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Prediction of landslide activation at locations in Beskidy Mountains using standard and real-time monitoring methods

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The paper presents landslide monitoring methods used for prediction of landslide activity at locations in the Carpathian Mountains (SE Poland). Different types of monitoring methods included standard and real-time early warning measurement with use of hourly data transfer to the Internet were used. Project financed from the EU funds was carried out for the purpose of public road reconstruction. Landslides with low displacement rates (varying from few mm to over 5cm/year) had size of 0.4-2.2mln m3. Flysch layers involved in mass movements represented mixture of clayey soils and sandstones of high moisture content and plasticity. Core sampling and GPR scanning were used for recognition of landslide size and depths. Laboratory research included index, IL oedometer, triaxial and direct shear laboratory tests. GPS-RTK mapping was employed for actualization of landslide morphology. Instrumentation consisted of standard inclinometers, piezometers and pore pressure transducers. Measurements were carried 2006-2011, every month. In May 2010 the first in Poland real-time monitoring system was installed at landslide complex over the Szymark-Bystra public road. It included in-place uniaxial sensors and 3D continuous inclinometers installed to the depths of 12-16m with tilt sensors every 0.5m. Vibrating wire pore pressure and groundwater level transducers together with automatic meteorological station analyzed groundwater and weather conditions. Obtained monitoring and field investigations data provided parameters for LEM and FEM slope stability analysis. They enabled prediction and control of landslide behaviour before, during and after stabilization or partly stabilization works. In May 2010 after the maximum precipitation (100mm/3hours) the rates of observed displacements accelerated to over 11cm in a few days and damaged few standard inclinometer installations. However permanent control of the road area was possible by continuous inclinometer installations. Comprehensive monitoring and modelling methods before the landslide counteraction stage could lead to a safer and more economical recognition of landslide remediation possibilities.

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