Monitoring Landslides and Subsidence:

Railway Environment

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Agenda

- Background to Railway Environment
- Failure Statistics and Problem Areas
- Existing Monitoring Asset Techniques
- Working with other Stakeholders and Partnerships
- European Space Agency (ESA) Feasibility Study
- Review and Conclusions
Background to Railway Environment

- Major Asset Owner
- Nature of asset
- Ageing asset
- Performance of assets influenced by external factors
- Increase in traffic volumes
- Climate change
- Limited budgets
Incidents: Earthworks Failure: Type and Year

Earthworks Failure - Analysis by Type and Year

<table>
<thead>
<tr>
<th>Earthwork Failure Type</th>
<th>Number of Failures</th>
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<tbody>
<tr>
<td>Cutting slip</td>
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<tr>
<td>Cutting washout</td>
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<tr>
<td>Embankment washout/ earthflow</td>
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<td>Embankment slip</td>
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<td>Embankment scour</td>
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<td>Desiccation</td>
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<td>Rock fall</td>
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<td>Pipe collapse</td>
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<td>Drain collapse</td>
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<td>Movement</td>
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<tr>
<td>Embankment washout</td>
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<tr>
<td>Other</td>
<td></td>
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</tbody>
</table>

Legend:
- 2004/05
- 2005/06
- 2006/07
- 2007/08
- 2008/09
- 2009/10
- 2010/11
- 2011/12
Mining Related Railway Incidents

![Graph showing mining related railway incidents over time. The graph displays the number of incidents per 5-year period, with a trend line indicating an increasing trend.]
Subsidence from Shallow Mineworkings

Typical failures include:
- Void migration leading to surface collapse
- Shaft collapses
- Adit collapses
Sidelong Ground: Ben Cruachan on the West Highland Line at Loch Awe
Landslip: Rock / Soil Interface
Pinmore Slip Stranraer Line: 20/11/11
River Erosion: Bridge of Allan
Mud / Scree Slide: Achnasheen
Monitoring Assets and Techniques

- Examinations
- Inspections
- Earthwork assets actively monitored with equipment
- Techniques include inclinometers, extensometers etc
- Other techniques under development
- Extreme weather procedure, vulnerable assets list
- Challenge is to expand monitoring all visible earthwork assets
Glen Douglas Monitoring

The problem site is located in the area of Glen Douglas south of Arrochar and Torbet on the West Highland Railway line (WHL) and lies within a highly complex geological structure known as the Tay Nappe. The railway is approximately 120m above sea level (Loch Long) on sidelong ground with an upper slope height of around 100m and a lower embankment height of 120m at an average angle of 32 degrees—see section below.

Above railway level the major postglacial landslide zone known as Munro's Goula is well defined by scarp features and is approximately triangular in plan although the margins of the slip are indistinct below railway level and difficult to determine with confidence. It is believed the slip zone is extensive and extends up to a maximum elevation of approximately 180m above sea level—see section below for details. Scree and till materials cover the upper part of the area between the railway and road. The rock “pinnacles”—see adjacent photographs are isolated blocks which are migrating downslope within the slip zone and are not main rock. The lower sections of the hillside comprise glacial till and boulder materials. A stream emerges approximately 30m below R.L. Its origins have not been found. A pressurised water main is located above the main slip area.

The railway has been experiencing misalignment and settlement problems over the last 60 years on the 200m long section of track at Ballater 360yards (centre around pinnacle of rock—see photographs). The Mainline has to park / tamp and site this stretch of line on average every 3 to 4 weeks. Previously this was every 2 to 3 months. A monitoring regime has been in place for some years and has been relatively successful in keeping trains on the track however past investigations have confirmed that we are now entering a critical era of uncertainty with regards to the stability of the rock and slip zone above and below the railway and a new regime of monitoring and works will be required for the future safety of the line.
Glen Douglas: Monitoring Rock Outcrop
Glen Douglas Monitoring
Working with other Stakeholders and Partners

• Working with key stakeholders –
  – Flood management groups
  – Local liaison with Farmers
  – Working in partnerships - BT and Transport Scotland

• Challenge to improve communications
ESA Study: Predicting, Monitoring, and Alerting of Landslides and Subsidence Affecting Transport Infrastructure

- High profile incidents on both railway and roads
- Incident trends in Scotland static
- Network Rail recognise more reactive than pro active
- Network Rail and Transport Scotland recognise limitations of conventional monitoring
- NR working in partnership with Transport Scotland on the above feasibility study
- Sites for development are Glen Douglas, Falkirk High and the “Rest and Be Thankful” north of Arrochar
ESA Study Objectives: Predicting, Monitoring, and Alerting of Landslides and Subsidence Affecting Transport Infrastructure

- Workshop held with Industry partners and contractors.

- Objectives
  - Better understanding of soil moisture
  - Better understanding of ground stability
  - Interface and improve existing terrestrial monitoring systems
  - Develop an integrated information system
  - Provide alert system real time
Review and Conclusions

• Background to the Railway and its earthwork assets

• Incident failure trends static

• Working in a challenging environment

• Railway industry response more reactive than proactive

• Existing monitoring regime

• Working in partnership with Transport Scotland and others

• Step change can be achieved with the help of the Satellite industry.