Asset Management of the Railway Slope Network and the Relevance to Irish Roads

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Paul Doherty and Catherine Joyce, 28th September 2016
Iarnród Éireann Irish Rail Network

- 2,800 km Track
- 3,700 Cuttings & Embankments (1,300 km)
- 3,700 Bridges
- 995 Level Crossings
Infrastructure Asset Management System (IAMS)

- SAP PM
- GIS Viewer
- Asset Register
- Work Bank
- Other SAP Modules
Representation of Asset on IAMS
Case Studies - Recent Failures

- Wicklow Derailment 2009
- Cabra Slope Failures 2012
- Waterford Station Rockfall Dec 2013
- Rushbrooke Rockfall March 2014
Case Studies - Recent Remediation

Farranfore Rock Bolting & Netting 2013
Rushbrooke Rock Nailing & Shotcreting 2014
Mallow-Tralee Combing & Rock Removal 2015
Bray Head Rock Nailing & Netting 2015
IÉ Need for a Decision Support Tool

- Difficult to predict failures
- Subjective assessment of assets
- Network-wide review of assets required
- Robust procedures for safe management of assets
- Decision support tool for maintenance & renewals budgets
- Life-cycle management of assets
• Gavin & Doherty Geosolutions (GDG) is a specialist geotechnical engineering consultancy
• Offices in London, Edinburgh, Dublin and Belfast.
• GDG was formed in 2011 in a challenging market
• Grown throughout the last five years
• Team of 25+ highly qualified engineers
• Majority of our staff are PhD qualified
• We provide innovative geotechnical solutions across a broad range of engineering problems
DRIVERS:

- Heavy reliance on visual assessments (walk-over surveys, internal reports)
- Subjective consideration of past failures, with no direct analysis of failure modes (e.g. Planar/ translation, etc.)
- Move from reactive to predictive analysis of the network risk
- Ensure that slope risk can be analysed in a live process to consider variables such as rainfall
Risk Model Development

- Risk management model
- Risk assessment for each geotechnical asset on the network
- Based on already existing data and advanced geotechnical analyses for slope stability
- Decision Support Tool with in-built cost-benefit analysis for risk management strategies
- The tool is easily updated by final user
Risk Model Development

- Risk values – product of hazard and vulnerability assessments of elements at risk
- \( R = f [H, V, E] \)

- Hazard assessment
  - Landslide identification
  - Hazard mapping
  - Probability of occurrence determination

- Vulnerability assessment
  - Elements at risk identification
  - Event scenarios
  - Consequences

- Risk analysis
  - Risk value calculation

- Risk assessment
  - Evaluating risk against acceptance criteria

- Risk management
  - Decisions!
  - Risk mitigation, management plan
Risk Model Development

3 STAGE PROCESS

• Stage 1: Data requirements and initial hazard model

• Stage 2: Model refinement and Vulnerability assessment

• Stage 3: Risk Model and Decision Support Tool
STAGE 1

- Data Sources
- Asset Inventory restructured
- Influencing parameters defined and quantified
- Database populated
- Probabilistic failure model developed
LiDAR Processing

- LiDAR Data: Critical Cross Sections Identified for Every Asset
• Slope Characteristics: Comparison of Old versus New Data for Network
STAGE 1: FAILURE MODES CONSIDERED

- TRANSLATIONAL
- ROTATIONAL
- WEDGE
STAGE 1: PROBABILISTIC MODELLING

• High Level of Uncertainty Across the Asset Characteristics
• Consider COV of input parameters depending on data source
• Develop quantifiable risk profiles
• Hasofer Lind method used to calculate the probability of failure associated with each asset and its coupled limit state
• Outputs: reliability index (\( \beta \)), probability of failure

Risk Model Development

\[ g(X) = R - S \]

\[ Pf = \beta / \sigma \]

Outputs: reliability index (\( \beta \)), probability of failure
Risk Model Development

STAGE 2: MODEL REFINEMENT (HAZARD ANALYSIS)

- Consider qualitative variables within a Degradation Factor

Drainage

Vegetation

Slip History

Condition
STAGE 2: VULNERABILITY ASSESSMENT & CONSEQUENCE ANALYSIS

- If slope fails – what happens next?
STAGE 2: REFINE GUI

Risk Model Development

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STAGE 3

- Asset risk values are obtained.
- Tool’s in-built slope asset management plan gives generic remediation and mitigation strategies for slopes with different risk profiles.
- A **cost benefit analysis tool** as an independent module is used in parallel with the slope management plan to inform decisions on where expenditure should be focused.
Risk Model Output

Final distribution of Pfs for baseline, hazard and risk

Outputs validated against known hotspots!
GUI – intuitive, versatile, interrogation options
- Possibilities for output: Excel, graphical, PDF. Automatic report-making
Conclusions

- Detailed asset characteristics defined for all earthworks
- Network wide risk model developed
- Analysis based on probabilistic models with coupled limit states
- Incorporates historical experience and anecdotal factors
- Output is a user friendly piece of software for use as a decision support tool
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