Non-Technical Summary of Tunnel Collapse at Shuakhevi HPP

Background

The Shuakhevi Hydropower Project in Adjara, Georgia, is an important energy development project that generates electricity by using the power of the river water. The project features three primary tunnels:

1. Chirukhistsqali to Skhalta Transfer Tunnel (6.25 km long).
2. Skhalta to Didachara Transfer Tunnel (9.2 km long).
3. Shuakhevi Headrace Tunnel (17.8 km long).

Constructed between 2013 and 2017 using the drill-and-blast method, these tunnels were primarily unlined, relying on rock bolts and shotcrete (sprayed concrete) for structural support in key areas.

In 2017, during the commissioning phase when the tunnels were filled with water, few collapses and blockages were identified in the tunnels disrupting operations and necessitating investigations and repair efforts. Initial signs of damage were detected when water transfer operations failed, and turbine performance was affected due to sediment intrusion.

In response, Adjaristsqali Georgia LLC (AGL), the project company, launched a comprehensive investigation and testing program. The tunnels were remapped in detail based on thorough geological testing of over 1,000 samples. Based on this research, AGL created a comprehensive "Phase 2" rock support strategy. Experts from around the world were involved in reviewing the methodology. AGL engaged the expertise of 3G Austria and Professor Luiz DeMello of the University of São Paulo. The project's engineering contractor Mott MacDonald (UK) enlisted Germany's Zeidler Associates to assist in investigation and design. The Lahmeyer Group (now Tractebel) in their capacity as the Lender's Engineer provided further oversight of the investigations and the design of additional rock supports. AGL also brought on board Peter Pitts, one of the world's leading tunnel engineers, as project director.

Investigations

Tunnel inspection and further analysis findings were the following:

- While several blockages and collapses were identified, the total length of all damaged areas **did not extend 300 m.** The damage was noticed in Skhalta-Didachara Transfer Tunnel and Shuakhevi Headrace Tunnel. No damages were observed in Chirukhistsqali -Skhalta Transfer Tunnel.
- Cracks in shotcrete and problems with rock bolts indicated deficiencies in some of the installed support systems.

- Areas with fault zones and weak rock formations, such as "red breccia," were closely associated with the collapses. Such fault zones and weak rock formations were primary contributors to the failure of some of the tunnel sections.
- As mentioned above, more than 1,000 rock samples were sent to foreign internationally recognised laboratories. The testing revealed that some rock types exhibited significant reductions in strength and durability under wet conditions, contributing to structural instability. As a result, when exposed to water certain rock samples swelled and deteriorated. This water effect on certain rocks turned out to be another contributor to the issues with some of the tunnel sections.
- At some locations, the issues of fault zones, weak rock formations and water impact on some rocks were unforeseen and thus could not be fully addressed at the design stage.

Repair Works and Current Status

Comprehensive repair efforts were carried out to restore the tunnels to full operational capacity. The key measures included:

1. Scaling and Removal of Loose Rock: Unstable rock sections were removed to mitigate the risk of further collapses.
2. Enhanced Rock Support: Additional rock bolts and shotcrete were installed in critical areas to reinforce structural integrity.
3. Reinforcement and Stabilization: Existing support systems were strengthened to ensure long-term durability.

Post-repair, the tunnels underwent rigorous inspections and testing to verify their stability and functionality. The restoration process was completed successfully, and the hydropower project has since been operating efficiently and without any issues. Tunnel condition is monitored daily by operation engineers at Shuakhevi HPP through various technical parameters to ensure that there is no abnormality in the tunnels. All necessary measures have been implemented to ensure the long-term performance and reliability of the tunnels.

Conclusion

Investigation and rehabilitation work of the water diversion tunnels took around two years and cost around $ 120 Million. As a result, up to 80% of the tunnels is lined including full lining of Didachara-Shuakhevi pressure tunnel. The collapses in the tunnels at Shuakhevi HPP were caused by a combination of natural geological conditions and construction-related challenges. However, with the successful completion of extensive repair works, the tunnels have been fully restored. The Shuakhevi HPP is now operating effectively, demonstrating the efficacy of the implemented solutions. Thorough maintenance and continuous monitoring are in place to prevent future issues.

Damaged Tunnel sections

Tunnel sections after rehabilitation