An Overview on Slope Stability & Slope Failures

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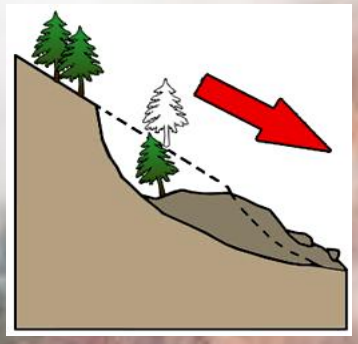
Slope Stability

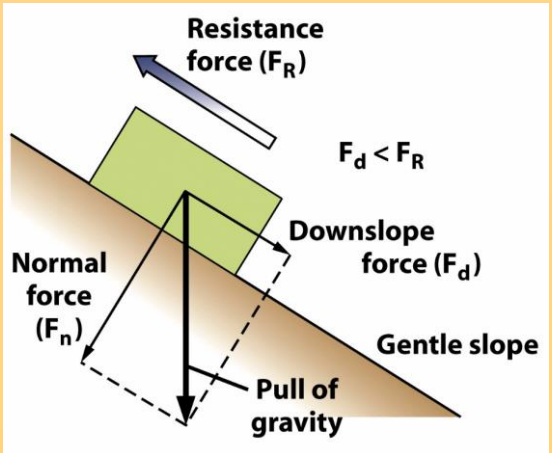
- Slope failure referred to as mass wasting, is the downslope movement of rock debris and soil in response to gravitational stresses.
- Slope stability is based on the interplay between **Driving** and **Resisting** forces.



Downslope forces = Gravity

Does gravity act alone? NO!! Slope angle, climate, slope material, and water contribute to the effect of gravity.

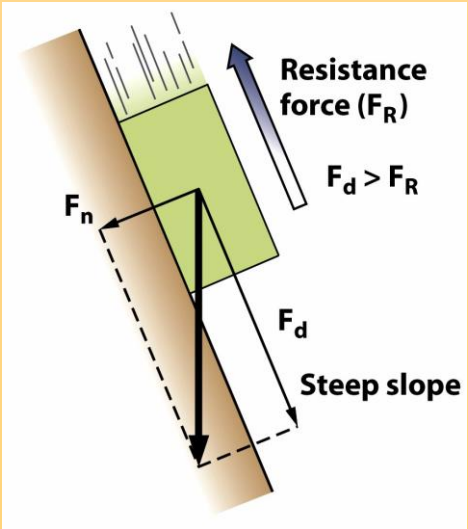
- ✓ The weight of Earth materials.
- ✓ The weight of added water.
- ✓ The weight of added structures.



Resisting forces = Shear strength

Shear strength is a function of cohesion (ability of particles to attract and hold each other together) and internal friction (friction between grains within a material).

- ✓ Chemical weathering weakens slope material.
- ✓ Internal Friction between grains within a material.



Safety Factor (Fs)

F_s is the ratio of resisting forces to the driving forces, or

$$F_s = \frac{\tau_f}{\tau_d}$$

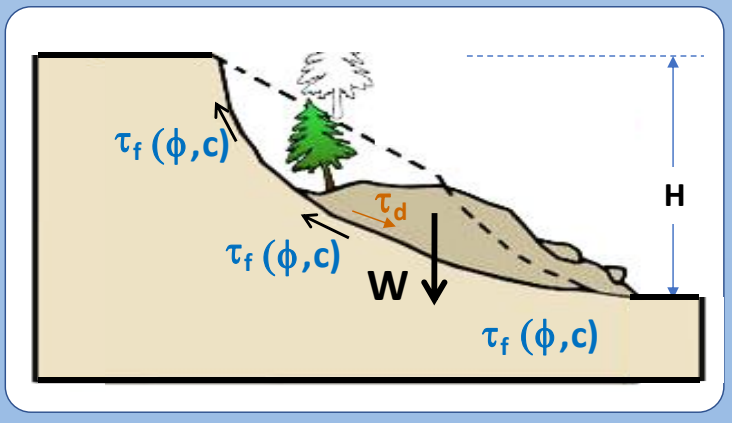
Shear strength (resisting movement)
average shear strength of the soil.

$$\tau_f = c' + \sigma' \tan \phi'$$ (Available)

Shear stress (driving movement)
average shear stress developed along the potential failure surface.

$$\tau_d = c'_d + \sigma' \tan \phi'_d$$ (developed)

- ✓ Generally, FS ≥ 1.5 is acceptable for the design of a stable slope
- ✓ If factor safety F_s equal to or less than 1, the slope is considered in a state of impending failure.



$F_S < 1$ → unstable
$F_S \approx 1$ → marginal
$F_S >> 1$ → stable

$$F_s = \frac{c' + \sigma' \tan \phi'}{c'_d + \sigma' \tan \phi'_d}$$

Where:
c' = cohesion
ϕ' = angle of internal friction
c'_d, ϕ'_d = cohesion and angle of friction that develop along the potential failure surface

Types of Slopes

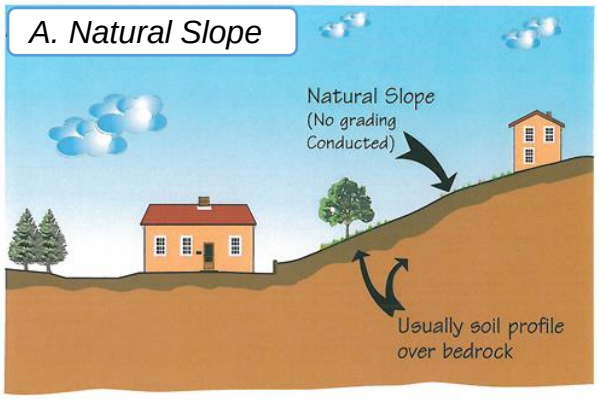
Slopes can be categorized into two groups:-

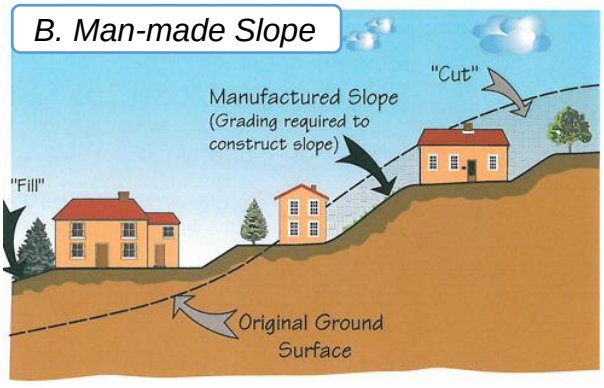
A. Natural slope

- ✓ Hill sides
- ✓ Mountains
- ✓ River banks

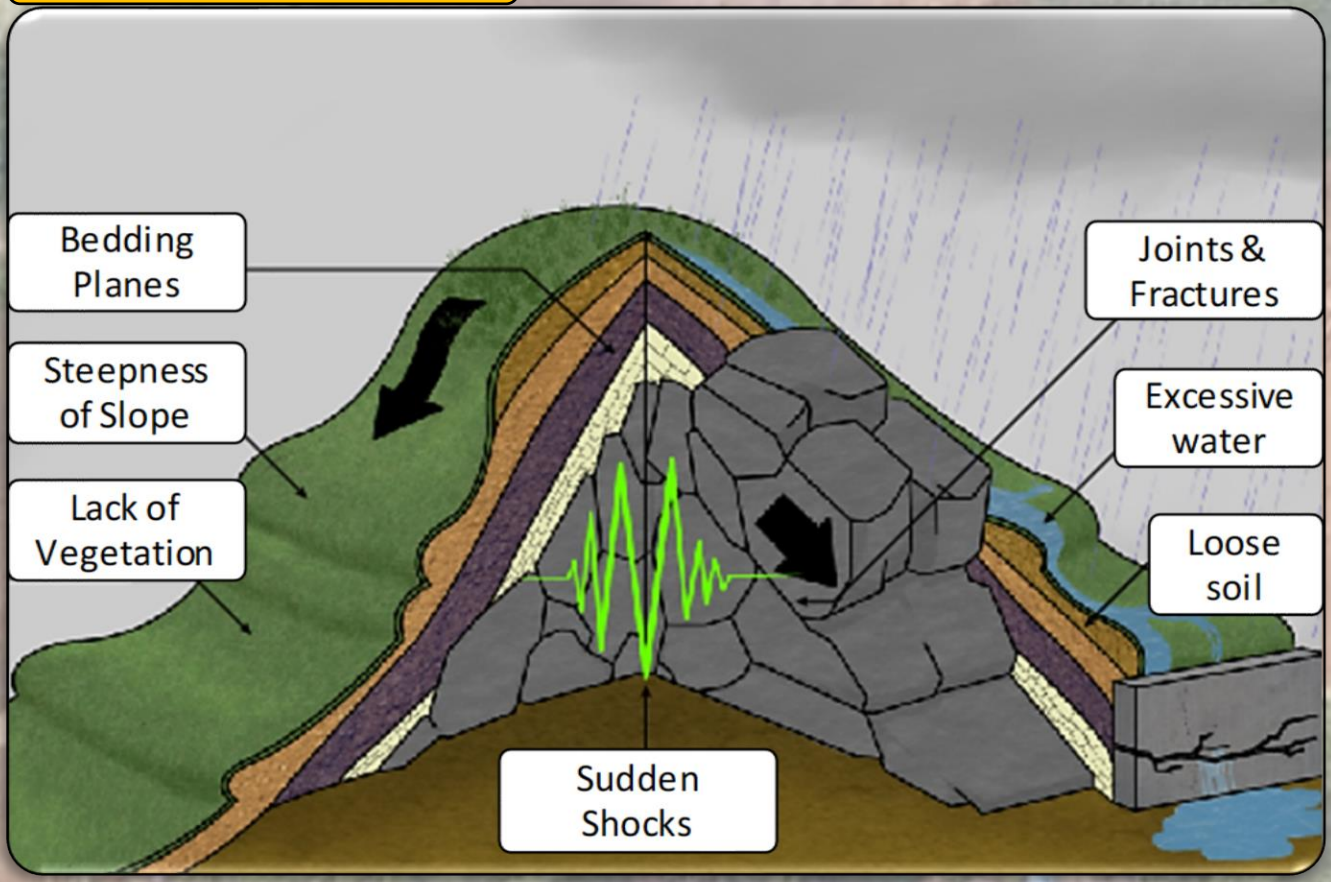
B. Man-made slope

- ✓ Fill (Embankment)
- ✓ Earth dams
- ✓ Canal banks
- ✓ Excavation sides
- ✓ Trenches
- ✓ Highway Embankments

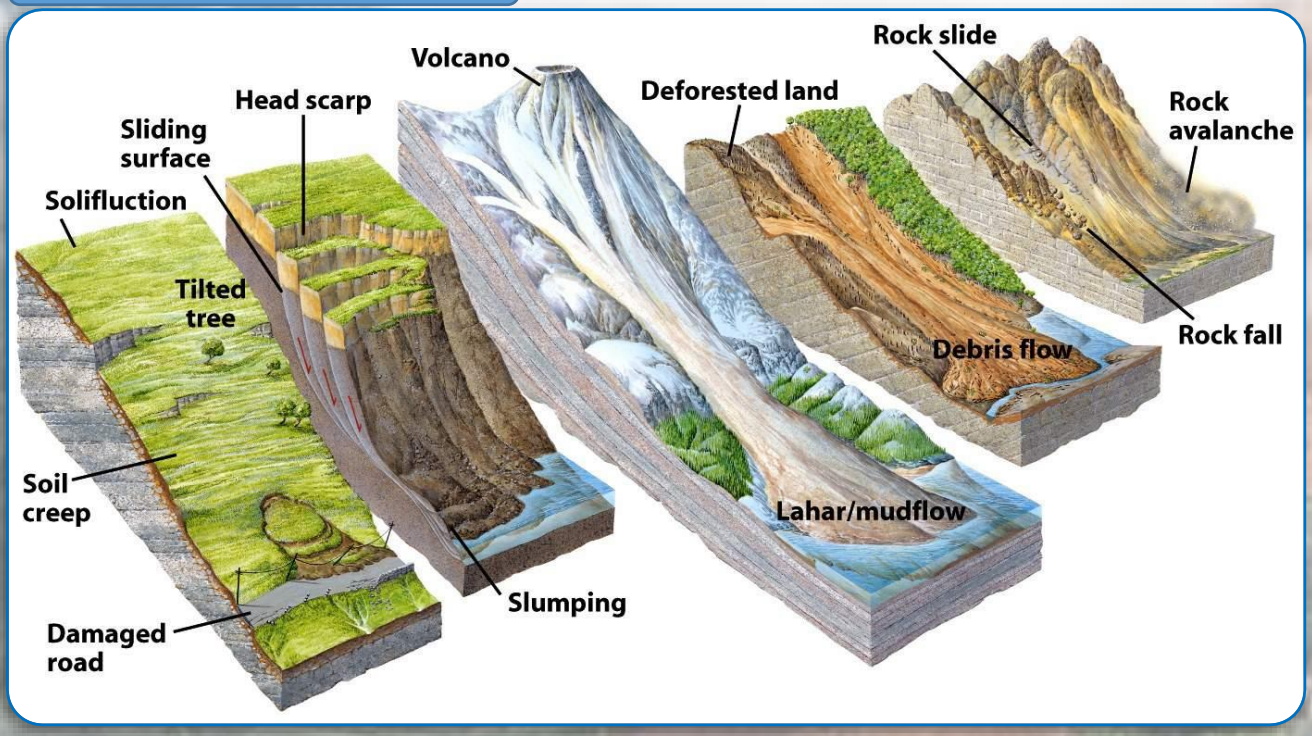




Causes of Slope Failure

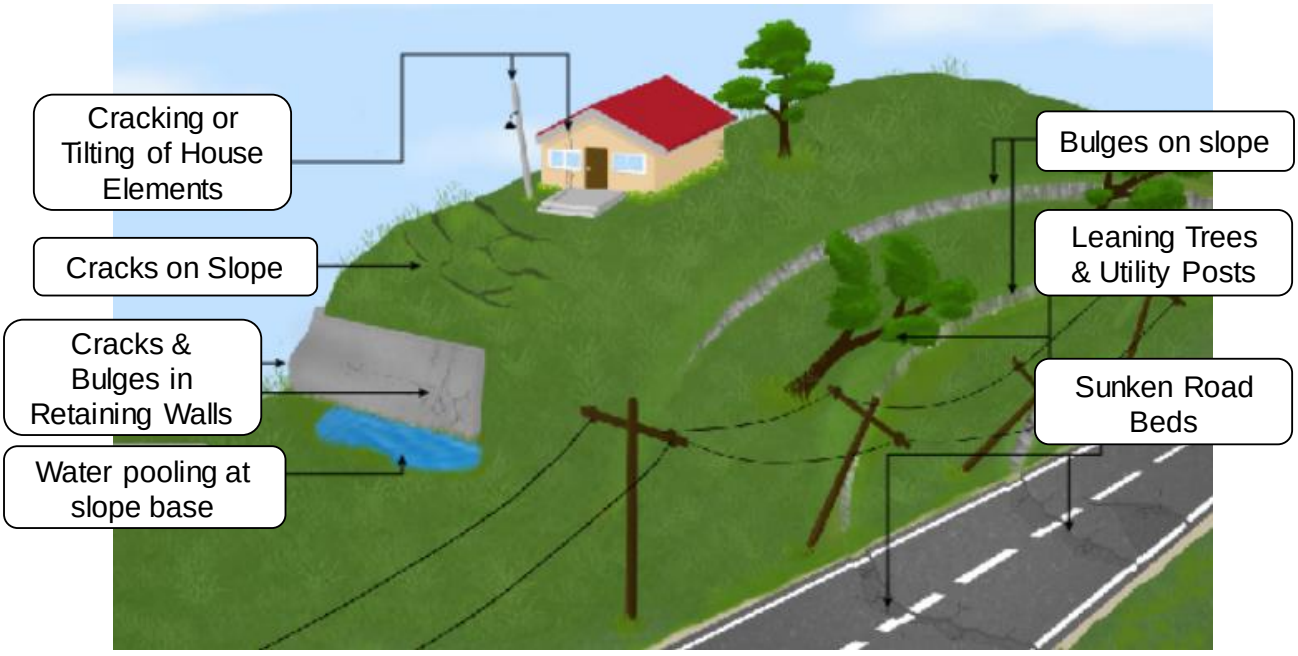


Types of Mass Wasting

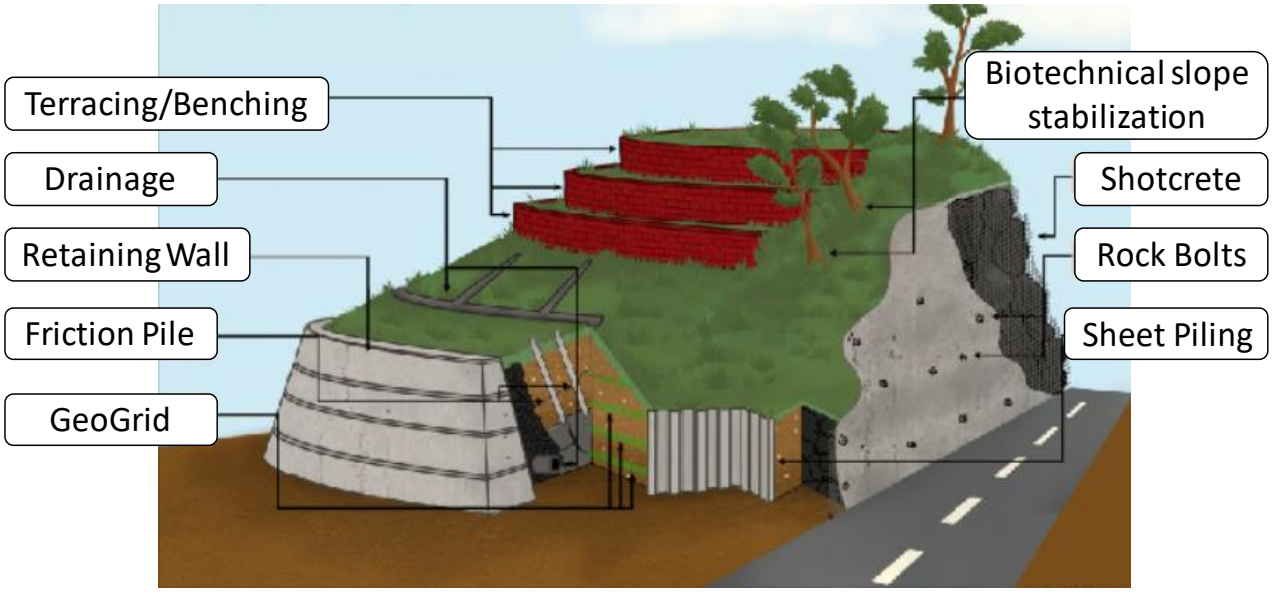


Type of Movement	Material Involved	
	Rock	**Soil**
Falls	Rockfall	Soilfall
Slides • Rotational • Translational	Rock slump block Rock slide	Soil Slump Block Debris Slide
Flows — Slow	Rock Creep	Soil Creep
Flows — ⇓ / Fast	Earthflow Mudflow Debris Flow Debris Avalanche	
Complex	Combinations of two or more types of movement	

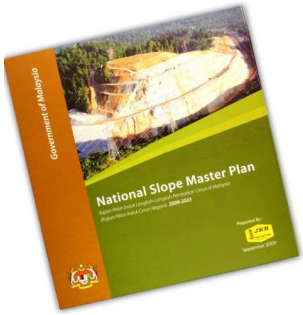
Indication of Impending Slope Failure



Slope Stabilization/Repair Method



National Slope Master Plan (2009-2023)



- ✓ Study commissioned by Cawangan Kejuruteraan Cerun (CKC), JKR from 2006-2008
- ✓ Goal : To reduce ricks and losses due to landslides nationwide
- ✓ 10 components or areas of concentration
- ✓ 34 strategies and 77 actions plans

National Slope Master Plan Component

1. Policy & Institutional Framework
3. Hazard Mapping & Assessment (HMA)
3. Loss Assessment (LA)
4. Early Warning System (EWS)
5. Information Collection, Interpretation, Dissemination & Archiving (ICIDA)
6. Training (TRN)
7. Public Awareness & Education (PAE)
8. Loss Reduction Measures (LRM)
9. Emergency Preparedness, Response & Recovery
10. Research & Development (R&D)

Role of JKR in Slope Management

- ✓ Slope Engineering Branch (CKC) under JKR was formed after a rockslide at NKVE near Bukit Lanjan (Feb 2004)
- ✓ The latest slope assessment systems for predicting landslides at the micro level of assessment developed by the JKR is the Slope Management and Risk Tracking System **(SMART)**
- ✓ ONLY **Slopes along Federal Roads** Under JKR's Responsibility
- ✓ CREaTE have been included under **Working Group 5** in Slope Transformation Plan