## Chapter 2

# Non tectonic deformation

Non-tectonic deformations are the immediate or delayed response to the action of **gravity**, often combined with **erosion agents**, on geological layers. This involves a gradual superficial displacement of the soil and altered rocks, following the slope. In this chapter, we will learn two type of non-tectonic deformation witch are;

- **Creep**
- **Land slide**

### 1. Creep

#### Definition

***Creep*** is the slow, imperceptible deformation of slope materials under low stress levels, which normally affects only the shallow portion of the slope, but can be deep-seated where a weak zone exists. It results from gravitational and seepage forces, and is indicative of conditions favourable for sliding (fig. 1).

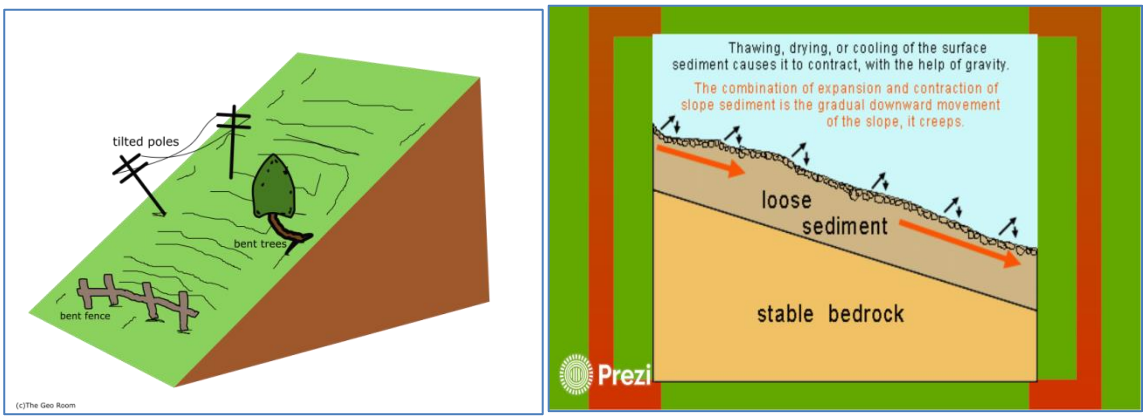



Fig. 1. Creep movement

#### Recognition

**Creep** is characteristic of cohesive materials and soft rock masses on moderately steep to steep slopes. Its major surface features are parallel transverse slope ridges ("cow paths") as illustrated in Fig 2.image 01, and tilted fence posts, poles, and tree trunks. Straight tilted tree trunks indicate recent movement (Fig 2.image 02), whereas bent tree trunks indicate old continuing movement (Fig 2.image 03). The essential characteristic of creep is the absence of a clear boundary between the moving zone and the stable zone.

**Creep** is most noticeable during wet periods (fig.3). The primary cause is the small vertical movements in the soil resulting from the repeated cycles of wetting and drying of clay minerals or the freezing and thawing of water. When moistened, the clay fragment swells, and as it dries, it contracts and settles back into a vertical position.


Fig. 2. Creep characteristic.

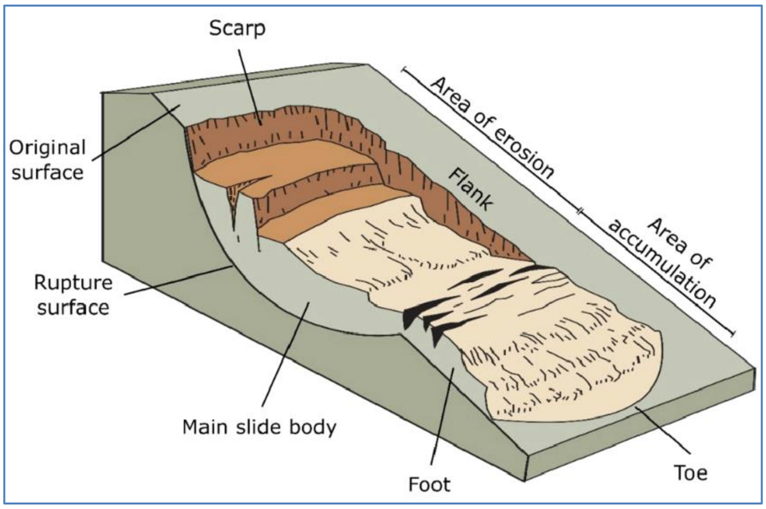
Fig. 3. Panoramic view of the creep phenomenon.

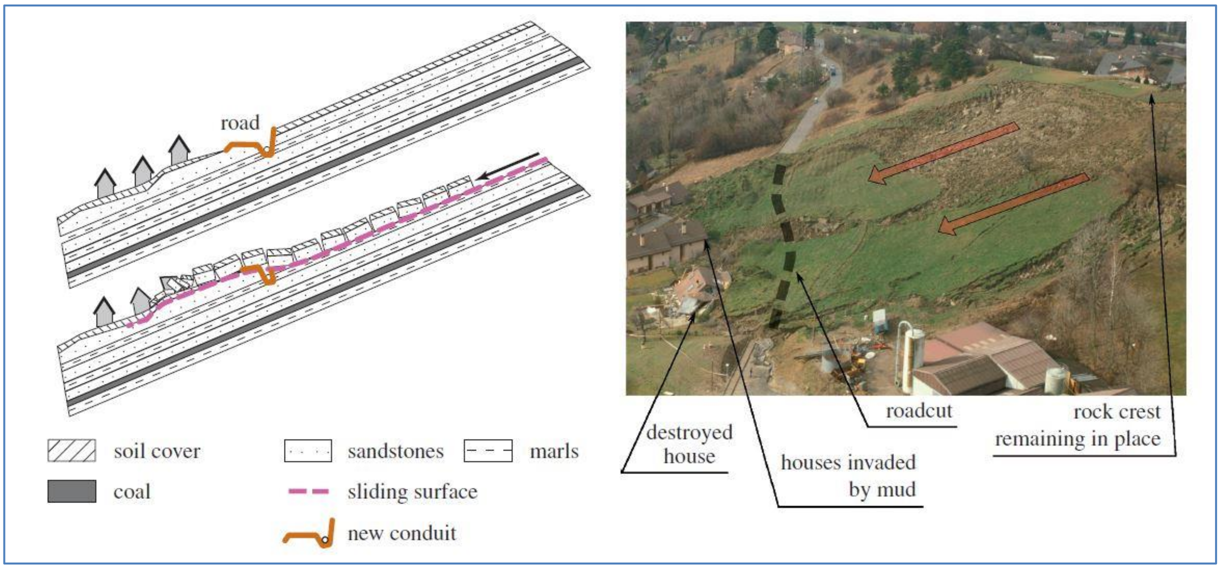
**2- Landslides:**

**2-1- Definition of a Landslide:**

A landslide is a geological phenomenon involving the movement of loose or rocky materials along a rupture surface. Landslides can cause natural disasters leading to fatalities. They generally occur in weakly cohesive materials (like marl and clay). A landslide happens when the shear stresses caused by driving forces (such as weight) exceed the soil's resistance along the rupture surface.

The volume of landslides can vary greatly from a few cubic meters (small slides) to several million cubic meters (entire slopes). The driving force behind this phenomenon is always **gravity** the soil moves under the effect of its own weight.




**Triggering factors** generally include:

1) Changes in the hydraulic regime (material saturation, increased pore pressure, etc.);
2) Earthworks (excavations or fill);
3) Natural erosion (runoff, riverbank erosion);
4) Accelerations caused by earthquakes.

**2-2- Areas Prone to Landslides:**

Certain areas are more prone to landslides:

- **Cliffs** are high-risk zones because water infiltrates cracks in the rock. When it freezes, it exerts significant pressure. The freeze/thaw cycle weakens the rock, causing the cracks to deepen and widen until the point of rupture (leading to rockfalls and collapses).
- **Areas with moderate slopes (40°–50°)** are also at risk. The humus layer resting on the underlying soil can slide when it becomes very wet (landslides).
- **Grounds with subsoil containing cavities** (either natural or man-made) are also risk zones, as they may collapse or sink.

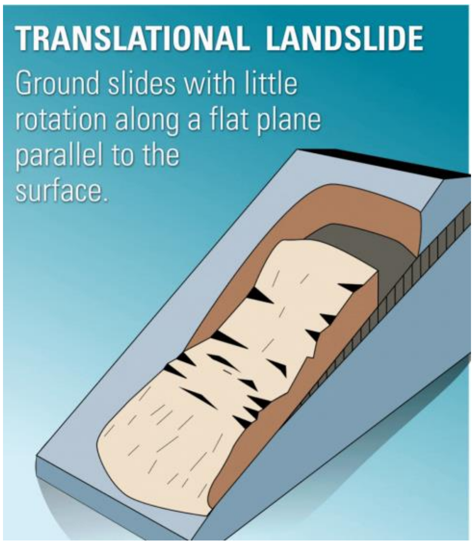
**2-3.Types of landslides**

Two main types of landslides exist, which may sometimes combine to create complex landslides:

- **Planar landslides**
- **Rotational landslides** (simple or complex)

**a) Planar or translational Landslides:**

They occur along a plane, usually at a discontinuity between two different types of materials (e.g., the limit between weathered material and the underlying rock — see Figure I-2). The rupture follows a thin, weak layer, often affected by water action.




**b) Rotational Landslides:**

In these movements, the sliding mass rotates along a curved, roughly circular surface. Movements may be **simple** or **complex**.

❖ **Simple Rotational Landslides:** These common movements have a rupture surface approximating a circle and are studied using classic soil mechanics methods. They can be:

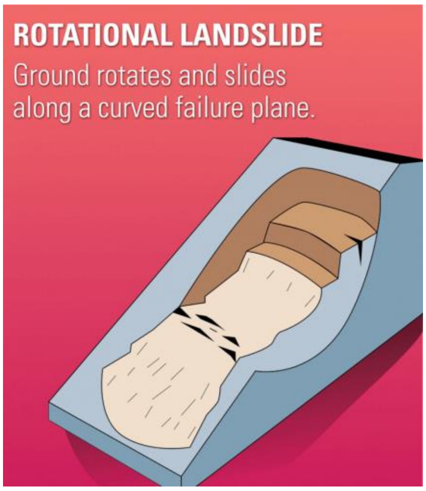
- **Superficial** (e.g., crest and toe slides)
- **Deep** (affecting fills over soft soils or deeper rupture circles touching the bedrock).

❖ **Complex Rotational Landslides:** These involve a rupture surface that is **non-circular**. Possible causes include:

- Structural anisotropy;
- Mechanical anisotropy;
- Variations in mechanical properties with depth;
- Removal of toe support leading to backward failure or collapse.

**Examples:**

- **Stepwise slides**, where a series of shallow slides create a stepped topography.
- **Slides caused by toe removal**, resulting in terrain wedge collapses.
- **Composite landslides**, combining elements of planar and rotational slides.




**2-4- General Appearance of Landslides:**

A slope failure due to sliding typically shows as a block displacement of part of the slope. The sliding surface can be approximated as a cylindrical surface. Thus, analysis is carried out using slices of unit thickness cut perpendicular to the rupture surface axis. In cross-section, the rupture surface appears as a **circular arc**.

The top of the slope subsides, and a toe bulge forms at the bottom.

**2-5- Main Causes of Landslides:**

The instability process of a slope depends on:

**2-5-1- The Nature of the Terrain:**

Factors include:

a) **Terrain Geometry:**

The slope angle is the first factor determining stability. The critical slope angle depends on the nature of soils/rocks (their shear strength) and the presence of groundwater.

**b) Shear Strength of Soils and Rocks:**

Mechanical strength is crucial in slope stability. Slope failure mechanisms involve shear strength. At any point, this resistance depends on the material's nature, its history, and the stress state (affected by loads, unloading, groundwater fluctuations, etc.).
For reactivated landslides, movements occur along pre-existing rupture surfaces. Here, **residual shear strength** is important.

Two key soil parameters must be known:

- Short-term or long-term shear strength;
- Residual shear strength.

In stiff clays often found in unstable slopes, shear tests show a peak strength followed by a significant drop the final value is the **residual strength**, determined by repeated shear tests.

Stability analyses typically use:

- Peak shear strength for first-time failures;
- Residual strength for reactivated slides.

**2-5-2- External Actions on the Soil:**

**c) Hydraulic Actions:**

Understanding the site's hydraulic regime is crucial for analyzing instability and designing solutions. This requires studying a much larger area because water supply conditions can be complex and linked to distant terrain layers.

Observations must cover long periods to capture worst-case conditions (e.g., a year with a 10-year return rainfall event). Often, extrapolations are necessary.

Key elements:

- Pore pressures at the rupture surface;
- Groundwater feeding conditions;
- Ground permeability;
- Temporal changes in the water table — movements may sharply increase beyond a critical threshold.

**d) Climatic and Human Actions:**

Major climatic factors include water inputs (rainfall, snowmelt, etc.).
Human actions, like modifying slopes through loading/unloading (constructions, excavations), can also destabilize slopes.

**e) Rain, Snow, Evapotranspiration:**

Groundwater is primarily replenished by rainfall and snowmelt. Other sources include leaks from ditches, reservoirs, water supply, or sewage systems.

**f) Earthquakes:**

Seismic activity can cause landslides through:

- **Liquefaction** of fine saturated soils (silts, sands), triggering sliding of overlying formations;
- **Inertial forces** directly destabilizing the slope.

**g) Construction on Slopes:**

Building embankments on natural slopes reduces overall stability. If the natural slope is already in equilibrium or has experienced past slides, new loads (embankments, foundations, retaining structures) can trigger serious movements and damages, even total destruction of structures.

**h) Excavations on Slopes:**

Excavations made for buildings or roads can trigger major disorders, especially on marginally stable natural slopes. Sliding surfaces often extend far upslope. Such phenomena are explained by the **removal of the toe support**: even small excavation volumes can cause large-scale landslides. Steepening the slope (by cutting) further worsens the stability.