

The Periglacial Legacy: Landslide Stabilisation on the M25



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Engineering Group Forum 23rd November 2011

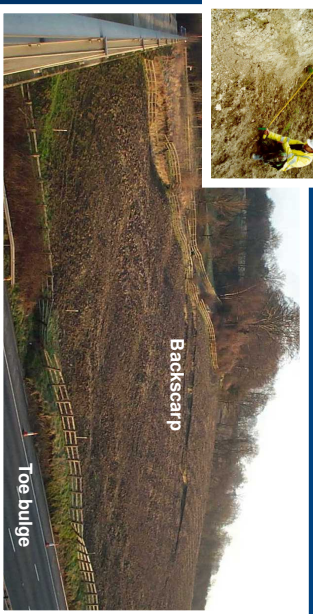


Introduction

- 19-20th Dec 2000: Major landslide on N side of M25
- Gault Clay cutting only 11 degrees
- Effected hard shoulder and adjacent over-bridge
- Potential to cause closure of anticlockwise carriageway
- Need for fast track approach



Landslide Morphology

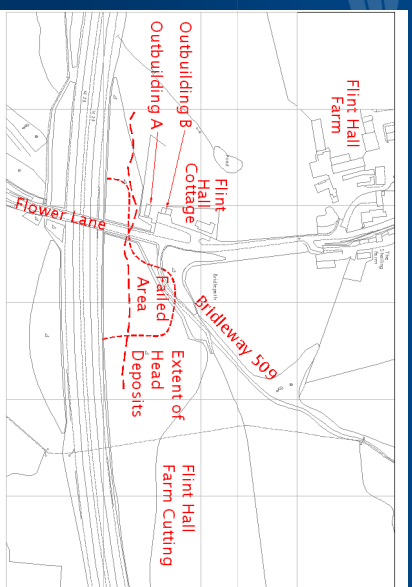


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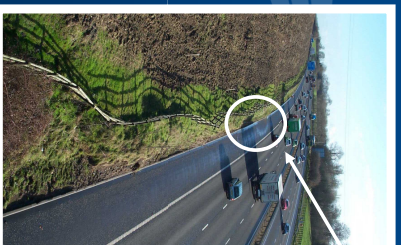
- Introduction
- Landslide morphology
- Geological setting
- Investigation & monitoring
- Design of remedial works
- Construction
- Post construction monitoring
- Conclusions



Introduction: Plan of site



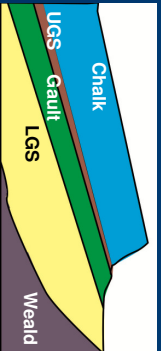
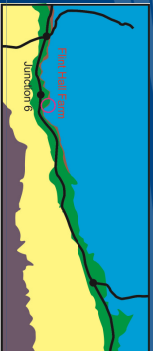
Hard
Shoulder
heave



Tensional zone beneath the
bridge – graben structure



Geological Setting

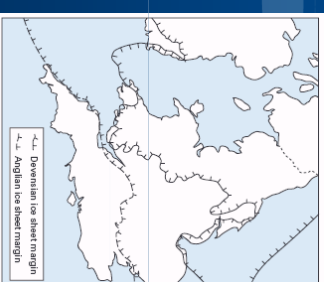


- Gault part of N Downs escarpment
- Very stiff grey fissured silty clay
- Deposited in deeper water during marine transgression
- Subsequently mantled by Head deposits



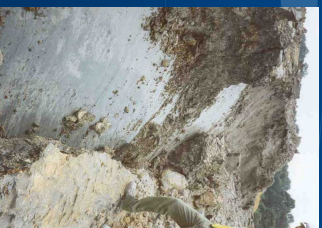
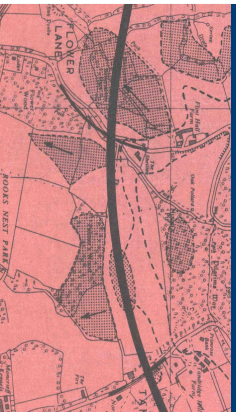
Periglacial Processes

- Literally 'around the glacier'
- Cold climate features due to intense frost action
- Cryoturbation – mixing of soil layers during free-thaw
- Solifluction – downslope movement of saturated soils
- Development of shear surfaces



Previous Failures

- Below: Soils and Materials Report, 1976 (pre construction)
- Right: Failure surfaces found during construction



Investigation & Monitoring

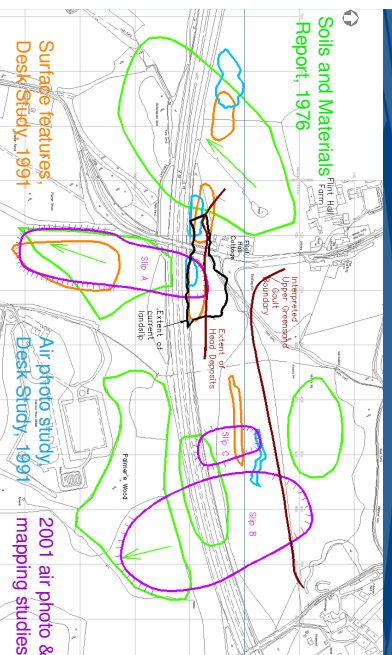
- Immediate actions:
 - Traffic management
 - Alarm system
 - Contingency planning
 - Low tech slope monitoring
 - Emergency drainage
- Geomorphological mapping
- Multiphase GI
- Instrumentation



Geomorphological Mapping



Summary of Geomorphology



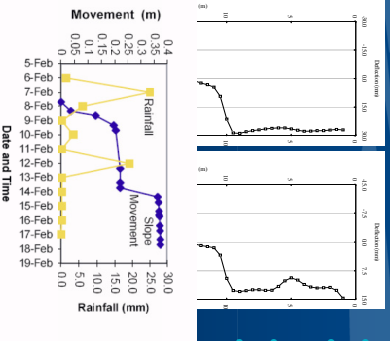
Investigation



- Identify ground conditions and mechanism
- confirm extent of failure
- quantify risk to properties



Monitoring



- 15 no. inclinometers
- 34 no. standpipe and 2 no. ww piezometers
- 94 No. slip indicators
- bridge monitoring - tiltmeter, crackmeter, temperature, surveying



Design Process

- Properties based on lab testing, literature & back analysis
- 60 year design life meant structure solution required
- Pile to provide 20% increase in FoS
- Drainage to further improve FoS; plus help prevent instability above and below pile line

	c'	phi	Cu
Head	0	14	50
Gault	1	24	100
Residual	0	14	50



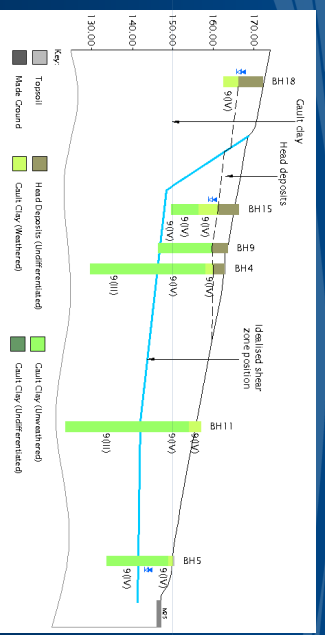
Detailed Soil Logging



- Only possible in shored pits
- Allowed Identification of:
 - Slip surface
 - Gault / Head Interface
 - Ice wedges
 - Desiccation cracks

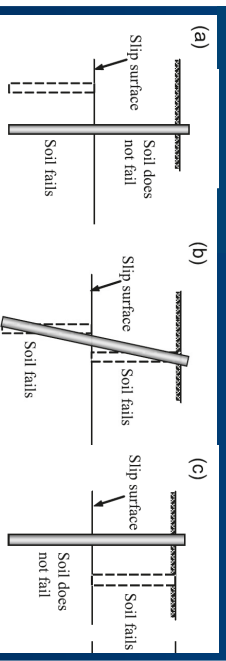


Geological Model

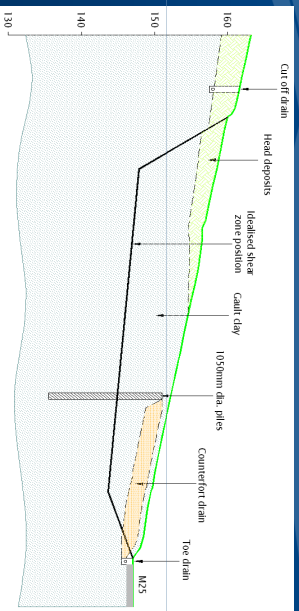


Design Process II

- Establish restoring force and drainage required to achieve desired factor of safety
- Calculate pile size, length, spacing and determine required position within slip



Final Solution



Construction Contract Strategy

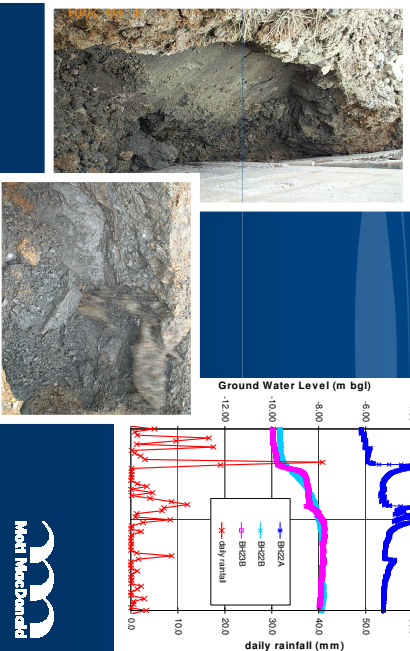
- Work carried out by RCS under ECC Option E ('cost plus')
- Allowed easy adjustments to design if required
- Highways Agency carried all the ground and weather risk
- Risk priced into contract and money released as risk reduced
- Project complete on time and 30% below budget at £2.8m
- All works complete within one year



Construction



Construction Observations



Post Construction Monitoring

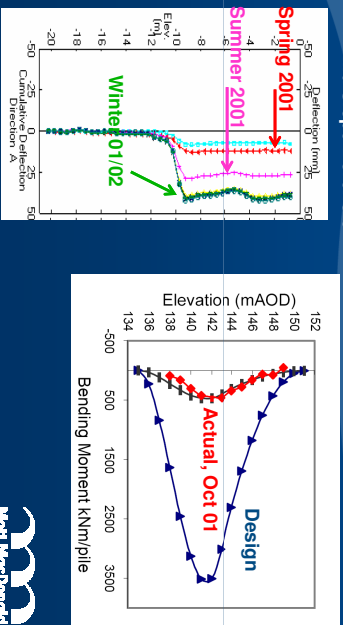
- residual risk management by continued monitoring
- inclinometers within piles and slope; piezometers; monitored by TRL as part of HA research programme



Mobilisation during First Winter

BH4 Mid Slope Borehole

Pile Bending Moments



Ongoing Management

- Flint Hall Farm just one location of this stretch of M25 and M26 which requires ongoing risk management.
- Adjacent instrumentation at Rook's Nest Farm continues to show small shear movements.
- Important Gault corridor landslide risk study by Mouchel



References

- Davies et al (2003). Stabilisation of a Landslide on the M25 Highway London's Main Artery. 12th Pan-American Conference on soil mechanics and geotechnical engineering. 22-25 June.
- Garder & Barker (2005). The performance of a single row of spaced bored piles to stabilise a Gault Clay slope on the M25, TRL Report 627
- Ellis et al (2011). Landslides on Gault: geomorphological identification and qualitative risk assessment. QJEGH 44, 35-48

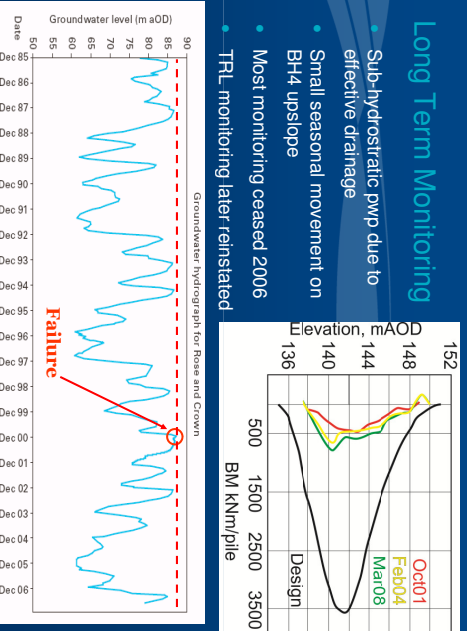
Acknowledgements

- Atkins - David Wright & Verity Smith
- Highways Agency - David Patterson & Raphael Lung
- TRL
- Geotechnical Observations
- Mouchel Parkman Ltd

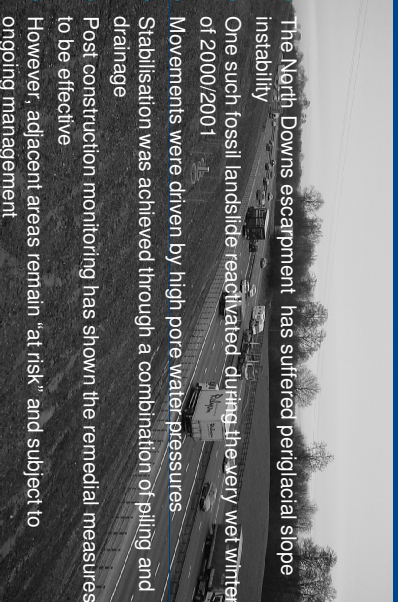


Long Term Monitoring

- Sub-hydraulic pwp due to effective drainage
- Small seasonal movement on BH4 upslope
- Most monitoring ceased 2006
- TRL monitoring later reinstated



- The North Downs escarpment has suffered periglacial slope instability
- One such fossil landslide reactivated during the very wet winter of 2000/2001
- Movements were driven by high pore water pressures
- Stabilisation was achieved through a combination of piling and drainage
- Post construction monitoring has shown the remedial measures to be effective
- However, adjacent areas remain "at risk" and subject to ongoing management



Summary

