



Abstract

Slope and Groundwater Monitoring for 3D Numerical Modelling to Ensure the Structural Health of an Alpine Road Tunnel Crossing an Active Rock Slide [†]

Giacomo Tedesco ^{1,*}, Stefano Bondua ², Lisa Borgatti ^{1,2}, Giulia Bossi ¹, Paolo Fabbri ³, Leonardo Piccinini ³ and Gianluca Marcato ¹

¹ CNR-IRPI, National Research Council of Italy - Institute for -Geo-Hydrological Protection, 35127 Padova, Italy; lisa.borgatti@unibo.it (L.B.); giulia.bossi@irpi.cnr.it (G.B.); gianluca.marcato@irpi.cnr.it (G.M.)

² DICAM, Department of Civil, Chemical, Environmental and Materials Engineering, Alma Mater Studiorum - University of Bologna, 40126 Bologna, Italy; stefano.bondua@unibo.it

³ Department of Geosciences, University of Padova, 35122 Padova, Italy; paolo.fabbri@unipd.it (P.F.); leonardo.piccinini@unipd.it (L.P.)

* Correspondence: giacomo.tedesco@irpi.cnr.it

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Abstract: Railways and roads frequently cross natural corridors like alluvial plains and alpine valleys. Here, structures and infrastructures can be affected by natural hazards such as floods and landslides. In some cases, the design has disregarded the possible interactions between slope processes and linear infrastructures. This work summarizes a 20-year long research comprising monitoring and laboratory data, field investigations and numerical modelling about an active 25-million m³ rock block slide threatening the serviceability of a highway tunnel in the Eastern Italian Alps, along the Tagliamento River Valley. The effectiveness of 3D geotechnical and hydrogeological numerical modelling calibrated on long-term monitoring datasets in planning countermeasures for landslide risk mitigation is demonstrated. A correlation between rapid snowmelt and/or extreme rainfall events and landslide activity is found. Moreover, monitored stream and spring discharges, together with seepage along the tunnel, appear to be strictly related to the displacements measured by GNSS and in-place inclinometers. In particular, the landslide accelerates once the threshold of 20 l/s in the tunnel seepage discharge is overcome. The continuous monitoring of specific electrical conductivity in five points allows tunnel discharge to be characterized identifying two type of groundwater circulation, one deeper and one perched, developing during extreme event. These facts clarify the role played by rainfall infiltration and groundwater flow in the fractured rock mass in promoting slope movements and damage in the tunnel lining. Based on these observations, two different 3D codes are used for groundwater flow simulation (FEFLOW by DHI-WASY) and stress and strain analysis (FLAC3D by ITASCA). The actual conditions of the slope and the possible countermeasures have been simulated. In FEFLOW, the Equivalent Porous Medium (EPM) approach is adopted with a model domain of 8-km² including the landslide and the infrastructures. In FLAC3D, the properties of the sliding surface are reduced to simulate the wetting caused by the rising of hydraulic head in the fractured rock mass during the snowmelt or rainfall events. The 300-m long extension of an already existing T-shape drainage tunnel is analyzed. The simulated countermeasure work induces a lowering of the hydraulic head in the rock mass; consequently the reduced geotechnical properties have to be applied to a smaller section of the slip surface, resulting in a decrease of displacements. Even though the stabilizing effect is not definitive, mainly because of the volume of the unstable slope, the extension of the drainage tunnel reduces both the intensity and the duration of the water seepage into the tunnel with direct benefits for the tunnel serviceability.

Keywords: Landslide Risk Mitigation; Tunnel; Modelling; FLAC3D; FEFLOW



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