



Monitoring Dam Performance Using Tiltmeters

Extracted from paper by M O'Reilly, S A L Read and P F Foster, *Submitted to ANCOLD/NZSOLD conference on dams, The Challenge - Managing Dams in a Competitive Business Environment, Sydney, 31 August - 1 September 1998.*



Applied Geomechanics 700-Series tiltmeters have been successfully used to continuously monitor deformations at the Ohau A, and Aviemore Power Stations and Waitaki dam in New Zealand. With due care to installation details, they combine the sensitivity to detect small tilts ($<1 \mu\text{radian}$) together with superior long-term stability (drift $< \pm 10 \mu\text{radians/year}$).

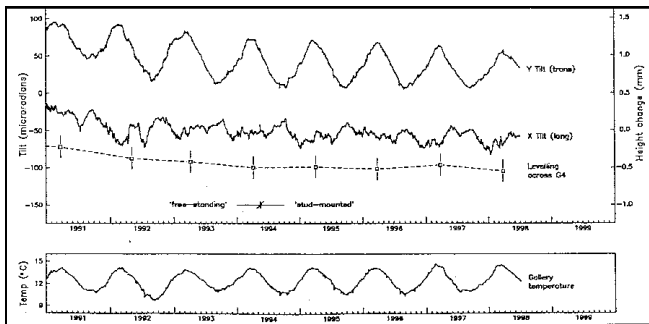


Figure 1: Long term results from machine G4 block at Ohau A Powerhouse. Confidence limits for precise leveling across block (X Tilt direction) $\approx \pm 10 \mu\text{radians}$.

Figure 1 above shows the tilts detected since 1991 in the Ohau A Powerhouse pump gallery, where the tiltmeter has been undisturbed since May 1994. Annual precise levelling surveys since 1989 have shown height changes along the length of the pump gallery (X Tilt direction) of $< 2\text{mm}$ - illustrated in Figure 1 as height differences across the G4 block. The similarity of the tiltmeter and precise levelling results demonstrates the long-term stability for the tiltmeter, with a drift within $\pm 10 \mu\text{radians/year}$. The agreement between the methods also increases confidence in the tiltmeter should anomalous tilts be detected by the continuous monitoring between surveys.

Figure 2 illustrates the tilts detected in the X Tilt (transverse) direction on the Waitaki dam block 10. Annual thermal cycles are well defined, with the dam rotating upstream (i.e. negative tilt) with increasing air and lake temperatures. The greatest tilt variations are in the air gallery, where temperatures are very similar to those of Lake Waitaki, (shown in Figure 2).

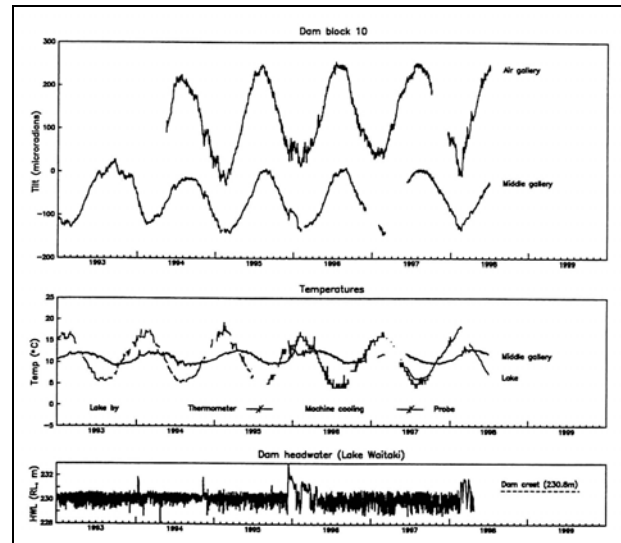


Figure 2: Long term results from dam block 10 at Waitaki dam. X Tilt (dam transverse) direction, with Lake Waitaki temperatures and headwater fluctuations.

Deformations associated with use of the overflow spillway in significant flood events are also apparent in Figure 2. In December 1995, the largest event monitored, tilts up to $20 \mu\text{radians}$ were detected by the tiltmeters in dam block 10; movements equivalent to dam crest displacements of $0.5\text{--}1.0 \text{mm}$.

Some other dams where Applied Geomechanics tiltmeters have been used:

- Grand Coulee Dam, Columbia River, Washington
- Hoover Dam, Colorado River, Arizona
- Morrow Point Dam, Colorado River, Colorado
- Mactaquac Dam, St. Johns River, New Brunswick
- Municipal Water Supply Dam, Ironton, Ohio
- Loch Lomond Dam, Santa Cruz, California
- Leniham Dam, Los Gatos, California
- Garvey Reservoir, Los Angeles, California
- Coolidge Dam, Gila River, Arizona
- Boundary Dam, Washington