LANDSLIDES AND SLOPE STABILITY

APPLICATION NOTES
“The term “landslide” describes a wide variety of processes that result in the downward and outward movement of slope-forming materials including rock, soil, artificial fill, or a combination of these.” (USGS, 2004).

A change in the stability of a slope can be caused by a number of factors, acting together or alone, natural (groundwater pressure, toe erosion, earthquake, etc...) or occurring with human activities (blasting, excavations, constructions, etc...)

Instrumentation in landslides usually monitors not only the body of the landslide, but also the buildings in the area, the protective structures, the weather parameters and, if needed, seismic parameters.

**LANDSLIDE TYPES**
- Rotational landslide
- Translational landslide
- Lateral slide
- Rockfall
- Topple
- Debris flow

**AIMS**
- Landslide early warning system (EWVS)
- Monitoring of buildings in or nearby landslide areas
- Railway and road safety
- Monitoring performance of protective structures
### EXAMPLE OF ROTATIONAL LANDSLIDE MONITORING

<table>
<thead>
<tr>
<th>INSTRUMENT</th>
<th>PURPOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire crackmeter</td>
<td>Monitoring of cracks in rock masses or ground displacement</td>
</tr>
<tr>
<td>Vented pressure transducer</td>
<td>Measurement of water level in standpipe piezometer</td>
</tr>
<tr>
<td>Digital MEMS in-place inclinometers</td>
<td>Monitoring of deep lateral movements in sliding areas</td>
</tr>
<tr>
<td>Standpipe piezometer (slotted tube)</td>
<td>Utilized to measure water table with water level indicator or pressure transducer</td>
</tr>
<tr>
<td>Casagrande piezometer (blind tube)</td>
<td>Pore pressure pressure or water table with water level indicator or pressure transducer</td>
</tr>
<tr>
<td>Meteorological station</td>
<td>Monitoring of meteorological parameters such as rain, wind, temperature, etc...</td>
</tr>
<tr>
<td>Water level indicator</td>
<td>Monitoring of water table level in standpipe and Casagrande piezometers</td>
</tr>
</tbody>
</table>

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**LANDSLIDE BODY**

- slipping surface
- water table level
- river

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**EXAMPLE OF ROCK MASS MONITORING**

<table>
<thead>
<tr>
<th>INSTRUMENT</th>
<th>PURPOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical target or miniprism</td>
<td>Monitoring displacement with geodetic methods</td>
</tr>
<tr>
<td>Jointmeter / crackmeter</td>
<td>Measurement of small cracks in rock mass or buildings</td>
</tr>
<tr>
<td>Wire deformometer</td>
<td>Surface displacement monitoring in rock masses</td>
</tr>
<tr>
<td>Borehole extensometer</td>
<td>Monitoring subsurface displacements in rock masses</td>
</tr>
<tr>
<td>Waterproof tiltmeter</td>
<td>Monitoring rotation in big rock masses</td>
</tr>
<tr>
<td>Electric anchor load cell</td>
<td>Measure anchor tension</td>
</tr>
</tbody>
</table>

**POSSIBLE CRACK**

**UNSTABLE ROCK MASS**
### Instrumentation

<table>
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<tr>
<th>Instrument</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH profile digital inclinometer</td>
<td>Monitoring of lateral subsurface movements</td>
</tr>
<tr>
<td>VW piezometer</td>
<td>Monitoring pore-water pressure and over-pressure remediation in soils</td>
</tr>
<tr>
<td>Tiltmeter (horizontal application)</td>
<td>Monitoring rotation of wall</td>
</tr>
<tr>
<td>Hydraulic anchor load cell</td>
<td>Measurement of anchor tension</td>
</tr>
<tr>
<td>Mexid miniaturized MPBX</td>
<td>Monitoring subsurface movement and related deformation of retaining wall</td>
</tr>
<tr>
<td>Target or miniprism</td>
<td>Monitoring displacement with geodetic methods</td>
</tr>
</tbody>
</table>

**Example of Retaining Wall Monitoring**

![Diagram of retaining wall monitoring](image-url)
OMNIAlog Data Acquisition System

The OMNIAlog system is designed to be versatile and flexible. By adding modular components to OMNIAlog datalogger, the systems can be configured to handle the simplest or the most complex projects. A single logger, housed in a cabinet with multiplexer expansion boards and a communications interface, can manage a large number of sensors. The systems are easily adapted for different applications by using external multiplexer boxes. Such distributed systems can be connected in a daisy chain or star configuration. Recorded data can be downloaded to a USB memory stick or pushed to remote ftp servers. Alerts can be sent by SMS or email, and graphs and reports can be generated on web pages for access anywhere.

The WMS is a software platform designed and developed by Field Srl to validate, process, convert, manage, and automatically display data and graphs from geotechnical, structural, dynamic, meteorological and environmental monitoring systems. OMNIAlog and miniOMNIAlog dataloggers, equipped with any communication interface, send data to a remote server. The server then validates the data, removing spikes and anomalous readings, and processes the readings, converting them to engineering units, and finally adding them to its SQL database. The readings are then made available in the form of charts or tables through the “Galemys” application. The entire process is automated so that current data is available 24 hours a day, 7 days a week.

If a reading value exceeds a preset alarm threshold, the WMS can send an alarm notification via SMS or e-mail to the mobile phones of registered users.
FOR MORE DETAILED INFORMATION ON THE INSTRUMENTS CLICK ON THE RELATED PICTURE:

CASAGRANDE AND STANDPIPE PIEZOMETERS

WATER LEVEL INDICATOR

VENTED PRESSURE TRANSDUCERS

VIBRATING WIRE PIEZOMETERS

INCLINOMETER CASINGS

INCLINOMETER SYSTEM

BH PROFILE IPI INCLINOMETERS

DIGITAL MEMS IN-PLACE INCLINOMETERS

MPBX BOREHOLE EXTENSOMETER

MEXID MINIATURIZED EXTENSOMETERS

HYDRAULIC ANCHOR LOAD CELL

ELECTRIC ANCHOR LOAD CELL

WIRE EXTENSOMETER

WIRE DEFORMOMETER

JOINTMETERS

OPTICAL TARGETS AND MINIPRISMS

TILTMIETER

WATERPROOF TILTMIETER

OMNIALOG DATALOGGER

WMS WEB MONITORING SYSTEM
MAIN REFERENCE PROJECTS

Zumpano slope monitoring, Italy - LIDL Italia
ESRC Siberian landslide monitoring, Russian Federation - LLC Geocommerce
San Leo Rockfall, Italy - Field Srl
Various landslide monitoring, Taiwan - Jovian Engineering Consultant Co. Ltd.
Petra archaeological site rockfall, Jordan
Maratea rockfall monitoring, Italy - S.M.A. S.p.a.
Various Landslides monitoring for Sochi Olympic Games, Russia - AGT Systems
Sibiu Landslide monitoring, Romania - Astaldi SPA Succ. Romania
Miglionico Landslide monitoring, Italy - S.M.A. S.p.a.
Stuttgard landslide monitoring, Germany - Geomesstec
Pipeline Slope monitoring, Greece - DEPA Co.
Crocefieschi-Busalla rock masses monitoring, Italy - Campra Rocciatori
Landslide monitoring in Sakhalin II project, Russia - AGT Systems
Molunghi landslide monitoring, Italy - Provincia La Spezia

Wire crackmeter installed in Petra archaeological site, Jordan
Waterproof tiltmeter installed on Vico Equestre rock wall, Italy
Wire extensometer installed in Maratea rockfall, Italy

RELATED VIDEO

LANDSLIDE MONITORING INSTRUMENTATION, SISGEO VIDEO PRESENTATION

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