Strategic geotechnical asset management challenges

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Technical Director, Civils Asset Management, Mott MacDonald

Ground related risk to transportation infrastructure, The Geological Society
26 October 2017

Examples

<table>
<thead>
<tr>
<th></th>
<th>Network Rail</th>
<th>Highways England</th>
<th>High Speed 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Network length</strong></td>
<td>9,800 miles of railways</td>
<td>4,400 miles of motorways &amp; major roads</td>
<td>68 miles of railways</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>England, Scotland &amp; Wales</td>
<td>England</td>
<td>Channel tunnel to London</td>
</tr>
<tr>
<td><strong>Earthworks</strong></td>
<td>191,000</td>
<td>49,000</td>
<td>2,500</td>
</tr>
</tbody>
</table>
Definition of strategic asset management

<table>
<thead>
<tr>
<th>Level</th>
<th>Coverage</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Whole organisation</td>
<td>• Asset management policy development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High level, long-term corporate investment planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Target setting &amp; corporate KPI reporting</td>
</tr>
<tr>
<td>Tactical</td>
<td>Sub-area of organisation</td>
<td>• Detailed medium-term works planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Works prioritisation</td>
</tr>
<tr>
<td>Operational</td>
<td>Individual scheme of works</td>
<td>• Optimisation of scheme design</td>
</tr>
</tbody>
</table>
Risk definition

Risk = Likelihood x Consequence

Risk bow tie diagram

Threats
- Weather
  - Rain
  - Hot dry
  - Freeze thaw
  - Climate change
- Deterioration
- Drainage
- Vegetation
- Animals
- Change of use
  - External
    - Flooding
    - Mining
    - 3rd party

Earthworks hazard
- Inventory
  - Type
  - Height
  - Angle
  - Geology
- Condition indicators
  - Movement
  - Water
  - Vegetation
  - Burrowing

Interventions

Risk event

Mitigations

Impact
- Safety
- Performance
- Environment
- Reputation
- Infrastructure
Earthworks hazard - inventory

<table>
<thead>
<tr>
<th>Feature</th>
<th>Network Rail</th>
<th>Highways England</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum height</td>
<td>3.0m</td>
<td>2.5m</td>
</tr>
<tr>
<td>&lt; Minimum height</td>
<td>Excluded</td>
<td>Minor earthwork</td>
</tr>
<tr>
<td>Segmentation</td>
<td>~100m</td>
<td>No</td>
</tr>
<tr>
<td>Geometry</td>
<td>Lidar</td>
<td>Assessed</td>
</tr>
<tr>
<td>Knowledge</td>
<td>100% of &gt;3m</td>
<td>100%</td>
</tr>
</tbody>
</table>

Earthworks hazard - condition

Subjective assessment
Defect level classification used
Earthwork level hazard rating trialled
Risk based frequency

Objective assessment
Earthwork level hazard category (EHC) used
Risk based frequency
Predicting failure

Distribution of factor of safety

Instability indicators
- None
- Precursor indicators
- Failure

Factor of safety

26/10/2017  
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Global Stability Resilience Appraisal (GSRA)

Stability chart boundaries vary with:
- Geology
- Failure mode
- Pore pressure conditions

Failures mainly in high vulnerability

FoS & condition poorly aligned
- Failure vs precursors
- Progressive failure
- Extreme weather events
- Degradation rates vs inspection interval

Challenges:
- Combined approach to improve predictability
- Historic interventions
- Vegetation impact

High plasticity clays – Deep seated failure – High pore water pressure

Slope angle (Cot B)

Upper bound  Lower bound

All Assets  Failed Assets
Condition degradation analysis

Analysis of all available earthwork condition inspections

Probabilistic method

Outputs condition state change matrix for a given time period

Assessed by:
- Earthwork type
- Geology
- GSRA vulnerability

Degradation rates

Degradation matrices applied to artificial portfolio for visualisation

Degradation rate increases with:
- Plasticity (liquid limit & clay fraction) ~2x
- GSRA vulnerability ~3x

First time for evidence based degradation rates for a national portfolio

Challenges:
- Pooled degradation rates from across asset owners
- Variation in degradation rates with asset age

Soil cuttings condition forecast by vulnerability

- Low vulnerability
- Moderate vulnerability
- High vulnerability

Soil cuttings condition forecast by plasticity

- Lowest plasticity
- Intermediate plasticity
- High plasticity
- Highest plasticity
Consequence – safety impact

- Earthwork failure
- Geotechnical assessment
  - Train derail
  - Debris on track or track undermined
  - No derailment
  - Track not affected

Severity of impact
- Collision with another train
- Train falls down embankment
- Collision with obstacle
- Rapid deceleration
- Emergency stop
- Controlled incident

Asset Criticality Score

Fatilities & Weighted Injuries (FWI)
- 1.0 Fatality
- 10 Major injuries
- 200 Minor injuries/major shock
- 1,000 Non reportable minor injuries/minor shock

Earthwork Asset Criticality Band (EACB)

Safety risk matrix

- Likelihood of risk event
- Consequence of risk event
Multiple risks, multiple assets

Impact on likelihood

- Return to as new
- Some improvement
- Does not get worse
- None

Cost per earthwork

- £0.1k
- £1k
- £10k
- £100k
- £1m

Intervention options

New build
Renew
Refurbish
Maintain
Examine
Investigate & monitor

Network Rail
Intervention impacts on risk matrix

Consequence (EACB)

5
Maintain
Refurbish
Renew
Renew
Renew

4
Maintain
Maintain
Renew
Renew
Renew

3
Examine
Maintain
Refurbish
Renew
Renew

2
Examine
Examine
Maintain
Refurbish
Renew

1
Examine
Examine
Examine
Maintain
Renew

Likelihood (EHC)

A B C D E

Mitigation options

Impact on consequence

Reduced to nil
Some reduction
Advance warning

£0.1k £1k £10k £100k £1m

Cost per earthwork
Mitigation impacts on risk matrix

Intervention policy options

Rock cuttings

Soil cuttings

Embankments
Strategic Decision Support Tool (DST)

DST balances
- Degradation
- Interventions & mitigations
- Various policies & scenarios

Outputs
- Costs & whole life costs
- Optimum intervention policy
- Condition & risk profiles

Cross-asset, fence to fence asset management

Cross-asset, fence to fence objectives:
- Reduce costs
- Reduce delays

Currently:
- Earthworks, drainage & vegetation

Challenges:
- Quantification of cross-asset interactions
- Planning DSTs
- Definition of new cross-asset business processes
- Breaking down of cooperate management silos
- Greater flexibility in budget management
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