Breakthrough with Using of Various Countermeasure Works in Landslide Topography and Cliff Cone Deposit Sections

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The Kuji Osanai Tunnel Project, in Kuji City on the northern coast of Iwate Prefecture, is the construction of a 1445.3 meter-long road tunnel with the cross-sectional area of 109 to 128 ㎡. This paper describes the countermeasures for the tunnel's small overburden section with landslide topography, the boundary fault section in fracture zone, and the talus cone sediment at the tunnel portal.

1. Small overburden with landslide topography

The section with a minimum of 6 m overburden consisted mainly of conglomerate, with unconsolidated talus cone sediment and soil in the upper part. Landslide topography was also observed.

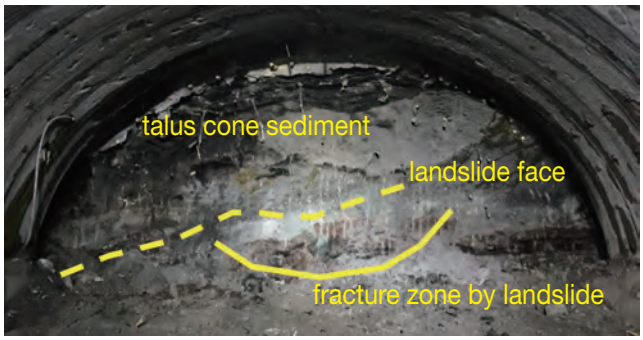

Photo 1 Landslide face

To prevent ground loosening by excavation, following measures were taken while monitoring the behavior of the landslide soil mass:
-early closure by primary invert
-dewater boring
-long steel pipe forepiling and long facebolt
-flash setting shotcrete

2. Boundary fault area with fracture zone

The boundary fault was located near the center of the tunnel length. A localized collapse occurred in front of the assumed point. Excavation was continued on the assumption that it was a branch fault rather than the main fault, but a large-scale collapse occurred at a point 2 meters further down the tunnel.
Based on the scale of the collapse, a boundary fault was assumed, and a borehole camera was used above and in front for void investigation to confirm the area affected by collapse.
2)-1 Countermeasures for the collapsed area
Following shear reinforcement and support reinforcement measures were taken to prevent the expansion of a large loosening area and plastic area.
- long steel pipe forepiling and long facebolt
-temporary upper half inverts and additional rock bolts
-primary invert with invert strut
2)-2 Measures for the ground ahead of the face
Through void investigation, interbedded clay soils with reduced ground strength were identified. Thus, following measures were taken for the crown, face and support reinforcement.
- long steel pipe forepiling and long facebolt
- primary invert with invert strut

Photo 2 Ground squeeze

3. Areas with thick layer of talus cone sediment

A talus cone sediment layer with an N value of less than 5 was about 10 m thick, filling the valley. To prevent deviation of earth pressure, excavation started after soil cement fill was placed. As the proportion of talus cone sediment in the face increased, it became difficult for the face to self-support.
Long steel pipe forepiling and long facebolt were performed, but the injection pressure was not sufficient with less than the initial pressure of +0.5 MPa. Collapse occurred again, due to squeezing of the ground. Therefore, the grout management was changed so that the grout agent will have not only durability but also a ground improvement effect, and the injection amount was set to achieve the initial pressure of + 2.5 MPa.
Although this tunnel was built under difficult ground conditions, challenges were overcome by adopting a relatively versatile auxiliary tunneling method. We hope that this report will serve as a reference for future tunneling projects

Photo 3 Large collapse