Landslides

Overview

- Landslides are mass-movements of rock, earth and debris down slope (Cruden, 1991), under the force of gravity, and can take several kinematic forms. The damage caused by a landslide is very much dependant on its speed, location and proximity to people and assets.
- BGS’ National Landslide Database is the most extensive source of information on landslides in Great Britain and is updated as and when landslides occur. BGS also has a 24-hour Landslide Response Team, which is deployed to survey and assess landslides.
- BGS produces digital geological maps showing areas susceptible to landslides as well as locations of previous mass movements.

Why do landslides occur?

If the force of gravity acting on a slope exceeds the strength of the material forming the slope, then the slope will fail and movement occurs. External factors, such as weather conditions, can result in the reduction or increase in the strength of the slope.

What are the consequences of it occurring?

This is largely dependent on the location and proximity to assets (e.g. settlements, infrastructure etc), landslide type, speed of event, magnitude and frequency of landslide movement(s). Rockfalls and flows tend to be more rapid than other types and as such may represent a greater geohazard in terms of the amount of energy released.

Costs are to local councils, the Highways Agency, Network Rail, insurance companies, businesses and individuals.

Types of landslide

There are five kinematically distinct types of landslide identified by Varnes (1978) and Dikau et al. (1996):

a) Falls: A fall starts with the detachment of soil or rock from a steep slope along a surface on which little or no shear displacement takes place. The material then descends largely by falling, bouncing or rolling.

b) Topples: A topple is similar to a fall except that it involves the forward rotation, out of the slope, of a mass of soil and/or rock about a point or axis below the centre of gravity of the displaced mass.

c) Slides: A slide is the downslope movement of a soil or rock mass on a distinct slide or shear surface, occurring dominantly on the surface of rupture or relatively thin zones of intense shear strain.
These can be rotational or translational depending on the geology, structure and hydrogeology. Rotational slides involve a semicircular shear surface. Translational slides usually occur on planar slip surfaces.

d) Flows: A flow is a spatially continuous movement in which shear surfaces are short lived, closely spaced and usually not preserved after the event. The distribution of velocities in the displacing mass resembles that in a viscous fluid.

e) Spreads: Lateral spreading is characterised by the low-angled slopes involved and the unusual form and rate of movement. A spread is an extension of a cohesive soil or rock mass combined with a general subsidence of the fractured mass of cohesive material into softer underlying material. The rupture surface is not a surface of intense shear. Spreads may result from liquefaction or flow (and extrusion) of the softer material.

Varnes (1978) also presented a sixth mode of movement: complex failures. These are failures in which one of the five types of movement described above is followed by another type (or several types). For such cases the name of the initial type of movement should be followed by the next type of movement: e.g. rockfall debris flow (WP/ WLI, 1990).

In reality, almost all landslides involve more than one type of movement either concurrently in different parts of the failure or evolving downslope over time into different failures.

Susceptible locations

The British Geological Survey (BGS) National Landslide Database holds information on over 15 000 landslide events in Great Britain. Inland areas susceptible to landsliding include the Pennines, North Yorkshire, the South Wales Coalfield and debris flows in mountainous areas such as the Highlands of Scotland. Many of these landslides are linked to the last glaciation and are now heavily degraded and stabilised; others are still active.

The south and east ‘soft rock’ coasts of England have geology that is sufficiently weak to be affected by coastal erosion. Some very large, deep-seated, active landslides are located in this area (e.g. Folkestone Warren in Kent, and Black Ven in Dorset). Other types of landslides include flows (e.g. those seen in the London Clay at Herne Bay, Kent) and falls and topples (e.g. Beachy Head, Sussex, and Portland Bill, Dorset).

BGS produces the GeoSure national dataset, which provides information about potential ground movement, including landslides, in the form of 1:50 000 scale digital maps (http://www.bgs.ac.uk/products/geosure/).

Scientific detail

Monitoring and measurement

The BGS National Landslide Database is the most extensive source of information on landslides in Great Britain. Selected information from the database is available as a free online resource as part of BGS’ online GIS — the GeoIndex. The database currently holds over 15 000 records which are continually being updated. New records are added as landslide information is made available. These data come from a variety of sources including published BGS geological maps and active surveys. Other sources include commissioned and research studies, information from the public and a number of regional databases inherited or compiled by BGS since the 1970s.
including the Department of the Environment (DoE) National Landslide Database constructed in the 1990s. Each landslide is documented as fully as possible with information on location, name, size and dimensions, landslide type, trigger, damage caused, movement date, age and with a full bibliographic reference. The database is linked to a GIS which displays the landslides as point data. The way in which landslides have been mapped by BGS over the centuries has evolved and improved considerably. Many of the maps display the landslide deposit and no other information; many early maps do not make reference to ‘landslips’ at all. With modern landslide mapping techniques, landslides are now being mapped and documented in areas previously unknown e.g. the North York Moors.

Terrestrial Light Detection and Ranging (LiDAR) is a technique used by a land-based laser scanner which, combined with a highly accurate differential GPS, enables BGS to produce 3D computer models of landslides. Using several scans made at different times, we can accurately calculate volume change and can ascertain far more information about how the cliff or landslide is changing than is possible from traditional levelling or photographic techniques.

A landslide observatory has been established by BGS at Hollin Hill, North Yorkshire, which incorporates several technologies including terrestrial and aerial LiDAR and geophysics. The observatory has a weather station, instrumented boreholes, movement gauges and geophysical data is sent back to the office telemetrically.

How is the hazard characterised?

BGS does not record ‘severity’ of landslides in the same way that earthquakes are characterised by magnitude. The ‘severity’ of a landslide would depend on its size, speed and location in terms of economic impact such as damage to human life or assets. These are all recorded in the BGS National Landslide Database, but landslides are not ranked according to their severity, although some statistics involving impact could be determined from the database.

Landslides can cause secondary hazards such as, for example, fire if utilities such as gas were disrupted. Landslides can be a secondary hazard of flooding or earthquakes.

Triggering mechanisms

Landslides can be triggered by:
- rainfall
- snowmelt
- poor drainage of the slope
- oversteeping of the slope
- removal of material at the toe of the slope (e.g. coastal erosion or man-made cutting)
- addition of water on the slope (e.g. man-made ponds)
- loading of the slope (additional weight to the upper slope)
- structural or lithological weaknesses

Scenarios for future events

Predictions of increased rainfall, storminess and sea-level rise in association with climate change, are likely to result in the reactivation of currently stabilised or dormant landslides and an increase in first-time landslides such as debris flows. Slope

Monitoring and response by BGS

When a significant landslide is reported, the BGS Landslide Response Team (a core team of engineering geologists, geologists and geomorphologists who specialise in landslides) is sent to assess it. They collect data for the National Landslide Database to underpin scientific research, and provide local advice. They will speak to the media and publish a web page as soon as possible describing the event. BGS has various landslide data including the National Landslide Database, 1:10 000 and 1:50 000 scale digital geological maps of mass movements (DiGMap50 and DiGMap10) and a national digital dataset of areas susceptible to landsliding (GeoSure).
UK Geohazard Note
May 2012

UK Examples

Holbeck Hall landslide, Scarborough, North Yorkshire, England

The Holbeck Hall Hotel was destroyed as a result of a landslide that took place over a period between the 3rd and 5th of June 1993. Following an unusually wet period in May, a pre-existing (relict) landslide reactivated and began to move downslope, the bulk of the movement taking place overnight. The foundation of the hotel was partially undermined and most of the structure of the hotel subsequently collapsed. The remains of the hotel were later demolished. The movement of the slide and collapse of the hotel was sufficiently slow to allow residents to be evacuated and electricity and gas supplies to be switched off before they caused fire.

St Dogmaels landslide, Pembrokeshire, Wales

On 14th February 1994, landsliding was reported on slopes above the village of St Dogmaels. This landslide followed a period of heavy rainfall. Although the landslide appeared to be slow-moving and did not immediately threaten the village, provisions were made to implement the local emergency plan, which involved evacuating the village. This preparation was led by the police with the support of other emergency services and the military. On advice from engineering geologists, it was decided not to implement the emergency plan, although people from houses located on the landslide were evacuated. Several houses were severely affected and damage was caused to an 11 kV power line and to water mains supplies. In the event, the landslide did not affect the main village.

Nefyn landslide, Lleyn Peninsula, North Wales

On 2nd January 2001, a fatal landslide occurred in the coastal village of Nefyn. A series of small slides swept two cars over the cliff and onto the beach below. Tragically one of the occupants was killed and another seriously injured in the incident. Nefyn Bay is between Penrhyn Nefyn and Penrhyn Bodeilas and has been subject to minor landsliding activity for many years. The landslides of January 2001 occurred after a period of heavy rainfall along a stretch of coast that comprises weak superficial deposits. The amount of water and the weak nature of the deposits contributed to the instability.
movements may be seen across the country and the effects of these may have an economic impact.

Some communities are built on old, large, slow moving landslides, such as Ventnor on the Isle of Wight or parts of Lyme Regis in Dorset. A worst case scenario event would be for a landslide such as these to undergo rapid movement. This would most likely cause a large economic loss locally and potentially loss of life.

References