

Geo Tech Note:

Tiltmeters For Slope Monitoring



A tiltmeter is an instrument that measures its own rotation and, therefore, the rotation of the structural element or portion of ground to which it is connected. Nearly all ground movement exhibits some degree of rotation. Even landslides that are predominantly translational will produce tilts that are easily detected with Jewell Instruments electrolytic tiltmeters. The sensitivity of these tiltmeters to ground movement exceeds that of the other commonly used instruments including wheeled inclinometers and vibrating-wire and foil strain gauges. Because tiltmeters are typically left in place and continuously recorded, mechanical repositioning errors do not occur.

Slope Behavior

If a slope is moving, tiltmeter surveying can determine the direction of movement, delimit the areas of deformation and, in many cases, reveal the mechanism, e.g. slope creep (Fig. 1), slumping (Fig. 2), settlement, etc.

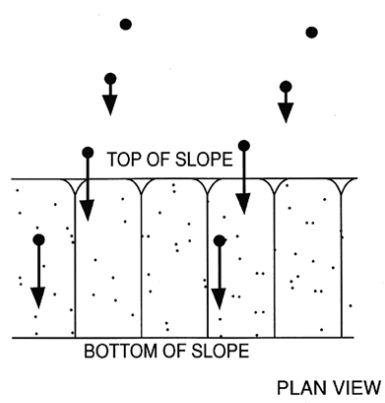


Figure 1

When used to initially evaluate movement at a site, tiltmeters can indicate whether there is a need for inclinometers, the frequency with which inclinometer surveys should be performed and the spacing of inclinometer holes. Inclinometer surveys, on the other hand, can reveal the depths of subsurface slip surface(s) and the vertical distribution of slide movement.

LANDSLIDE

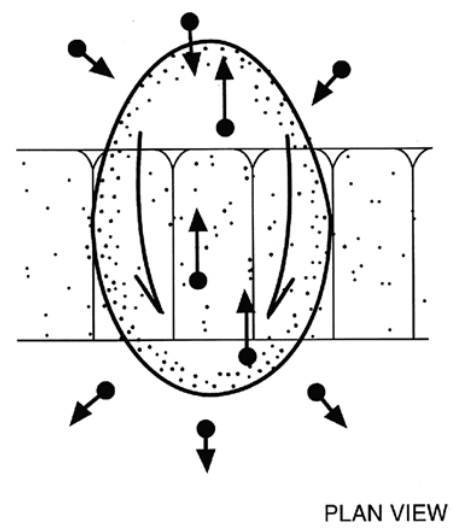


Figure 2

Tiltmeters

When a slope is suspected of being unstable, a common response is to immediately install one or more inclinometer holes. If the slope in question is moving rapidly, this approach usually will yield a good indication of deformation rates and mechanisms after a few weeks or months of diligent inclinometer surveying. However, if the movement is slow or episodic, inclinometer surveys may not be effective within the time frame or budget allotted to a project. The results are likely to be inconclusive or even erroneous because the data are too near the limits of system resolution.

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To avoid such problems, one or more high-resolution tiltmeters (Fig. 3) may be deployed in locations originally designated for in inclinometer use. If a slope is moving at a slow rate, continuously monitored tiltmeters normally can establish an average movement rate and direction within a few weeks (Figs. 4 and 5).

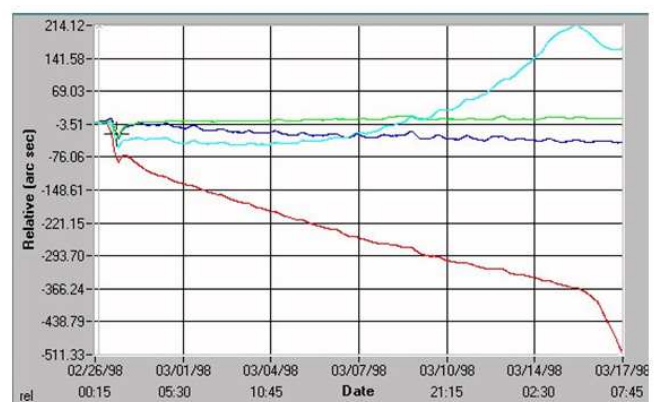


Figure 4: Rate of Movement

Continuous monitoring ensures that events are captured that would otherwise go undetected by periodic manual readings. Tiltmeters are easily automated fulfilling the demand for labor savings and continuous measurements.

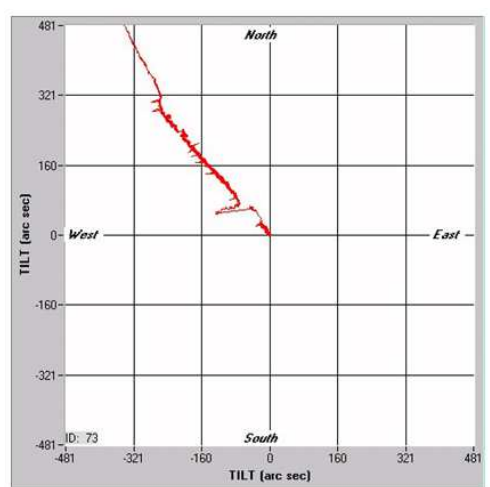


Figure 5: Direction of Movement

Integrated Slope Monitoring

The most effective monitoring systems often combine several types of instruments to track the behavior of potentially unstable slopes. These include tiltmeters, piezometers, extensometers, and time domain reflectometry (TDR). The high sensitivity of tiltmeters makes them an important component of any system designed to provide advance warning of potentially hazardous conditions or even catastrophic failure (Fig. 6). In most cases the inclusion of tiltmeters allows alarm thresholds to be set well below dangerous levels of movement, providing plenty of time for preemptive action.



Figure 6: Laguna Nigel, California Landslide