

Case Study- Upstream Slope of Bala Hydropower Station Monitoring, Sichuan, China



Background

The Bala Hydropower Station, located in Ma'erkang City, Aba Prefecture, Sichuan Province, is a key national project in China's Western Development Program and a key construction project in Sichuan Province during the 14th Five-Year Plan period.

Its installed capacity is 746,000 kilowatts, its reservoir capacity is 133.8 million cubic meters, and its designed annual power generation is 2.553 billion kilowatt-hours. Construction on the station began in early 2021, with sluice gates opened and water impounded in early 2025, and full operation commenced in August.

Challenges

As the dam entered full operation and the water level continued to increase, the slope near Sejiang Village upstream of the dam began to deform. This deformation showed an accelerating trend as the water level rose. After authoritative investigations and on-site observations, it was discovered that the landslide was substantial and, if it entered the Sejiang River, would pose significant risks. These potential risks are estimated as follows:

- A rapid rise in the surrounding water level would significantly impact the structural safety of the dam;
- This would cause silt accumulation in the reservoir and a sudden decrease in storage capacity, necessitating a significant desilting effort;
- Sudden and abnormal fluctuations in the water level would pose significant safety risks to nearby personnel.



Figure 1: Bala Hydropower Station

Solution

An on-site investigation by experts revealed that the deformation of the reservoir slope is closely related to the combined effects of continuous rainfall upstream and the increase in the dam's water level. Continuous rainfall upstream causes rainwater to continuously seep into the slope's rock and soil, increasing its weight and the downward force on the slope. It also softens the rock and soil structure, reducing its shear strength and weakening the slope's stability. Furthermore, the increase in the dam's water level and the resulting rise in the reservoir's water level cause the lower slope's rock and soil to remain submerged for extended periods, further exacerbating the softening. Furthermore, the hydraulic pressure generated by the rising water level alters the slope's force balance, increasing the risk of deformation. These combined effects disrupt the slope's original stability, leading to a more pronounced deformation problem.

Due to the rapid deformation of the slope at the site and the relatively complex internal deformation, manual on-site monitoring carries installation risks and delayed data availability, hindering real-time monitoring of the site's conditions. These factors led the owner to take a proactive approach and implement a program to collect ground and underground stability data which included high-precision GNSS sensors for monitoring ground movement and ADM array displacement meters for measuring subsurface movement. The array displacement meter which conducts comprehensive monitoring at full depth and is the primary means of deformation monitoring. The sensors were connected to the relevant system to collect and remotely stream near real-time data to the platform. The specific deployment monitoring location is shown in the figure below :

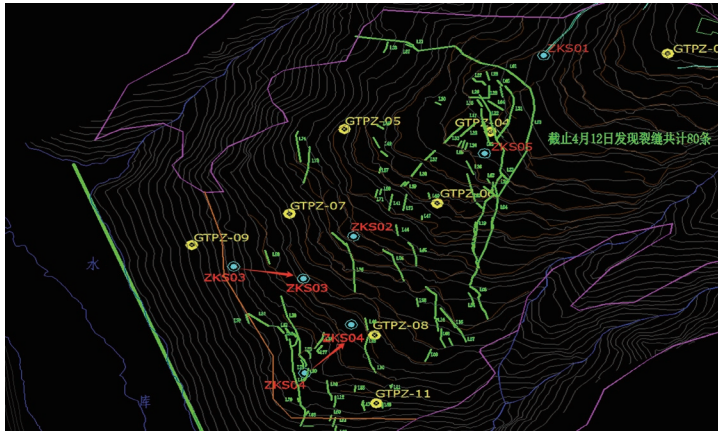


Figure 2: Crack location

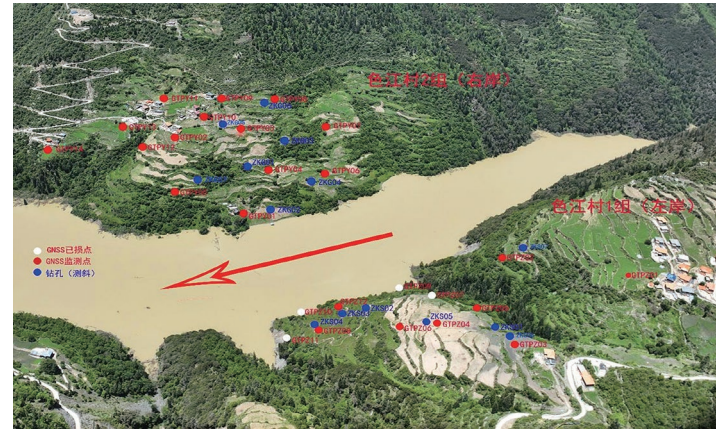


Figure 3: GNSS and ADM deployment locations

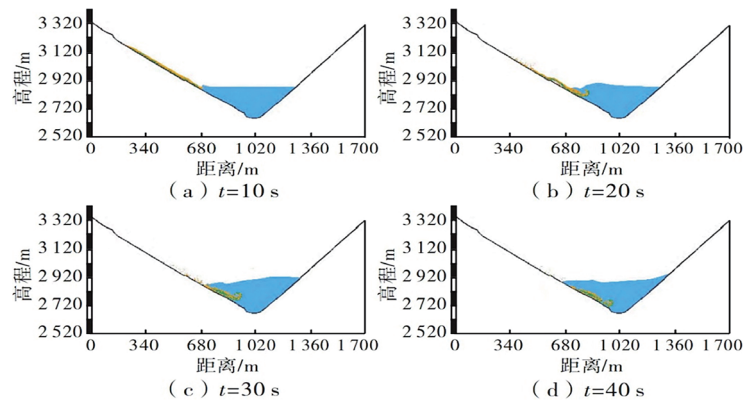


Figure 4: Evolution of landslide surge caused by loose rock layer sliding along the line

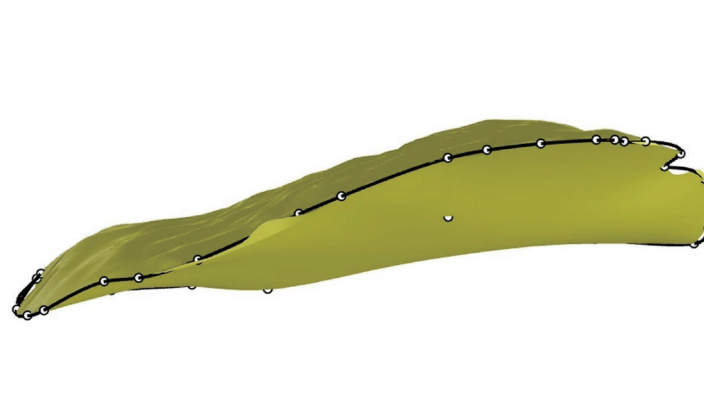


Figure 5: Model of the evolution of water along the landslide caused by sliding of loose rock layers



Figure 6: Some Deployment diagram of installing instruments

Results

After a month of real-time monitoring of the designated landslide, it was observed that the landslide had rapidly deformed since its installation on June 26th, with the maximum deformation exceeding 1 meter. Following the

reservoir release on July 8th, the deformation subsequently slowed and began to converge. By the end of July, the deformation rate had dropped below 1 mm/day, and the danger had been eliminated.

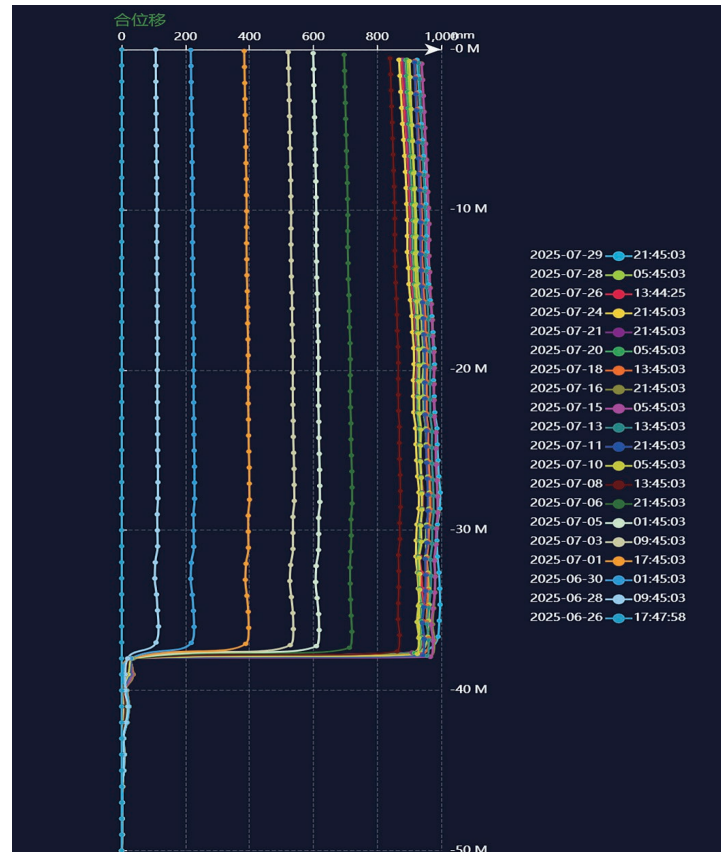


Figure 7: Cumulative deformation curve of monitoring



Figure 8: Cumulative deformation curve of monitoring

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The Bala Hydropower Station, a key national project for Western Development and a priority in Sichuan's 14th Five-Year Plan, faced critical slope deformation near the upstream Sejiang Village after its full operation in August 2025. Rising reservoir levels triggered significant landslide movement with accelerating trends, posing severe risks to dam integrity, sharp reservoir capacity reduction, and public safety.

During this critical period, the technical team accurately identified the compounded effects of continuous rainfall and reservoir filling as the primary causes. They replaced delayed and risky manual monitoring with an automated real-time system using array-type displacement meters (flexible inclinometers). The monitoring data clearly captured deformation dynamics, providing crucial support for reservoir regulation. Following controlled water release and flood discharge on July 8, deformation slowed rapidly and stabilized. By late July, the deformation rate fell below 1 mm/d, successfully mitigating the danger. This scientific and efficient technical solution ensured the safe operation of the power station, receiving high recognition from the project owner.