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Commentary

Time Domain Reflectometry (TDR) Technology for Landslide Forecasting

Michael E. Brown*

Department of Geosciences, Mississippi State University, Mississippi, USA

DESCRIPTION

Landslides are one of the repeated geological hazards in the rainy season. Landslides caused fatalities, economic losses and damage to the property. Of all natural hazards worldwide, landslides are responsible for 17% of deaths. The frequency of landslides is increased due to global warming, and subsequently, damage and losses associated with landslides are also increased. So, forecasting these landslides becomes more important now. Time Domain Reflectometry (TDR) technology is a measuring technique that was first introduced in the 1930s for locating damages in line cables. It works on the electromagnetic wave principle. The basic TDR measuring setup consists of a pulse generator, an oscillator, and a sampler. In this process, a pulse generator sends an electric pulse to the cable, which is under test. A waveform sampler is used to record returning echoes due to impedance mismatch in the cable. In landslide assessment and slope stabilization, locating and monitoring the temporal development of localized shear deformations in a slope is important. In general, slope inclinometers are used to measure these deformations in slope. The TDR technique is introduced in landslide monitoring programs to improve both the temporal and spatial resolution and reduce cost. Now Time Domain Reflectometry (TDR) technology is becoming a convenient and most valuable tool for continuous monitoring of the development of localized shear deformation in rock and soil masses.

The working principle that follows in this process is that the amplitude of the TDR reflected pulse in the sampler due to pinched deformation is proportional to the sliding displacement of a slope. TDR reflections due to impedance changes are recorded to conclude the measured information. These reflections are implemented through a specially designed multi-conductor waveguide to measure the dielectric characteristics and related physical properties. Characteristic impedance and localized shear deformations of the sliding plane are measured with a sensing cable. The characteristic impedance of the cable is reduced when the plane's cross-section is compressed due to the sliding deformation. If the impedance goes from high to low at the top of the sliding surface, then it indicates a negative step reflection. At the bottom of the sliding surface, impedance goes from low to high, indicating a positive step reflection. The shearing mechanism of the localized shear deformation indicates a spike-like negative reflection. The travel time is recorded where the reflection occurs, and it is determined by the location of the sliding plane. The peak reflection spike is defined as the amplitude of the reflection spike related to the amount of sliding displacement.

The detection process is as follows; the coaxial cable is inserted into the depth of the sliding plane of the monitored slope, where the coaxial cable is deformed due to shear force. Installation of a TDR cable is done mechanically by soil nailing. The shear displacement and shear bandwidth are measured, and the rectangular area around the deformed cable is figured out as a shear box. The shear box is a model for cable-grout-ground interaction. Based on the idealized elastic analysis, ground stress acting on the cable-grout assembly is determined. The solid aluminum outer conductor semi-rigid coaxial cables are used for rocks and soils, and less rigid coaxial cables with braided copper wires as the outer conductors are used. The sensing section of the cable is made with Portland cement, with a 5 mm radius. The TDR device extended cable length is about 20 meters. The backfilled material is also made from either Ottawa sand or fine gravel. Due to pore pressures, strength in between the soil layers is weakened in the monsoon season and causes landslides. With TDR high temporal resolution technology, even a thin sliding plane is also captured so that this technology can effectively contribute to early warnings.

Correspondence to: Michael E. Brown, Department of Geosciences, Mississippi State University, Mississippi, USA, E-mail: ebrown.mich@gmail.com

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