14/01/2020

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Title: **Engineering mitigation of a water bearing fissure in the Chalk**
Name of author: **Emily Riley**
Affiliation: **CVB JV Tideway East**
Geotechnical area: **Site Investigation and Groundwater Control**

The Problem

- A shaft being sunk into Chalk was predicted to intercept a steeply inclined water bearing fissure intercepting the base of a diaphragm wall (D-wall) shaft at 66mbgl. Lateral and vertical extent of fissure unknown.
- Baseline pumping tests >14 l/s, limited by discharge consents. Maximum possible water inflow rates unknown but postulated to be in excess of 80 l/s.

- Programme and equipment constraints meant that increasing diaphragm wall depth would not be possible.
- Additional investigation was required to confirm mitigation options to allow safe and successful shaft internal excavation.

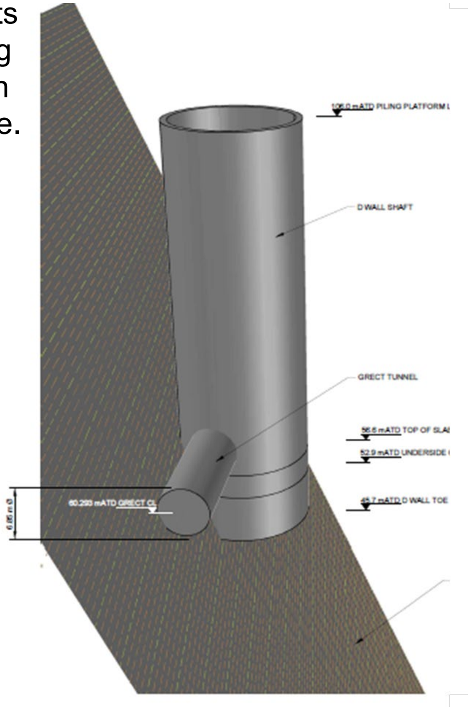

Figure 1 – Schematic of suspected feature on completion of contractor ground investigation (Golder, 2018).

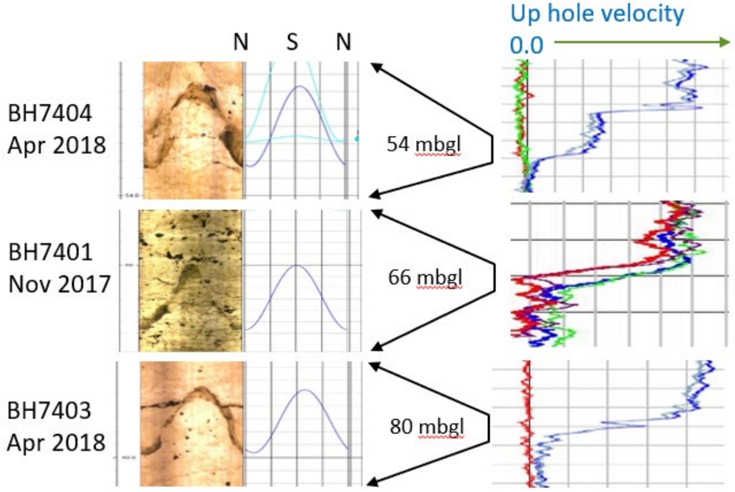

Figure 2: Borehole geophysics: Image and Fluid logs (EGS / WJUK, 2018)

The Solution

- Pumping tests, pumped borehole geophysics and geological logging North and South of the initial interception of the feature delineated the fissure plane.
- Confirmation of inflow. D-wall at planned depth would not provide an effective cut off.
- Targeted grouting inside shaft footprint, using known points of interception prior to D-walling.
- Verification via post D-walling pumping tests and coring through the base of D-wall to verify grouting extent

The Contribution

- Inflow from fissure identified at the expected depths within additional boreholes, confirming feature.
- A grouting campaign using cement-based grouts utilised the known points of interception. Injection of 20m³ of grout which accounted for 38% of predicted fissure infill if a continuous planar feature 50mm wide across the full shaft diameter was assumed.
- No additional mitigation works required to permit shaft excavation, minimising programme impact.
- Logging of marker horizons during borehole drilling and shaft excavation indicated offsets of >1m, which may have been overlooked if geophysical data not available.
- The fissure investigations highlighted the importance of undertaking integrated investigations, and enabled an efficient grouting campaign.

Figure 3 – Identification of grout within fault zone. Confirmed by materials testing

References:

Mortimore, R.N., Newman, TG, Royse, K, Scholes, H and Lawrence, U (2011). *Chalk: its stratigraphy, structure and engineering geology in east London and the Thames Gateway.* Quarterly Journal of Engineering Geology and Hydrogeology. Vol 44.

Stanley, M. et al. (2012). *Design and construction of the Thames Water Lee Tunnel shafts, London*. Tunnels and Tunnelling International, April 2012, 103-108.

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Title of presentation: Clay Cut Slope Deterioration
Name of author: Dr. Harry Postill
Affiliation: Loughborough University
Geotechnical area: Numerical Modelling and Slope Stability

29/11/2019

The Problem

- High-plasticity clay infrastructure earthwork assets are deteriorating due to seasonal pore water pressure cycles causing seasonal ratcheting.
- The mechanism of seasonal ratcheting and long-term behaviour of slopes due to different weather patterns (i.e. climate change) is not well understood.
- Understanding slope deterioration rates and where slopes are within their life-cycle is critical for earthwork asset management strategies (see Figure 1).

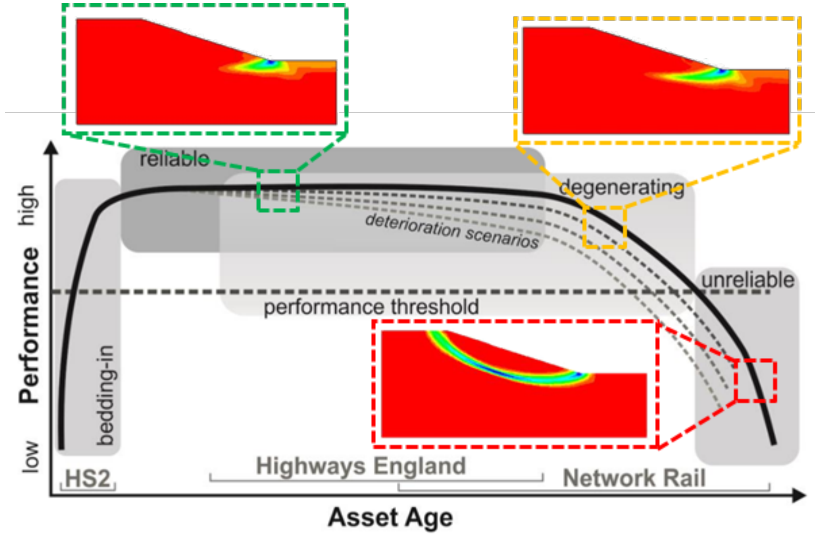

Figure 1 - Generalised deterioration model for transport earthworks (after Glendinning, *et al.*, 2015)

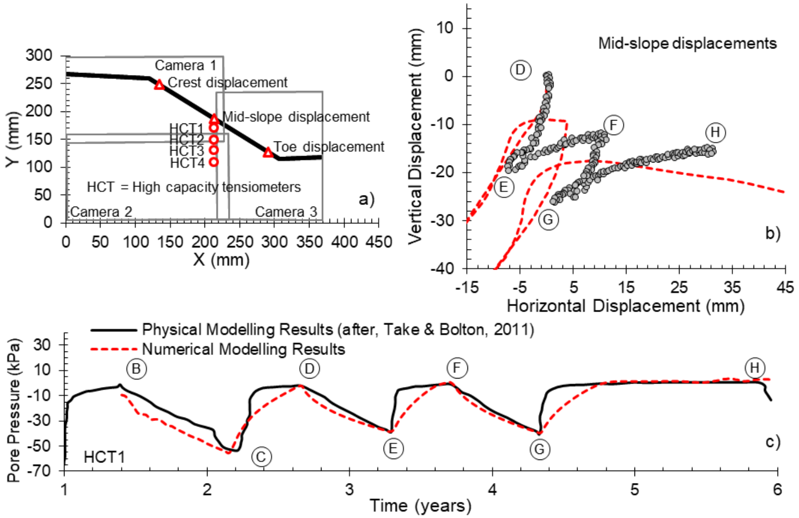

Figure 2 – Validation of numerical model behaviour against centrifuge experimentation (after Postill et al. 2019)

The Solution

- Validated numerical modelling approaches can be used to investigate long-term slope behaviour.
- The mechanism of seasonal ratcheting (i.e. hydrogeological stress cycles causing displacements and progressive failure have been captured in the modelling approach presented.

The Contribution

- Seasonal wetting and drying stress cycles can lead to mobilisation of post-peak strength and progressive failure in clay slopes.
- Seasonal stress cycles will change due to climate change. We have looked at the effect of different weather sequences on slope behaviour and shown that failure occurred earlier in a model considering climate change (i.e. wetter winters and drier summers) (see Figure 3).

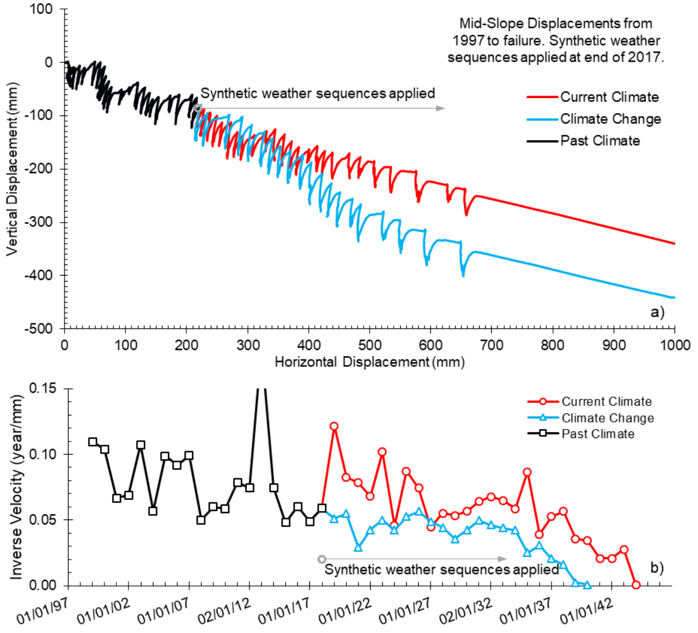

Figure 3 – Effect of climate change on slope model behaviour

References:

Glendinning, S. et al. (2015) Research-informed design, management and maintenance of infrastructure slopes: development of a multi-scalar approach. In: *IOP Conference Series: Earth and Environmental Science 26 (2015)*. IOP Publishing, 012005.

Postill, H. et al. (2019) Modelling seasonal ratcheting and progressive failure in clay slopes: a validation. *Canadian Geotechnical Journal.*

Take, W. A. & Bolton, M. D. (2011) Seasonal ratcheting and softening in clay slopes, leading to first time failure. *Géotechnique*, 61(9) 757-769.

Cooling Prize 2013

Title of presentation: The uplift capacity of transmission pylon foundations
Name of author: Frederick Levy
Affiliation: University of Southampton & National Grid
Geotechnical area: Undrained soil mechanics

The Problem

- 2020 renewable targets (BERR, 2008) in combination with saturation of capacity has necessitated a major program of restringing and uprating old high voltage transmission cables (Clark et al., 2006). This program will result in significant increases of loading on transmission pylon foundations systems due to larger cable sizes.
- Studies undertaken by University of Southampton and field tests by National Grid have demonstrated that the design basis for transmission pylon foundations may not be reliable (Lehane, 2008).
- The present failure rate of pylon foundations is extremely low, suggesting that there are additional factors contributing to uplift resistance.

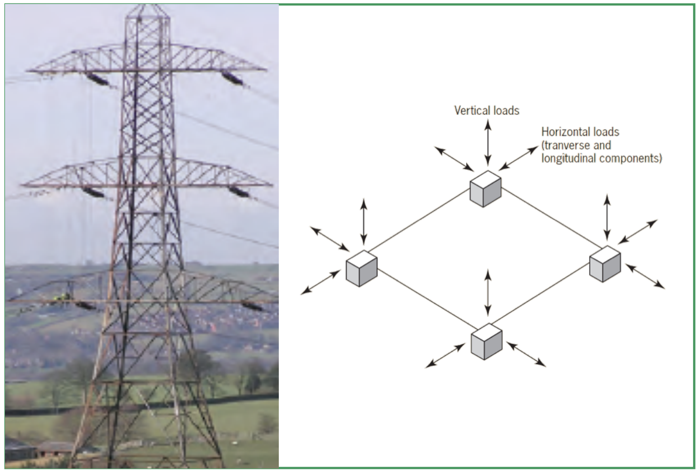

Figure 1 – A typical transmission pylon (left) and typical loads (right)

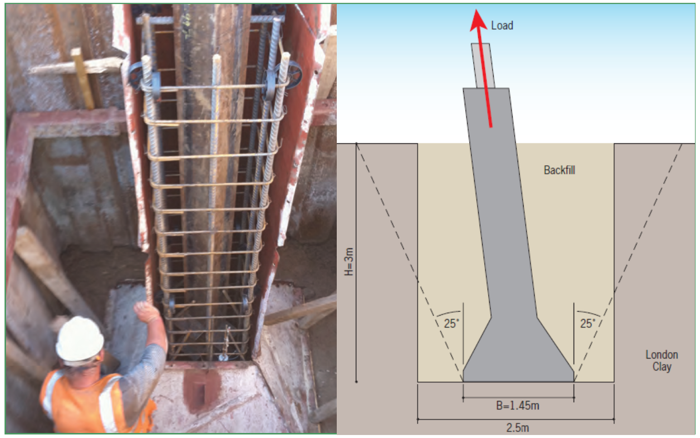

Figure 2 – Foundations tested on site

The Solution

- Investigate pylon foundation capacity by conducting a set of full-scale rapid foundation uplift testing to compare the dynamic response to standard static testing practise.
- Testing was conducted over two weeks in July 2012. Five 10m deep CPTs were used to characterise the site and backfills.
- A set of numerical back-analysis studies were conducted to reproduce the load-displacement behaviour of the tested foundations.

The Contribution

- The series of field tests on a number of full-scale footings has confirmed that base suction may contribute significantly to footing performance. In the cases where suctions did not develop, the uplift performance of the footings was poor.
- Current testing practice may have led to an undue underestimation of foundation uplift capacity due to the manner of test load application (slow vs rapid). A new load testing protocol has been proposed to National grid.
- With recent developments in data logging and transmission it would be relatively straightforward to fully instrument a pylon. Through such endeavours a better design and testing rationale may be developed..

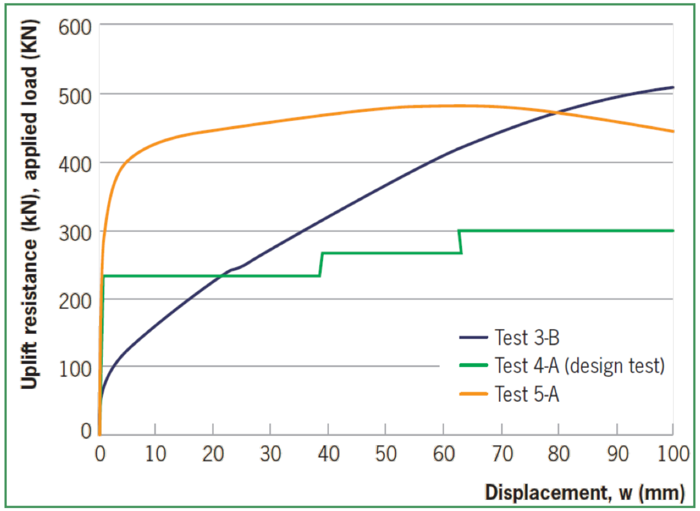

Figure 3 – Test 5-A (suction), Test 3-B (no suction) and Test 4-A (current National Grid testing practice)

References:

BERR (2008) *UK Renewable Energy Strategy*. Department for Business Enterprise Regulatory Reform, London, UK.

Clark, M; Richards, D J; and Clutterbuck, D (2006) *Measured dynamic performance of electricity transmission towers following controlled broken-wire events*. International Council on Large Electronic Systems, Paris, France, Paper B2-313.

Lehane, B M; Gaudin, C; Richards, D J; and Rattley, M J (2008) Rate effects on the vertical uplift capacity of footings founded in clay. *Géotechnique*, 58(1): 13-21.