Causes of landslides

Landslides are caused when the stability of a slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors, acting together or alone:

Natural causes:

- groundwater pressure acting to destabilize the slope
- Loss or absence of vertical vegetative structure, soil nutrients, and soil structure.
- erosion of the toe of a slope by rivers or ocean waves
- weakening of a slope through saturation by snowmelt, glaciers melting, or heavy rains
- earthquakes adding loads to barely-stable slopes
- earthquake-caused liquefaction destabilizing slopes (see Hope Slide)
- volcanic eruptions

Human causes:

- vibrations from machinery or traffic
- blasting
- earthwork which alters the shape of a slope, or which imposes new loads on an existing slope
- in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock
- Construction, agricultural, or forestry activities which change the amount of water which infiltrates into the soil.

Types of landslide

Debris flow

Slope material that becomes saturated with water may develop into a debris flow or mud flow. The resulting slurry of rock and mud may pick up trees, houses, and cars, thus blocking bridges and tributaries causing flooding along its path.

Debris flow is often mistaken for flash flood, but they are entirely different processes.

Muddy-debris flows in alpine areas cause severe damage to structures and infrastructure and often claim human lives. Muddy-debris flows can start as a result of slope-related factors, and shallow landslides can dam stream beds, provoking temporary water blockage. As the impoundments fail, a "domino effect" may be created, with a remarkable growth in the volume of the flowing mass, which takes up the debris in the stream channel. The solid-liquid mixture can reach densities of up to 2 tons/m³ and velocities of up to 14 m/s (Chiarle and Luino, 1998; Arattano, 2003). These processes normally cause the first severe road interruptions, due not only to deposits accumulated on the road (from several cubic meters to hundreds of cubic meters), but in some cases to the complete removal of bridges or roadways or railways crossing the stream channel. Damage usually derives from a common underestimation of mud- debris flows: in the alpine valleys, for example, bridges are frequently destroyed by the impact force of the flow because their span is usually calculated only for a water discharge. For a small basin in the Italian Alps (area = 1.76 km²) affected by a debris flow, Chiarle and Luino (1998) [*citation needed*] estimated a peak discharge of 750 m3/s for a section located in the middle stretch of the main channel. At the same cross section, the maximum foreseeable water discharge (by HEC-1), was 19 m³/s, a value about 40 times lower than that calculated for the debris flow that occurred.

Earth flow

Earthflows are downslope, viscous flows of saturated, fine-grained materials, which move at any speed from slow to fast. Typically, they can move at speeds from .17 to 20 km/h. Though these are a lot like mudflows, overall they are slower moving and are covered with solid material carried along by flow from within. They are different from fluid flows in that they are more rapid. Clay, fine sand and silt, and fine-grained, pyroclastic material are all susceptible to earth flows. The velocity of the earth flow is all dependent on how much water content is in the flow itself: if there is more water content in the flow, the higher the velocity will be.

These flows usually begin when the pore pressures in a fine-grained mass increase until enough of the weight of the material is supported by pore water to significantly decrease the internal shearing strength of the material. This thereby creates a bulging lobe which advances with a slow, rolling motion. As these lobes spread out, drainage of the mass increases and the margins dry out, thereby lowering the overall velocity of the flow. This process causes the flow to thicken. The bulbous variety of earthflows is not that spectacular, but they are much more common than their rapid counterparts. They develop sag at their heads and are usually derived from the slumping at the source.

Earthflows occur much more during periods of high precipitation, which saturates the ground and adds water to the slope content. Fissures develop during the movement of clay-like material creates the intrusion of water into the earthflows. Water then increases the pore-water pressure and reduces the shearing strength of the material.[2]

Shallow landslide

Landslide in which the sliding surface is located within the soil mantle or weathered bedrock (typically to a depth from few decimetres to some metres). They usually include debris slides, debris flow, and failures of road cut-slopes. Landslides occurring as single large blocks of rock moving slowly down slope are sometimes called block glides.

Shallow landslides can often happen in areas that have slopes with high permeable soils on top of low permeable bottom soils. The low permeable, bottom soils trap the water in the shallower, high permeable soils creating high water pressure in the top soils. As the top soils are filled with water and become heavy, slopes can become very unstable and slide over the low permeable bottom soils. Say there is a slope with silt and sand as its top soil and bedrock as its bottom soil. During an intense rainstorm, the bedrock will keep the rain trapped in the top soils of silt and sand. As the topsoil becomes saturated and heavy, it can start to slide over the bedrock and become a shallow landslide. R. H. Campbell did a study on shallow landslides on Santa Cruz Island California. He notes that if permeability decreases with depth, a perched water table may develop in soils at intense precipitation. When pore water pressures are sufficient to reduce effective normal stress to a critical level, failure occurs. [5]

Deep-seated landslide

Landslides in which the sliding surface is mostly deeply located below the maximum rooting depth of trees (typically to depths greater than ten meters). Deep-seated landslides usually involve deep regolith, weathered rock, and/or bedrock and include large slope failure associated with translational, rotational, or complex movement.

LANDSLIDE RISKS

A landslide is the movement of a mass of rock, debris or earth down slope. Whilst the causes of slope movement can be quite complex, all slides have two things in common, they are the result of failure of part of the soil and rock materials that make up the hill slope and they are driven by gravity. Landslides can vary in size from a single boulder in a rock fall to tens of millions of cubic metres of material in a debris avalanche. While not as well recognised as many other hazards such as cyclones, storm surge, floods and earthquakes, in Australia landslides cause more economic loss as well as injury and loss of life than is generally recognised.

Whilst the Thredbo, New South Wales, landslide which killed 18 people in July 1997, or the Gracetown, Western Australia, cliff collapse which caused nine fatalities in September 1996, made the world news, many smaller events kill one or two people at a time, and do not receive such extensive media coverage. In Australia, a total of 88 people are known to have been killed by 38 landslides since 1842. An additional 115 people are known to have been injured. It is almost certain that these statistics are incomplete and that the number of fatal events is much higher than presently reported. Globally landslides are one of the most common geohazards accounting for about 25% of the annual death toll from natural hazards (Hansen, 1984).

Data are too incomplete to give accurate costs incurred from landslides but are estimated to total about 500 million dollars since 1900. This may equate to hundreds of millions, or perhaps billions, of present-day dollars. Landslides have caused many instances of damage and disruption to buildings, roads, railways, and pipelines. An example is the Wollongong-Sydney-Brisbane railway, where costs associated with landslide damage are estimated to average $25 million per year during the period 1989-1996. The costs prior to 1989 are not available. More than 200 buildings throughout Australia have been damaged by landslide. Many of these were destroyed; the total cost is estimated to be of the order of $30 million in present-day dollars.

By developing and applying reliable and accurate methods for assessing landslide hazard and risk it is possible to enhance forward planning strategies leading to disaster mitigation, reduce economic losses and build safer communities and environments.