NZGS GEOTECHNICAL ENGINEERING BASICS:

SLOPE STABILITY ASSESSMENT

New Zealand Geotechnical Society

DISCLAIMER: This reference guide is not a standard. It is a 'rough guide' based on common practice in New Zealand. The recommended calculation process/analytical methods within this document are not intended to be codified nor does the document hold any legal requirement/standing in New Zealand. The accuracy of the process described below depends highly on the expertise of the geoprofessional regarding the modelling of the design, the understanding of various soil models and their limitations, the selection of material parameters, and the ability to judge the results.

1. Preliminary Slope Assessment

- **Greenfield or Brownfield site?**
  - If it is a previously developed slope, how long has the slope existed?
- **What type of slope is it and how are you changing it?**
  - Cut/fill slope?
  - Adding loading to top (road, rail, house, building, etc.)
  - Reinforced slope or Unreinforced slope?
  - Retaining wall?
  - Terraced walls?
- **What is the life of the slope?**
  - Is the slope temporary for construction or a permanent feature?
- **What is the site geology/geomorphology/topography (Scale and Accuracy of Geological Map should be considered)?**
  - GNS New Zealand Geology Web Map
  - Local geology maps (1:50,000)
  - GNS 3D geology models
  - GNS Regional Geology Books
- **Evidence of static/seismic instability at or near the site using historical aerial imagery (i.e. tension cracks, shallow failures, runout, nearby slumping, etc.)?**
  - Retrolens
    - Stereophoto (for 3D effects)
  - Regional/Local Council GIS
  - LINZ Data Service
  - GNS Landslide Database
  - Google Earth Pro

2. Detailed Slope Assessment

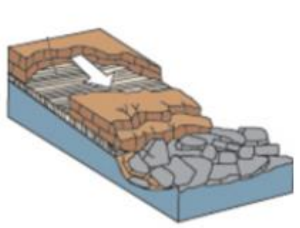
- **Establish a ground model and soil parameters for the units on the site.**
  - Do you have site-specific ground investigation/laboratory data?
  - NZGD investigation points nearby?
  - Perform a back-analysis of the slope.
- **Establish a ground water table (GWT)**
  - Do you have a site-specific GWT measurement?
  - Is there a regional scale groundwater surface for your local council?
  - Search nearby local council bore consents
- **Establish Seismic Parameters**
  - Peak Ground Acceleration (Determined from NZGS/MBIE Module 1, NZS 1170.0, NZS 1170.5, NZTA Bridge Manual)
  - Liquefaction/Cyclic Softening
    - Residual soil strength (typically modelled with Vertical Stress Ratio)
    - Reduced shear strength
  - Seismic soils strength (undrained parameters)
- **Decide on the most probable failure mode associated with the site geology (Soil/Rock) - (multiple can apply)**
  - Circular/Noncircular
  - Wedge/Planar failure
  - Toppling Failure
  - Debris Flow
  - Slumping
- **Decide on the design methodology**
  - Limit Equilibrium (Slice method)
  - Finite Element Modelling (Strength Reduction Factor)

3. Slope Stability Calculation

- **Choose an assessment software based on the failure type.**
  - GEOSLOPE - Circular, noncircular, wedge failures
  - SLIDE - Circular, noncircular, wedge failures
  - PLAXIS - Circular, slumping, noncircular
  - RS2 - Circular, slumping, noncircular
  - RocPlane - Planar sliding
  - Swedge – Wedge failure
  - Rocfall/Roctopple - Rockfalls, toppling
- **Choose a Limit Equilibrium analysis method (which accounts for both moment and force equilibrium:**
  - Morgenstern-Price
  - Spenser
  - Janbu (Generalised)
- **Set spatial limitations on calculation**
  - Horizontal
    - 4x slope height for seismic loading cases - **Note**: this is not typically used when assessing liquefied slope instability.
    - 2x slope height for static loading cases
  - Vertical:
    - Ensure model extends deep enough to incorporate deep seated failures.
- **Seismic Slope Displacements:**
  - Check the Newmark Rigid Block Method and acceptable displacements within NZTA Bridge Manual.
    - Ambraseys and Srbulov (1995)
    - Jibson (2007)
    - Bray and Travasorou (2007)

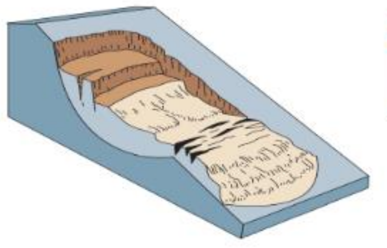
4. Design Requirements/Standards

- **Commonly:**
  - Static Case - Long Term (Drained) Parameters with surcharges (**FoS ≥ 1.5**)
  - Temporary Stability Cases Event (**FoS ≥ 1.2**)
    - Construction
    - High Rainfall Event
    - Rapid Drawdown
    - Scour
  - Seismic Cases - (**FoS ≥ 1.0 to 1.1) -or- (Newmark Displacements < required codes/standards)**
    - SLS
    - ULS/DCLS
    - CALS
    - Liquefied cases
- **Check applicable standards based on design practice for detailed requirements:**
  - Roads - NZTA Bridge Manual
  - Rail – KiwiRail Codes and Standards
  - Residential/Commercial Developments - Regional/Local Council Code of Practice (CoP)
- **If a slope fails prior to meeting code/standard:**
  - Can the slope be modified?
  - Remove load from the head or add load to the toe.
- **Slope Stability 'Rules of Thumb':**
  - A 1:4 slope could be considered stable on NZS 3604 'good ground'
  - Soil friction angle should be greater than slope 'angle of repose' if the slope is stable.
  - Geogrid reinforcing can be used to steepen the angle of a slope

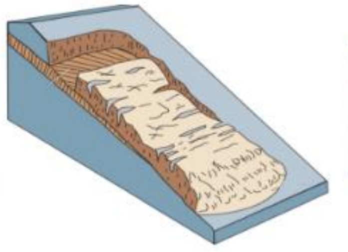


Rock Slide

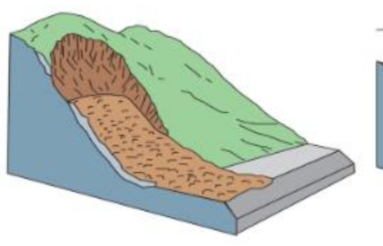
Rock Topple



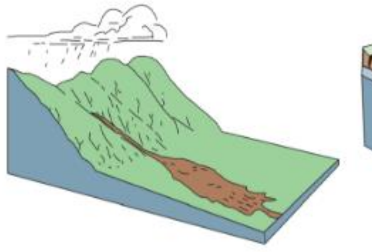
Rotational Failure



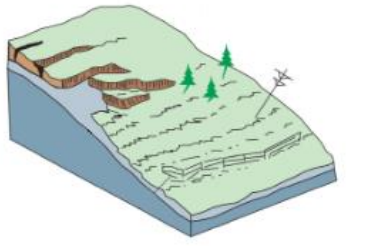
Translational Failure



Debris Flow



Earth Flow



Slow Earth Flow (Creep)

Note: *Figures sourced from US Geological Survey Circular 1325 - The Landslide Handbook—A Guide to Understanding Landslides (2008), with kind permission for reproduction.)*