LANDSLIP AND SLUMPING HAZARDS

LANDSLIPS AND SLUMPING HAZARDS

#Mass movement = the large-scale downwards movement of soil and rock down a slope due to gravity.

 # A landslip (or a landslide) = is a rapid down slope movement of blocks of rock along a slip plane.

#A slump = a rotational downwards and outwards movement of incompetent rock and material.

Mass movement is not accompanied by a moving agent such as a river, glacier or ocean wave.

Mass movements are slope processes which can include landslips, slumps, flows and falls. While they may seem less spectacular than other natural disasters like volcanoes, tsunamis fires, earthquakes and floods, yet they cause more annual damage than all of these, making them one of the most underestimated natural hazards.

They can range from very slow soil creeps to almost instantaneous rock falls.

1. Very slow movement: **Soil** creep (Continuous, low scale but low magnitude)
2. Fast movement: **Avalanches** (instantaneous, large-scale, infrequent and high magnitude)
3. Dry movement: **Rock falls** (instantaneous, infrequent and high magnitude)
4. Very fluid movement: **Mudflows** (instantaneous, infrequent, high magnitude)

#Avalanche = a sudden flow of a large mass of snow or ice down a slope or cliff, sometimes at speeds exceeding 160 km/hr (100 mph).

#Mudflows =

WHAT ARE THE NATURAL CAUSES OF LANDSLIPS AND SLUMPS?

*Landslides occur when **gravitational and other types of shear stresses** within a slope **exceed the shear strength** (resistance to shearing) of the **materials that form the slope.***

Usually a series of events will result in mass movement rather than one single determining factor. The final figure is usually something such as **heavy rainfall, earthquakes or a volcanic eruption.**

There are two main reasons for mass movement:

A. **A reduction in shear strength (the internal resistance, of the materials making up the slope, to shearing forces/downwards movement).**
B. **An increase in the shear stress (the force acting on a body that causes movement of that body down the slope).**

Rock type and features

Strong competent rocks have a higher shear strength and are less likely to fail than weak, incompetent rocks. The rock type will also affect the type of failure exhibited; incompetent rocks tend to slump whereas competent rocks tend to slip.

The porosity and permeability of a rock affects the ability to support and store water within the mass. The higher these two factors, the more likely a landslip is to occur. When impermeable and permeable layers are sandwiched between each other lubricated slip planes may develop along bedding planes. Water saturates the porous rock above and a slip failure is likely at the junction of impermeable/permeable rock.

Geological structures like bedding planes, joints and faults are planes of weakness in the rock. If present, the rock will often fail along them, e.g. reactivated fault planes.

Physical features

The dip of bedding planes is also critical. If bedding planes dip towards a valley, then blocks of rocks are more likely to fail (a big problem when creating a reservoir in a valley with dipping layers on either side).

Weathering results in the weakening and disintegration of rocks. This produces loose unconsolidated material which has a lower shear strength: slip failure is more likely.

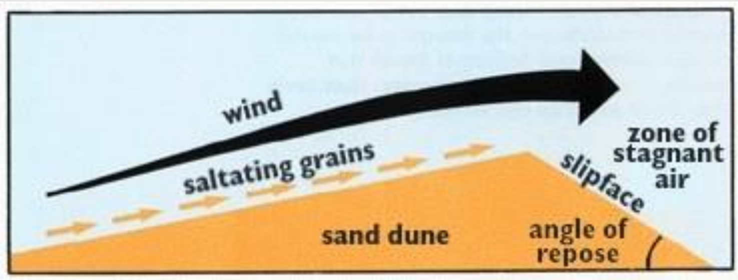
Slope angles

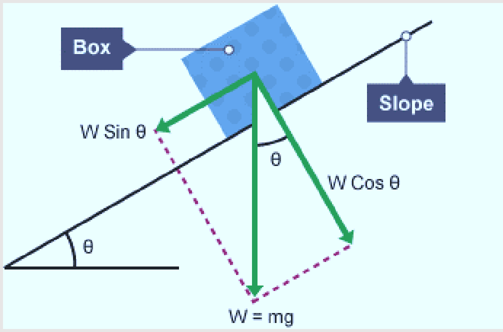
Slopes are stable when **the shear strength/forces resisting movements** along that slope, e**xceed the forces/shear stress of material driving movement down** the slope.

 # Angle of repose = The maximum angle at which a sloping surface formed of loose material is stable at.

For example,

Dune sandstones typically have a windward slope of < 25^0 and a **lee ward/dip slope of maximum ~ 37^0**.





The **steeper the gradient** for a particular material, the larger the component of gravity acting down the slope, so **failure is more probable.**

Water saturation

Water that is able to **penetrate porous and permeable** rocks will not only **increase the weight** of the material but also increases **the pore-fluid pressure**, resulting in an **reduction of friction and cohesion forces within the rock.** This is particularly common along bedding planes (a lubricated slip plane forms).

The fluid phase acts to weaken Si-O bonds when pressure is applied. **Increasing pore-fluid pressure will lower the strength** of the rock and encourage **flow within the rock.**

Heavy or prolonged rainfall can become a serious problem. It will also act to increase the rainfall and so rise the water table (increasing pore-fluid pressure and lubricating slip planes). When the particles become **saturated** their **cohesion is reduced a**nd the frictional/shear strength is decreased.

Water saturation is form: Raising water tables or heavy rainfall.

Other factors

- Increased **freeze thaw activity** will also cause a **reduction in shear forces**. Landslides more common in colder conditions. This may also mean there is more weight of snow and ice increasing shear stresses.
- Steepening or undercutting of a slope will increase the slope angle (until it exceeds the angle of repose) and also reduces slope strength.
- Vibrational shock and earthquake waves can destabilize the slope and may even trigger landslides in urban areas.

Factors contributing to increased shear stress	
Factor	**Examples**
Removal of support through undercutting or slope steepening	Erosion by rivers and glaciers; wave action, faulting; previous rock falls or slides
Removal of underlying support	Undercutting by rivers and waves; subsurface solution
Loading of slope	Weight of water; vegetation; accumulation of sediments
Lateral pressure	Water in cracks; freezing in cracks; swelling; pressure release
Short-term stresses	Earthquakes; movement of trees in wind
Factors contributing to reduced shear strength	
Factor	**Examples**
Weathering effects	Disintegration of rocks; hydration of clay minerals; solution of minerals in rock or soil
Changes in soil and ground-water pressure	Saturation; softening of material
Changes of structure	Creation of fissures in clays; remoulding of sands and clays
Biological effects	Burrowing of animals; growth and decay of roots

Mass movement is most common in colder conditions (increased freeze thaw & rock falls) and after heavy precipitation.

WHAT ARE THE HUMAN CAUSES OF LANDSLIPS AND SLUMPS?

- Adding **weight by building** on top of the slope.
- **Removing materia**l from the **base of the slope for buildings or road cuttings**.
- **Leaking water mains** and **sewage pipes** adding water.
- **Removal of vegetation** that **intercepts water and binds soil** together
- Creation of **impermeable** surfaces such as **tarmac** that i**ncrease surface run-off**
- V**ibration** form **heavy traffic, machinery or blasting**

WHAT ARE THE MAIN TYPES OF MASS MOVEMENT?

Soil creep

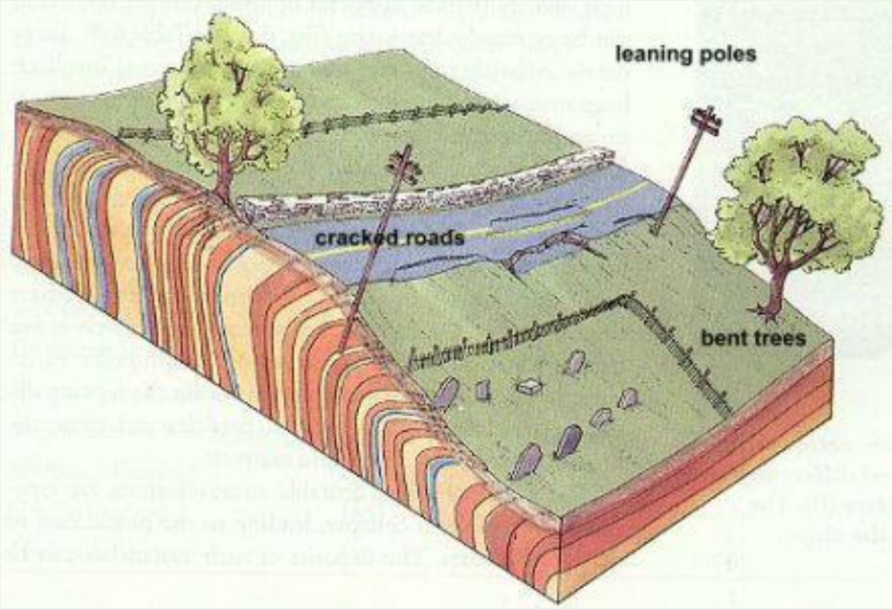
Soil creep is the slow progression of rock and soil down a low grade slope

This is one of the **slowest** types of mass movement. It is slow, small scale and occurs mainly in **winter** in **mid-latitude** regions. These are very important where flows and slides are not common.

When groundwater freezes it **lifts particles of soil and rocks and when there is a thaw**, the particles are **set back down,** but g**ravity always causes the rocks and soil to settle just a little farther downslope than where they started from**.

However, individual soil particles can be pushed to the surface by number of processes: **water freezing, heating or wetting & drying.** Circa 75% of movement is induced by **moisture changes and associated volume change.**

For instance when soil is wet, soil particles increase in size and weight, and expand at right angles. When the soil dries out, it contracts vertically. As a result, the soil slowly moves downslope.

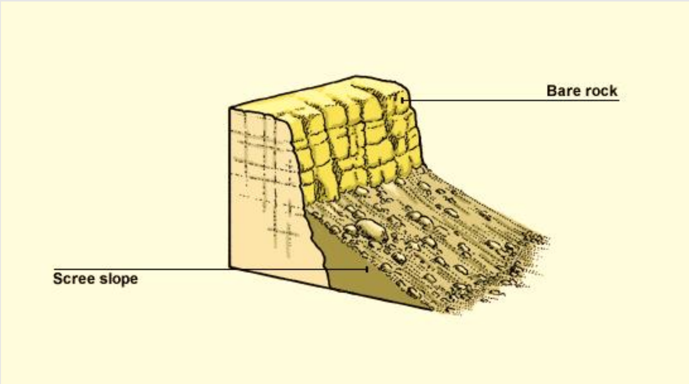


Rock fall

This is the rapid, free-fall of rock from a steep cliff-face. The fragments fall from the face of the cliff due to the force of gravity acting on their mass. This is made worse by freeze thaw action which disintegrates and loosens rock.

Bare, well jointed rock is very vulnerable to rock fall, water may enter joints, freeze and expand (by ~ 9%) and then crack the rock. A scree slope of fallen rock forms at the base of the cliff.

Erosion may also prise open liens of weakness.



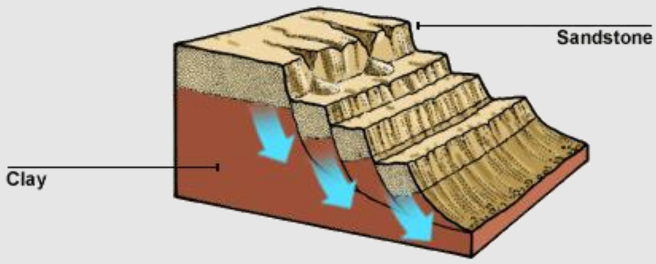
Landslips / Landslides / land slumps

These are occasional but rapid movements of blocks of earth and rock moving downward along a slip plane.

Rotational slumping will occur along a concave upwards slip plan. The slip surface of a rotational landslide tends to be deep. Blocks of failed material will rotate as they fail and often tilt backwards towards the slope.

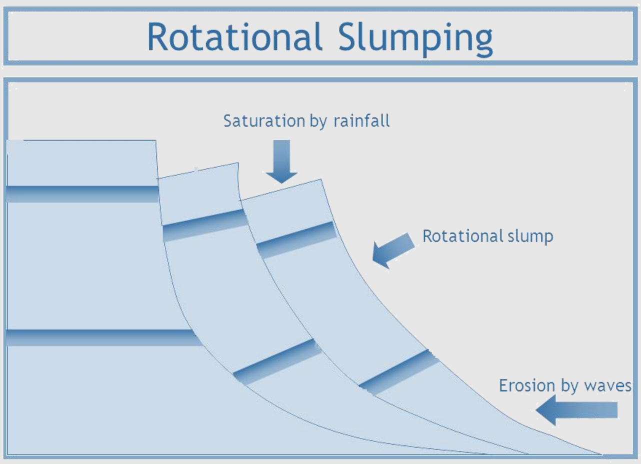
These are most common after periods of heavy rainfall. Water infiltrates the porous and permeable overlying Sandstone, saturating it. It builds up at the bedding plane between the underlying impermeable clay and overlying permeable sandstone. This plane is lubricated by the water and with the weight of the rock above forcing downwards, the saturated material moves and slumps down as a slip plane is developed. Undercutting of a steep slope by the sea will weaken the rock's support so increase slumping.

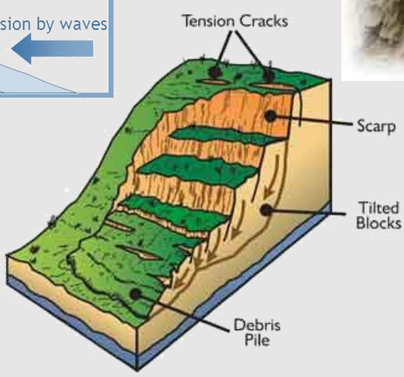
There needs to be weak rocks, steep slopes and it is best where there is active undercutting.



Rotation occurs about the axis parallel to the slope.

If slippage of material is along a curved slip plane then it is rotational slumping. A series of massive steps called terraces can form.



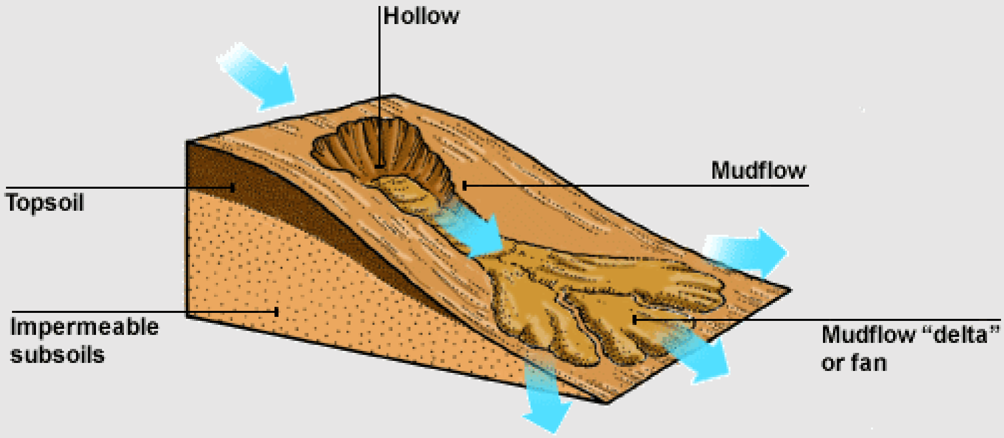


Mudflow

These are **continuous process** which are **less jerky** and more likely to **contort (twist or bend form the normal shape) the mass into a new form.**

Fine grained materials (like deeply weathered clays < 0.0039mm) become saturated in water, loose their cohesion and flow downhill as a very fluid mass. Flow occurs fastest at the surface and slow down with depth.

This occurs on **steep slopes (> 10^0 inclination**). It is a rapid but continuous motion which occurs after periods of **heavy rainfall.** When there is enough vegetation to bind the soil in place, saturated soil flows over **impermeable sub soil.**



Millimeters (mm)		Micrometers (µm)	Phi (ϕ)	Wentworth size class		Rock type
	4096		-12.0	Boulder	Gravel	Conglomerate/ Breccia
	256		-8.0	Cobble		
	64		-6.0	Pebble		
	4		-2.0	Granule		
	2.00		-1.0	Very coarse sand	Sand	Sandstone
	1.00		0.0	Coarse sand		
1/2	0.50	500	1.0	Medium sand		
1/4	0.25	250	2.0	Fine sand		
1/8	0.125	125	3.0	Very fine sand		
1/16	0.0625	63	4.0	Coarse silt	Silt	Siltstone
1/32	0.031	31	5.0	Medium silt		
1/64	0.0156	15.6	6.0	Fine silt		
1/128	0.0078	7.8	7.0	Very fine silt		
1/256	0.0039	3.9	8.0	Clay	Mud	Claystone
	0.00006	0.06	14.0			

To summarize …