

A joint initiative for recycling sludge generated by shield tunneling excavation

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ABSTRACT

The Hanshin Expressway Yamatogawa Route, have a length of 9.7km, was planned to connect the Osaka bay area and the inland area from east to west. This expressway has the feature of the underground structure in almost whole route. The cut-and-cover method is adopted for the western section of this route for 3.1km-long. The eastern section of the route for 4.4km-long are the shield tunnel method, because there are important facilities such as railways and the water purification plant on the ground.

The excavation sludge taken from the ground during shield work is discharged from the tunneling shaft of the shield machine. This discharged earth is brought to the Earth Recycling Project area to built in the Osaka bay area, where it is recycled as landfill. The recycled soil will be utilized for the No.6 Lumber Yard Land Reclamation Project implemented by Osaka City.

Keywords. shield tunnel, excavation sludge, earth recycling project, recycled soil, land reclamation

INTRODUCTION

In urbanization area of Japan, the expressway networks have been essential for an industry, economic activity and people's daily life. However, they usually cause traffic jam in metropolitan areas, because these networks have not been completed yet. This is why we have been constructing the necessary routes, but there is little space for developing new highways. Additionally an environmental consciousness has been increased, so it's becoming difficult to build road structures on the ground, for example an elevated bridge.

Under such conditions, it is necessary to plan the new expressway netwoek, named "Osaka Urban Reclamation Loop Road" and have a length of approximately 60km, in order to revolutionize the motor traffic flow drastically, and to improve chronic congestion in the core of Osaka and the deterioration of the route environment greatly. The Hanshin Expressway Yamatogawa Route, which consists of a part of this loop road, is constructed as almost underground structure for 10km-long along the Yamatogawa River.

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.

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.

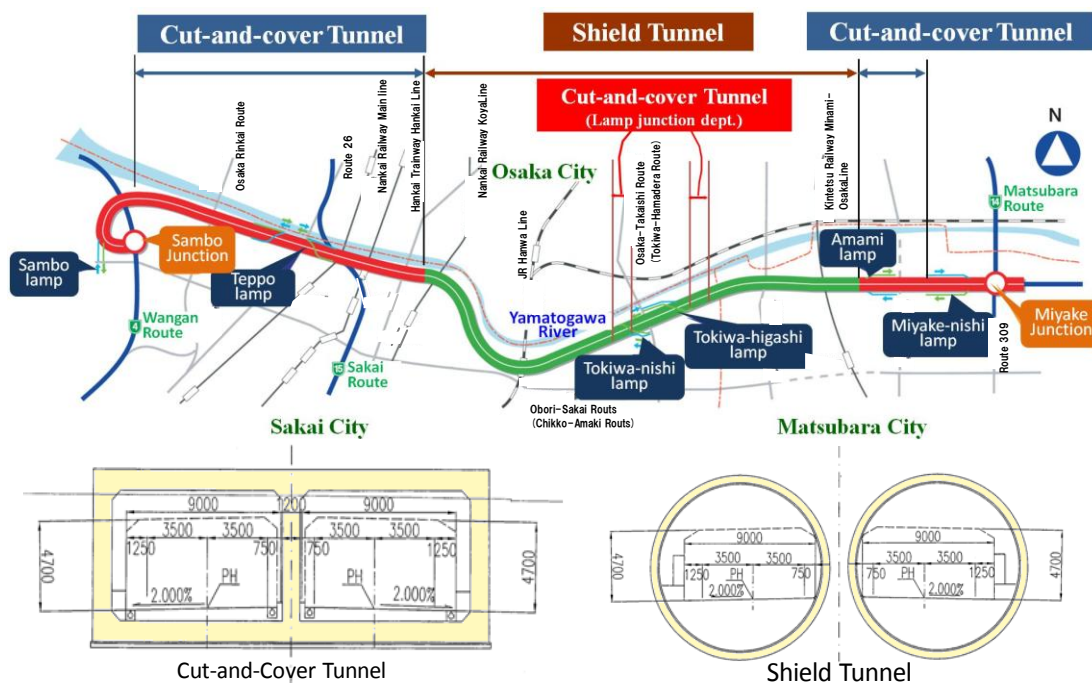


Figure 1. Yamatogawa Route

Joint Project for Resource Recycling

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.

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 CO2 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.

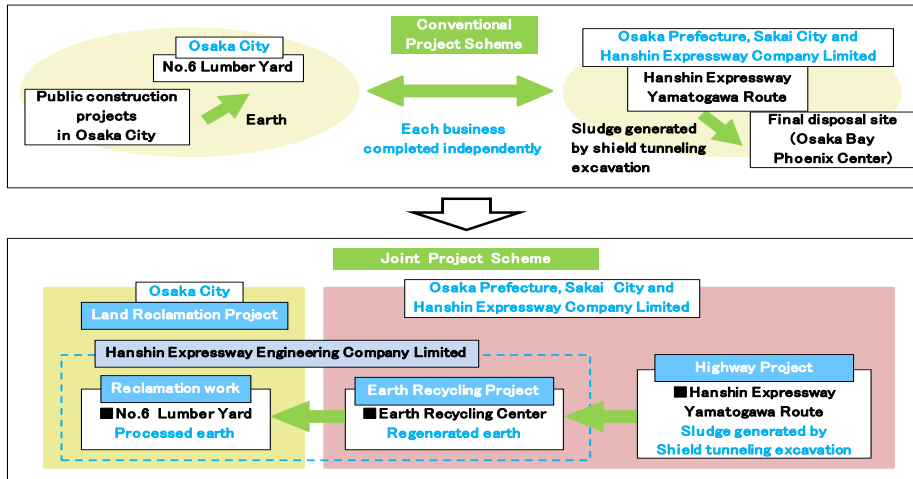


Figure 2. joint project represents

Land Reclamation Project at No. 6 Lumber Yard

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.



Photo 1. No.6 Lumber Yard

Overview of the Earth Recycling Project

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.

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.

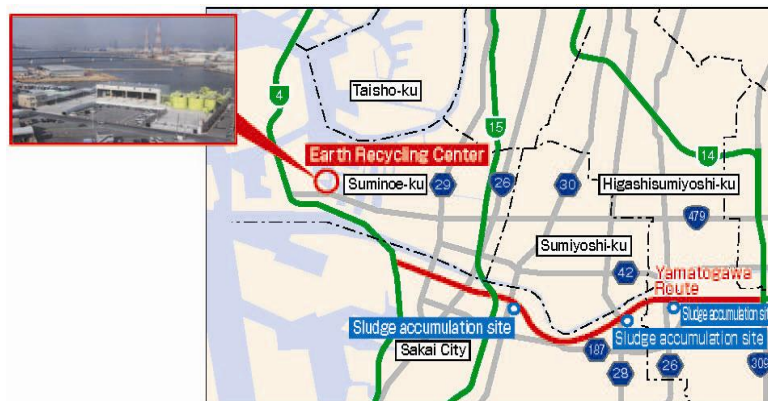


Figure 3. No.6 Lumber Yard

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.

Table 1. Main Control Functions

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

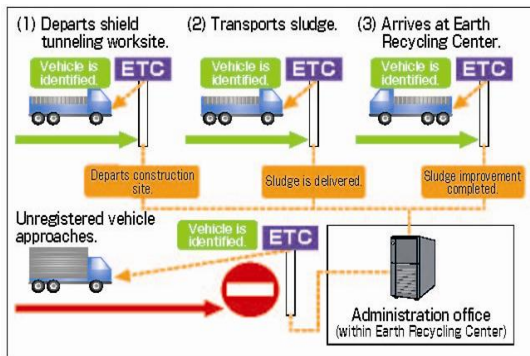


Figure 4. No.6 Lumber Yard Control of sludge transport with electronic manifest system

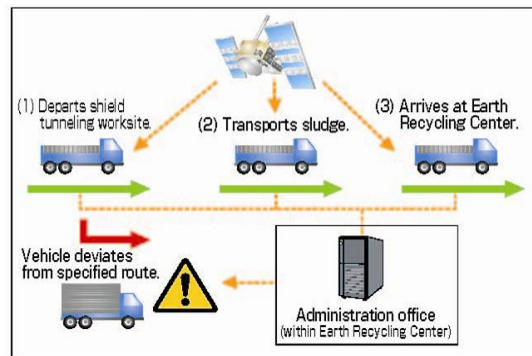


Figure 5. No.6 Lumber Yard Control of sludge transport with global positioning system (GPS)

Quality Control of 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 tunnelling 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.

Table 2. 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/m ² 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 <ul style="list-style-type: none"> 1) Lead: 0.01 mg max. per liter of sample liquid, and 150 mg max. per kg of earth 2) Arsenic: 0.01 mg max. per liter of sample liquid, and 150 mg max. per kg of earth 3) Fluorine: 0.8 mg max. per liter of sample liquid, and 4,000 mg max. per kg of earth 4) Boron: 1.0 mg max. per liter of sample liquid, and 4,000 mg max. per kg of earth

CONCLUSION

This paper introduced a collaborative project supporting the efficient use of resources and the proper disposal of sludge generated by shield tunneling excavation.

Collaboration with road projects of the Yamatogawa Route and land reclamation projects is contributing to efficient use of resources and appropriate treatment of construction sludge while reducing CO2 emissions and extending the life of final disposal sites. It is also helping to reduce the cost of each project.

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