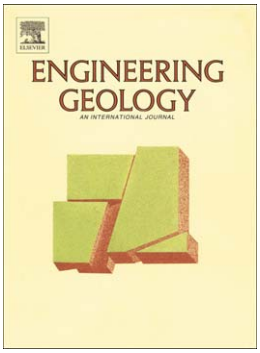

Quantitative-mechanistic model for assessing landslide probability and pipeline failure probability due to landslides

Juan Pablo Alvarado-Franco, David Castro, Nicolas Estrada, Bernardo Caicedo, Mauricio Sánchez-Silva, Luis A. Camacho, Felipe Muñoz-Giraldo

PII: S0013-7952(17)30556-2
DOI: doi:10.1016/j.enggeo.2017.04.005
Reference: ENGEO 4543

To appear in: *Engineering Geology*

Received date: 9 July 2016
Revised date: 15 February 2017
Accepted date: 7 April 2017

Please cite this article as: Alvarado-Franco, Juan Pablo, Castro, David, Estrada, Nicolas, Caicedo, Bernardo, Sánchez-Silva, Mauricio, Camacho, Luis A., Muñoz-Giraldo, Felipe, Quantitative-mechanistic model for assessing landslide probability and pipeline failure probability due to landslides, *Engineering Geology* (2017), doi:10.1016/j.enggeo.2017.04.005

Quantitative-mechanistic model for assessing landslide probability and pipeline failure probability due to landslides

Juan Pablo Alvarado-Franco[a], David Castro[a], Nicolas Estrada[a,*], Bernardo Caicedo[a], Mauricio Sánchez-Silva[a], Luis A. Camacho[a], Felipe Muñoz-Giraldo[b]

[a]*Department of Civil and Environmental Engineering, Universidad de los Andes, Bogotá, Colombia*
[b]*Department of Chemical Engineering, Universidad de los Andes, Bogotá, Colombia*

Abstract

This paper presents a quantitative-mechanistic model for assessing the probability of failure along pipelines due to their interaction with landslides. The model input parameters include elevation, soil thickness, soil mechanical and hydraulic properties, rainfall and evapotranspiration series, pipeline alignment, and pipe properties. Given that a high level of uncertainty characterizes some of these properties, they can be defined as probability density functions. The landslide occurrence and pipeline failure probabilities in each point are thus estimated by means of Monte Carlo simulations, and these probabilities are mapped to hazard exposure levels using a linguistic scale. Finally, in order to illustrate the capabilities of the model, a pipeline in central Colombia is used as a case study. The model is characterized by its simplicity, its computational efficiency, and its independence from calibration procedures at the slope scale. In this sense, it can be seen as a valuable tool that complements existing methodologies and can provide useful information to support decision-making processes.

Keywords: Quantitative model, mechanistic model, landslides, pipeline failure, TOPMODEL, Monte Carlo simulation, Colombia.

1. Introduction

Pipelines are constructed on extensive linear corridors along which they are exposed to multiple external threats, which include earthquake shaking, ground displacements, construction disturbances, ground settlements, movements due to freeze and thaw processes, and acts of terrorism or sabotage (Baum et al. (2008)). The U.S. Department of Transportations Pipeline & Hazardous Materials Safety Administration (PHMSA) has a record of pipeline incidents. According to PHMSA, in the period between 1993 and 2012, property damages due to pipeline incidents, exceeding the cost of 50,000 (in 1984 dollars), have had a cost over 6.3 US$ billion. During this time period there were, on average, more than 250 pipeline incidents per year, without a year where that number dropped below 220 (Baum et al. (2008)). More than 2.5 million barrels of hazardous liquids were spilled and only about half were recovered in cleanup efforts, which just keeps getting more expensive. Oil spills often result in both immediate and long-term environmental damage that can last for decades after the spill occurs. Moreover, on top of the direct damage to property and the environmental impact, pipeline incidents may also threaten life. For example, in 2011 an explosion of an oil pipeline nearby Dosquebradas (a small town in Colombia) caused 31 fatalities and left over 70 people severely injured.

A subset of the hazards to which pipelines are exposed is known as *geohazards*, which includes geotechnical and hydrological processes such as landslides, erosion, fluvial dynamics, and neo-tectonics. In pipeline corridors that cross mountainous terrains, a particularly important geohazard is that of landslides, specially if the pipes are buried. In this conditions, high landslide susceptibility frequently translates into high hazard to the pipeline.

*Corresponding author
Email address: n.estrada22@uniandes.edu.co (Nicolas Estrada)