Tunnel Water Inflow Recovery

Location: **Yukon, Canada**

Sector: **Tunnels**

Case Description

A 6 m x 5 m hydropower tunnel was being excavated using drill and blast methods through poor ground conditions below the water table towards a large head pond reservoir. Conventional grout curtains were constructed using cement grout to fill water-bearing fissures and open fractures prior to each development blast.

Grout curtain drill holes were encountering increasing water inflow volumes as the tunnel approached the head pond reservoir. When blasting one of the final rounds in the tunnel, an open fracture was exposed that resulted in a water inflow of 1,500 GPM and flooding of the tunnel face. Tunneling operations were suspended until this water inflow could be stopped.

Solution

After the flooded tunnel was dewatered using large pumps, it was observed that the water inflow was entering at the top corner of the tunnel wall through an open fracture measuring approximately 30 cm wide x 60 cm high x 100 cm deep that was directly connected to the head pond reservoir through various water-bearing fissures.

A water control gate measuring 80 cm x 80 cm was fabricated using 1/2 inch steel plate. An opening measuring 30 cm x 30 cm was cut through the water control gate to allow temporary passage of the 1,500 GPM water inflow.

A sliding door with doorframe and closure bolts was fabricated on the outside face of the water control gate. A wooden frame consisting of 15 cm x 15 cm timbers was attached to the inside face of the water control gate to fill open space between the water control gate and the tunnel rock wall.

Four 25 mm diameter grout hoses were installed directly into the opening and pushed as far as possible into the water-bearing fissures.

The steel water control gate assembly was positioned at the corner of the tunnel wall and was attached to the wall using conventional rock bolts so that the 30 cm x 30 cm opening was aligned directly with the water inflow fracture.

Water control gate fabrication

A temporary wooden sluice measuring 2.4 m long was inserted through the opening in the water control gate and into the open fracture to divert the majority of the water inflow away from the water control gate.

Water control gate and water diversion sluice

Supplementary large diameter drainage hoses were installed between the water control gate and the irregular rock profile and enclosed using metal and wood construction materials that were sealed with fast-curing chemical grout.

After all of the water inflows had been diverted through the wooden sluice and supplementary drainage hoses, wooden formwork was constructed and the water control gate was encapsulated with concrete to create a water-tight seal surrounding the water inflow channel.

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Workers closing a water control gate to stop a 1,500 GPM water inflow

Two cement grout plants were set up adjacent to the water inflow site and a four-way header was assembled to allow all four of the grout hoses behind the water control gate to be grouted at the same time.

After all preparations for grouting had been made, the temporary wooden sluice was removed from the opening of the water control gate. The water control door was then closed and secured in position using the tie-down bolts. After the door was closed, the water inflow was stopped for the first time in over a month.

Water control gate in closed position

Grouting operations commenced immediately using a thick cement grout with calcium chloride as an accelerator. Grouting pressures were monitored to avoid the use of excessive grouting pressure acting on the water control gate.

Four-way header for cement grouting

After pumping 3,000 kg of cement behind the water control gate and into the water-bearing fissures, grouting operations were terminated. Cement grout was allowed to cure for 24 hours before opening the water control gate and removal of concrete formwork.

After a month of difficult work to encapsulate the water inflow, a permanent seal was finally achieved. Subsequent probe hole drilling in the area of the original water inflow encountered minimal residual water inflows.

Dry tunnel excavation

Peter White, P.Eng., is a senior engineer and grouting specialist with over 25 years of experience working on many different types of pressure grouting operations at hundreds of project locations around the world.