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Stability Analysis of Soil and Rock Slopes

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Chapter 1
Slope Instabilities

1.1. Introduction

Slope instabilities are one of the geological hazards that more economic and life losses cause each year. This phenomenon can have a natural origin (geological morphology) or an anthropogenic one (slopes made as a complement of other infrastructures, such as the results of excavations and embankments) and can occur both in soils and rocks.

In geology and engineering, slope instabilities are often referred as *landslides*. That term may have different definitions with slight differences, but usually a landslide is understood as any downslope movement of soil or rock under the effects of gravity and the landform that results from such movement (Highland & Bobrowski, 2008). However, it is interesting to note that the term slope instability is more general than landslide.

The analysis of the stability of slopes is a key aspect in the design of any infrastructure such as roads, railways, canals, pipelines and dams as well as in mining operations. For common infrastructures, slopes reach heights up to 40 or 50 m, although slope of more than 200 m can be built on some occasions. These slopes should normally be projected as vertical as possible for economic reasons and must be stable in the long term. On the other hand, mining slopes are designed based on the mineral deposit to be exploited and may need to be stable exclusively for a short or medium term.

The potential instability of slopes is not only related to infrastructures or mining operations, but it is also of high importance in other areas of Civil Engineering like land use planning, urbanism and environmental issues. Although many landslides take place in sparsely populated mountain areas where material damage and deaths are lower than the one produced by other hazards like floods or earthquakes, some slope instabilities around the world resulted in infamous disasters (e.g. Fig. 1.1) with a great amount of life losses, for instance:

- The Vargas landslide (Venezuela) in December 1999, caused between 1500 and 3000 deaths.
- The Monte Elgon landslide (Uganda) in March 2010, caused ca.350 deaths.
- The Niteroi favela landslide (Río de Janeiro, Brazil) in April 2010, caused around 200 missing persons in the Niteroi favela.
- The Leh landslide (Ladakh, India) in August 2010, caused ca.190 deaths and 400 missing persons.
- The Medellin landslide (Colombia) in December 2010, caused ca. 45 deaths.
- The Río de Janeiro landslide (Brazil) in January 2011, caused ca. 800 deaths and a great number of missing persons.
- The Uttarakhand landslide (India) in June 2013 together with an important flooding and both phenomena caused around 6000 deaths.
- The Aab Bareek landslide (Afganistán) in May 2014, caused ca.350 deaths.
- The Salgar landslide (Colombia) in May 2015, caused ca.90 deaths.
- The Santa Catarina Pinula landslide (Guatemala) in November 2015, caused around 280 deaths and 70 missing persons.
- A landslide in the south of Bangladesh in June 2017, caused ca. 150 deaths.
- The Freetown landslide (Sierra Leone) in August 2017, caused around 400 deaths and destroyed more than 100 houses.
- The Petropolis landslide (Río de Janeiro, Brazil) in August 2017, caused ca. 150 deaths.

Slope instabilities are often linked to flooding and sometimes with earthquakes, like the ones occurred in China in 1920 (100000 deaths) and Peru in 1970 (22000 deaths), or even to volcano eruptions, like the Armedo landslide (Colombia) generated by the "Nevado de Ruiz" volcano in December 1999, which caused ca. 23000 deaths after affecting some lahar deposits. However, separating victims generated by floods or earthquakes and by landslides is difficult, since authorities usually do not distinguish between them.

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