Case studies of Advanced Construction and Demolition waste(CDW) Recycling initiatives and technologies In JAPAN

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Title	**Bon Terrain Construction Method (High moisture content mudbank recycling system)**	
Theme classification	○	Prevention
		Re-use
	○	Recycle
		Reduce Co2
		Legacy
		Business to overseas
		Etc.
Technology development stage	○	Practical use
		Scheduled to be put into practical use by 2020
		Scheduled to be put into practical use after 2020
Specific content	-Professor Hiroshi Takahashi of Graduate School, Tohoku University and the MORI Forest Environmental Technology Laboratory Co. ,Ltd have jointly developed the Bon Terrain process. This process provides additional characteristics, such as superior strength, superior earthquake resistance, superior durability, and others, to bottom deposits of dam pond by loading and mixing the fibrous deposits improvement material, “Bon Fiber”, together with fixation agent. -Banking of rivers and dam ponds, to which this process had been applied before the Great East-Japan Earthquake occurred, developed no crack and liquefaction damage the Earthquake actually occurred.	
Appeal point	**-Contribution to recovery and reconstruction in the site of large-scale sedimentation disasters that have occurred frequently** This process enables recycling of deposits left after tsunami as raw materials into highly-functional ground materials, contributing thereby to rapid restoration from disaster. This environmentally-conscious process enables recycling of various organic deposits in the original locations while offering substantially favorable impacts on the society. Our efforts to promote “Monozukuri (manufacturing)” through cooperation among academic, industrial, and governmental circles has been highly evaluated and awarded the 6th Monodukuri Japan Prize in 2015. This technology is expected to offer extremely high propagation effects through significant contribution to the reconstruction and restoration of large-scale sedimentation disasters that are probable in the future. Contribution to strengthening of the national land is also expected. **-Efforts to support overseas development of the new technologies** Major 2011 flooding of the Chao Phraya River in Thailand has caused continuing flood disaster for more than a month. Professor Hiroshi Takahashi, Graduate School of Tohoku University, the associate developer of this process, and the staff of Advanced Construction Technology Center visited Kasetsart University, King Mongku’s University ,Pak Kred city in the neighborhood of Capital Bangkok. There, they outlined the technology and performed publicly the laboratory experiment using Thailand clay. At suggestions of the Pak Kred municipal staff, this process was named Soil Dike Super Fiber Method”to facilitate easy understanding of technology by the Thai engineers. We expect that our “Monodukuri Technology” will contribute to assistance and aid for reconstruction overseas in the future.	

NETIS registration No. TH-020042-V

High moisture content mudbank recycling system

Bon Terrain Construction Method

Bon Good **Terrain** Soil

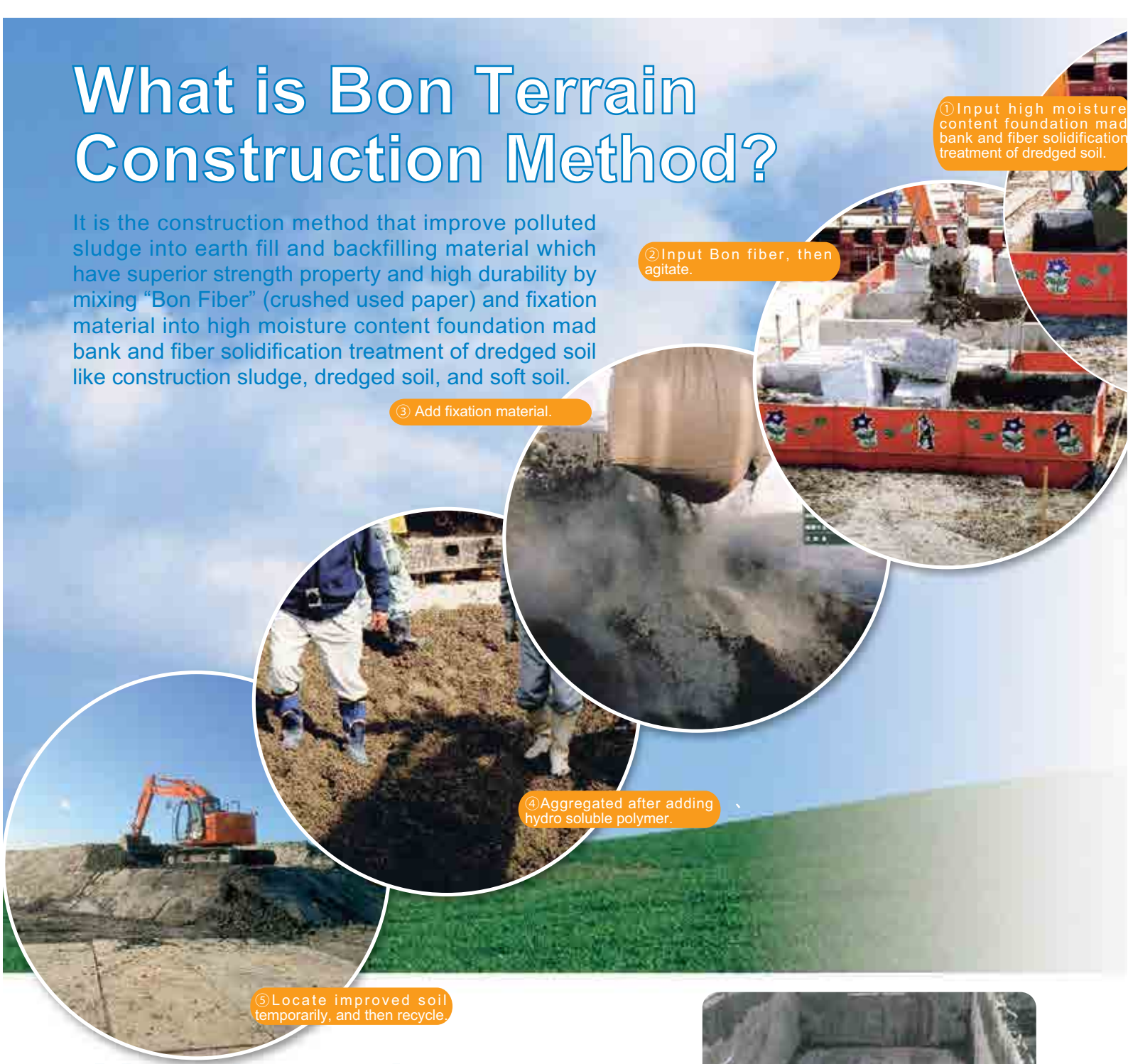
Recycling all the "Construction polluted sludge", "Dredge soil", and "Soft soil" without dehydration with using used paper

Certified by Advanced Construction Technology Center
No.1703 Dec. 2005

Bon Terrain Committee

What is Bon Terrain Construction Method?

It is the construction method that improve polluted sludge into earth fill and backfilling material which have superior strength property and high durability by mixing “Bon Fiber” (crushed used paper) and fixation material into high moisture content foundation mad bank and fiber solidification treatment of dredged soil like construction sludge, dredged soil, and soft soil.

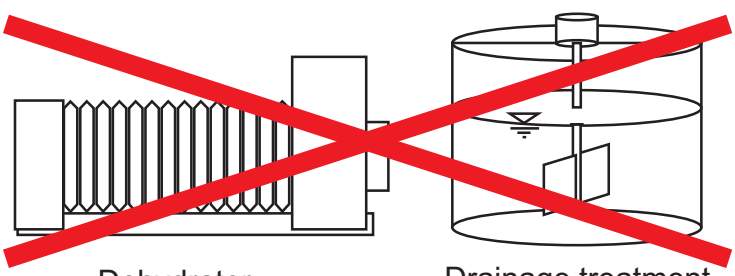


You do not have to install dewatering process and drainage treatment equipment.

■It is possible to improve 500% of moisture content like high moisture content foundation mad bank and fiber solidification treatment of dredged soil which needed dewatering process.

■It is possible to improve the soil with keeping high moisture content foundation mad bank and fiber solidification treatment of dredged soil’ s water content. And it does not need to drain away.

■You do not have to install dewatering process and drainage treatment equipment.



Dehydrater

Drainage treatment equipment

The chance has come for an environment business.

●This construction method obtained “Construction technology screening certification” from Advanced Construction Technology Center.

●This construction method was awarded “Construction engineering award” from Japan Institute of Construction Engineering.

●This construction method was awarded “Minister of land, infrastructure and transportation award” at “The 6th person of merit for industry-academic-government combination implementation citation” which was hosted by Cabinet office, the ministry of Internal affairs and communications, ministry of education, culture, sports, science and technology, and ministry of economy, trade and industry.

The feature of Bon Terrain construction method

■It is possible to transport high moisture content foundation mad bank and fiber solidification treatment of dredged soil (500 of moisture content) promptly just after improvement by adding and mixing hydro soluble polymer.

■All you have to do is install attachment for agitating into backhoe without special equipment.

■Construction will be done in 30minutes for 1 cycle.

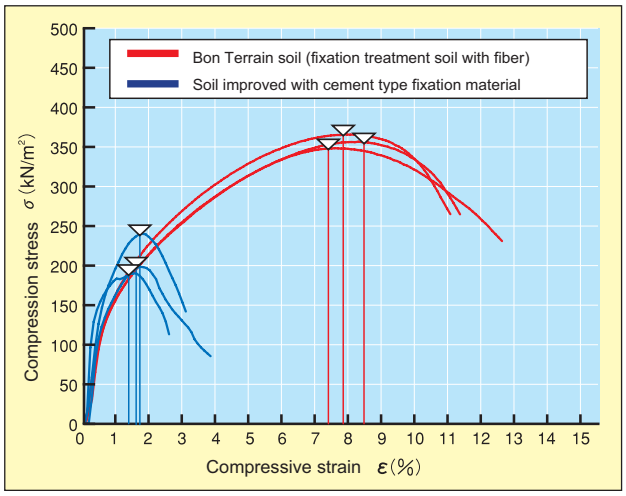
■Bon fiber and hydro soluble polymer are produced in proper production process and are safe products.

Construction name: Urban area water space upgrading project　Land creation of Haga pond area / Outline : Improving storage reservor soil with Bon Terrain and recycling as banking material of Shinsui park

Superior strength character

It is useful to use Bon Terrain as ground material for the earthquake countermeasures which is persistent to changing in shape because it is bigger uniaxial compression strength and breaking strain compared with solidification treatment soil.

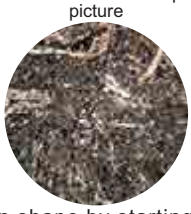
Superior strength character



Add 100kg/m of cement type fixation material into 150% of moisture content soil （σ28）

Bon Terrain soil

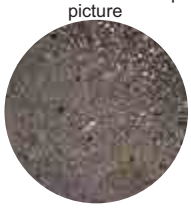
Polarization microscope picture



Bon terrain soil holds against changing in shape by starting barreled change, and deploying of stress through fiber.

Solidification treatment soil

Polarization microscope picture



Obvious shear plane comes out, and fixation soil starts local deformation concentration. After that, it will be broken by small strain.

Big breaking strain
Small deformation coefficient

Persistent property

The material for the earthquake countermeasures

According to repeating triaxial compression exam, it was found that Bon Terrain soil has high dynamic strength. It means that it is hard to be liquefiable compared with solidification treatment soil because Bon Terrain hardly increase express pore pressure.

Backfilled manhole with mountain sand was raised by liquefaction by earthquake

Shaft and backfilling of open-cut part by Bon Terrain soil
The year 1999 Suka River public sewer west rainwater arterial , the 3rd construction

Bund breaking by North Miyagi earthquake (Naruse River, Miyagi pref.)

Bon Terrain reform of soft soil deposited on anti-flood pond. Recycling as bund earth fill material
The year 1999 Hamao area embankment construction

Highly durable reformed soil

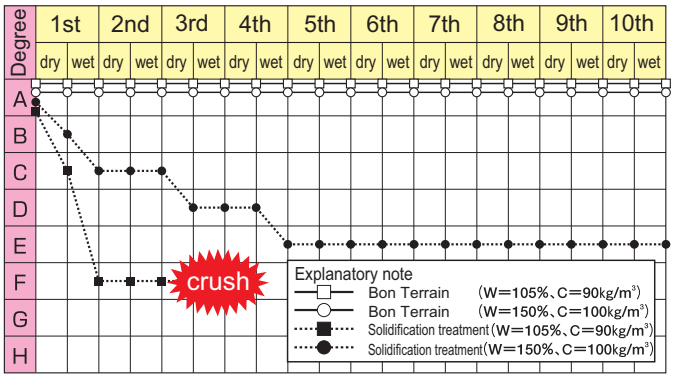
It is useful to use Bon Terrain reformed soil as the highly durable ground material because it has high durability to wet-dry repeating by climate condition and freezing and thawing.

Wet-dry repeating test

According to repeating wet dry test, we found that the test piece of solidification treatment soil is crushed by cracking. However, Bon Terrain showed that it has high durability.

Degree of Soundness

Degree	Cracking	Lack
A	Outwardly mostly no change	
B	Tiny and local cracking	Local Surface delamination
C	Partly obvious cracking	Missing part of the test piece
D	Entirely obvious cracking	Bigger cracking of the test piece
E	Partly or wholly falling of test piece	
F	Totally falling and crashing of test piece, but it remains	
G	Totally falling and crashing of test piece, but it is massive	
H	Totally falling and crashing of test piece, but it is grain refinning and muddy	



Bon Terrain redormed soil

After 10 cycle W=105% C=90kg/m³

No change after 10th cycle

Solidification treatment soil

After 2 cycle W=105% C=90kg/m³

Wholly crushed after 2nd cycle

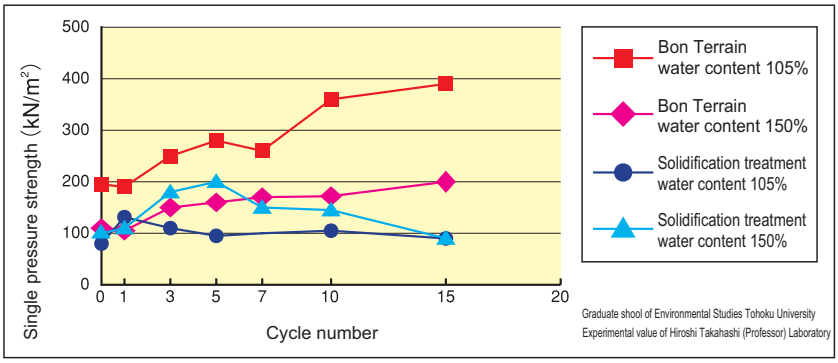
Repeating dry and wet test: It is conformed with "Advanced process of construction sludge and Development of usage technique" which the former Ministry of Works Civil engineering Research worked hand in hand with Advanced Construction technology center and 22 of private companies

Freezing and thawing test

According to the freezing and thawing test, it was found that solidification treatment soil is decreasing in uniaxial compression strength, however, Bon Terrain showed high durability without decreasing.

Testing method

- Curing for 7 days after making test piece
- Melting for 12 hours at 21℃ after freezing for 12 hours at -21℃ (1 cycle)
- Uniaxial compression test after 0,1,3,5,7,10,15 cycle



Recycling as low permeability material

Coefficient of permeability is k=10^{-5}~10^{-6}cm/s, Permeability is extremely low and it is under the level of k=10^{5} cm/s which indicates water interception that fildam core material demands. It is usefule to use this as superior bund filling because of low permeability and no cracking by repeating dry and wet test.

Example of construction

Construction name:	Ohe area regional water function implementation business (supplemental equipment and facilities business) Yakushiga pond leakage prevention construction
Promoter:	Ohe-machi, Nishimurayama-gun, Yamagata Pref.
Outline:	For the purpose of content securement, reinforcement of dam body, and leakage prevention of the storage reservoir, we improved deposited sand which into Bon Terrain soil. Then we recycled as earth fill of dam body.(Over qc=800kN/m^2 of Second class improved soil, ,under 10^{-6}cm/s of coefficient permeability)

BEFORE k=6.02×10^{-5}cm/s

Superior Workability

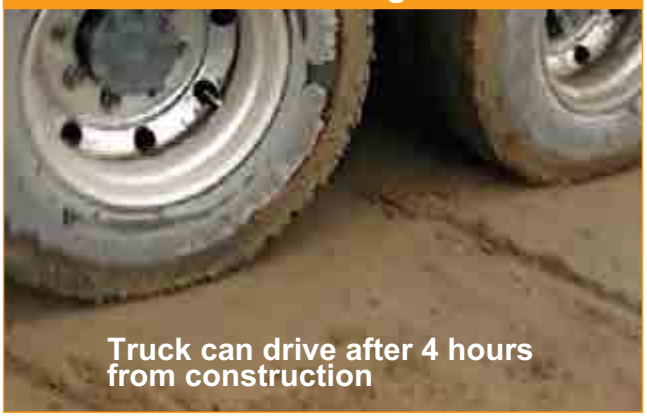
Niigata Chuetsu earthquake caused large volume of soft soil. But it was improved in-situ, and activating surface compaction. It means that this contributed to prompt disaster recovery.

① Condition of soft soil (around w=100%)

② Improving by aggitating In-situ

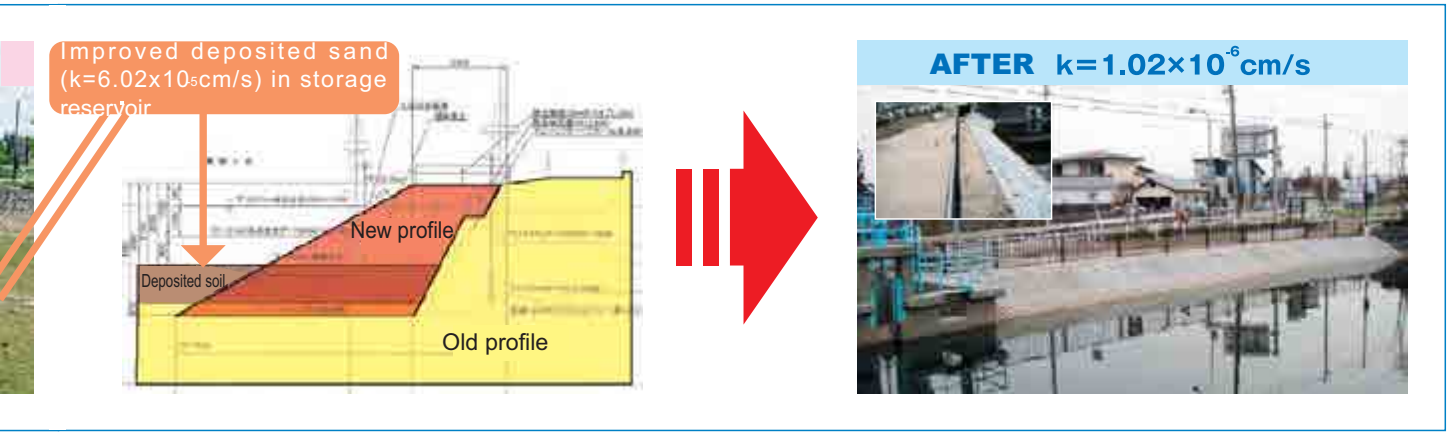
③ Forming

④ No track while driving truck



Construction name : Imogawa river channel blockade measurement construction / Promoter : Ministry of Land, Infrastructure Transport and Tourism Hokuriku regional development bureau Yuzawa Sabo office

	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{+1}	10^{+2}
Permeability	Factually impermeable		Exceptionally low		Low		Medium		High			
Available soil	Viscous soil		Microscopic sand, silt sand - silt - clay mixed soil				Sand and conglomerate		Clean conglomerate			



Glass prevention effect

Glass prevention effect of Bon Terrain soil reduced weeding by using for center divider and road shoulder filling. It activated reducing road maintenance cost.

Construction name : The year 1994 primary distributor Tendo-Sagae line street improvement construction
Promoter : Murayama branch, Yamagata Pref.

Keiji Masuko Chairman

Former Ministry of Works River Bureau Sand Arrestation Manager
Civil engineering manager of Fukushima Pref.

Bon Terrain construction method is recycling high moisture content mudbank to earth fill material and vegetation base material by aggregating fixation without dewatering process. Recycling construction sludge also reduces polluting load on global environment by reducing huge resource and energy consumption of industrial waste disposal. We would like to make new recycling system upgrade scholarly and technically. Thank you for your assistance and cooperation.

Marks

August, 2002	Selected by Ministry of Land, Infrastructure, Transport and Tourism Tohoku area Development Bureau Technology application committee as "The earth fill construction technology of high moisture contet soil"
August, 2002	Selected by Ministry of Land, Infrastructure, Transport and Tourism Tohoku area Development Bureau Technology application committee as "The in-plant recycling technology of construction sludge"
October, 2002	Prize-winning of Chairman from Redeuce, Reuse, Recycle Promotion Council
November, 2002	Registered for the New Technology Information System(NETIS-Ministry of Land, Insfrastructure, Transport and Tourism) Evaluated as pilot project "Bon Terrain Construction Method / TH-020042"
March, 2003	Selected by Ministry of Land, Infrastructure, Transport and Tourism Chubu area Development Bureau Technology application Committee as "Recycling technology for construction sludge from foundation pile which is constructed on site"
November, 2003	Selected by deputy minister of Land, Infrastructure, Transport and Tourism Public construction technology evaluation committee as "Recycling technology of dredge soil"
December, 2006	Certified by Advanced Construction Technology Center
July, 2007	Received a prize of "Land and Infrastructure Development Technology " from Japan Institute of Construction Technology
June, 2008	Received a prize of "Minister's prize, Ministry of Land and Infrastructure, Transport and Tourism" at "The 6th person of merit for industry-academic-government combination implementation citation" hosted by Cabinet office, the ministry of Internal affairs and communications, ministry of education, culture, sports, science and technology, and ministry of economy, trade and industry.

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