The Blocked Access Road

George read the telegram for the second time: “Access road to powerhouse blocked with massive landslide from spillway discharge. Your presence at site required immediately. Gonzalez.”

George was the project engineer for a 30-MW high-head, two-unit Pelton- powered hydro development on the eastern slopes of the Andes. Electricity from the project supports a mining operation. George had never been to the site, yet he could not understand the telegram. The project’s spillway was on one side of the steep river valley, while the access road was on the opposite side. The site’s topographic drawings were limited to the immediate area around the structures, so they were of no use to George in his search for an explanation of the accident. And, the small-scale aerial photos showed a wide separation between spillway location and access road.

However, George was looking forward to the trip. It would be his first visit to the remote site -- a journey that would end with a flight on an ancient DC3 through a 4,900-meter-high mountain pass (at the altitude limit for the airplane!), followed by a rapid descent to a narrow grass strip in the valley near the site.

The layout of this remote hydro facility is typical for a high-head development on a steep mountain river. A masonry weir is positioned across the river, with a low-level sluice gate to discharge bed load. This gate is adjacent to a stoplog-controlled intake parallel to the flow, followed by a gravel trap and sand trap. Both traps contain low-level sluices and weir spillways to discharge excess flows back into the river. At the end of the sand trap, there is another intake equipped with trashracks and a gate leading to an unpressurised 2.5-kilometer-long tunnel. The tunnel leads to a small forebay with daily storage perched some 300 meters above river level,

high up on the right side of the valley. The forebay has a small spillway (the one that caused the landslide) for use on occasions when flows entering the tunnel are not shut off in time and the forebay is full. After the forebay, there is an intake with racks leading to a steel penstock with an upstream shutoff valve, and then into a powerhouse about 20 meters above river level, so as to be above flood level.

The access road is on the left side of the valley, which was the most convenient location for cableway access to the tunnel's intermediate adits high up on the opposite side, at about every 600 meters along the road. Due to the steep 13 percent gradient of the river, the access road contains many switchbacks, but generally follows the river bank, at about 20 to 40 meters above river level. The "V"-shaped valley has side slopes of about 40 degrees. There is an almost 500-meter horizontal distance between the forebay spillway and the access road.

George was driven down the access road to the slide, where he could look up the opposite slope to the spillway, which appeared as a small masonry wall. Below the spillway, there was an extensive scar on the mountain where all of the overburden had been washed away down to river level, blocking the river and also the access road. A bulldozer was at work, cutting a notch in the slide debris to facilitate discharge over the blockage before the access road was flooded. Another bulldozer was removing debris from the road. No lives had been lost, and with the downstream river valley uninhabited, there was no danger from the expected slide washout flood. The road was anticipated to open in about two days, but the river would remain blocked for a further month, due to the low flows in the dry season.

George pulled out the topographic drawings, and realized that the "creek" shown on the drawing below the spillway was only an intermittent stream that flowed in the wet season -- far too small to receive the spillway flow; hence, the washout. With a slope of 0.6 percent in the

rough, hand-excavated tunnel, it was not possible to raise the forebay dam to the same level as the sand trap spillway without incurring excessive cost, hence the need for a forebay spillway. The accidental spillway overflow occurred when the forebay was being filled for the first time. The water volume in the tunnel had not been taken into account when the sand trap's intake gate was closed at full forebay.

A lengthy discussion at the site resulted in a decision to leave the design as originally conceived, since any future spill at the forebay would not result in any more material being washed down the now cleared and bare rock mountainside. However, a chart was produced, showing when the sand trap intake gate should be shut off to prevent forebay overflow, as a function of forebay water level and tunnel flow. Following this chart would reduce forebay spills to rare occasions.

Lessons Learned

It is very difficult for a design engineer to envision site conditions without ever visiting the site, especially where topography is steep and limited to the immediate vicinity of the structures. In this case, the plant owner was insistent that costs be kept low. Consequently, expensive site visits were restricted to construction engineers. Fortunately, this attitude changed after the accident, and regular site visits were encouraged for the next developments on the same river. From a consultant's viewpoint, the consultant should insist that the civil project design engineer visit the site prior to commencement of design, and thereafter with the resident engineer to fix structure locations, and at suitable intervals during construction.

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