Earth Recycling Project

A joint initiative for recycling sludge generated by shield tunneling excavation

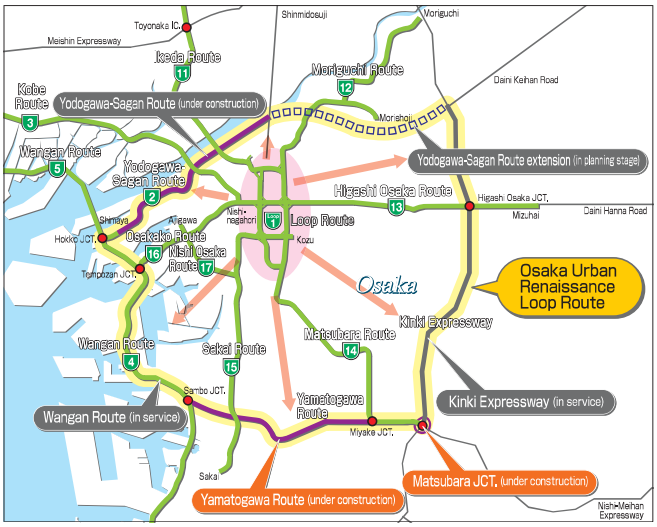
阪神高速技術

The Yamatogawa Route Project and Associated Shield Tunneling Excavation

The Yamatogawa Route: A major segment of the Osaka Urban Renaissance Loop Route

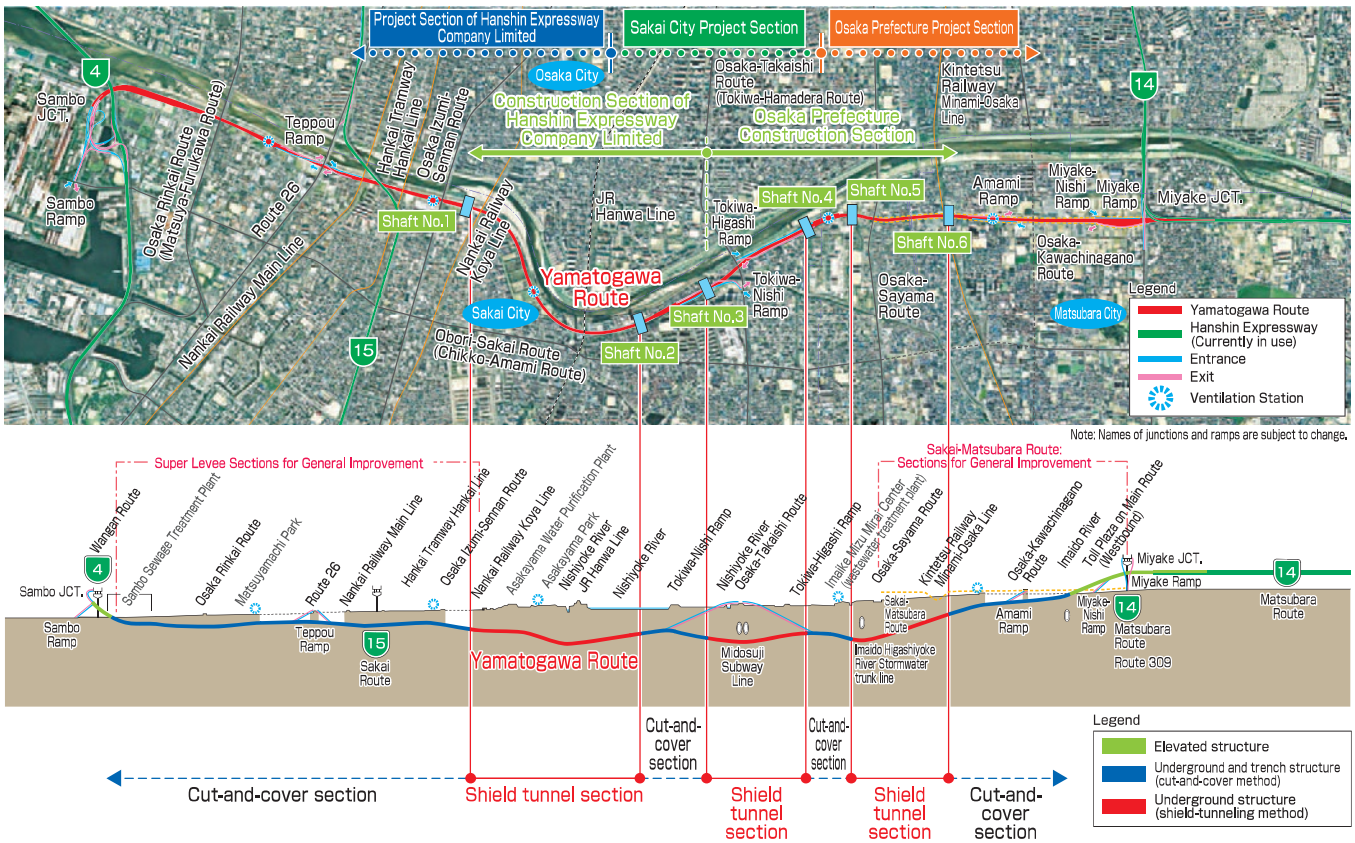
In August 2001, in an effort to invigorate Osaka while improving the chronic traffic congestion of urban Osaka and the worsening roadside environment along its expressways, the Urban Renaissance Headquarters of the Japanese government established the Osaka Urban Renaissance Loop Route Project in the center of Osaka. The Yamatogawa Route is an expressway extending a total length of 9.7 km that serves as part of the loop route. This route will link to the Hanshin Expressway Route 14 Matsubara Route at Miyakenaka in Matsubara and to the Hanshin Expressway Route 4 Wangan Route at Chikko Yawatamachi, Sakai-ku in Sakai.

When the Yamatogawa Route is completed, it will directly link the coastal area to the hinterland of southern Osaka while greatly reducing traffic congestion on the local east-west traffic corridors. It will also ease the traffic burden on the Hanshin Expressway Route 1 Loop Route, the Route 13 Higashi Osaka Route, and the Route 14 Matsubara Route. In short, the Yamatogawa Route is expected to significantly invigorate the Kansai Metropolitan Area both socially and economically.



Improvements to the Yamatogawa Route undertaken by Osaka Prefecture, Sakai City, and Hanshin Expressway Company Limited

Beginning in 2006, following the privatization of Hanshin Expressway Public Corporation and the transition of Sakai into an ordinance-designated city, improvements to the Yamatogawa Route were jointly undertaken by Osaka Prefecture, Sakai City and Hanshin Expressway Company Limited. With careful consideration for regional environmental conservation, the Super Levee Improvement Project (a project of the Ministry of Land, Infrastructure, Transport and Tourism) is being implemented in coordination with other improvement projects in the environs.



Three sections totaling 3.9 km to be excavated with the shield-tunneling method

About 40 percent of the 9.7-km total length of the Yamatogawa Route, as well as part of the ramps, is being constructed with the shield-tunneling method. This approach uses a cylindrical excavator called a shield machine, which excavates by driving forward into the ground while preventing tunnel collapse at the leading edge of the excavator. The tunnel is constructed of pre-fabricated circular segments that are assembled behind the shield machine.

The sludge generated during the excavation is used elsewhere in the project.

Shield Machine used by Hanshin Expressway Company Limited to excavate a section of the main route

Shield Machine used by Osaka Prefecture to excavate a section of the main route

Land Reclamation Project at No. 6 Lumber Yard

The Land Reclamation Project at No. 6 Lumber Yard has been restarted to make the land available for other purposes.

No. 6 Lumber Yard was originally a marine area used to hold imported raw logs. The Port and Harbor Bureau of Osaka City, however, decided to reclaim this area as a stockyard for sawn lumber. Osaka City first ordered the reclamation of Area 1; however, the reclamation work was halted when reclamation of Area 1 was completed. Osaka City later prepared a new scheme to restart the reclamation work as a joint project. The completed Area 1 covers 3 hectares, while Area 2 project spans 8.3 hectares. Upon completion of the reclamation work, the total area will cover 11.3 hectares, or 113,000 square meters. Easy access to this reclaimed area makes it suitable not only as a lumber yard but also a physical distribution center or industrial center.
For the Land Reclamation Project at No. 6 Lumber Yard, the Port and Harbor Bureau has assumed responsibility for north bank protection work, while Hanshin Expressway Engineering Company Limited is in charge of land reclamation work, which includes earth recycling.

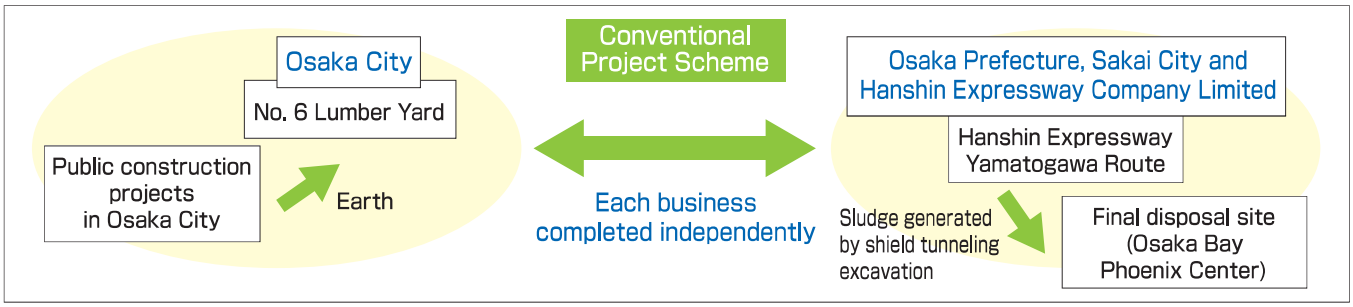
Joint Project for Resource Recycling

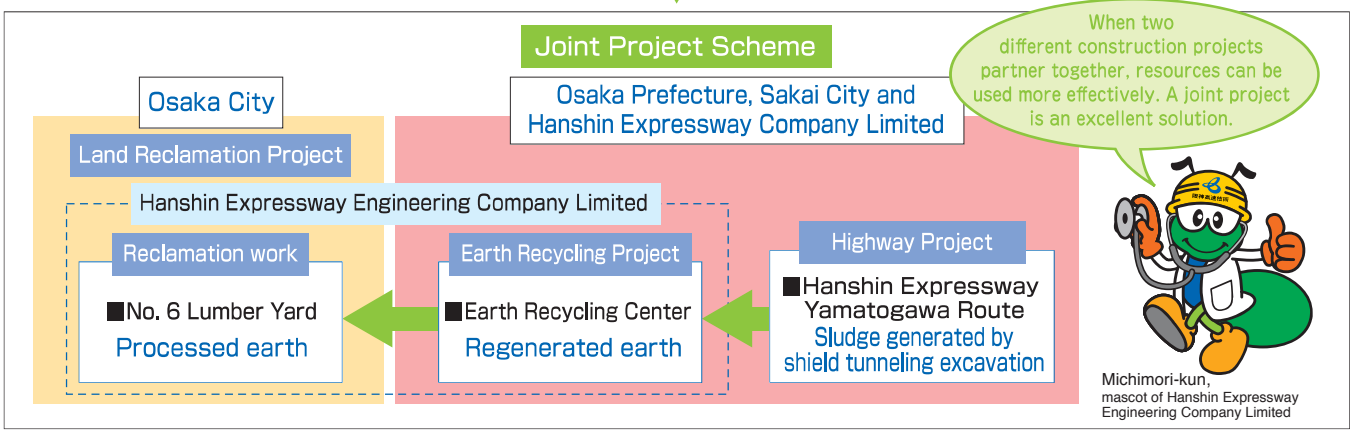
Ensuring efficient use of resources by utilizing sludge generated from shield tunneling excavation

In an effort to contribute solutions to the issues of global warming and resource depletion, it is necessary to establish resource recycling systems capable of reusing and recycling resources in order to reduce environmental impacts. Conventionally, sludge generated from construction work has a particularly low recycling rate. In 2006, therefore, the Land, Infrastructure and Transport Ministry established a policy to promote recycling and proper disposal of sludge from construction sites. During the same year, the Environment Ministry recommended active adoption of the "separate designation system" to promote recycling of sludge from construction sites.
This Joint Resource Recycling Project, therefore, was established with this separate designation system. This joint project will reuse sludge generated from shield tunneling excavation of the Yamatogawa Route for the Land Reclamation Project at No. 6 Lumber Yard under the orders of the Port and Harbor Bureau.

Joint project established to reduce construction costs.

In February 2008, the Committee to Examine the Method of Recycling Construction Sludge from the Yamatogawa Route Project, comprising capable and experienced individuals, proposed the establishment of this Joint Resource Recycling Project. The "separate designation system" was used to combine the two different public projects comprising this joint project: construction of the Yamatogawa Route and Land Reclamation Project at No. 6 Lumber Yard. This joint project will result in effective use of resources, proper disposal of sludge generated from shield tunneling excavation, extension of the useful life of the final disposal sites, and reduction of CO_2 emissions. It will also reduce the costs of each project.
As a company involved in the recycling business, Hanshin Expressway Engineering Company Limited carries out the sludge generated by shield tunneling excavation, recycles the sludge, and uses the recycled product for land reclamation. In addition, Hanshin Expressway Engineering is in charge of the separate designation system, which includes supervisory and management roles. As a member of the Hanshin Expressway Group, Hanshin Expressway Engineering is contributing to the emergence of a society committed to recycling.
This joint project represents the first time such a scheme has been adopted for highway construction work in Japan.





Implementing Environmental Measures and Contributing to the Community

Encircling Wall

In an effort to control dust dispersion, we are erecting a three-meter high wall around the facility.

Turbid Water Treatment Plant

Following processing in the turbid water treatment plant located within the facility, treated wastewater is recirculated for cleaning purposes.

Addition of Greenery

We are taking steps to maintain our facilities in harmony with the community by planting more greenery around the site and by providing flowerbeds with seasonal blossoms.

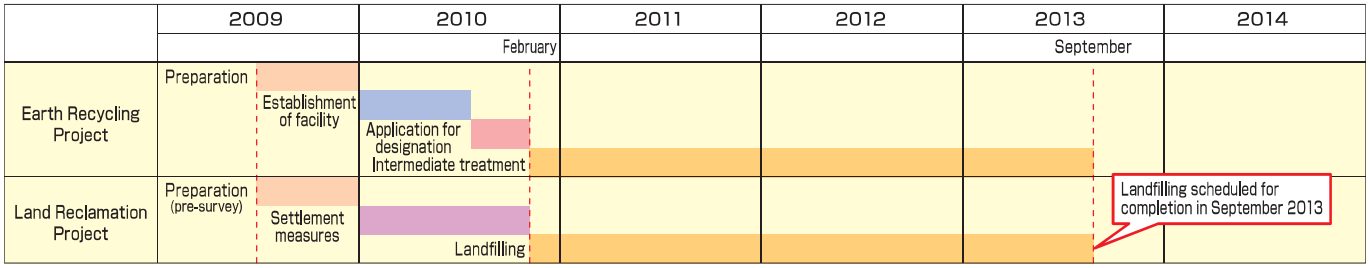
Cleanup Initiative

We undertake regular cleanups of local streets in order to maintain a cleaner environment.

Chronology of Joint Projects

February 2008	The Committee to Examine the Method of Recycling Construction Sludge from the Yamatogawa Route Project submitted a business plan for a recycling operation for No. 6 Lumber Yard. It was proposed as a collaborative project supporting the efficient use of resources and the proper disposal of sludge generated by shield tunneling excavation. It contributes to the extension of the final disposal sites by applying separate designations to the individual public works of the Yamatogawa Route Project and the Land Reclamation Project of the Port and Harbor Bureau of Osaka City. With the submission of this proposal, Osaka Prefecture, Sakai City, and Hanshin Expressway Company Limited announced that they would work jointly toward its realization.
July 2008	It was recommended that we reopen our project in order to take advantage of the opportunity presented by the No. 6 Lumber Yard Land Reclamation Project Study Group established by Osaka City in March 2008. Promoting the No. 6 Lumber Yard Land Reclamation Project with the Earth Recycling Project associated with the construction of the Yamatogawa Route would contribute greatly to improving the balance sheet of the project. The Project Re-evaluation Subcommittee under the Third Osaka City Administration Evaluation Committee issued an assessment that implementing such a project would be advantageous.
June 2009	Osaka Prefecture, Sakai City, Osaka City, Hanshin Expressway Company Limited, and Hanshin Expressway Engineering Company Limited entered into the No. 6 Lumber Yard Land Reclamation Project, jointly agreeing to undertake the Earth Recycling Project for the sludge generated by shield tunneling excavation from the Yamatogawa Route of the Osaka Prefectural Road. Hanshin Expressway Engineering Company Limited became the primary contractor for the Earth Recycling Project.

Project Progress Chart



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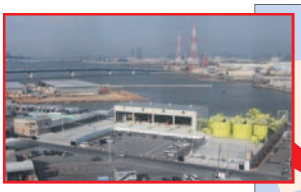
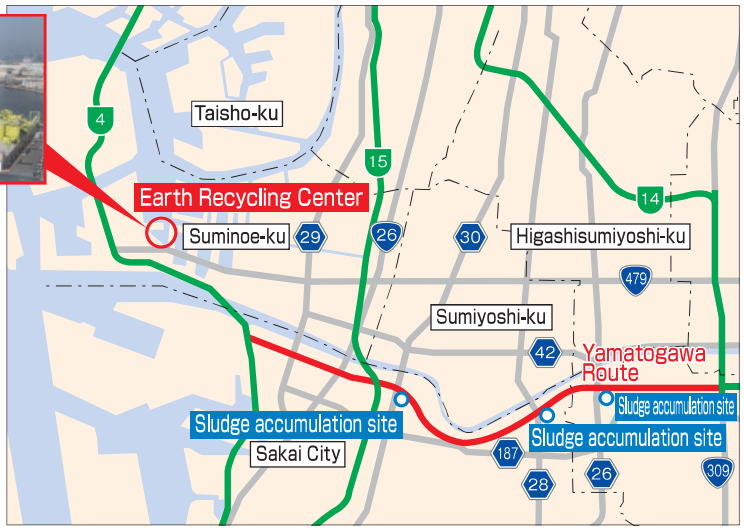
Overview of the Earth Recycling Project

Contributing to society by recycling sludge generated from construction work

The shield tunneling work for excavation of the Yamatogawa Route generates sludge. We are recycling this sludge for a large-scale public land reclamation project. To enable recycling of the sludge generated by shield tunneling work for land reclamation, we must specify the earth quality standard and quality control method and improve the sludge for processing. Therefore, we have constructed an Earth Recycling Center on a 7,000-square-meter site on the southwest side of the No. 6 Lumber Yard in Suminoe-ku, Osaka City. In this center, the sludge generated by shield tunneling work will undergo quality improvement, sorting, and solidification. After that, the earth will be reused for the Land Reclamation Project at No. 6 Lumber Yard.





- Land reclamation work period
  February 2011–September 2013
- Land reclamation site
  No. 6 Lumber Yard near Nankohigashi 1-chome, Suminoe-ku, Osaka
- Approximate amount of earth to be used for land reclamation project
  750,000 m³
- Quality of processed earth
  pH: Neutral
  Cone index: 400 kN/m² minimum (equivalent to Class 3)

ETC Electronic Manifest System

Monitoring sludge transport with an ETC manifest system

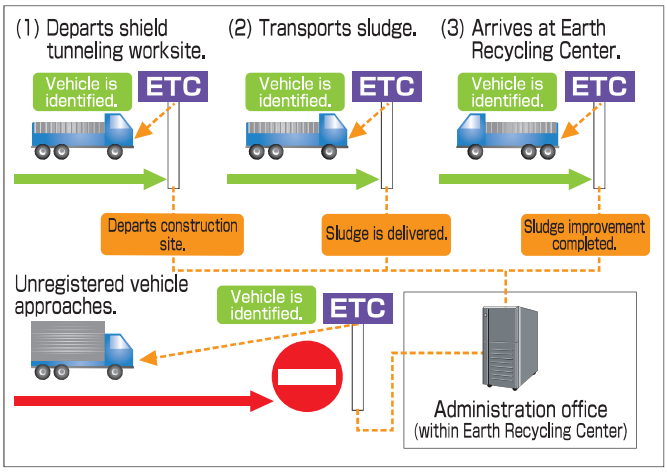
An electronic toll collection (ETC) manifest system has been introduced to monitor the sludge generated by the Yamatogawa Route shield tunneling project. The electronic manifest system monitors all the sludge generated at the shield tunneling site to ensure it is transported to the Earth Recycling Center and confirms that no sludge is dumped illegally. This system also determines whether earth from other locations has been brought into the Earth Recycling Center. The electronic manifest system includes a GPS navigation system and communications system so that system operators can monitor the transport routes and give directions ("wait," "detour," etc.) to the drivers in a traffic jam or an emergency. This system contributes to effective real-time control of sludge transport.
This is the first such ETC manifest system developed and implemented in Japan. Similar systems are likely to be adopted in various locations in Japan in the near future.

Monitoring Room

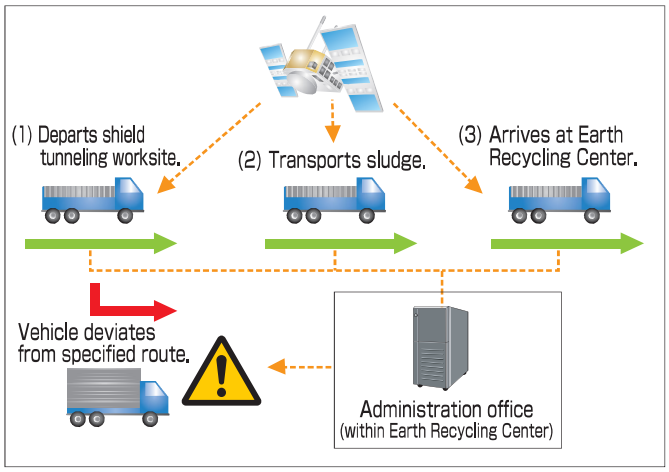
Main Control Functions

- Identifies each vehicle arriving at the entrance of the Earth Recycling Center to prohibit admission of unregistered vehicles.
- Prevents illegal tampering with numeric values and failure to enter essential data in order to protect the integrity of sludge data.
- Monitors the current location and route of each vehicle in real time.
- Issues an alarm should a vehicle depart from a specified route.
- Gives directions (such as "take alternate route" or "wait") if a vehicle is caught in traffic congestion.

Control of sludge transport with electronic manifest system



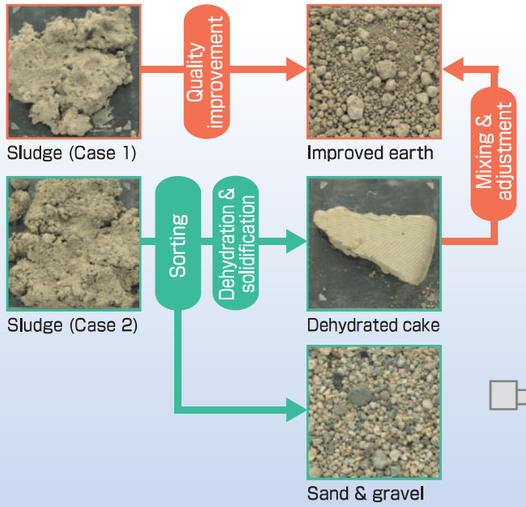
Control of sludge transport with global positioning system (GPS)



Overview of the Earth Recycling Center

Improving the sludge generated by shield tunneling work while protecting the surrounding environment

The Earth Recycling Center houses an administration office, receiving pits, sludge improvement facility, sorting facility, belt conveyors, and other facilities. Sludge transported from the shield tunneling worksite to the Earth Recycling Center is improved and sorted. In the improvement facility, the sludge is mixed with neutralizing solidification material to upgrade its quality to make it suitable for use in land reclamation. In the sorting facility, the earth is sorted according to grain size. Silt and mud, which have a small grain size, are sent to an offsite intermediate processing facility where they are dehydrated and solidified. They are then mixed with the improved (neutralized and solidified) earth to make the earth suitable for land reclamation. Sand and gravel, which have a large grain size, are recycled.
The water used for cleaning in the Earth Recycling Center is circulated and reused. In addition, various devices have been installed to prevent dispersion of dust and dirt and reduce noise and vibration. These various measures have been implemented in the Earth Recycling Center as a means of protecting the surrounding environment.




Tugboat, earth barge, dedicated earth loader vessel

Plant processing capacity (average)

Quality improvement: 1,920 m³/day
Sorting: 400 m³/day
Total: 2,320 m³/day

The volume of recycled earth is equivalent to the total volume of four or five 25-meter swimming pools.


Michimori-kun,
mascot of Hanshin Expressway Engineering Company Limited

Sludge delivery

When a vehicle is identified at the ETC gate as a registered vehicle, it is permitted entry to the receiving building where the vehicle's load is accepted. The hydraulic shovel loads the sludge into the appropriate processing channel according to the condition of the sludge.

① Quality improvement (neutralization & solidification)

When the sludge has a high water content, a neutralizing solidification material is added to the sludge to adjust its pH value and hardness. As a result, the sludge is improved into high-quality earth optimized for land reclamation.

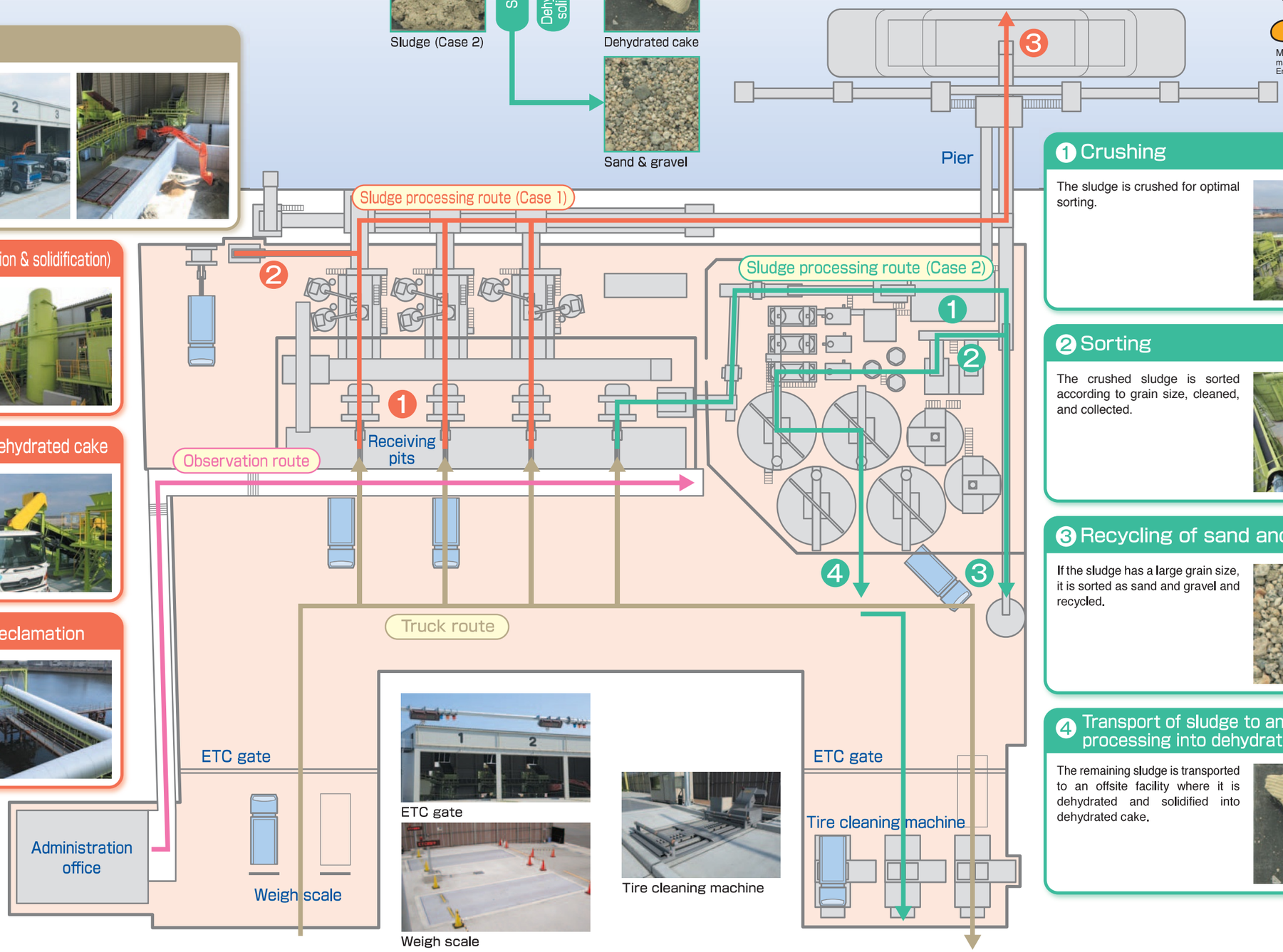
② Mixing of improved earth with dehydrated cake

The improved earth is mixed with dehydrated cake brought in from an offsite facility to make high-quality earth optimized for land reclamation.

③ Utilization of earth for land reclamation

Once quality improvement is completed, the improved earth is loaded onto a belt conveyor for transfer to the pier. There, it is loaded on an earth barge and used for land reclamation.


Administration office



① Crushing

The sludge is crushed for optimal sorting.

② Sorting

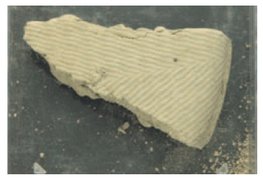
The crushed sludge is sorted according to grain size, cleaned, and collected.

③ Recycling of sand and gravel

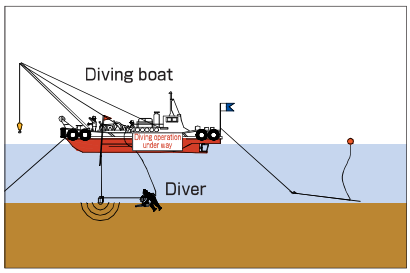
If the sludge has a large grain size, it is sorted as sand and gravel and recycled.

④ Transport of sludge to an offsite facility for processing into dehydrated cake

The remaining sludge is transported to an offsite facility where it is dehydrated and solidified into dehydrated cake.

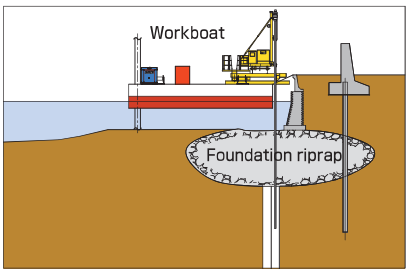


Reclamation Process



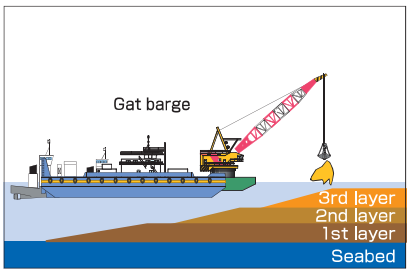
Preliminary Investigation

Before land reclamation is started, divers investigate the condition of the seabed.



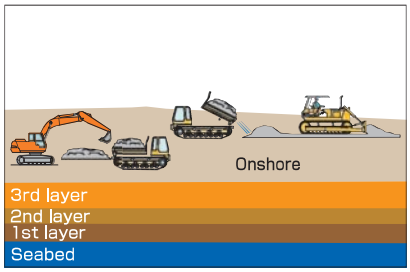
Settlement Prevention

A stress relief wall is constructed between the bulkhead and the reclamation area to protect the bulkhead and rear structure from stress.



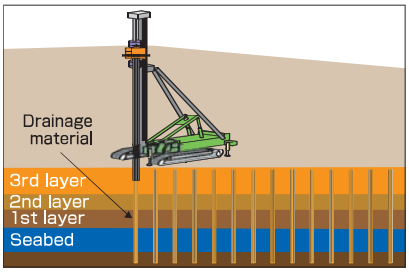
Reclamation (underwater work)

Dedicated earth loader vessels (a gat barge and other equipment) are used to build up thin layers of earth on the seabed (with each layer about one-meter thick).



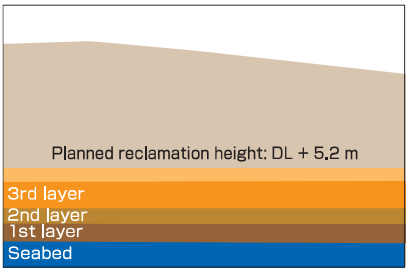
Reclamation Work 1 (onshore work)

Bulldozers and rolling equipment are used to build up and compact the thin layers of earth.



Consolidation

Upon completion of the reclamation work, plastic drainage panels are inserted into the soft clay layer of the seabed to promote consolidation.



Reclamation Work 2 (onshore work)

The earth is built up to the planned reclamation height. This completes the reclamation work.

Quality Control of Improved Earth (Voluntary Control)

Effectively controlling the quality of the improved earth

To ensure the quality of the recycled earth, we have prepared a quality control manual in compliance with the relative laws and regulations. This manual sets out the quality control standards and criteria.

Before preparing the quality control manual, we verified the state of the earth at the Yamatogawa Route shield tunneling worksite by conducting indoor tests and by verifying the quality of the improved earth using the actual earth improvement facility and through chemical tests. After verifying the criteria and earth improvement conditions, we compiled the quality control manual.

Initial reclamation stage (10,000 m³) February–March 2011

【Control standards (reclamation standards) for elusion and content test】

(1) Earth quality tests: pH value (between 6.0 and 9.0), cone index (400 kN/m² minimum), turbidity

(2) Chemical tests: From the results of experiments, we have determined that the following chemical content should be checked. → Using the official method, simplified method

- Lead: 0.01 mg max. per liter of sample liquid, and 150 mg max. per kg of earth
- Arsenic: 0.01 mg max. per liter of sample liquid, and 150 mg max. per kg of earth
- Fluorine: 0.8 mg max. per liter of sample liquid, and 4,000 mg max. per kg of earth
- Boron: 1.0 mg max. per liter of sample liquid, and 4,000 mg max. per kg of earth

Note: We reevaluated the control standards (reclamation standards) specified at the initial reclamation stage. In addition, we held a Business Evaluation Committee Meeting (Quality Control Division Meeting) to examine and determine control items and the inspection schedule.

【Business Evaluation Committee Meeting】

- Quality evaluation, examination of quality control manual (review of the control items, inspection schedule, etc.)
  April 2011

Reclamation stage From April 2011

Michimori-kun,
mascot of Hanshin Expressway Engineering Company Limited