Managing our Railway Geotechnical Assets

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Geotechnics in the Rail Industry: National Railway Museum 11/05/15
Asset Management in Network Rail

Network Rail’s Delivery Plan for Control Period 5
31 March 2014

The Asset Management Excellence Model™ (AMEM)

Risk and Review
Organisation and People Enablers
Asset Knowledge Enablers
Lifecycle Delivery Activities
Asset Management Strategy and Planning
Asset Management Decision-Making

Sustainability, Reliability, Capability
A brief history of time in Railway Geotechnics
Examinations and Asset Inventory
Asset Definitions and Asset Count

Table 1-1 Earthworks data (as at 02/05/2014)

<table>
<thead>
<tr>
<th>Asset Type</th>
<th>Earthwork assets</th>
<th>Earthwork inspection 5 chains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankments</td>
<td>99,329</td>
<td>332,774</td>
</tr>
<tr>
<td>Soil Cuttings</td>
<td>70,149</td>
<td></td>
</tr>
<tr>
<td>Rock Cuttings</td>
<td>15,073</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>184,551</td>
<td></td>
</tr>
</tbody>
</table>

Whole earthwork

1 inspection 5ch containing 1 embankment asset

1 inspection 5ch containing 1 embankment asset & 1 soil cutting asset

Soil cutting

Mixed cutting containing 1 soil cutting asset & 1 rock cutting asset

Rock cutting

5 chains (~100m)
Prioritisation; SSHI / RSHI & EPM

<table>
<thead>
<tr>
<th>Condition Rating</th>
<th>SSHI or RSHI</th>
<th>Planned Examination Interval (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Poor* (TP)</td>
<td>SSHI &gt; 14.5, or RSHI &gt; 200</td>
<td>1 as for Poor</td>
</tr>
<tr>
<td>Poor (P)</td>
<td>SSHI ≥ 10, or RSHI ≥ 100</td>
<td>1</td>
</tr>
<tr>
<td>Marginal (M)</td>
<td>SSHI 10 – 6, or RSHI 100 – 10</td>
<td>5</td>
</tr>
<tr>
<td>Serviceable (S)</td>
<td>SSHI ≤ 6, or RSHI ≤ 10</td>
<td>10</td>
</tr>
</tbody>
</table>
Continuous improvement, policy application and work-bank development

<table>
<thead>
<tr>
<th>Earthworks Asset</th>
<th>Criticality Band</th>
<th>Criticality Band</th>
<th>Earthworks Hazard Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Examine</td>
<td>Maintain</td>
<td>Renew</td>
</tr>
<tr>
<td>4</td>
<td>Examine</td>
<td>Maintain</td>
<td>Renew</td>
</tr>
<tr>
<td>3</td>
<td>Examine</td>
<td>Maintain</td>
<td>Refurbish, Renew</td>
</tr>
<tr>
<td>2</td>
<td>Examine</td>
<td>Maintain</td>
<td>Refurbish, Renew</td>
</tr>
<tr>
<td>1</td>
<td>Examine</td>
<td>Maintain</td>
<td>Refurbish, Renew</td>
</tr>
</tbody>
</table>

Earthworks safety risk
## Intervention Activity (Renewal)

<table>
<thead>
<tr>
<th>NEW BUILD</th>
<th>RENEWAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTRUCTION OF ASSET TO EC7 AND NR STANDARDS</td>
<td>PLANNED INTERVENTION</td>
</tr>
<tr>
<td></td>
<td>- STRENGTHENING</td>
</tr>
<tr>
<td></td>
<td>*most common</td>
</tr>
<tr>
<td></td>
<td>- RECONSTRUCTION</td>
</tr>
<tr>
<td></td>
<td>- OPTIMISED PLANNING AND INVESTMENT</td>
</tr>
<tr>
<td></td>
<td>- INCLUDING BRINGING ASSETS BACK INTO USE</td>
</tr>
<tr>
<td></td>
<td>- OPTIMISED PLANNING AND INVESTMENT</td>
</tr>
<tr>
<td></td>
<td>- ACCESS PERMITTING</td>
</tr>
<tr>
<td></td>
<td>- NOT A TYPICAL SOLUTION</td>
</tr>
<tr>
<td></td>
<td>- LOWER / HIGHER COST??</td>
</tr>
<tr>
<td></td>
<td>- BALANCE BETWEEN COST, PROGRAMME, SAFETY AND ASSET DETERIORATION</td>
</tr>
<tr>
<td></td>
<td>- HIGHEST COST</td>
</tr>
<tr>
<td></td>
<td>- HIGHEST DISRUPTION</td>
</tr>
<tr>
<td></td>
<td>- QUICKEST SOLUTION</td>
</tr>
<tr>
<td></td>
<td>OFTEN DEPLOYED</td>
</tr>
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</table>
Accelerated Intervention
Wettest Year and Wettest Winter on Record

[Diagram showing rainfall data with notable spikes for specific years and events.]
Derailments attributed to Geotechnical Failures
Wettest Winter on Record

![Graph showing number of earthwork failures and mean annual rainfall over years.]

- **Stonegate Embankment (Kent)**
- **Teignmouth Sea Cliffs (Western)**
- **Hooley Cutting (Sussex)**

*A better railway for a better Britain*
Wettest Winter on Record

Ockley Embankment (Sussex)  High Brooms Cutting (Kent)  Botley Embankment (Wessex)

Liphook Embankment (Wessex)  Wadhurst Cutting (Kent)  Brantham Cutting (Anglia)
6.4 It is essential to ensure that similar weather events next winter would be managed to cause much less disruption to passengers, and that the physical resilience of the network is progressively strengthened in future years.

6.11 the only rail line in Britain that has not suffered any material weather related disruption over the last few years, and certainly last winter, was HS1 which has been built and maintained to modern standards throughout.

6.12 It is also the case that the railway network suffered from severe investment restrictions and tight financial constraints for a number of decades under British Rail, and subsequently under Railtrack. A number of areas of asset management suffered as a result, particularly earthworks, drainage and vegetation management, with priority given to trains and track. Much of this relative neglect is in the process of being rectified by Network Rail through its work programmes for the last regulatory Control Period, 2009-2014 (CP4) and the current regulatory Control Period just started (CP5), but the experiences of last winter indicate that there are several areas that need sharper focus. This is underpinned by an increasingly robust asset management approach.

Recommendation 40: Network Rail should maintain a strong focus on trialling newly available condition monitoring and slope stabilisation technologies, working with academic and other researchers and with other railway administrations, to improve its ability to identify and anticipate slopes that will fail and target remedial work as efficiently as possible. In addition Network Rail should continue to commission academic research into possible slope stabilisation techniques short of physically rebuilding.

6.20 This must include repair and subsequent maintenance of crest drains above cutting slopes, which have often been neglected or fallen into disrepair,
Sustainability, Reliability, Capability
Digital Surface Model

All classes
Ground
Digital Terrain Model

All classes
Ground
Cross Section
Digital Surface Model and Digital Terrain Model
DSM example: Colchester Embankment (LTN1)
The Future Vision...
Earthwork Examinations: Improved understanding of likelihood of failure

Chris Power: Principal Engineering Geologist – Mott MacDonald

Geotechnics in the Rail Industry: National Railway Museum 11/05/15
CP5 earthworks risk matrix

- ‘Portfolio level’ prioritization matrix
- All asset types considered
- Concentration on soil cuttings in this presentation
Likelihood of asset failure
CP4 – SSHI/RSHI

Earthworks Failure Probabilities

- Embankments
- Soil Cuttings
- Rock Cuttings

Probability of failure in 5 year period

SSHI Condition Class of Asset

Servicable: 0.06% 0.11% 0.42%
Marginal: 0.17% 0.31% 0.98%
Poor: 1.82% 0.55% 2.97%
Drivers for change

- Move to a **risk-based** approach
- Decision making based on **likelihood of failure** not condition
- **Likelihood of failure** based on data
- More granularity in decision-making processes (**5 categories**)
- **Removal** of emotive category names (Serviceable, Marginal, Poor)
- Clarification of **nomenclature**
- **Continuous improvement**
Available data

- Asset inventory
  - NR/L3/CIV065: *Examination of Earthworks*
  - Field data capture (visual examinations) since 2005
  - Soil and Rock Cuttings and Embankments

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- Failures
  - NR/L3/CIV028: *The management of reports of Safety-Related Events on Civil Engineering infrastructure*
  - >1000 failure records from 2003 to present

GISMo Image courtesy of JBA
Analysis process

Negatively weighted parameter

Positively weighted parameter

All ~200 parameter values

Total Hazard Index

Split into 5 Earthwork Hazard Categories

e.g. Slope angle < 15 deg and height < 3m

e.g. Slope angle > 35 deg and height > 10m
SSHII (for comparison)

- CIV065 (all assets)
- CIV028 (failed assets - real)
- CIV028 (failed assets – smoothed)
Revised Hazard Indices – Soil Cuttings

Soil Cutting Hazard Index (SCHI)

- CIV065 (all assets)
- CIV028 (failed assets – real)
- CIV028 (failed assets – smoothed)

Earthwork Hazard Category

Frequency density

Soil Cutting Hazard Index (SCHI)
Results - SCHI

**SSH1 Proportions**

- S: 47.6%
- M: 48.3%
- P: 3.6%
- TP: 0.4%

**SCHI Proportions**

- A: 45.4%
- B: 30.4%
- C: 20.1%
- D: 3.7%
- E: 0.4%

- All assets (proportion)
- Failed assets (proportion)
**Results - SCHI**

### Annual probability of failure

<table>
<thead>
<tr>
<th>A (S)</th>
<th>B (M)</th>
<th>C</th>
<th>D (P)</th>
<th>E (TP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSHI</td>
<td>0.04%</td>
<td>0.07%</td>
<td>0.49%</td>
<td>0.82%</td>
</tr>
<tr>
<td>New HI</td>
<td>0.01%</td>
<td>0.05%</td>
<td>0.16%</td>
<td>0.48%</td>
</tr>
</tbody>
</table>

### Annual probability of failure (Normalized to lowest value)

<table>
<thead>
<tr>
<th>A (S)</th>
<th>B (M)</th>
<th>C</th>
<th>D (P)</th>
<th>E (TP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSHI</td>
<td>1</td>
<td>2</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>New HI</td>
<td>1</td>
<td>4</td>
<td>15</td>
<td>51</td>
</tr>
</tbody>
</table>
Application

- Standards updated
- NR CP5 earthworks policy updated
- Whole Life Cost modelling updated
- SEHI/SCHI and EHC on examination field tool
- Examination frequency driven by EHC
- Work bank prioritisation now **guided** by EHC
Portfolio level prioritization

- SEHI/SCHI/EHC are **national**, whole **portfolio** level parameters
- They statistically improve the understanding of likelihood of failure **on average**
- On a **site-by-site** basis, some anomalies will exist (as they did with SSHI)
- Use of outputs **MUST** be combined with experienced input from Route earthworks teams
- CP5 planning based on this premise, through use of the **Powerpack** work bank tool
Consequence of asset failure
Common Consequence Tool

- Developed for Network Rail by Arthur D. Little

Earthworks-specific input: \( p(\text{Derailment} \mid \text{Failure}) \)
**P (derailment | failure)**

- Historical data + expert opinion

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<tbody>
<tr>
<td>Number of CIV028-recorded failures</td>
<td>307</td>
<td>485</td>
<td>488</td>
</tr>
<tr>
<td>Number of earthworks-caused derailments</td>
<td>2</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Average Probability of derailment given failure (%)</td>
<td>0.7</td>
<td>2.3</td>
<td>2.1</td>
</tr>
</tbody>
</table>

- Volume of failure
- Hardness of material (cuttings only)
- Likelihood of failure reaching the track
- Line speed
- Train weight (embankments only)
Future improvements

- Capture of further (historical) failure data
- Inclusion of performance data (particularly for embankments)
- Future review and update of parameter weightings
- Consideration of Rock Slope Hazard Index
- Consideration of slope stability assessments
  - Refinement for geology types
  - Refinement for slope morphologies
Thank you

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