

Natural Landslides Hazard on the Strategic Road Network of England

This guidance note is intended for non-specialists of ground-related hazards and describes the potential for Natural Landslides to impact the safety and performance of the Strategic Road Network (SRN). Together with the Natural Landslides Hazard Rating map and corresponding hazard assessment note on Highways England's Geotechnical Data Management System / Geographical Information System ([HAGDMS](#) / HAGIS), the three products support effective management of the Natural Landslides risk to the network.

This guidance note does not replace the need for local and site-specific assessment by Highways England's geotechnical specialists.

How to use this guidance note:

Part I: provides an overview of Highways England's risk management of Natural Landslides hazards

Part II: outlines steps in the risk management framework to enhance the network resilience to Natural Landslides

Part III: provides further background information specific to Natural Landslides, its relevance to the SRN, and key sources of reference

A detailed commentary on the history and distribution, geography and hazards presented by landslides in the UK can be found in 'The National Landslide Database of Great Britain: acquisition, communication and the role of social media - (Pennington et al. 2015)' published in British Geotechnical Survey's NORA library.

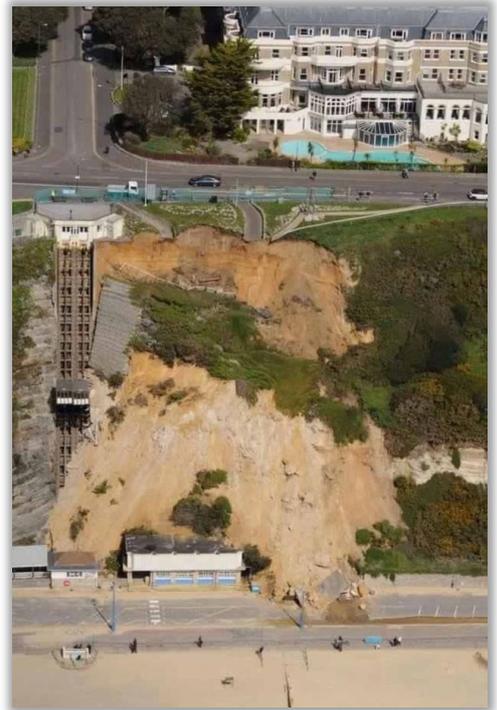
Part I Highways England's approach to managing Natural Landslides risks

A landslide is a mass movement of rock and/or soil on a slope due to the force of gravity. Natural slopes above or below the level of the carriageway are distinct from engineered slopes failures as they have not been structurally designed or constructed. Landslides involving natural slopes are usually much larger than engineered slope failures and generally do not originate on the SRN. The background of Natural Landslides and their impact on the SRN is summarised in Part III.

This guidance note addresses specifically natural soil slopes – natural rock slopes present a very minor risk to the SNR in England. For hazard associated with Engineered Soil Slopes and Engineered Rock Slopes see the corresponding hazard guidance notes.

The risk presented by Natural Landslides is not new to Highways England. Any new assessment of the risk should make due consideration of the following factors:

- At the time of construction of the SRN or at the time of undertaking improvement schemes, Natural Landslides and related risks should have been investigated and mitigated appropriate to the standards or advice that applied at the time. Where available, relevant records are held in HE's geotechnical database held on HAGDMS.
- The Geotechnical Risk Management procedures were introduced in the 1990s. Specifically, [HD22 Managing Geotechnical Risk](#) was first published within the [Design Manual for Roads and Bridges](#) (DMRB) in 1992. It is therefore reasonable to assume that for schemes post 1992 there is an improvement in the reliability of information captured and retained, along with increased standardisation in investigation, design, and mitigation methodologies across schemes.



Natural Landslide, Bournemouth, 2016.
Source: BBC (Tracey Jones)

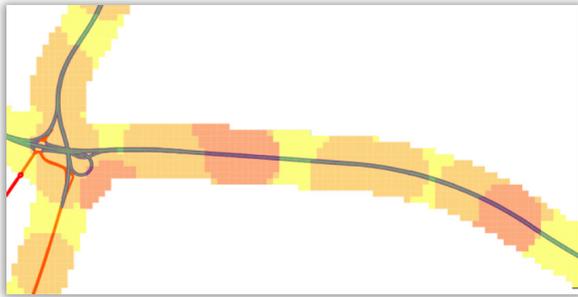
1.0 Current ground risk management requirements:

[HD22/08](#) (DMRB Volume 4) presents a framework for geotechnical risk management and is a mandated requirement on all highway schemes where a ground investigation or geotechnical design is required. It establishes the principles of early risk identification and continuity of the geotechnical risk register through the project life cycle from concept to handover.

[HD41/15](#) (*Maintenance of Highway Geotechnical Assets*) provides guidance on the identification and management of 'At Risk Areas' including those of potential Natural Landslides related risk. Consideration of the hazard posed by Natural Landslides to the existing SRN should form a part of the GeoAMP (Geotechnical Asset Management Plan) process. The GeoAMP is prepared by the Operations service provider, reviewed on an annual basis (at a timeframe agreed with Highways England), and is submitted for agreement by HE.

For guidance on the application of current requirements please refer to the Advice contacts below.

2.0 The Highways England Natural Landslides Hazard Rating Map



Section of the Natural Landslides Hazard Rating map

An HE specific Natural Landslides Hazard Rating map for a 1km corridor centred on the Strategic Road Network has been prepared. This can be accessed on HAGDMS / HAGIS. Version 1 of the hazard map is a synthesis of information relating to Natural Landslides obtained over several years from British Geological Survey (BGS). The derivation of this map is explained in detail in a hazard assessment note available on the HA GDMS download page: [HAGDMS Natural Landslides Hazard Rating data description \(April 2017\)](#).

The map is intended as a high level hazard awareness map only. **It does not replace the need to seek expert advice** from within Highways England and undertake site-specific studies. As noted above, consideration of Natural Landslides is an inherent part of risk management within Highways England's geotechnical standards.

3.0 Further advice

To obtain further advice on the hazard Natural Landslides poses to the Strategic Road Network, or for any other issues associated with ground-related hazards, please contact one of the Geotechnical Advisors available within [Highways England's Geotechnics and Pavement Group](#).

Role of Highways England's Geotechnical Advisors:

- Technical oversight of schemes, to ensure the technical input is appropriate, complies with HE standards and delivers good value.
- Cascading local knowledge and good or bad experiences from other projects
- Evaluating and supporting innovation opportunities to promote efficient delivery.
- Providing asset data and information management services.
- Managing knowledge improvement for the geotechnical discipline, including Standards and Advice Notes and supporting Integrated Asset Management in Highways England.

Part II Using the Natural Landslides Hazard Rating map to enhance resilience of the SRN



Resilience of the Strategic Road Network comes from both adequate design and maintenance, mitigation of hazards, and having appropriate response and recovery measures in place should the hazard occur. Selection of appropriate mitigation (proactive, pre-event) measures versus response and recovery (reactive, post-event) cannot be prescriptive, but the guidance below can be used to support risk-based decision making.

1. Define the hazard event

A hazard 'event' can be defined as *'the event that could occur due to the presence of the hazard'*. The following are different hazard events related to the presence of natural slopes along or beneath the SRN, and these present different risks to the network:

- Incursion of material onto carriageway – potential obstruction and damage
- Subsidence of part or all of a carriageway, structure or other asset where a natural slope supports the SRN – could be sudden or progressive
- Impact damage to structures and other above-surface SRN assets due to a moving soil mass / debris
- Instability and damage to sub-surface SRN assets including foundations and buried utilities (e.g. drainage, power, communications)

2. Consider potential external triggers of the hazard event

There may be little or no warning of a Natural Landslides-related event, but if specific triggers have been identified, these can be monitored to improve the management of the risk. The following are the main potential external triggers of a Natural Landslides hazard event:

(A) Natural triggers

- Heavy or sustained rainfall/snowfall – may be during or following the storm event
- Groundwater regime change (refer also to the Groundwater Flooding hazard guidance note)
- A surface flooding event – may also have an man-made underlying cause
- Cyclic natural degradation (e.g. tidal erosion, freeze-thaw cycles, shrink-swell cycles)
- Erosion (surface or groundwater flow)
- Animal burrowing
- Earthquakes

Note that the above water related features (surface or groundwater, flooding etc.) may be exacerbated by climate change.

(B) Human activity-related triggers

- Leakage from nearby water mains, sewerage or drainage
- Change in surcharging or loading
- Removal of vegetation – may be contributing to slope stability
- Degradation / loss in performance of any stabilisation measures such as soil nails or anchors (also see the Aggressive / Corrosive Soil and Groundwater hazard guidance note)
- Water seepage from service duct backfill which may act as a water reservoir
- Human activity nearby e.g. excavation at toe of slope – also includes third party activities outside the boundary fence, e.g. changes in ploughing patterns

Highways England Geotechnical Advisors can provide further information of potential triggering actions.



Hazard

Triggers

Likelihood

SRN Impact

Risk

Response measures

3. Assess the likelihood of the hazard event occurring

The *hazard rating* given on the Natural Landslides Hazard Rating map is not an absolute indicator of the likelihood of a hazard event occurring, but a relative indicator of the potential presence of Natural Landslides, compared to the rest of the network. The Natural Landslides hazard rating is not directly comparable to hazard ratings derived for other hazard types.

To undertake a qualitative assessment of the likelihood of a natural landslide hazard event, the following factors are relevant:

(A) The likely occurrence of Natural Landslides

- Refer to the Natural Landslides Hazard Rating map
- Within the Highways England boundary: evidence of movement – e.g. condition of assets (pavement, geotechnical, drainage, and structures), known landslide sites as identified in GeoAMPs, monitoring or any other evidence recorded in the Geotechnical Asset Database (GAD)
- Outside the Highways England boundary: poor slope condition / low inherent stability – as indicated by factors that would be considered within geotechnical principal inspections (HD 41/15), 3rd party monitoring and reporting, remote survey data, etc.

(B) Presence of any mitigating / exacerbating features

- Presence, condition and effectiveness of slope improvement / stabilisation measures – as installed during construction / maintenance of the SRN, or by third parties
- Size (height / volume) of slope and distance of slope from the SRN – to indicate the context and proximity of the SRN relative to a potential landslide, and the likelihood that a slope failure would interact with the road network

(C) Indicators that a triggering action (as listed in Step 2: Triggers) is likely to occur

These may be considered by the type of triggering mechanism:

- Water-related inundation / saturation / destabilisation:
 - A history of flooding (also refer to the Groundwater Flooding hazard guidance note)
 - Observed / forecast heavy or prolonged rainfall – the impact of our changing climate on soil slopes is an important consideration. Evidence of past instability alone may no longer be sufficient.
 - Blocked / insufficient / absent drainage, also
 - Water/wastewater pipes in poor condition, e.g. aged or damaged through construction-induced ground movements and may leak
 - Presence of service ducts or poorly compacted backfill – granular backfills may act as a localised source reservoir (if exposed at the surface / have connectivity with other water sources)

- Loading of slope and undermining slope integrity:
 - Construction, new structures, or temporary plant may indicate loading beyond a stable limit (primarily an issue with improvement schemes) – within or outside the Highways England boundary
 - Traffic loading (volume) increases

It should be noted that Natural Landslides generally originate from slopes outside the SRN boundary and there is limited control over the management of stability triggers

An understanding of the likelihood of a Natural Landslide occurring may also be assessed from historical records and frequency of similar problems on the strategic road network and the surrounding area. Where HAGDMS contains report records* demonstrating that this hazard was assessed in accordance with current risk management procedures and standards it is reasonable to assume a lower likelihood of a hazard event.



Hazard

Triggers

Likelihood

SRN impact

Risk

Response measures

4. Consider the potential impact on the safety and/or performance of the SRN

A quantitative assessment of impact on a national scale is not possible, but at a local level, the following factors should be considered to understand the potential impact:

(A) Factors specific to the hazard event:

- The rate of failure and the amount of warning available – a rapid, catastrophic failure presents the highest safety consequence.
- The size of the potential failure – impact to the network (damage / obstruction) is linked to the volume of debris deposited from a slope above the carriageway, or area of SRN undermined by a slope failure below the carriageway. Natural landslides, although rare, can potentially be very large.
- The location of the potential failure – a natural landslide impacting a main running lane presents both higher safety impact and higher performance impact than one that affects only a hard shoulder / remote from the carriageway.
- Consideration of potential diversion of the route, investigation and remedial works – the longer these could take, the longer the performance impact.

(B) Factors specific to the location of the hazard event on the network:

- The speed and volume of traffic using the road – where higher it typically correlates to an increased safety impact.
- The type of pavement – a sudden/catastrophic failure is more likely where there is loss of support beneath by a rigid pavement whereas a flexible pavement show early signs of a failure.
- The type of road – smart motorways being the most important in terms of performance, down to All Purpose Trunk Roads (APTR) being the least.
- Presence of technology – smart motorways could be assumed better able to respond to an event in terms of traffic management.

* The Topic Search tool within HAGDMS facilitates a search across several of the system's databases for information related to a particular topic, for a chosen location. Topics are pre-defined by the System Administrator and currently cover a number of ground-related hazards and therefore the databases searched are focused on geotechnics rather than drainage.



5. What is the risk (considering likelihood and impact) that Natural Landslides presents to the SRN?

This can be qualitatively assessed, and should inform subsequent decision making. Uncertainty should be recognised and decisions should typically be cautious, particularly where there are high levels of uncertainty (or lack of data).



6. Select appropriate measures to mitigate risk and enhance resilience

Measures taken to mitigate risk and enhance resilience may be either proactive or reactive. Typically, the greater the safety or performance risk to the SRN in terms of both likelihood and impact of an event, the greater the benefits of undertaking proactive mitigation. When selecting appropriate measures, there should be early engagement with Geotechnical Specialists from Highways England, service providers and land owners (where the slope is outside the SRN boundary).

High level risk management measures are likely to be specific to both the hazard event and whether it is a construction and/or on-going operations risk, but all measures would fall into one of the following categories:

- **Investigation:** To understand the current condition and therefore likelihood of the hazard event. Investigation may reduce the uncertainty and hence reduce the need for additional mitigation measures.
- **Intervention:** Where there is an evident cost-benefit in implementing measures (barriers) to prevent the hazard event from occurring, or mitigating measures to limit the impact should it occur.
- **Monitoring:** To allow appropriate operational responses to be implemented in anticipation of a potential hazard event.
- **Response and recovery:** To respond rapidly to a potentially unexpected hazard event, development of response plans is recommended for areas of known Natural Landslides risk. Response plans should include:
 - i. Engagement with Highways England technical specialists – named focal points (and responsibilities) should be clearly identified.
 - ii. Identification of third party land owners where the slope is located outside the SRN boundary, or that will be potentially impacted should an HE-owned slope fail. Also procedures for gaining access where required to third party land.
 - iii. Being prepared to close lanes and/or implement diversions, and have an understanding of the potential duration of these measures until the SRN may be fully operational – this includes a broad range of communications, such as Highways England’s suppliers, road users and the general public. These should be linked to Incident Response Plans (IRPs).
 - iv. Likely response options should be identified – based on the particular hazard events and anticipated consequences. The time and resources that would be required to implement the options should also be considered.
 - v. Incident recording – following initial recovery, a full record of the mitigation works (as part of Health and Safety file recording), the cause of the event assessed, the risk of similar events occurring elsewhere on the network evaluated, and appropriate actions taken to manage the incident should be recorded. All geotechnical events must be recorded on HAGDMS.

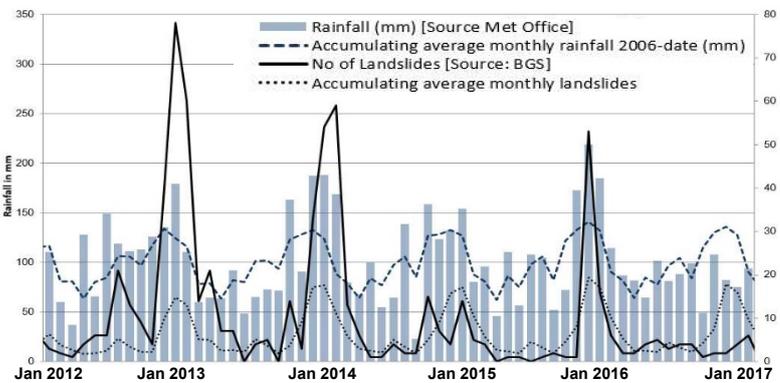
Part III An overview of Natural Landslides in England

1.0 Background of natural soil slopes and failures

Natural soil slopes above and/or below the level of the carriageway are present on sections of the SRN throughout England. Unlike engineered slopes that have been made by excavating through the natural topography (cuttings) or constructed by mounding fill material (embankments), natural slopes were formed through geological processes without specific engineering design. Landslides that involve natural soil slopes are usually longer or deeper compared to engineered slope failures, and so tend to mobilise greater masses of soil. More often they occur progressively, although sudden failures can also occur.



Natural slope landslide at Flint Hill Farm, Surrey, 1997. Source: HAGDMS



Landslides in the BGS UK database (includes failures of natural slopes and railway cuttings). Source: BGS

Landslides and especially large scale destructive landslides are not a common phenomenon in Great Britain. However, in recent years (e.g. the winters of 2012-13, 2013-14 and 2015-16 and the summer of 2012) there was a marked increase in the number of landslide events which corresponded to extensive periods of prolonged rainfall (see figure left). With the expected increase in extreme rainfall events due to climate change, England is likely to see more frequent Natural Landslides.

A summary of the common mechanisms of landslides is shown in the table below (as classified by the BGS). These have been generated based on the form of the movement of the recorded failures as well as taking into account the materials involved.

Movement type	Material		
	ROCK	DEBRIS	EARTH
FALLS	<p>Rock fall</p>	<p>Debris fall</p>	<p>Earth fall</p>
TOPPLES	<p>Rock topple</p>	<p>Debris topple</p>	<p>Earth topple</p>
SLIDES	<p>Single rotational slide (slump)</p>	<p>Multiple rotational slide</p>	<p>Successive rotational slides</p>
	<p>Rock slide</p>	<p>Debris slide</p>	<p>Earth slide</p>

Movement type	Material		
	ROCK	DEBRIS	EARTH
SPREADS	<p>Normal sub-horizontal structure, Gully, Camber slope, Dip and fault structure, Valley bulge structure (glanced off by erosion), Thinning of beds, Plane of discollement, Competent substratum</p>	<p>e.g. cambering and valley bulging</p>	<p>Earth spread</p>
FLOWS	<p>Solifluction flows (Periglacial debris flows)</p>	<p>Debris flow</p>	<p>Earth flow (mud flow)</p>
COMPLEX	<p>e.g. Slump-earthflow with rockfall debris</p>	<p>e.g. composite, non-circular part rotational/part translational slide grading to earthflow at toe</p>	

BGS adapted classification of natural landslides based on the material and movement type of the failure. (Source: BGS)

2.0 Natural Landslides and the Strategic Road Network

The hazard posed can be considered to arise from the potential for a landslide to occur which collapses onto or undermines and destabilised the Highways England estate. The landslide related hazards could be present due to:

- unidentified, and hence unmanaged susceptible slopes in close proximity to or below the network
- change to groundwater regimes (natural / artificial)
- undermining the slope through excavation
- inadequate stabilisation methods (compared to current practice/guidance), which may correlate to the approximate date of treatment and the assessed conditions then
- the stabilisation measures employed have deteriorated subsequently due to changes unforeseen at the time of works (e.g. chemical, groundwater or surface flooding) or have reached the end of their serviceable life

The type of hazard that the presence of slopes that are susceptible to landslides presents to the SRN is further significantly influenced by the angle, size and nature of the slope and its proximity to the network.

Natural slopes typically extend or exist beyond the SRN boundary, and usually outside of the responsibility and control of Highways England. Consequently the effectiveness and degree to which they are maintained is considerably variable. This presents a challenge to HE's management of Natural Landslide risk.

3.0 Key references and further information

Natural Landslides Hazard Rating map, 2017, HAGDMS / HAGIS.

HAGDMS Natural Landslides Hazard Rating data description, 2017.

Pennington, C.V.L., Freeborough, K.A., Dashwood, C., Dijkstra, T.A., Lawrie, K., 2015. The National Landslide Database of Great Britain: Acquisition, communication and the role of social media. *Geomorphology* 249, 44–51.

Acknowledgement and contact details

This work has been informed by two tasks currently being undertaken as part of HE's Innovation Programme: Task 1-085 *Resilience enhancement measures for geotechnical assets* and Task 1-062 *Geotechnical Hazard Knowledge*.

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