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Seismic Response of Slopes Using Different Material Models and Computational Dimensions

Amir M. Kaynia[1, 2]

1- Norwegian Geotechnical Institute (NGI), Oslo, Norway
2- Norwegian University of Science and Technology (NTNU), Trondheim, Norway

Abstract

This paper presents an overview of the numerical and practical solutions commonly used for assessment of seismic response of slopes. The focus of the study is the role of material model and dimension of analysis on the slope response. Results from both simple elasto-plastic models and advanced constitutive models are presented, and the role of three-dimensional slope geometry on the seismic response of slopes is demonstrated. In addition, a brief review of simple computational methods often used in mapping of seismic slope displacements over large areas is presented. In all the cases, examples of applications are presented in order to highlight the key features of the models and solutions.

Keywords: Earthquake, landslide, material models, multi-dimensional computation

1. INTRODUCTION

Landslides represent a major threat to human life, property, built environment and infrastructure in most mountainous and hilly regions of the world, and the frequency of their occurrence is on the rise. The main reasons for the observed increase in landslide disasters are a greater susceptibility of surface soil to instability as a result of overexploitation of natural resources and deforestation and greater vulnerability of the exposed population as a result of growing urbanization and uncontrolled land-use.

While most studies on landslides have focused on rain-induced failures, more recent earthquakes, most notably the devastating Wenchuan earthquake, have underlined the significance of earthquake in triggering major landslides. The 2008 Wenchuan earthquake with magnitude M_s=8 shook severely the entire Sichuan province, and triggered more than 15,000 landslides of different forms which alone caused more than 20,000 fatalities in an area of about 50,000 km^2 (e.g. [1]). This event and similar recent earthquakes have stimulated more research on modeling of earthquake response of slopes and earthquake-induced landslides along with methods for mapping and mitigation of unstable slopes.

This paper gives an overview of the methods for earthquake analysis of slopes with a focus on the scale of analysis and degree of computational detail.

2. METHODS FOR EARTHQUAKE RESPONSE ANALYSIS OF SLOPES

Methods of analysis, prediction and mapping of earthquake-induced slope movements and landslides can be broadly divided into three categories:

1. Methods based on rigorous dynamic analysis of slope: These methods provide the most reliable picture of the response of a slope under an earthquake, but require detailed information about the geometry, stratification and mechanical properties of the slope (e.g. [2]). A variety of codes are available for numerical simulation of slope response under earthquake loading. Most existing 2-D/3-D numerical codes (e.g. PLAXIS, FLAC and UDEC) use a variety of plasticity models, and are flexible in representing complicated slope geometries although model generation is often labor intensive. Therefore, these methods are suitable for small-scale (local) applications, for example in connection with design of lifelines and infrastructure facilities.
2. Methods based on dynamic response of slope modeled as sliding rigid block [3] or its variations: These methods require less data than Methods 1 and are thus suited for regional applications. As in Method 1, the result of analysis by a rigid block model is the earthquake-induced displacement of the slope under