2-10 Estimation of Excavation Stability from Measurements
—Application of Observational Construction to Sedimentary Formations—

Table 2-2 Measurement item and use of result

observation / investigation item	use of result (item)										
	(1) construction of underground facilities				(2) research and development on advancement of tunnel design and execution technology						(3) geological feature research
	daily management		step management								
	verification of excavation surface and support selection	monitoring of existing support and evaluation of long-term stability	modification of behavior model and measurement control criterion	feedback for design and execution of later steps	verification of design technology in actual use	studies for rational evaluation of rock mass	studies for advancement of rock foundatoin model	comparative analysis on mechanical excavation disturbance due to difference of shaft excavation method / diameter	analysis of long-term behavior of rock foundation after excavation	studies for risk management of underground facilities	investigation and verification of environmental model
excavation surface observation	●	○	○	○	●	●	○	○	○	○	●
elastic wave velocity		△				●					○
schmidt hammer		△				●					○
equotip hardness test		△				●					○
needle penetration test		△				●					○
point load test		△				●					○
convergence	△	●	●	○	●	●	○	○	○	○	△
underground displacement			●	○	●		○	○	●	○	△
rock bolt axial tension		○	●	○	●		●	○	●	○	
shotcrete stress		○	●	○	●		○	○	●	○	
lining concrete stress		○	●	○	●		○	○	●	○	
steel support stress		○	●	○	●		○	○	●	○	
preceding displacement			●	○	●		●	○		○	△
borehole load test			○	○	●						○
unconfined compression test			○	○	●						○
triaxial compression test			○	○	●						○
brazilian test			○	○	●						○

● : key item ○ : taken into consideration △ : referred to in considerations

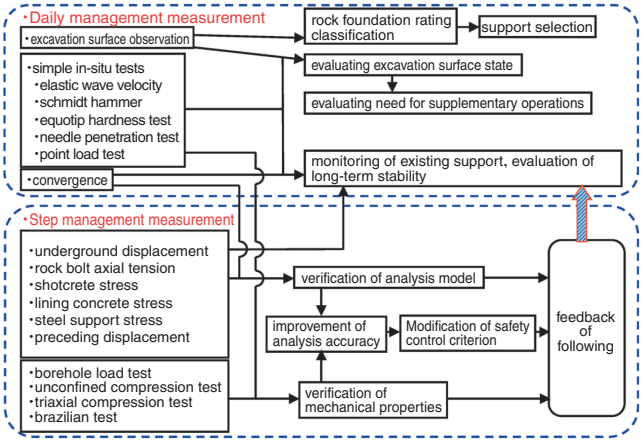

Fig.2-24 Observational construction flow

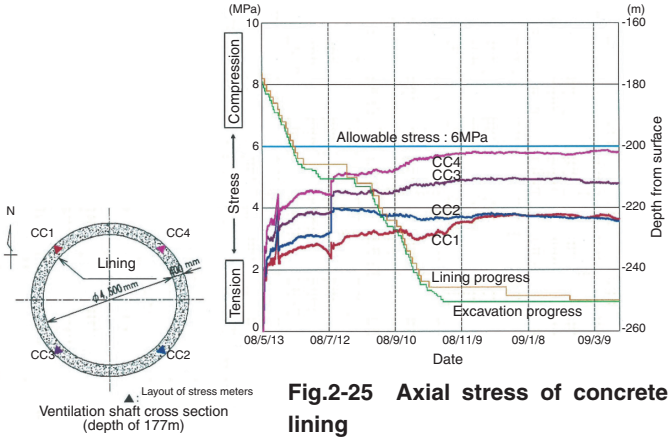

Fig.2-25 Axial stress of concrete lining

In construction of the underground facilities, it is difficult to accurately predict deep geological environmental features by surface-based investigation. Therefore, the observational construction plays an important role in achieving safe and rational construction. The stability of underground facilities is estimated by excavation surface observation and measurements of deformation and stress during construction. This estimation of stability is used as feedback for design and construction in subsequent steps.

Sedimentary formations around the underground facilities at the Horonobe URL Project are became mainly neogene sedimentary rocks (diatomaceous mudstone, siliceous mudstone). They are classified as soft rock from a strength aspect. The observational construction in sedimentary soft rocks has been uncommon. Thus, at the beginning of construction of these underground facilities, a plan for measurements and observational construction program based on the operations design was set.

The measurement plan included (1) consistency with safe and rational construction of the underground facilities, (2) feedback of measurements into design and construction of subsequent steps, (3) verification of the geological environmental model. Specific items which are being measured and utilized are shown in Table 2-2.

Also, the observational construction program being carried out is divided into two main classes. One is daily measurement that is aimed at selection of excavation support methods and monitoring of existing support, the other is step management measurement that is aimed at verification of analysis models and feedback to following steps. These are shown in Fig.2-24.

As an example, axial stress of the concrete lining at the depth of 177m from the surface in the ventilation shaft is shown in Fig.2-25. It can be seen that all lining stresses are under the allowable stress (6MPa), but the maximum stress at CC4 is almost the allowable stress and prediction analysis value. In addition, stress at CC3,4 is almost 1.3~1.5 times that at CC1,2 due to the direction of the major horizontal principal stress. It has been found to be in the east/west direction, and the minor principal stress is in the north/south direction (principal stress ratio is 1.4) from surface-based investigation. Judging from the above, the support of the underground facility is rational and underground facility is safe.

This measurement plan and the observational construction program will be continue to be carried out.

Reference

Yamasaki, M. et al., Observational Construction and Behavior Measurements for Underground Research Shaft Excavation of the Horonobe Underground Research Laboratory Project, The 12th Japan Rock Mechanics Symposium, 2008, p.305-311, in CD-ROM. (in Japanese).