

the Finite Element method. The tunnels have been excavated according to the shotcrete method. The support in most areas only consisted of a very thin shotcrete lining and radial bolts in the area of the roof. Depending on the degree of jointing and weathering, locally advancing support by means of spiles has been applied.

The internal lining of reinforced concrete has been constructed in parallel to the heading of the tubes. Mucking and delivery of materials was carried out through the cross cuts. The breakthrough was achieved in April 2014 and thus within schedule. The predicted distribution of the excavation and support classes along the tunnel has been in good agreement with reality.

### **16:15 849 - PROBLEMS OF LARGE RELIEF OR WEATHERED SHEAR JOINTS IN GRANITES AND BASALTS IN BRAZILIAN DAM FOUNDATIONS**

G.R. Sadowski, *University of São Paulo*

Large subhorizontal joints have been found in the foundation excavations in basalt and granite of Brazilian Dams. Some spread for hundreds of square meters showed slickensides—polished surfaces plus striations—and laminations interpreted as related to shear displacement, what substantially reduced their shear strength and imposed special reinforcement measures against the potential sliding of overlying concrete structures. The geological characteristics of these discontinuities have raised speculations related to their origin, be it related to mechanisms of bulging, cambering or to some tectonic or primary geological event. Several geologists and engineers from the northern hemisphere including Terzaghi already showed to be concerned with their role in granite foundations while in the southern regions Brazilian authors have found similar occurrences but also affecting individual lava flows of continental flood basalts in the foundations of major dams of the Parana Basin, which they designated under the particular name of “fault-joints”. This double-standard designation is self-explanatory of the difficulties involving their origin and related geomechanical properties: faults or just shear joints?

Recently, similar features were encountered in the foundations of large dam constructions in anorogenic granites inserted in the realm of the Brazilian Amazon, where some of these discontinuities exhibit features common to tectonic thrusting combined with deep tropical weathering. The evidence of preshearing along the surfaces of such fractures, also associated to products of deep weathering, reduces their geomechanical strength substantially, suggesting values of ultimate  $\phi$  spanning 12 to 28°. The detection of these discontinuities during initial investigation phases continues to be a major complex task in geological risk evaluations surveys. Trenching associated to some geophysical exploration techniques, although considered to be very basic exploration techniques are still the suggested methods for their forecast and previous determination.

### **16:30 905 - ROCK ENGINEERING TECHNIQUES OF TYPICAL LARGE DAMS IN WESTERN CHINA AND THE PRACTICES**

Qixiang Fan, Yifeng Wang, and Jianliang Pei, *China Three Gorges Corporation*

In recent 20 years, the rapid development of civil engineering construction has greatly accelerated the advancement of rock engineering and enhanced the theoretical level as well as the practical technique. In southwest China a series of huge hydropower station