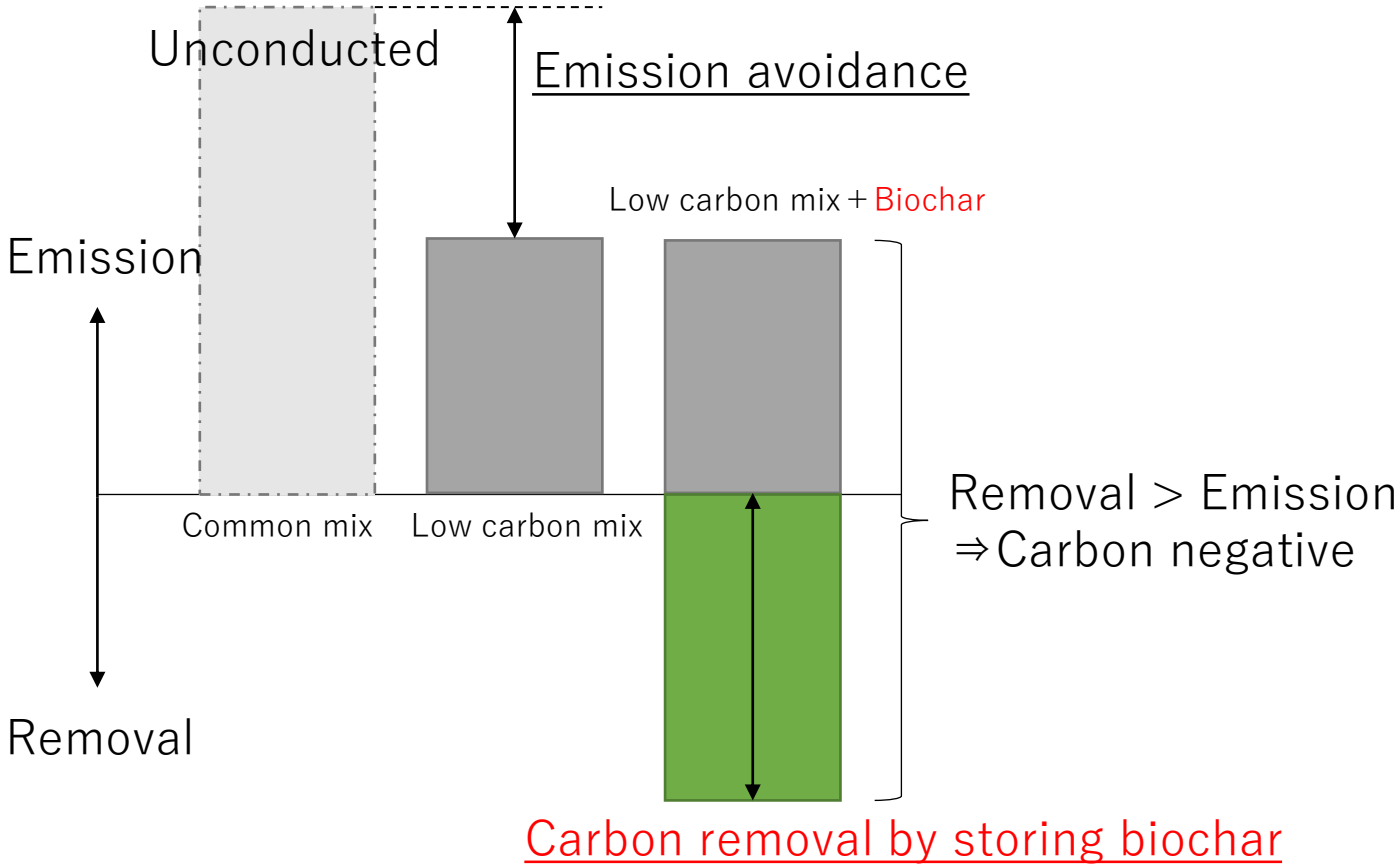
■ Enabling carbon neutral/negatives

- □ Not an emission avoidance but **carbon removal**
- □ If CO_2 removal by biochar exceeds emission from concrete materials, the concrete itself is **carbon negative**.

Carbon sequestration by biochar concrete

Carbon removal by biochar concrete

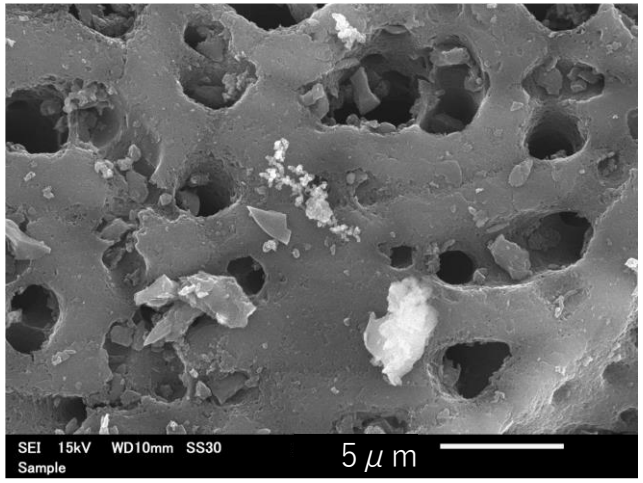




Overview of the mixed biochar

Production process

Storage condition



Microstructure

Appearance	Black powder (<2mm) or grain (2~5mm)	
Packaging	Plastic bag (20kg)	
Standard mixing volume	20~80kg/㎥	
Dry density	1.8g/cm^3	
Chemical composition	**Carbon**	**77%**
	Water	16%
	Volatile matter	5%
	Ash	2%
Ingredients harmful to concrete	Alkali (K_2O&Na_2O in ash)	0.4%
	Chloride	

Effective CO_2 fixation by biochar

Following '2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories'

Effective CO_2 fixation by biochar = **CO_2 fixation by biochar** − **CO_2 emission while collecting raw materials and producing biochar** = **2.29 kg-CO_2/kg※4**

Carbon content※1 × Carbon residual after 100 years※2
× CO_2 molecular weight/carbon atomic weight
= 0.776 × 0.89 × 44/12 = 2.532 kg-CO_2/kg

CO_2 emission while collecting raw materials※3
+CO_2 emission while producing the biochar※3
= 0.057 kg-CO_2/kg+0.176 kg-CO_2/kg
= 0.233 kg-CO_2/kg

※1：Based on test results of the biochar
※2：Value when storing the biochar to soils

※3：Calculated from fossil fuels and electricity used in the production of biochar

※4：In case of biochar under consideration

Voluntary carbon credit

Biochar Concrete Applications by Carbonex ←Certified by Carbonfuture

Lasts for more than 100 years | Project capacity: 88.91 tCO_2e · 95% utilized | Western Europe

Methodology: EBC-Sink

Capacity

Total and sold capacity of the project in tonnes CO_2 equivalent:

95%

0 tCO_2e — 88.91 tCO_2e

3.96 tCO_2e of this portfolio are still available!

3.96 tCO_2e of this portfolio are still available!

Price per tonne:

€214.20 (incl. 19% VAT)

Credit price : 214 €/t-CO_2

Buy your share

Enquiry

Get Started

Credit : 88.91 t-CO_2
Sold : 84.95 t-CO_2(95%)

https://platform.carbonfuture.earth/balancer/portfolios/view/main/3a3e64c4-22c6-49e1-95f0-e32841763c07

Characteristics as an industrial product

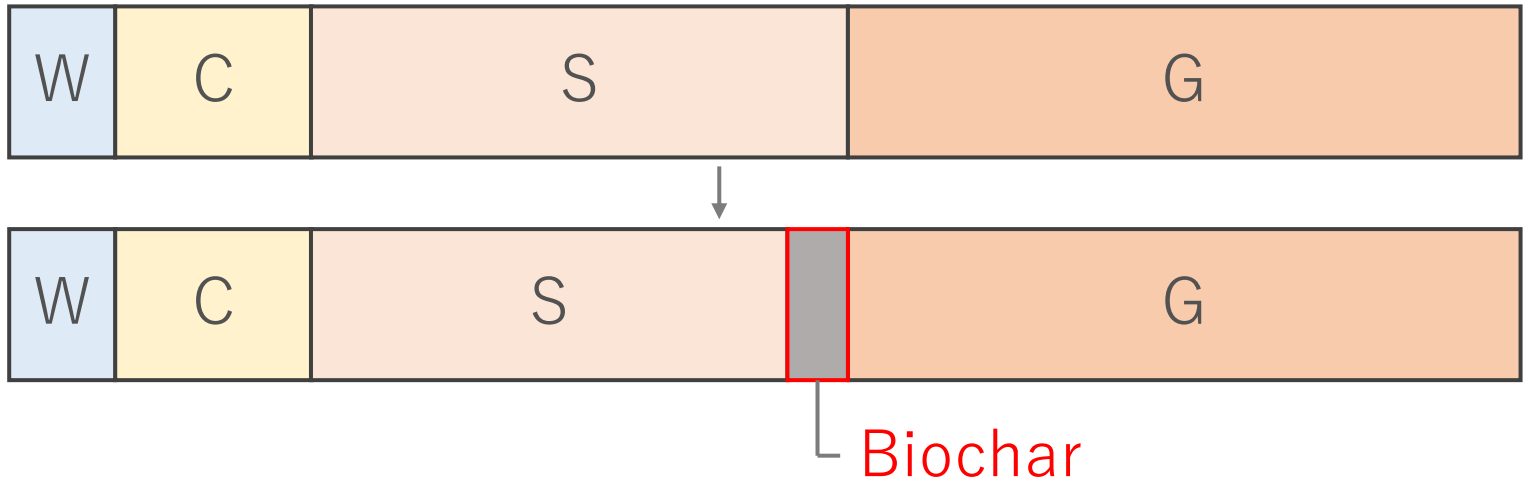
Mix design

Required specification

- Fresh property
- Compressive strength
- Durability

Standard mix at the plant

Mix with biochar



W : Water
C : Cement
S : Sand
G : Gravel

Test

- Fresh property ⇒ Chemical admixture addition is adjusted (increased)
- Compressive strength ⇒ Confirmed to perform enough strength

→ **Application**

Almost same as common concrete production methods

Additional step

Adding the biochar while mixing at concrete plants

↓

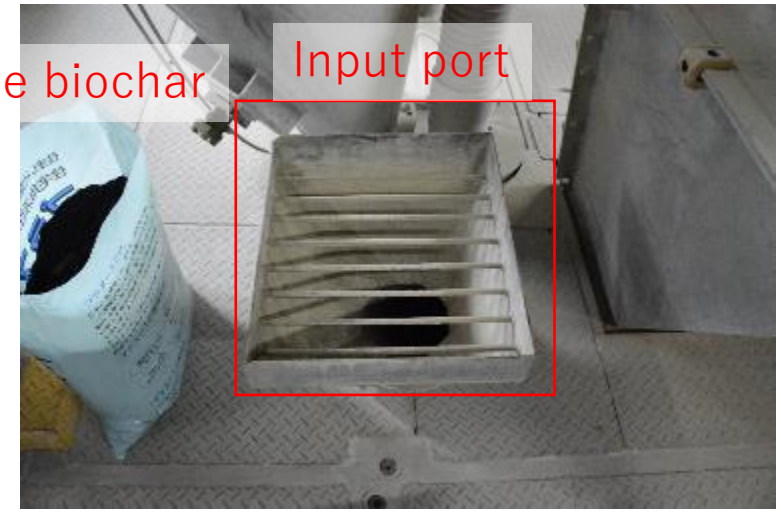
Transporting to construction sites by agitator trucks

↓

Acceptance test

↓

Pumping and Casting



Biochar is bagged 20 kg each
Addition is controlled with the number of bags

Performance of the biochar concrete①

Test Mix

Materials | CO_2 calculation

Concrete Mix	Blast furnace slag cement (Type B)	Water	Biochar (Powder)	Biochar (Grain)	Crashed sand	Mountain sand	Crashed stone	Water reducer	CO_2 emission from materials other than biochar	CO_2 fixation by biochar	Total CO_2 emission as concrete
	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)	(C×%)	(kg/m^3)	(kg/m^3)	(kg/m^3)
BB-Control	307	169	0	0	327	491	1008	0.8	141	0	**141**
BB-P15	307	169	15	0	317	476	1008	1.4	141	34	**107**
BB-G30	307	169	0	30	307	461	1008	1.0	141	69	**72**
BB-G60	307	169	0	60	288	432	1008	1.5	141	138	**3**

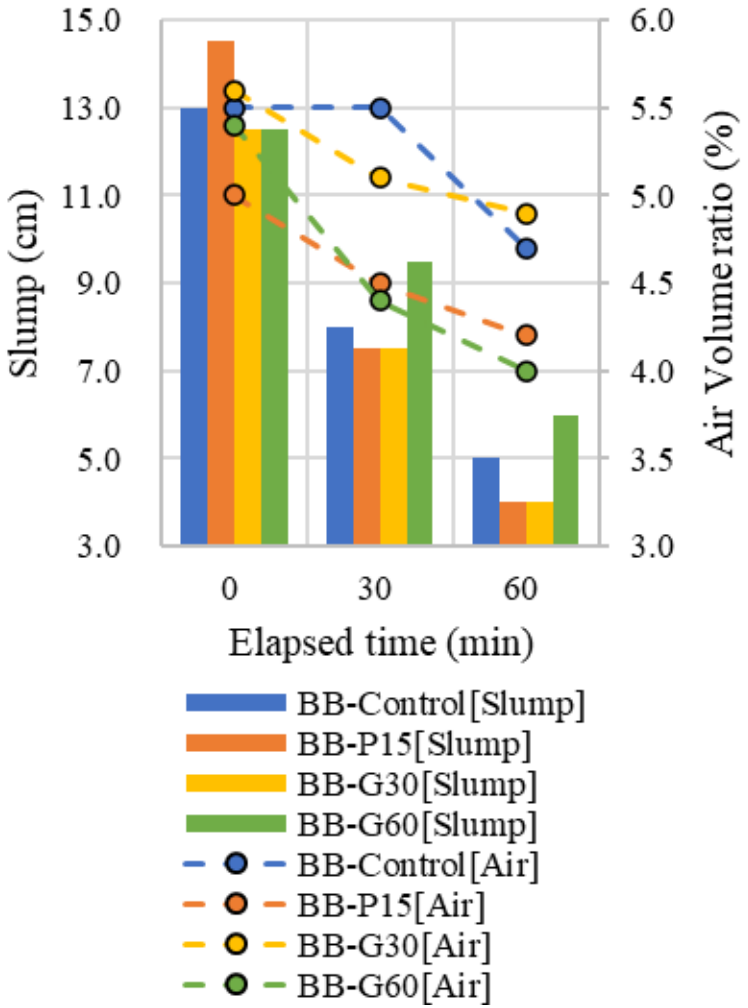
BB means Blast furnace slag cement type B

Performance of the biochar concrete②

Test Mix

Concrete Mix	Biochar (Powder)	Biochar (Grain)	CO_2 emission from materials other than biochar	CO_2 fixation by biochar	Total CO_2 emission as concrete
	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)
BB-Control	0	0	141	0	**141**
BB-P15	15	0	141	34	**107**
BB-G30	0	30	141	69	**72**
BB-G60	0	60	141	138	**3**

Fresh property test

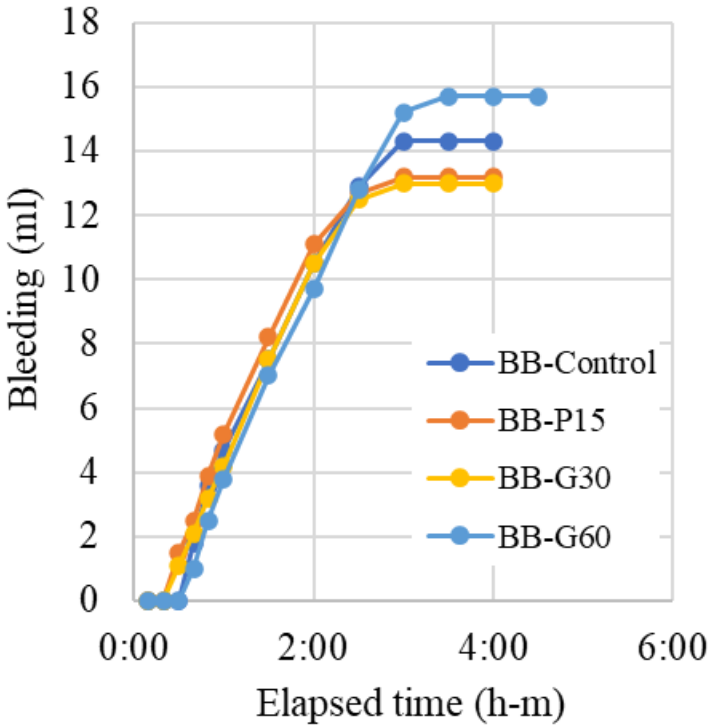


Performance of the biochar concrete③

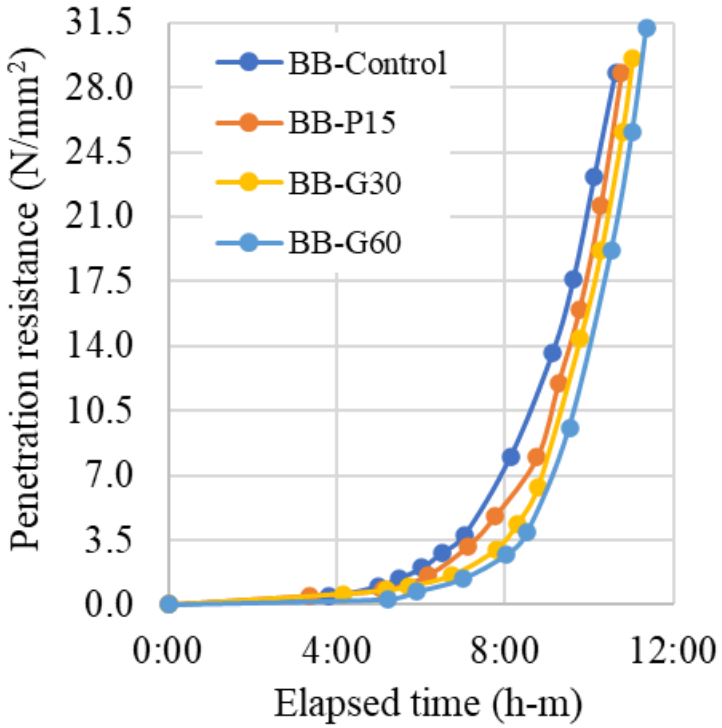
Test Mix

Concrete Mix	Biochar (Powder)	Biochar (Grain)	CO_2 emission from materials other than biochar	CO_2 fixation by biochar	Total CO_2 emission as concrete
	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)
BB-Control	0	0	141	0	**141**
BB-P15	15	0	141	34	**107**
BB-G30	0	30	141	69	**72**
BB-G60	0	60	141	138	**3**

Bleeding test



Setting test

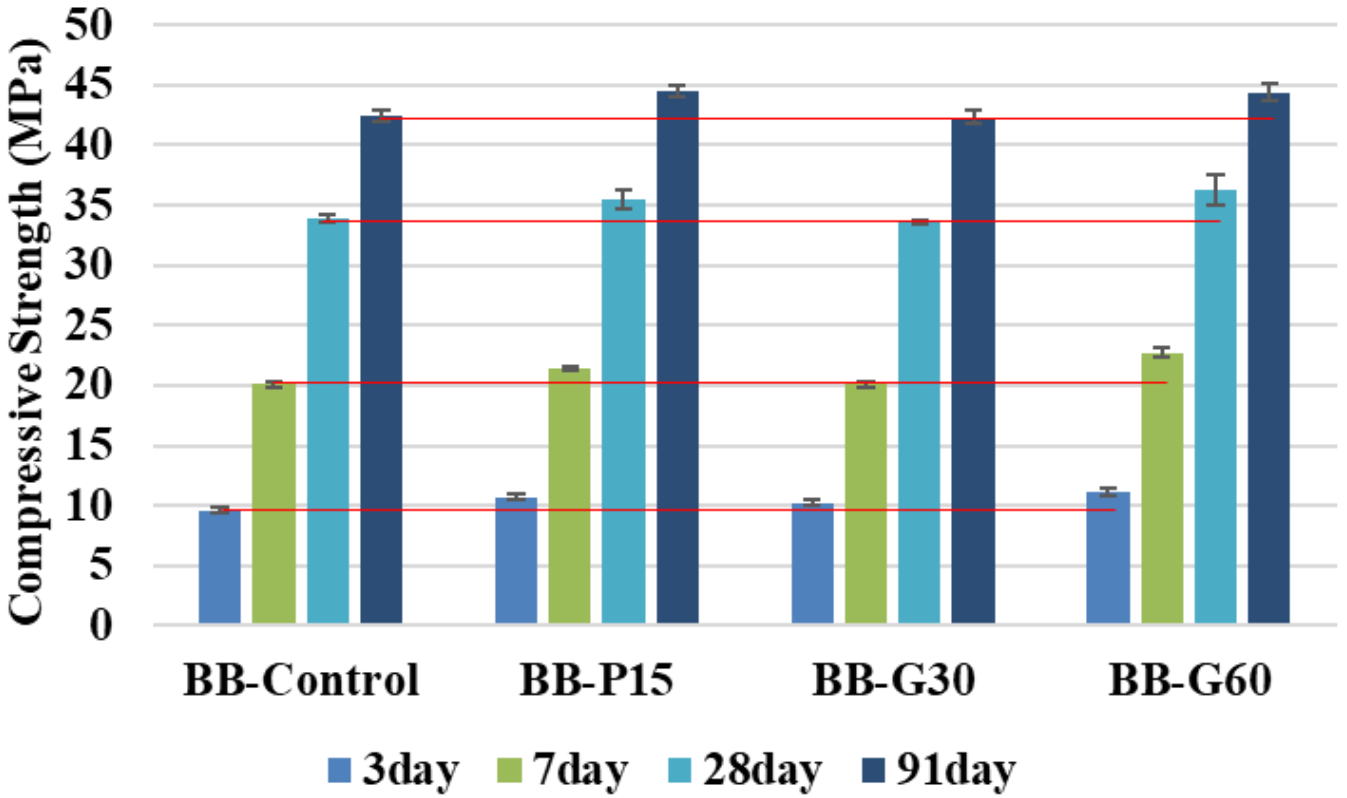


Performance of the biochar concrete④

Test Mix

Concrete Mix	Biochar (Powder)	Biochar (Grain)	CO_2 emission from materials other than biochar	CO_2 fixation by biochar	Total CO_2 emission as concrete
	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)
BB-Control	0	0	141	0	**141**
BB-P15	15	0	141	34	**107**
BB-G30	0	30	141	69	**72**
BB-G60	0	60	141	138	**3**

Compressive strength test

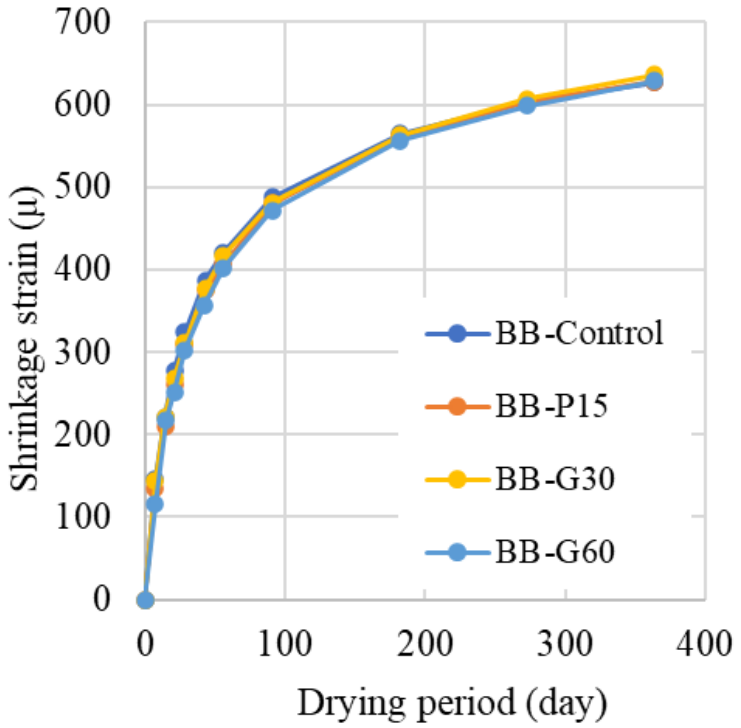


Performance of the biochar concrete⑤

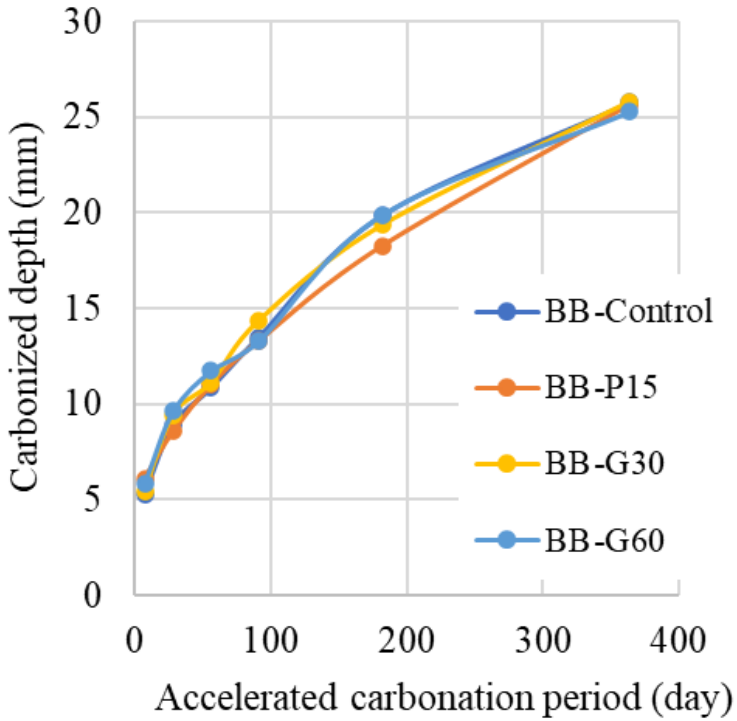
Test Mix

Concrete Mix	Biochar (Powder)	Biochar (Grain)	CO_2 emission from materials other than biochar	CO_2 fixation by biochar	Total CO_2 emission as concrete
	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)
BB-Control	0	0	141	0	**141**
BB-P15	15	0	141	34	**107**
BB-G30	0	30	141	69	**72**
BB-G60	0	60	141	138	**3**

Dry shrinkage test



Accelerated carbonation test



Application to pavement

Procedure

20th, Oct, 2022

Unloading

Acceptance test

Casting

Complete

In use

CO_2 calculation

Concrete Mix	Biochar (Grain)	CO_2 emission from materials other than biochar	CO_2 fixation by biochar	Total CO_2 emission as concrete
	(kg/m^3)	(kg/m^3)	(kg/m^3)	(kg/m^3)
Original	0	199	0	**199**
Low carbon	0	143	0	**143**
Low carbon + Biochar (Applied)	60	143	136	**7**

Total casted concrete volume : 34.5 m^3

Total CO_2 reduction : (199-7) × 34.5 = 6.6 t-CO_2

CO_2 removal by biochar : 136 × 34.5 = 4.7 t-CO_2

CO_2 emission avoidance by low carbon cement : (199-143) × 34.5 = 1.9 t-CO_2

ASEAN opportunity

ASEAN opportunity

■ Biochar concrete can support biomass utilization without waste

- Jatropha : Oil → **Biofuels**
- Sorghum : Grain → **Food, Feed**
- Eucalyptus : Timber → **Paper pulp**

Upstream

Residue → Carbonized to **Biochar**

↓

Carbon removal
through biochar concrete,
soil amendment and etc.

Downstream

Summary

Summary

- Purpose of biochar concrete : Carbon removal
- Method : Storing biochar(carbon) into concrete for a long period
- Decarbonizing effect : 2.29kg-CO_2/kg ※
- Performance : Equivalent to the standard mix ※
- Utility : On-site casting and pumping possible ※
- ASEAN opportunity : Making effective use of unused biomass

※Depends on kind of biochar

Contact Us

https://f.msgs.jp/webapp/form/20233_fydb_7/index.do