Special feature article

Technical Development for Space Creation and Maintenance Utilizing Geotechnical Engineering and for Seismic Reinforcement of Earth Structures

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1 Introduction

The following three structures come to mind when thinking of technology related to space creation and maintenance in geotechnical engineering, the author's area of expertise.

a. Tunnels (underground spaces)
b. Retaining walls (partially underground space)
c. Cut slopes (aboveground spaces)

This article covers introductions of examples in technical development and applications of new technologies that the author has had the opportunity to be involved in. It also covers expectations for technical development related to projects for earth structures currently underway as part of “Seismic Reinforcement Against Earthquakes Directly beneath Tokyo Metropolitan Area.”

2 Space Creation and Maintenance Utilizing Geotechnical Engineering

2.1 Open Cutting for Shield Tunnels

Fig. 1 shows an example of open cutting worksite for a shield tunnel on the Tokyo Metropolitan Expressway Central Circular Route with temporary supports set up on the right side. This is a technique where wide spaces such as entrances to passageways to the surface, intersections, and merging parts are built by cutting open some segments after building the shield tunnel.

Similar techniques were employed in the construction of Tokyo Waterfront Area Rapid Transit’s Oimachi station. By boldly taking on development of and practical application of such techniques once thought impossible to attain, large reductions in environmental burden and costs have become possible.

Another technique related to shield tunnels considered to be innovative is a construction method to eliminate need for departure shafts and arrival shafts by having departure and arrival both be above ground. This was developed as a technique for building underpasses in a short amount of time, but there are possibilities for application to other uses as well because shafts are unnecessary.

2.2 Retaining Walls Not Needing Struts

Fig. 2 shows an example of an excavation worksite using inclined earth retaining walls. The retaining wall on the right side is set at an incline to the ground behind it. Compared to a vertical wall, the active earth pressure acting from the ground behind the wall is lower, so work without struts can be done in self-standing forms like in this example. As a result, ease of work is greatly improved for building structures in internal spaces.

Similar leaning type retaining wall structures have been used from long ago with retaining walls as permanent structures. However, this had been completely overlooked for application to temporary retaining walls. A new technique was thus established by a change of perspective.

Another technique that revolutionarily streamlined retaining walls was use of hat-shaped steel sheet piles. Reduction of cross-sectional performance taking into consideration efficiency of jointing was necessary with conventional steel sheet piles. But by eliminating that necessity and increasing the effective width, economic efficiency was improved and applicability to permanent in addition to temporary structures was increased.

Profile

1962 Born in Suginami Ward of Tokyo
1985 Graduated from the Department of Civil Engineering, Faculty of Engineering, the University of Tokyo
1987 Completed masters course at the Department of Civil Engineering, Graduate School of Engineering, the University of Tokyo
1987 Researcher at the Public Works Research Institute of the Ministry of Construction
1991-1992 Visiting Engineer at the Massachusetts Institute of Technology (Overseas researcher for the Science and Technology Agency)
1994 Associate professor at the Institute of Industrial Science, the University of Tokyo
2003 Professor at the Institute of Industrial Science, the University of Tokyo
and required performance at the actual site. Examples include reinforcement of pier frames and bridge girders and supports, reinforcement of rear embankments, reinforcement that combines those, and making integrated structures that eliminate supports.

3.2 Earthquake Damage and Countermeasures for Embankments and Cut Slopes

Damage to embankments occurred in various locations and a cut slope suffered large-scale collapsing in the 2011 Earthquake off the Pacific Coast of Tohoku. But in many cases, there were locations with little or no damage close by to the damaged locations. We expect to gain valuable new knowledge that will contribute to future measures for earthquake resistance by conducting case studies and back-analysis that take into consideration factors such as differences in ground conditions at individual locations.

For example, embankments between Izumizaki and Yabuki on the Tohoku Line (near 200k400m post) settled excessively in the earthquake. Gabions at the toe of the embankments showed continuous drainage even in normal situations, as is shown in Fig. 5. It is assumed that in earthquakes too the groundwater level is within the embankment, causing collapse.

3 Seismic Reinforcement of Earth Structures

3.1 Earthquake Damage on Piers and Countermeasures to Prevent Damage

Fig. 4 shows horizontal cracking penetrating the frame of a pier on the Shizu Overpass on the Suigun Line as a result of the 2011 Earthquake off the Pacific Coast of Tohoku. Unevenness of about 30 cm occurred at the boundary with the rear embankment.

When building new piers, construction methods that provide a high level of resistance to earthquakes based on new findings can be employed, such as use of structures where reinforcing material is laid in approach blocks with cement-treated soil. On the other hand, it is difficult to conduct seismic reinforcement that is effective and economical to piers in use.

In the future, it will be necessary to conduct a variety of technical development that will allow the most appropriate construction method to be selected according to conditions and required performance at the actual site. Examples include reinforcement of pier frames and bridge girders and supports, reinforcement of rear embankments, reinforcement that combines those, and making integrated structures that eliminate supports.

4 Conclusion

This article has covered my personal opinions on space creation and maintenance utilizing geotechnical engineering and on technical development for seismic reinforcement of earth structures. I believe that into the future it will be important to make effective use of knowledge accumulated up to now and take on the challenge of developing new technologies.